Coal India Limited

(A Government of India Enterprise)
CIN: L23109WB1973GOI028844

COAL INDIA LIMITED HEAD OFFICE
Coal Bhawan Premise No-04 MAR, Plot No-AF-III, Action Area-1A,
Newtown, Rajarhat, Kolkata-700163
E-mail: gmsolar.cil@coalindia.in

Tender

For

Setting up of Grid Connected 300 MW Ground Mounted Solar PV plant

at

Khavda, Gujarat

Tender ID : 2024_CILHQ_316279_1

Introduction

- Coal India Limited (CIL) is the state-owned coal mining corporate came into being in November 1975 is at the forefront of the nation's coal production in the Indian energy sector, CIL. CIL alone produces around 83% of country's entire coal output. In a country where 69% of the total electricity generation is coal based, CIL virtually empowers the nation's power sector. Around 80% of CIL's total supplies are catered to power sector.

- CIL is currently developing several Solar, Floating & Hybrid innovative Renewable Energy Projects. In the years to come CIL has a major role to play in the Renewable Energy sector's development. The company has an aim to develop a total cumulative capacity of 5 GW of Renewable Energy by the year 2025-26.

- In this regard CIL participated in Gujarat Urja Vikash Nigam's (GUVNL) auction to supply power from 600 MW of grid-connected solar power project (Phase XXI) to be set up at Khavda Solar Park, Gujarat. CIL was awarded a capacity of 300 MW and the organization envisages the execution of green energy technologies by way of implementing ground based Solar PV Power Plant for setting up 300 MW grid connected Solar Photovoltaic (PV) Power Projects.

- The selection of the Contractor for the "Design, Engineering, Supply of all the necessary components including PV modules, Construction, Erection, Testing & Commissioning of 300 MW (AC) Ground mounted Solar PV Project along with DC Overloading at Khavda Solar Park, having 5 Years Plant O&M" will be carried out by Coal India Limited (A Government of India Enterprise), Coal Bhawan Premise No-04 MAR, Plot No-AF-III, Action Area-1A,Newtown, Rajarhat, Kolkata-700163 (hereinafter referred to as 'CIL' or EMPLOYER or OWNER). For the purpose of all procurement activities related to the said works, CIL shall be referred to as 'CIL or Employer or Owner'.

- CIL, therefore, invites bids from eligible bidders to participate in the tender for Design, Engineering, Supply of all the necessary components including PV modules , Construction, Erection, Testing & Commissioning of 300 MW (AC) Ground mounted Solar PV Project along with DC Overloading at Khavda Solar Park, having 5 Years Plant O&M.

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SECTION – I: NOTICE INVITING TENDER (NIT)

कोल इंडिया लिमिटेड
(भारत सरकार का उपक्रम)
सौर विभाग
परिसर सं.-04 एम.ए.आर., प्लॉट नं.-ए.एफ.-III,
एक्शन एरिया- 1A, न्यू टाउन,
राजरहाट, कोलकाता-700156
फोन: 033 23244024, *फैक्स*: 033 23244082
वेबसाइट: www.coalindia.in

Coal India Limited
(A Government of India Enterprise)
Solar Division
Premises No. 04 MAR, Plot No. AF-III,
Action Area 1A, New Town,
Rajarhat, Kolkata-700156
Phone: 033 23244024, Fax: 033 3244082
Website: www.coalindia.in

Ref. No.: CIL/HQ/SOLAR/KHAVDA_300/01 **Dated**: 29.08.2024

e-TENDER NOTICE

1. Tenders are invited on-line on the website **https://coalindiatenders.nic.in** from the eligible bidders having Digital Signature Certificate (DSC) issued from any agency authorized by Controller of Certifying Authority (CCA), Govt. of India and which can be traced up to the chain of trust to the Root Certificate of CCA, for the following work:

	Scope Of Work	Design & engineering, procurement & supply of equipment and materials (including PV modules, testing at manufacturers works, multi – level inspections, packing and forwarding, supply, receipt, unloading and storage at site, associated civil works, services, permits, licenses, installation and incidentals, insurance at all stages (Including Insurance of PV Modules), erection, testing and commissioning of 300 MW (AC) Grid connected ground mounted Solar PV Power Plant along with DC Overloading and performance demonstration with associated equipment and materials on turnkey basis at Khavda Solar Park along with 5 (Five) years comprehensive operation and maintenance from the date of commissioning or Operational Acceptance, whichever is later. 1. Design, Procurement & Supply, and erection of the following, in all respect: a) Supply, Packing and Forwarding, Transportation of PV Modules up to Khavda Solar Park, Gujarat including Transit insurance of crystalline Solar PV Modules with nominal wattage and dimensions as mentioned in scope of supply for 1500V System Voltage including DC overloading and mandatory spares.

		b) The Total capacity of PV modules to be procured under this tender, excluding mandatory spares is 405 MWp (minimum). c) Module mounting structures and fasteners. Installation, Erection, Testing and Commissioning of Modules (as supplied by owner) along with demonstration of the performance parameters. d) All power conditioning systems including junction boxes, Inverters/ PCU, DC and AC circuit breaker(s). e) All associated electrical works and equipment required for interfacing line/ cable (i.e., transformer(s) – power and auxiliary, breakers, isolators, lightning arrestor(s), LT/other panels, protection system, cables, metering etc., but not limited to) as per technical specifications. f) Design, supply, erection, testing & commissioning defined in scope of work/ TS as per project requirement and associated switchgear equipment and metering equipment as per technical specification and state regulations. g) All associated civil works, including design and Engineering, for: Earthwork for Site grading, cutting, filling, levelling & compacting, internal Roads, Storm water drainage in the requisite project land as required for development of this Solar PV Power Plant h) Construction of Passage for Cleaning of Solar PV Project i) Construction of rainwater drainage, if required j) Setting up of a comprehensive Fire Protection system as per the Hazardous area classification for the site k) Supply of mandatory spares & special tools and tackles l) Demonstration of performance of the plant as per the requirement specified in the bidding documents. m) Comprehensive operation & maintenance of the ground mounted SPV plant for 5 (Five) years as mentioned in detailed scope of work from the date

		of commissioning or Operational Acceptance, whichever is later, as detailed in technical specification, including supply and storage of all spare parts, consumables, repairs/ replacement of any defective equipment etc. n) Obtaining all associated statutory and regulatory compliances and approvals for successful construction, commissioning and operation of plant
B	Capacity Utilization Factor (CUF) or Minimum Net Electrical Energy Generation Guarantee (Minimum NEEGG)	Minimum CUF= 28% at delivery point CUF = plant output in kWh / (installed plant capacity in kW * 365X24) Minimum NEEGG = 73,58,40,000 Units (for 1st year)
C	Tender ID. and date	**2024_CILHQ_316279_1, dated: 29.08.2024**
D	Source of Fund	Owner as defined in the Bid Data Sheets (BDS) intends to finance the package through domestic funding and own resources.
E	Type of Tender	"Single Stage Two Part "online Bidding system..
F	Bidders Eligibility Criteria	It's a "Domestic Competitive Bidding" and hence this bid is open only for bidders registered within the Owner's country.
G	Scheduled Completion/ Contract Period	Scheduled Completion/ Contract Period shall mean: (i) Commissioning period upto 31.01.2026 or actual COD of Associated Transmission System of Khavda Solar Park (KPS-2) whichever is earlier, subject to minimum time period of 12 months from the date of LOA. However, if there is any further delay in commissioning of transmission line, the SCOD will stand auto extended upto 30 days from such commissioning and no LD will be deducted, and (ii) O&M period of 5 years after SCOD.
H	Cost of Bidding Document	Free of Cost

I	Tender Processing Fee	Free of Cost
J	Earnest Money Deposit (EMD)	INR 50 Lakhs.
K	Contract Performance Security	Applicable as per Section III – Special Conditions of Contract (SCC)
L	Date Time & Venue of Pre-Bid meeting & site visit	**Pre Bid:** As per Portal Details **Site Visit:** Prospective Bidders are advised to visit the proposed site to study the actual conditions and go through the plot plans attached in Annexure XVIII, connected to the present scope of work etc. including power evacuation system and Project capacities and get acquainted with the same before attending Pre-bid meeting. Note: CIL has been allotted Plot - 3,4 and 5 in GIPCL Solar Park (Phase-I) each plot measuring 450 Acres.

i) For Site visit of location of work, the prospective bidder(s) may contact Shri Deepak Jangid, Dy Manager (E&M)-Solar, CIL (Mob no. – 9680543389)

Tender inviting authority	Contact Person(s)/Tender Dealing Officer(s)
Sudarsan Bora **GM (E&M)** **Solar Dept.** **Coal India Limited** **gmsolar.cil@coalindia.in**	1. **Jitendra Kr. Singh** Sr. Manager (E&M) Solar Dept. singh.jitendra@coalindia.in 2. **Rajnesh Meena** Deputy Manager (E&M) Solar Dept. rajnish.meena@coalindia.in
For any Portal related queries please call at 24 x 7 Help Desk Number- 0120-4001 002, 0120-4001 005, 0120-4493 395 Email: support-eproc@nic.com	

2. Time Schedule of Tender

1	**Date of issuance of Tender**	**As per Portal**
2	Last Date and Time for submission of pre-bid clarifications	
3	Date and Time of pre- bid meeting	
4	Last Date and Time for downloading the NIT	
5	Start Date and Time for Online Tender submission	
6	Last Date and Time for Online Tender submission	
7	Date and Time of Technical Bid opening (Cover-I)	
8	Date and time of Opening of Financial Bid (Cover-II)	

Note:

a. The auto extension of submission of bid shall be applicable as per details mentioned in clause no.24 of NIT.

b. In case there is any change in date and time of price opening, the same shall be communicated to the Technically acceptable bidders through portal.

3. EMD/Bid security

3.1 The Bidder shall furnish, as part of his bid, a Bid Security/Earnest Money of the amount as shown in e-tender notice and in the form as deliberated below:
The Bidder will have to make the payment of EMD through ONLINE mode only. No Offline mode of Payment of EMD/Bid security shall be applicable and acceptable. In online mode the Bidder can make payment of EMD either through net banking from designated Banks/s or through NEFT/RTGS from any scheduled Bank. In case of payment through net-banking the money will be transferred to CIL/ Subsidiary designated Account. In case of payment through NEFT/RTGS the Bidder will have to make payment as per the Challan generated by system on e-Procurement portal. Bidder will be allowed by the system to submit the bid only when the EMD is successfully received in CIL/Subsidiary designated account and the information flows from Bank's Server to e-Procurement portal. The Earnest Money/ bid security for the unsuccessful Bidder shall be refundable as promptly as possible. The EMD shall bear no interest. No Bid will be accepted unless accompanied by requisite Bid Security/ Earnest Money Deposit as stated above.

3.2 Any Bid not accompanied by an acceptable Bid Security/EMD shall be rejected by the employer as nonresponsive unless otherwise exempted in the Bid document.

3.3 The EMD of rejected Bidders will be refunded at any stage directly to the account from where it had been received (except the cases where EMD is to be forfeited).

3.4 The Bid Security / EMD of successful Bidder may be retained and adjusted with Performance Security / Security Deposit at Bidder's option.

3.5 The Bid Security/Earnest Money may be forfeited:

a. if the Bidder withdraws the Bid after the end date of Bid submission during the period of Bid validity / extended validity with mutual consent; or

b. in the case of a successful Bidder, if the Bidder fails within the specified time limit to furnish the required Performance Security Deposit;

Additionally, the Company shall debar such defaulting Contractor from participating in future bids for a minimum period of 12(twelve) months.

3.6 The Bid Security/ EMD deposited with the Employer will not carry any interest.

3.7 No claim from the Bidders will be entertained for non-receipt of the refund in any account other than the one from where the money is received.

3.8 If the refund of EMD is not received by the Bidder in the account from which the EMD has been made due to any technical reason, then it will be paid through conventional system of e-payment. For this purpose, Bidder should submit e-Mandate form as per Clause No.7 during bid submission.

3.9 In case the tender is cancelled then EMD of all the participating Bidders will be refunded unless it is forfeited by the Department. If the Bidder withdraws the bid online (i.e. before the end date of submission of tender) then the EMD will be refunded automatically after the opening of tender.

4. Pre-bid Meeting

The pre-bid meeting shall be held on hybrid mode (physical as well as through VC) as per the scheduled date & time, as specified in the e-Procurement portal. The purpose of the pre-bid meeting is to clarify the issues and to answer the questions on any matter that may be raised at that stage. Non-attendance at the pre-bid meeting will not be a cause for disqualification of bidder and it shall be presumed that the bidder does not require any clarification. The minutes of the Pre-Bid meeting shall be uploaded on the Portal, which can be viewed by all interested bidders.

5. Clarification of Bid

The bidder may seek clarification on-line within the specified period. However, the management will clarify as far as possible to the relevant queries.

6. User Portal Agreement

The bidders have to accept the on-line user portal agreement which contains the acceptance of all the Terms and Conditions of NIT and tender document, undertakings and the e-Procurement system through **https://coalindiatenders.nic.in** in order to become an eligible bidder. This will be a part of the agreement.

7. Eligible Bidders

7.1 The Invitation for Bid(s) is open to all Bidders including an individual, proprietorship firm, partnership firm, company registered under Companies Act, any legal entity or JV/Consortium. The bidders shall be eligible to participate only if they fulfill the qualifying criteria laid down separately hereinafter.

7.2 A firm that has been engaged by the Employer to provide consulting services for the preparation or supervision of the Works shall not be eligible to Bid.

7.3 Joint Venture(JV)/Consortium: Two or three companies/ contractors may jointly undertake contract/contracts. Each entity will be jointly and severally responsible for completing the task as per the contract JV/Consortium Details: - Name of all partners of a JV/Consortium (Not more than 3)

Joint Venture/ Consortium details:

Name of all Members of a JV/Consortium (not more than 3):

i. Lead Member (minimum participation share – 50%)
ii. Member (minimum participation share – 20%)
iii. Member (minimum participation share – 20%)

NOTES: JV/Consortium must comply the following requirements:

i) Following are the minimum qualification requirements for JV/Consortium:
   a) The qualifying criteria parameter e.g. experience of the individual partners of the JV/CONSORTIUM with be as deliberated under Clause 8 of NIT towards fulfillment of qualification criteria related to experience.
   b) The qualifying criteria parameter e.g. financial resources (turnover and Net-worth) of the individual partners of the JV/CONSORTIUM. will be added together, for the relevant period, and the total criteria should not be less than as deliberated under Clause 8 of NIT towards fulfillment of qualification criteria related to financial turnover. However, the required Net-worth shall be met by individual JV/CONSORTIUM partners.

ii) The formation of JV/Consortium or change in the JV/Consortium character/ partners after submission of the bid and any change in the bidding regarding JV/Consortium /will not be permitted.

iii) The bid, and in case of a successful bid- the agreement, shall be signed so as to legally bind all partners jointly and severally and any bid shall be submitted with a copy of the JV/Consortium Agreement providing the joint and several liabilities with respect to the contract.

iv) The pre-qualification of a JV/Consortium does not necessarily pre-qualify any of its partners individually or as a partner in any other JV/Consortium or association. In case of dissolution of a JV/Consortium, each one of the constituent firms may pre-qualify if

they meet all the pre-qualification requirements, subject to written approval of the employer.

v) The bid submission must include documentary evidence to the relationship between JV/Consortium partners in the form of JV/CONSORTIUM Agreement to legally bind all partners jointly and severally for the proposed agreement which should set out the principles for the constitution, operation, responsibilities regarding work and financial arrangements, participation (percentage share in the total) and liabilities (joint and several) in respect of each and all of the firms in the JV/Consortium. Such JV/CONSORTIUM Agreement must evidence the commitment of the parties to bid for the facilities applied for (if prequalified) and to execute the contract for the facilities if their bid is successful.

vi) One of the partners shall be nominated for being In-Charge of the contract and shall be designated as Lead Partner. This authorization shall be evidenced by submitting with the bid a Power of Attorney signed by legally authorized signatories of all the partners.

vii) The JV/CONSORTIUM Agreement must provide that the Lead Partner shall be authorized to incur liabilities and receive instructions for and on behalf of any and all partners of the JV/Consortium and the entire execution of the contract shall be done with active participation of the Lead Partner.

viii) The contract agreement should be signed by each JV/Consortium Partners. Subsequent declarations/letters/documents shall be signed by lead partner authorized to sign on behalf of the JV/CONSORTIUM or authorized signatory on behalf of JV/CONSORTIUM.

ix) The bid should be signed by the DSC holder submitting the bid.

x) An entity can be a partner in only one JV/Consortium. Bid submitted by JV/Consortium including the same entity as partner will be rejected.

xi) The JV/CONSORTIUM agreement may specify the share of each individual partner for the purpose of execution of this contract. This is required to fulfill eligibility criteria and also for the purpose of apportioning the value of the contract to that extent to individual partner for subsequent submission in other bids if he intends to do so for the purpose of the qualification in that Bid.

xii) The earnest money / bids security bank guarantee can be submitted by the JV/Consortium or one or more partners of the JV/Consortium.

xiii) The JV/CONSORTIUM agreement must specifically state that it is valid for the project for which bidding is done. If JV/CONSORTIUM breaks up midway before award of work and during bid validity period bid will be rejected. If JV/CONSORTIUM breaks up midway before award of work and during bid validity/after award of work/during pendency of contract, in addition to normal penalties as per provision of bid document, all the partners of the JV/CONSORTIUM shall be debarred from participating in future bids for a minimum period of 12 months.

xiv) JV/CONSORTIUM agreement shall be registered in accordance with law so as to be legally valid and binding on the members before making any payment.

xv) JV/CONSORTIUM shall open a bank account in the name of JV/CONSORTIUM and all payments due to the JV/CONSORTIUM shall be credited by employer to that account only. To facilitate statutory deductions all statutory documents like PAN/GSTIN, etc. in the name of the JV/Consortium shall be submitted by JV/CONSORTIUM before making any payment.

8. Eligibility Criteria to qualify for the award of contract and data/supporting documents to be uploaded online

Qualification of the bidder(s) will be based on their meeting the minimum eligibility criteria specified below regarding the Bidder's Technical Experience and Financial eligibility as demonstrated by the Bidder's responses in the corresponding Bid documents. The bid can be submitted by an individual Company or by a Joint Venture/Consortium of not more than 03 (Three) companies. (Specific requirements for Joint Ventures/Consortium are given below)

A. Work Experience

a) Bidders can participate through any one of the below mentioned qualifying routes. The Bidder shall be considered meeting Technical Eligibility criteria either from Route I or Route II.

Route I

The bidder should have experience in EPC execution of Ground mounted Solar PV Projects on Turnkey basis including Design, Supply (Supply of Modules shall be inclusive in the bidder's scope in the past experience), Installation and Commissioning of **cumulative capacity of 100 MW – with projects of capacity not less than 30 MW** in last seven financial years as on ending last day of month previous to the one in which bid applications are invited. However, such Grid connected Solar PV Power Plants must have been in satisfactory operation for at least six (06) months from the date of Commissioning. The certificate of Commissioning (including satisfactory performance of 6 months after commissioning) will be submitted by the bidder during bidding.

Route II

The bidder should have experience in execution of Ground mounted Solar PV Projects as a Developer of at least 01(one) Grid-connected Solar PV Power Plant(s) of **cumulative capacity of 100 MW – with projects of capacity not less than 30 MW** in last seven financial years as on ending last day of month previous to the one in which bid applications are invited. However, such Grid connected Solar PV Power Plants must have been in satisfactory operation for at least six (06) months from the date of Commissioning. The certificate of Commissioning (including satisfactory performance of 6 months after commissioning) will be submitted by the bidder during bidding.

The bidder shall also be considered qualified, in case the award for executing the reference work has been received by the bidder either directly from the owner of the plant or any other intermediary organization.

- Commissioning Certificate will be accepted if issued by a Govt entity.
- ITR and/or Form 16 (for the relevant year in which bidder has received the final payment of the job) will be additionally required in case work completion is issued by a non-Government entity.

Note:

1). The experience towards overseas jobs, if submitted, should be vetted/endorsed by the relevant* embassy/high commission concerned, towards authenticity of document in English or translated in English language. (*Relevant embassy/High Commission means the embassy/High Commission in India of the country where the bidder has executed the said work or country of origin of the bidder OR the Indian embassy in the country where bidder has executed the work or country of origin of the bidder.)

2). JV/Consortium, shall be allowed for participation in the bid.

The above qualification criteria can also be fulfilled by JV/CONSORTIUM either individually (by any of the JV/ CONSORTIUM member) or jointly.

However, the participating share of JV/CONSORTIUM partners shall be as below:

i) Lead Partner shall have at least 50% participating share in JV/CONSORTIUM

ii) Other partner(s) shall have at least 20% participating share in JV/CONSORTIUM.

Experience for those works only shall be considered for evaluation purposes, which match eligibility requirement stipulated above, on or before the last day of month previous to one in which tender has been invited (publication date of NIT). The experience of incomplete/ongoing works as on last date of eligibility period will not be considered for evaluation.

b) Scanned copy of documents to be uploaded by bidder(s) in Bidder space/ My Document.
The Applicant shall furnish details of such Solar Photo Voltaic-based grid connected power plant(s) in the formats given in Annexure-XVII(a) and Annexure-XVII(b) along with the following documents as documentary evidence:

Under Route I

A. Acknowledgement / Certificate from customer / client for successful execution of work / contract. The acknowledgement / certificate must contain following information:

- Name & address of Employer/Work Order Issuing authority of each experience.
- Capacity of Solar Project in MW (AC).
- Date of award of work for installation of Solar Plant/System.
- Date of commissioning of Solar Plant/System.

B. Self-attested copy of Work Order(s) or Contract(s).

C. The Performance Certificate must have been issued for a minimum duration of 06 (Six) months from the date of commissioning. The Performance Certificate/Joint meter reading (JMR) reports shall have been issued by any state/ central owned agencies or state power departments or authorized representative of Power offtaker (Discom/Private Power purchaser).

D. Percentage (%) share of each experience (In case the experience has been earned by the bidder as a partner in a JV/Consortium firm/partnership firm then the proportionate value of experience in proportion to actual share of bidder in that JV/Consortium firm/ partnership firm will be considered against eligibility else it shall be taken as 100%).

Under Route II

A. Letter of Award (LOA)/Work Order/Contract document/Certificate of Commissioning issued to the EPC player having following Information:

- Name & address of Employer/Work Order Issuing authority of each experience.
- Capacity of Solar Project in MW (AC).
- Date of award of work for installation of Solar Plant/System to EPC.
- Date of commissioning of Solar Plant/System.

B. The Performance Certificate must have been issued for a minimum duration of 06 (Six) months from the date of commissioning. The Performance Certificate/Joint meter reading (JMR) reports shall have been issued by any state/ central owned agencies or state power departments or authorized representative of Power offtaker (Discom/Private Power purchaser).

C. Percentage (%) share of each experience (In case the experience has been earned by the bidder as a partner in a JV/Consortium firm/partnership firm then the proportionate value

of experience in proportion to actual share of bidder in that JV/Consortium firm/ partnership firm will be considered against eligibility else it shall be taken as 100%).

Note:

For both cases (i.e. Route-I and Route-II), in addition to above document, the following is required:

- **Commissioning Certificate will be accepted if issued by a Govt entity.**
- **ITR and/or Form 16 (for the relevant year in which bidder has received the final payment of the job) will be additionally required in case work completion is issued by a non-Government entity.**

B. <u>Financial Eligibility Criteria</u>

a) **Financial Turnover -**

Average annual financial turnover during the last 3(three) years, ending 31st March of 2024 should be **INR 392,55,00,000/-** (Indian Rupees Three Hundred Ninety Two Crore Fifty Five Lakh only). The Turnover of bidder should exclude the "other incomes".

The intending bidders must submit the Financial Turnover certificate (with UDIN No.) issued by a Practicing Chartered Accountant having a membership number with Institute of Chartered Accountants of India, containing the information as furnished by bidder online. The foreign partner(s) should submit Financial Turnover certificate based on IFRS (International Financial Reporting Standards) accounting standard certified by a local practicing public accountant/audit firm duly vetted/endorsed by the relevant *Embassy/High Commission concerned, towards authenticity of document. (*Relevant embassy/High Commission means the embassy/High Commission in India of the country where the bidder has obtained Turnover certificate or country of origin of the bidder OR the Indian embassy in the country where the bidder has obtained Turnover certificate or country of origin of the bidder.)

In respect of the above eligibility criteria the bidders are required to furnish the following information on-line:
i) Annual turnover of each of the last 3 (three) years ending 31st March of the previous financial year.
ii) Name of the Chartered Accountant issuing the Profit and Loss A/c or the Turnover certificate.
iii) Membership Number of the Chartered Accountant.
iv) Date of certificate issued by Chartered Accountant.

Note:

a. In case the bidder is a JV/Consortium, the turnover of the individual partners of the JV/CONSORTIUM will be added together for each financial year and is to be furnished as the turnover of the bidder for that particular financial year. However, the information against Sl. No. (ii) & (iii) above will be given w.r.t. the lead partner of JV/CONSORTIUM only.
b. In case of JV/CONSORTIUM, if financial turnover of all the partners is not submitted; the JV/CONSORTIUM will not be disqualified and instead the required turnover will be calculated assuming zero value for partner/partners who has/have not submitted the financial turn over certificate.

Special Note:
Confirmation regarding possessing of Financial Turnover issued by Practicing Chartered Accountant in the form of Yes / No.
Scanned copy of documents to be uploaded by bidders: Financial Turnover certificate having a Unique Document Identification Number (UDIN) with Institute of Chartered Accountants of India.

b) NET WORTH

The Net Worth of the bidder (standalone / unconsolidated) as on the last date of each of the last three financial years just preceding the financial year in which bid has been submitted should be positive. Net Worth to be considered for this clause shall be the total Net Worth as calculated in accordance with the Companies Act, 2013 and any further amendments thereto.

The intending bidders must submit the Net Worth certificate (with UDIN No.) issued by a Practicing Chartered Accountant having a membership number with Institute of Chartered Accountants of India, containing the information as furnished by bidder online.

The foreign partner(s) should submit Net Worth certificate based on IFRS (International Financial Reporting Standards) accounting standard certified by a local practicing public accountant/audit firm duly vetted/endorsed by the relevant *Embassy/High Commission concerned, towards authenticity of document. (*Relevant embassy/High Commission means the embassy/High Commission in India of the country where the bidder has obtained Net Worth certificate or country of origin of the bidder OR the Indian embassy in the country where the bidder has obtained Net Worth certificate or country of origin of the bidder.)

C. <u>Permanent Account Number (PAN)</u>

The bidder should possess Permanent Account Number (PAN) issued by Income Tax department, Govt. of India.

<u>In respect of the above eligibility criteria the bidders are required to furnish the following information on-line</u>:

i) Confirmation regarding possessing of Permanent Account Number (PAN) issued by Income Tax department, Govt. of India in the form of Yes / No.

Scanned copy of documents to be uploaded by bidders (BIDDER SPACE/ MY DOCUMENT): PAN CARD of the bidder

(In case of JV, PAN card for each Indian partner of JV and Verifiable Tax Residency Certificate of respective country for each foreign partner or JV itself)

D. <u>Goods and Services Tax (Not Applicable for Exempted Services)</u>

The bidder should be either GST Registered Bidder under regular scheme

OR

GST Registered Bidder under Composition Scheme

OR

GST unregistered Bidder

In respect of the above eligibility criteria the bidder is required to furnish the following information online:

i. **Confirmation in the form of Yes/No regarding possessing of required document as enlisted in NIT with respect to GST status of the bidder.**

Scanned copy of documents to be uploaded by bidder(s) in support of information / declaration furnished online by the bidder against Eligibility Criteria as Confirmatory Document.

Note:

i. In case of JV/CONSORTIUM, Bidder should submit scanned copy of GST status of Lead Partner only or GST Registration Certificate of JV/CONSORTIUM itself.
ii. In case the work/service is awarded to a JV/Consortium participating in the tender they have to submit PAN, GST registration (as applicable in the tender and for the bidder status) etc. in the name of the JV/Consortium after Award of Work/Service before the payment of first running on account bill.
iii. If turnover of bidder exceeds exemption/threshold limit, the bidder must have GST registration as per GST Act and rules.
iv. During the execution of the contract if the GST status of the bidder changes, then the payment of GST, if any, to the contractor will be made as per the GST status declared by the bidder during tender stage based on which cost to company has been ascertained or at actuals, whichever is lower.

v. Scanned copy of documents to be uploaded by bidder(s) in support of information / declaration furnished online by the bidder against Eligibility Criteria as Confirmatory Document.

9. If the bidder is a subsidiary of a company, the experience and resources of the holding company or its other subsidiaries will not be taken into account. However, if the bidder is a holding company, the experience and resources of its wholly owned subsidiaries will be taken into consideration.

10. Even though the bidders meet the above qualifying criteria, they are subject to be disqualified if they have:

a) Made misleading or false representations in the forms, statements and attachments submitted in proof of the qualification requirements; and/or
b) record of poor performance such as abandoning the works, not properly completing the contract, inordinate delays in completion, litigation history, or financial failures etc.

Note:

1. If turnover of Bidder exceeds exemption/threshold limit, the Bidder must have GST registration as per GST Act and rules.
2. During evaluation of GST Registered Bidders the confirmation of their status shall be verified from the relevant Govt website (Not to be kept as a part of NIT).

11. <u>General Instruction for Submission of Bid:</u>

All the bids are to be submitted online on e-procurement portal of CIL. No bid shall be accepted offline. In order to qualify in the tender the Bidders have to accept the following conditions:

i. All the Terms and Condition of the NIT and Tender Document Unconditionally on line in the form of User Portal Agreement.
ii. Expected values of each of the General Technical Evaluation (GTE) items.
iii. Documents confirming the legal status of the Bidder as specified in the checklist given in the NIT.
iv. To upload online the scanned copy of documents, as specified in the NIT for evaluation by Tender Committee as per the checklist given in the NIT.

Data to be furnished by Bidder on-line:
Confirmation in the form of Yes/No for each GTE item.

Technical evaluation by the System:
System will capture data in the Yes/No format from the Bidder and will decide the eligibility for (i) & (ii) above.

For (iii) & (iv) the documents will be downloaded and evaluated by Tender Committee.

12. <u>Submission of Bid:</u>

12.1 In order to submit the Bid, the bidders have to get themselves registered online on the e-Procurement portal of CIL (https://coalindiatenders.nic.in) with valid Digital Signature Certificate (DSC) issued from any agency authorized by Controller of Certifying Authority (CCA), Govt. of India and which can be traced up to the chain of trust to the Root Certificate of CCA. The online Registration of the Bidders on the portal will be free of cost and one time activity only. The registration should be in the name of bidder, whereas DSC holder may be either bidder himself or his duly authorized person. The bidder is one whose name will appear as bidder in the e-Procurement Portal.

12.2 The bidders have to accept unconditionally the online user portal agreement which contains the acceptance of all the Terms and Conditions of Tender Document including General, Additional Terms & Conditions and Special Conditions of contract (SCC), Integrity Pact and other conditions, if any, along with on-line undertaking in support of the authenticity of the declarations regarding the facts, figures, information and documents furnished by the Bidder on-line in order to become an eligible bidder. No conditional bid shall be allowed/accepted.

12.3 The bidders have to accept unconditionally in GTE (General Technical Evaluation) the Undertaking at Annexure II regarding Genuineness of the information furnished by him on-line & authenticity of the scanned copy of documents uploaded by him on-line in support of his eligibility criteria declaration w.r.t Make in India order dated 16.09.2020 and compliance w.r.t procurement from the bidder of a country which shares a border with India & etc. and Annexure I (Letter of Bid).

12.4 Moreover, the following documents shall be considered from the Bidder's space/ My Document and no recycling will be done for these documents i.e. no further clarification will be sought from bidder -

Sl. No.	**Document**	**Scanned copy of documents uploaded by bidder in Bidder's space/ My Document**
1	**2**	**3**
1	Permanent Account Number (Ref. Clause No.8.C of NIT)	PAN card issued by Income Tax department, Govt. of India. *(In case of JV, PAN card for each Indian partner of JV and Verifiable Tax Residency Certificate of respective country for each foreign partner or JV itself)*
2	Goods and Services Tax	The following documents depending upon the status w.r.to GST as declared by Bidder in the BOQ sheet:

	(GST) Status of Bidder (Ref. Clause No.8.D of NIT)	a) Status: <u>GST Registered Bidder under regular scheme</u> Document: GST Registration Certificate (i.e. GST identification Number) issued by appropriate authority of India. b) Status: <u>GST Registered Bidder under composition scheme</u> Document: GST Registration Certificate (i.e. GST identification Number) issued by appropriate authority of India. c) Status: GST unregistered bidder: Document: A Certificate having UDIN from a practicing Chartered Accountant having membership number with Institute of Chartered Accountants of India certifying that the bidder is GST unregistered bidder in compliance with the relevant GST rules of. India. *(In case of JV/CONSORTIUM, Bidder should submit scanned copy of GST status of Lead Partner only or GST Registration Certificate of JV/CONSORTIUM itself.)* **Note:** a. If turnover of bidder exceeds exemption/threshold limit, the bidder must have GST registration as per GST Act and rules.
3	Legal Status of the bidder	<u>Document(s) covered under any one of the following sub-head(s)</u>: Any one of the following documents: 1. Affidavit or any other document to prove proprietorship/Individual status of the Bidder. 2.Partnership deed containing name of partners 3.Memorandum & Article of Association with certificate of incorporation containing name of Bidder 4. Joint Venture agreement containing name of partners and lead partner, Power of Attorney to the Lead Partner and share of each partner.

12.5 Confirmatory Documents: All the confirmatory documents as enlisted in the NIT in support of online information submitted by the bidder are to be uploaded in Cover-I by the bidder while submitting his/her/their bid.

Sl. No.	Eligibility Criteria	Scanned copy of documents to be uploaded by bidder(s) in support of information/declaration furnished online by the bidder against Eligibility Criteria (CONFIRMATORY DOCUMENTS)
1	Work Experience (Clause 8.A)	The Applicant shall furnish details of such Solar Photo Voltaic-based grid connected power plant(s) in the formats given in Annexure-XVII(a) and Annexure-XVII(b) along with the following documents as documentary evidence: Under Route I A. Acknowledgement / Certificate from customer / client for successful execution of work / contract. The acknowledgement / certificate must contain following information: • Name & address of Employer/Work Order Issuing authority of each experience. • Capacity of Solar Project in MW (AC). • Date of award of work for installation of Solar Plant/System. • Date of commissioning of Solar Plant/System. B. Self-attested copy of Work Order(s) or Contract(s). C. The Performance Certificate must have been issued for a minimum duration of 06 (Six) months from the date of commissioning. The Performance Certificate/Joint meter reading (JMR) reports shall have been issued by any state/ central owned agencies or state power departments or authorized representative of Power offtaker (Discom/Private Power purchaser). D. Percentage (%) share of each experience (In case the experience has been earned by the bidder as a partner in a JV/Consortium firm/partnership firm then the proportionate value of experience in proportion to actual share of bidder in that JV/Consortium firm/ partnership firm will be considered against eligibility else it shall be taken as 100%). Under Route II A. Letter of Award (LOA)/Work Order/Contract document/Certificate of Commissioning issued to the EPC player having following Information:

		• Name & address of Employer/Work Order Issuing authority of each experience. • Capacity of Solar Project in MW (AC). • Date of award of work for installation of Solar Plant/System to EPC. • Date of commissioning of Solar Plant/System. B. The Performance Certificate must have been issued for a minimum duration of 06 (Six) months from the date of commissioning. The Performance Certificate/Joint meter reading (JMR) reports shall have been issued by any state/ central owned agencies or state power departments or authorized representative of Power offtaker (Discom/Private Power purchaser). C. Percentage (%) share of each experience (In case the experience has been earned by the bidder as a partner in a JV/Consortium firm/partnership firm then the proportionate value of experience in proportion to actual share of bidder in that JV/Consortium firm/ partnership firm will be considered against eligibility else it shall be taken as 100%). For both cases (i.e. Route-I and Route-II), in addition to above document, the following is required: • Commissioning Certificate will be accepted if issued by a Govt entity. • ITR and/or Form 16 (for the relevant year in which bidder has received the final payment of the job) will be additionally required in case work completion is issued by a non-Government entity.
3	Net Worth (Clause 8.B)	The Net Worth of the bidder (standalone / unconsolidated) as on the last date of each of the last three financial years just preceding the financial year in which bid has been submitted should be positive. Net Worth to be considered for this clause shall be the total Net Worth as calculated in accordance with the Companies Act, 2013 and any further amendments thereto. The intending bidders must submit the Net Worth certificate (with UDIN No.) issued by a Practicing Chartered Accountant having a

		membership number with Institute of Chartered Accountants of India, containing the information as furnished by bidder online. The foreign partner(s) should submit Net Worth certificate based on IFRS (International Financial Reporting Standards) accounting standard certified by a local practicing public accountant/audit firm duly vetted/endorsed by the relevant *Embassy/High Commission concerned, towards authenticity of document. (*Relevant embassy/High Commission means the embassy/High Commission in India of the country where the bidder has obtained Net Worth certificate or country of origin of the bidder OR the Indian embassy in the country where the bidder has obtained Net Worth certificate or country of origin of the bidder.)
4	Financial Turnover (clause 8.B)	Average annual financial turnover during the last 3(three) years, ending 31st March of 2024 should be **INR 392,55,00,000/-** (Indian Rupees Three Hundred Ninety Two Crore Fifty Five Lakh only). The Turnover of bidder should exclude the "other incomes". (I) The intending bidders must submit the Financial Turnover certificate (with UDIN No.) issued by a Practicing Chartered Accountant having a membership number with Institute of Chartered Accountants of India *(In case of JV, turnover certificate for each individual partner of JV)* (II) Audited financial results i.e. Annual Report including Audited Balance Sheet and Profit & Loss Account Statement for immediate three preceding financial years to meet the above Financial Eligibility Criteria.
5	Verification of Local Content	A. All the Bidders at the time of bidding shall submit self-certification indicating the percentage of local content in the offered items in Undertaking as per format at Annexure X. B. All the Bidders shall submit along with its bid a certificate (with UDIN) from the statutory auditor or cost auditor of the company (in case of companies) or from a practicing cost accountant or practicing chartered account (in respect of suppliers other than companies) giving the percentage of local content (with Annexure X).

6	Digital Signature Certificate (DSC)	If the bidder himself is the DSC holder bidding on-line then no document is required. However, if the DSC holder is bidding online on behalf of the bidder then the Power of Attorney or any sort of legally acceptable document for the authority to bid on behalf of the bidder.
7	Undertaking by bidder on his/her/their Letter Head as per Annexure X.	Undertaking regarding relatives as employees of company, Arbitration clause (in case of partnership firm), compliance w.r.t procurement from bidder of a country which shares a border with India, Local supplier status of the Bidder as per NIT etc.
8	Detailed Project Schedule	Detailed Project Schedule as per Annexure XII
Note: Only one file in .pdf format can be uploaded against each eligibility criteria. Any additional/ other relevant documents to support the information/declaration furnished by bidder online against eligibility criteria may also be attached by the bidder in the same file to be uploaded against respective eligibility criteria.		

12.6 Letter of Bid (LoB): The format of Letter of Bid is given at Annexure I of Tender document. This will be the covering letter of the bidder for his submitted bid. The bidders have to accept unconditionally the Letter of Bid in GTE (General Technical Evaluation) at the time of bid submission. This online acceptance during bidding through GTE shall be construed as submission of LOB by bidder.

12.7 Price bid: The Price bid containing the Bill of Quantity will be in Excel format and will be downloaded by the bidder and bidder will quote the rates for all items on this Excel file.
The bidder shall quote the rate and GST amount as per the BOQ format. This file will be digitally signed and uploaded by the bidder after ascertaining the correctness of facts and figures.

Thereafter, the bidder will upload the same Excel file during bid submission in cover-Il. The Price-bid will be in BOQ format and the bidder will have to mandatorily fill all the sections / sheets of the BOQ Excel. The Price Bid of the tenderers will have no condition. The price bid which is incomplete and not submitted as per instruction given in this document is liable for rejection.

13. Net Electrical Energy Generation Guarantee (NEEGG)

13.1 The Bidder shall be required to quote in the Annexure X the year-wise Net Electrical Energy Generation Guarantee (NEEGG) for five (5) years period at the metering point. The Bidder shall

give NEEGG per annum after considering proposed configuration and all local conditions, solar insolation, wind speed and direction, air temperature & relative humidity, barometric pressure, rainfall, sunshine duration, grid availability and grid related all other factors and losses due to near shading, incidence angle modifier, irradiance level, temperature loss, array loss, module quality loss, module array mismatch loss, soiling loss and various inverter losses etc.

13.2 Bidders are expected to undertake their own study of solar profile and other related parameters of the area and make sound commercial judgment about power output i.e. Net Electrical Energy Guaranteed Generation.

13.3 The Bids should have the NEEGG equivalent to minimum 28% CUF (minimum 73,58,40,000 units) at the Delivery Point for the first year. The degradation in NEEGG quoted for any year shall not be more than 0.5% of that quoted for the previous year. If the Bidder anticipates any degradation of the modules during the first year, it shall be taken care of by the Bidder to provide additional capacity of solar PV modules to meet guaranteed generation at the end of first year to avoid liquidated damages/compensation on account of guaranteed generation.

Note: Any bid which does not meet the above mentioned minimum generation criteria will not be considered for further evaluation.

14. System for decision of L1 bidder

The L1 bidder will be decided based on Evaluated Bid Value (EBV). Illustrative computation of EBV is shown in Annexure-XI.

15. Bid Submission

All bids are to be submitted on-line on the website **https://coalindiatenders.nic.in**. No bid shall be accepted off-line unless otherwise specified.

16. System Requirement:

It is the bidder's responsibility to comply with the system requirement i.e. hardware, software and internet connectivity at bidder's premises to access the e-tender website. Under any circumstances, CIL shall not be liable to the bidders for any direct/indirect loss or damages incurred by them arising out of incorrect use of the e-tender system or internet connectivity failures.

17. Bid opening

17.1 The Technical bid (Cover-I) will be opened one day after the Bid submission end date or next working day whichever is later. Technical bid (Cover-I) will be decrypted and opened online by the "Bid Openers" with their Digital Signature Certificates on the prescheduled date & time of Tender Opening.

17.2 All the documents uploaded by Bidder(s) including EMD exemption documents (if any) and the Evaluation sheets generated by the system online shall be downloaded after opening of Technical bid (Cover-I). After decryption and opening of Technical bid (Cover-I) the “technical bid opening summary” will be uploaded on the same day.

17.3 The e-Procurement System will evaluate the Technical bids automatically on the basis of relevant data provided by Bidder through a form in an objective and structured manner while submitting bid. If the parameter given by Bidder in objective and structured manner does not confirm to required eligibility criteria as specified in the tender document then the bid will be evaluated by system as non-complied and shall be rejected automatically by the system.

17.4 Acceptance of Bidder in a general form of online declaration will be recognized and accepted as the certification regarding authenticity of all the information and documents furnished by them online and acceptance of all terms and conditions of the bid document, since such acceptance by Bidder with Digital Signature Certificate is legally tenable.

18. Confidentiality

Information relating to the examination, clarification, evaluation, and comparison of Bids, and recommendations for the award of a Contract, shall not be disclosed to Bidders or any other persons not officially concerned with such process. Any effort by a Bidder to influence the EMPLOYER's/ Owner’s processing of Bids or award decisions may result in the rejection of the Bidder's Bid and action shall be initiated as per procedure in this regard.

19. Contacting the Employer/ Owner

A. From the time of Bid opening to the time of award of Contract, if any Bidder wishes to contact the EMPLOYER/ Owner on any matter related to the Bid, it should do so in writing. Information relating to the examination, clarification, evaluation & recommendation for award shall not be disclosed.
B. Any effort by the Bidder to influence the EMPLOYER/ Owner in the EMPLOYER's 'Bid Evaluation', 'Bid Comparison', or 'Contract Award' decisions may result in the rejection of the offer/Bid and action shall be initiated as per procedure in this regard.

20. Examination of Bids and Determination of Responsiveness

20.1 Prior to the detailed evaluation of Bids, the Employer will determine whether each Bid:
a. meets the eligibility criteria defined in Clause 7 & 8;
b. is accompanied by the required securities and
c. is substantially responsive to the requirements of the Bidding documents.

20.2 A substantially responsive Bid is one which conforms to all the terms, conditions & specifications of the Bidding documents without material deviation or reservation. A material deviation or reservation is one:
a. which affects in any substantial way the scope, quality, or performance of the works;
b. which limits in any substantial way, inconsistent with the Bidding documents, the Employer's rights or the Bidder's obligations under the Contract; or
c. whose rectification would affect unfairly the competitive position of other Bidders presenting substantially responsive Bids.

20.3 If a Bid is not substantially responsive, it may be rejected by the Employer at its sole discretion.

21. Evaluation and Comparison of Bids

Bid shall be evaluated as per evaluation criteria mentioned below on the total project cost including GST. The EMPLOYER shall only use the criteria and methodology indicated in the Tender documents. No other criteria/ methodology shall be permitted.

A. After opening of Technical bid, the documents submitted by Bidder(s) in Cover I as enlisted in the NIT will be downloaded by the Evaluator and shall be put up to the Tender Committee. The Tender Committee will examine the uploaded documents against information/declarations furnished by the Bidder(s) online. If it confirms to all of the information/ declarations furnished by the Bidder online and do not change the eligibility status of the Bidder then the Bidder will be considered eligible for opening of price bid.
B. In case the Tender Committee finds that there is some deficiency in uploaded documents corresponding to the information furnished online or in case corresponding document have not been uploaded by Bidder(s) then the same will be specified online by Evaluator clearly indicating the omissions/shortcomings in the uploaded documents and indicating start date and end date allowing 7 days (7 x 24 hours) time for online re-submission by Bidder(s). The Bidder(s) will get this information on their personalized dashboard under “Upload confirmatory document” link. Additionally, information shall also be sent by system

generated email and SMS, but it will be the Bidder's responsibility to check the updated status/information on their personalized dash board regularly after opening of bid. No separate communication will be required in this regard. Non-receipt of e-mail and SMS will not be accepted as a reason of non-submission of documents within prescribed time. The Bidder(s) will upload the scanned copy of all those specified documents in support of the information/ declarations furnished by them online within the specified period of 7 days. No further clarification shall be sought from Bidder.

Note: The shortfall information/ documents should be sought only in case of historical documents which pre-existed at the time of the tender opening and which have not undergone change since then. These should be called only on basis of the recommendations of the TC. So far as the submission of documents is concerned with regard to qualification criteria, after submission of the tender, only related shortfall documents should be asked for and considered. For example, if the bidder has submitted a work order document related to a particular contract without its completion/ performance certificate, the certificate can be asked for and considered. However, no work order for new contract should be asked for so as to qualify the bidder.

C. It is responsibility of Bidders to upload legible/clearly readable scanned copy of all the required documents as mentioned above.
D. The tender will be evaluated on the basis of documents uploaded by Bidder(s) online. The Bidder(s) is/are not required to submit hard copy of any document through offline mode. Any document submitted offline will not be given any cognizance in the evaluation of tender.
E. In case the Bidder(s) submit(s) requisite documents online as per NIT, then the Bidder(s) will be considered eligible for opening of Price Bid.
F. Seeking clarification shall be restricted to confirmation of submitted document/online information only and it should be only for one time for a period of upto 7 days. The clarification shall be taken in online mode in the eProcurement portal of CIL only.
G. The verification of Document from source shall be done only in case of complaints received or on suspicion. This should be done either through speed post or through electronic communication. No anonymous/pseudonymous complaints shall be entertained.
H. In case Bidder(s) fails to confirm the online submitted information(s)/ declaration(s) by the submitted documents as (B) above, their/his bid shall be rejected; however, if the confirmatory documents do not change eligibility status of the Bidder in connection his submitted online information(s)/declaration(s), then his/their bid will be accepted for opening of Price Bid.
I. After Technical evaluation of tender, "Technical Evaluation Summary" will be uploaded by the Evaluator and price bid shall be opened on preschedule date and time mentioned in the NIT online in the e-Procurement portal of CIL. However, in case there is any extension of date and time of price bid opening, it shall be notified online and price bid shall be opened online on e-Procurement portal of CIL at rescheduled date and time.

J. In case none of the Bidder(s) complies the technical eligibility criteria as per NIT, then Bidder(s) will be rejected online and re-tender (if required) will be done (with the same or different quantity, as per the instant requirement).

22. <u>Purchase Preference under 'Make in India' Policy for "Local supplier".</u>

Under 'Make in India' policy of Government of India, Purchase Preference will be given to eligible bidders as per Public Procurement (Preference to Make in India), Order 2017 issued vide order No. P-45021/2/2017-B.E.-II dated 15th June 2017 (subsequently revised vide orders dated 28.05.2018, 29.05.2019, 04.06.2020, 16.09.2020 and 04.03.2021) of Department for Promotion of Industry and Trade, Ministry of Commerce and Industry.

The definitions of 'Class-I Local Supplier', 'Class-II Local Supplier', 'Non-Local Supplier' and 'Local Content' are as follows:
'Class-I Local Supplier' means a supplier, whose goods and/or services offered for procurement, has local content equal to or more than 50%.
'Class-II Local Supplier' means a supplier, whose goods and / or services, offered for procurement, has 20% or more local content but less than 50%.
'Non - Local Supplier' means a supplier, whose goods and / or services, offered for procurement, has local content less than 20%.
'Local Content' means the amount of value added in India which shall be the total value of the item procured (excluding net domestic indirect taxes) minus the value of imported content in the item (including all customs duties) as a proportion of the total value, in percent.

As per the OM dated 04.03.2021, it has been clarified by the Department for Promotion of Industry and Internal Trade, Ministry of Commerce and Industry that bidders offering imported products will fall under the category of Non-Local Suppliers. They can't claim themselves as Class-I Local Suppliers/Class II Local Suppliers by claiming the services such as transportation, insurance, installation, commissioning, training and after-sales service support like AMC/CMC etc. as local value addition.

In view of above, "Local content" will not include services such as transportation, insurance, installation, commissioning, training and after-sales service support like AMC/CMC etc. as local value addition.

In respect of the above eligibility criteria the bidder is required to furnish the following information online:
i) Confirmation in the form of Yes/No regarding possessing of required document indicating percentage of local content as enlisted in NIT.

Scanned copy of documents to be uploaded by bidder(s) in support of information / declaration furnished online by the bidder against Eligibility Criteria as Confirmatory Document.

23. Verification of Local Content

All the Bidders at the time of bidding shall submit self-certification indicating the percentage of local content in the offered items in Undertaking as per format at Annexure X.
All the Bidders shall submit along with its bid a certificate (with UDIN) from the statutory auditor or cost auditor of the company (in case of companies) or from a practicing cost accountant or practicing chartered account (in respect of suppliers other than companies) giving the percentage of local content (with Annexure X).
Nodal Ministry /CIL may constitute committees with internal and external experts for independent verification of self-declarations/ auditor's/ accountant's certificates on random basis and in the case of complaints.
Nodal Ministry / CIL may prescribe fees for such complaints.
All the Bidders at the time of bidding shall submit either self-certification indicating the percentage of local content in the offered items.
False declarations will attract banning of business of the bidder for a period up to two year and with process in line with Annexure-XVI – Guidelines on Debarment of Firms from Bidding.
A local supplier who has been debarred by any procuring entity for violation of above order shall not be eligible for preference under this Order for procurement by any other procuring entity for the duration of debarment. The debarment for such other procuring entities shall take effect prospectively from the date on which it comes to the notice of other procurement entities.

In terms of the above said policy, purchase preference shall be given to 'Class-I Local Supplier' over 'Class-II Local Supplier'. 'Non-Local Suppliers' are not eligible to participate in the tender.

24. Auto Extension of Critical Date

If number of bids received online is found to be less than 03 (three) on end date of bid submission then the following critical dates of the Tender will be automatically extended for a period of 04 (four) days of the following dates-

- Last date of submission of Bid.
- Date of Opening of Tender.
- Last date of Submission of EMD

If any of the above extended Dates falls on Holiday i.e. a non-working day as defined in the e-Procurement Portal then the same is to be rescheduled to the next working day.
This extension will be also applicable in case of receipt of zero bid.

Notes:

1.) The validity period of tender shall be decided based on the final end date of submission of bids.

2.) The auto extension shall work on the basis of number of bids received only. It may so happen that any of these bids may be eventually rejected during Tender Opening, Technical evaluation or further process of evaluation resulting the total number of valid bids becoming less than 03(three).

3.) After extension, the tender shall be opened irrespective of available number of bids on the extended date of opening of tender.

25. <u>One Bid per Bidder</u>

25.1 Each Bidder shall submit only one Bid, either individually, or as a proprietor, or as a partner in a partnership firm or as a partner in a joint venture or as a Company registered under Companies Act. A Bidder who submits or participates in more than one Bid (other than as a sub-contractor or in cases of alternatives that have been permitted or requested) will cause all the proposals with the Bidder's participation to be disqualified.

25.2 Conflict of Interest-

A Bidder may be considered to have a Conflict of Interest with one or more parties in this bidding process, if:

a) they have controlling partner(s) in common; or
b) they receive or have received any direct or indirect subsidy/financial stake from any of them; or
c) they have the same legal representative/agent for purposes of this bid; or
d) they have relationship with each other, directly or through common third parties, that puts them in a position to have access to information about or influence on the bid of another Bidder; or
e) a Bidder or any of its affiliate participated as a consultant in the preparation of the design or technical specification of the contract that is the subject of the bid; or
f) in case of a holding company having more than one Subsidiary/Sister Concern having common business ownership/management only one of them can bid. Bidders must proactively declare such sister/common business/management in same/similar line of Business;

All such Bidders having a Conflict of Interest, shall be disqualified.

26. <u>Refund of EMD</u>

A. If EMD is paid by the bidder in online mode (Direct Debit/NEFT/RTGS) then the EMD of rejected bidders will be refunded at any stage directly to the account from where it had been received (except the cases where EMD is to be forfeited).

B. No claim from the bidders will be entertained for non-receipt of the refund in any account other than the one from where the money is received.

C. If the refund of EMD is not received by the bidder in the account from which the EMD has been made due to any technical reason then it will be paid through conventional system of e-payment. For this purpose, if required, Tender Inviting Authority will obtain the Mandate Form from the Bidder.
D. In case the tender is cancelled then EMD of all the participating bidders will be refunded unless it is forfeited by the department.
E. If the bidder withdraws his/her bid online (i.e. before the end date of submission of tender) then his/her EMD will be refunded automatically after the opening of tender.
F. At the option of bidder, the EMD of successful bidder (on Award of Contract) will be retained by CIL and will be adjusted to Performance Security Deposit.

27. <u>Site Visit</u>

27.1 The bidder, at the Bidder's own responsibilities, cost and risk, is encouraged to visit and examine the Site of Works and it's surrounding, approach road, soil condition, investigation report, existing works, if any, connected to the tendered work, drawings connected to the work, if / as available and obtain all information that may be necessary for preparing the Bid and entering into a contract for execution of the works. The cost of visiting the Site shall be at the Bidder's own expense.

27.2 It shall be deemed that the Bidder has visited the Site/Area and got fully acquainted with the working conditions and other prevalent conditions and fluctuations thereto whether he/she/they actually visits the Site /Area or not and has taken all the factors into account while quoting his/her/their rates.

27.3 The Bidder, in preparing the bid, shall rely on the site investigation report referred to in the bid document (if available), supplemented by any information available to the Bidder.

27.4 The Bidder is expected, before quoting his rate, to go through the requirement of materials/workmanship, specification, requirements and conditions of contract.

27.5 The Bidder must request for permission to visit the site from the Employer through email at least 3 days prior to the planned visit.

27.6 The Bidder and any of its personnel or agents will be granted permission by the Employer to enter upon its premises and lands for the purpose of such inspection, but only upon the express condition that the Bidder, its personnel and agents will release and indemnify the Employer and its personnel and agents from and against all liability in respect thereof and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

28. Taxes and Duties

28.1 All duties, taxes (excluding Goods and Services Tax (GST) & GST Compensation Cess (if applicable) only) and other levies, royalty, building and construction workers cess (as applicable in States) payable by the bidder/Contractor under the Contract, or for any other cause as applicable on the last date of submission of Bid, shall be included in the rates, prices and the total Bid Price submitted by the Bidder. Applicable GST, if any, either payable by bidder or by company under reverse change mechanism shall be computed by system in BOQ sheet as per predefined logic.

28.2 All investments, operating expenses, incidentals, overheads, leads, lifts, carriages, tools and plants etc. as may be attendant upon execution and completion of works shall also be included in the rates, prices and total Bid price submitted by the bidder.

28.3 However, such duties, taxes, levies etc. which is notified after the last date of submission of Bid and/or any increase over the rate existing on the last date of submission of Bid shall be reimbursed by the company on production of documentary evidence in support of payment actually made to the concerned authorities.

28.4 Similarly, if there is any decrease in such duties, taxes and levies the same shall become recoverable from the contractor. The details of such duties, taxes and other levies along with rates shall be declared by the bidder.

28.5 The item wise rate quoted by bidder shall be inclusive of all taxes, duties & levies but excluding GST & GST Compensation Cess, if applicable. The payment of GST and GST Compensation Cess by service availer (i.e. CIL) to bidder/contractor (if GST payable by bidder/contractor) would be made only on the latter submitting a Bill/invoice in accordance with the provision of relevant GST Act and the rules made there under and after online filing of valid return on GST portal. Payment of GST & GST Compensation Cess is responsibility of the service provider/contractor.

28.6 Further, any GST credit note required to be issued by the bidder / contractor under the GST provisions should be issued within the time limit prescribed under the GST law.

28.7 However, in case bidder/contractor is GST unregistered bidder/dealer or GST registered under composition scheme in compliance with GST rules, the bidder/dealer shall not charge any GST and/or GST Compensation Cess on the bill/invoice. In case of unregistered dealer/bidder, GST, if applicable will be deposited by CIL directly to concerned authorities in terms with GST provisions.

28.8 Input tax credit is to be availed by CIL as per rule.

28.9 If CIL fails to claim Input Tax Credit(ITC) on eligible Inputs, input services and Capital Goods or the ITC claimed is disallowed due to failure on the part of supplier/vendor of goods and services in incorporating the tax invoice issued to CIL in its relevant returns under GST, payment of CGST & SGST or IGST, GST (Compensation to State) Cess shown in tax invoice to the tax authorities, issue of proper tax invoice or any other reason whatsoever, the applicable taxes & cess paid based on such Tax invoice shall be recovered from the current bills or any other dues of the supplier/vendor along with interest and penalty, if any.

28.10 The rates and prices quoted by the Bidder shall be fixed for the duration of the contract and shall not be subject to variations on any account except to the extent variations allowed as per the conditions of the contract of the bidding document.

28.11 The company reserves the right to deduct/ withhold any amount towards taxes, levies, etc. and to deal with such amount in terms of the provisions of the Statute or in terms of the direction of any statutory authority and the company shall only provide with certificate towards such deduction and shall not be responsible for any reason whatsoever.

28.12 In case of collection of minor minerals in area (both virgin and non-virgin), acquired by the Company under the Coal Act, the contractor will have to produce a royalty clearance certificate from the District Authorities before full and final payment.

28.13 Further, where any damages or compensation becomes payable by either the Company or the bidder / contractor pursuant to any provision of this Agreement, appropriate GST wherever applicable as per the GST provisions in force shall also apply in addition to such damages or compensation.

Note: During the execution of the contract if the GST status of the bidder changes, then the payment of GST, if any, to the contractor will be made as per the GST status declared by the bidder during tender stage based on which cost to company has been ascertained or at actuals, whichever is lower.

29. <u>Cost of Bidding</u>

The bidder shall bear all costs associated with the preparation and submission of his bid and the Employer will in no case be responsible or liable for those costs.

30. <u>Technical Specifications</u>

30.1 The tenderer shall closely study all specifications in detail, which govern the rates for which he is tendering.

30.2 The modules to be procured by the Contractor as per provision as contained in the O.M. dated 10.03.2021 issued by MNRE on the subject "Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirement of Compulsory Registration) Order, 2019-Implementation-Reg." and its subsequent amendments and clarifications (including MNRE's clarification ref. no.

F. No. 283/54/2018- GRID SOLAR-Part (1) dated 11.05.2021), shall be applicable for this Tender.

31. Currencies of Bid and Payment

The unit rates and prices shall be quoted by the Bidder entirely in Indian Rupees only.

32. Handing Over of Site

On completion of the work all rubbish, debris, brick bats etc. shall be removed by the contractor(s) at his/their own expense and the site cleaned and handed over to the company and he/they shall intimate officially of having completed the work as per contract.

33. Deployment of Manpower and Machineries

The tenderer(s) will deploy sufficient number and size of equipments/machineries/vehicles and the technical/ supervisory personnel required for execution of the work.

34. Change in Constitution of the Contracting Agency

Prior approval in writing of the company shall be obtained before any change is made in the constitution of the contracting agency, otherwise it will be treated as a breach of Contract.

35. Canvassing in Tender

Canvassing in connection with the tenders in any shape or form is strictly prohibited and tenders submitted by such tenderers who resort to canvassing shall be liable for rejection.

36. Letter of Award (LOA)

The Bidder, whose Bid has been accepted, will be notified /communicated by the Employer electronically online on the e-procurement portal of CIL prior to expiration of the Bid validity period. The L-1 bidder will get the information regarding award of work on their personalised dash-board on-line. On receipt of Letter of Award (LOA) of the tender issued by the Owner, the successful tenderer shall execute contract agreement in the company's prescribed form for the due fulfilment of the contract. Failure to enter into the required contract within the specified period in the work order shall entail cancellation of LOA and forfeiture of the Earnest Money. In addition, the department may debar the bidder from participating in future bids as per Annexure-XVI – Guidelines on Debarment of Firms from Bidding.

37. Bid Validity

The validity period of the tenders shall be **90 (Ninety)** days from the end date of bid submission. The validity period of tender shall be decided based on the final end date of submission of bids.
In exceptional circumstances, prior to expiry of the original time limit, the Employer may request the bidders to extend the period of validity for a specified additional period. The employer's request and the bidder's responses shall be made in writing. A bidder may refuse the request without forfeiting his bid security. A bidder agreeing to the request will not be required or permitted to modify his bid.
The tenderer shall not, during the said period or within the period extended by mutual consent, revoke or cancel his tender or alter the tender or any terms/conditions thereof without consent in writing of the company. In case the tenderer violates to abide by this, the Company will be entitled to take action as per clause No. 38 (Modification and Withdrawal of Bid) of NIT.

38. Modification and Withdrawal of Bid

Modification of the submitted bid shall be allowed on-line only before the deadline of submission of tender and the Bidder may modify and resubmit the bid on-line as many times as he may wish. Bidders may withdraw their bids online within the end date of bid submission and their EMD will be refunded. However, if the Bidder once withdraws his bid, he will not be able to resubmit the bid in that particular tender. For withdrawal of bid after the end date of bid submission, the Bidder will have to make a request in writing to the Tender Inviting Authority. Withdrawal of bid may be allowed till issue of work order/LOA with the following provision of penal action:
The penal actions are

1. If the request of withdrawal is received before online notification for opening of price bid, the EMD will be forfeited and Bidder will be debarred from participating in tenders in CIL/Subsidiary as per Annexure-XVI. The Price-bid of remaining Bidders will be opened and the tender process shall go on.
2. If the request of withdrawal is received after online notification for opening of price bid, the EMD will be forfeited and the Bidder will be debarred from participating in tenders in CIL/Subsidiary as per Annexure-XVI. The Price-bids of all eligible Bidders including this Bidder will be opened and action will follow as under:

    i. If the Bidder withdrawing his bid is other than L-1, the tender process shall go on.
    ii. If the Bidder withdrawing his bid is L-1, then re-tender will be done.

Note:

a) In case the Accepting Authority of the work is Board or Empowered Committee or FDs or CMD of CIL/Subsidiary Company, then the Competent Authority for forfeit of EMD and debarment shall be CMD of CIL/Subsidiary Company.
b) In case the Accepting Authority of the work is up to the level of Director of CIL/Subsidiary Company, then the Competent Authority for forfeit of EMD and debarment shall be Director of CIL/Subsidiary Company.

i. In case of above penal actions, Guidelines on Debarment of Firms from Bidding is to be followed.
ii. Penal action against clauses above will be enforced from the date of issue of such order.
iii. The standard operating procedure to handle withdrawal of bid after end date of submission shall be as per Guidelines for e-Procurement of Works and Services.

39. Postponement of scheduled date(s)

The Company reserves the right to postpone the date of receipt and opening of tenders or to cancel the tenders without assigning any reason whatsoever.

40. Contract Agreement Document(s)

This Tender Notice shall be deemed to be part of the Contract Agreement. The "General Terms & Conditions", Additional Terms & Conditions, Special Conditions of Contract (SCC), Technical Specifications, drawings (if any) and any other document uploaded on portal as NIT document forms an integral part of this NIT and shall also form a part of the contract agreement as per clause 2 of General Terms and Conditions.

41. Sub-letting of Work

The contract agreement will specify major items of supply of services for which the contractor proposes to engage Sub-Contractor/ Sub-Vendor. The contractor may from time to time propose any addition or deletion from any such list and will submit the proposals in this regard to the Engineer in Charge/ Designated Officer in Charge for approval well in advance so as not to impede the progress of work. Such approval of the Engineer in Charge/ Designated Officer will not relieve the contractor from any of his obligation, duties and responsibilities under the contract.

If a contractor submits his bid, qualifies and does not get the contract because of his not being the lowest, he will be prohibited from working as a sub-contractor for the contractor who is executing the work.

The total value of subcontracted work should not exceed 25% of the total contract value. Sub-contracting by the contractor without the approval of the Procuring Entity shall be a breach of contract, unless explicitly permitted in the contract. Procurement of material, hiring of equipment or engagement of labour will not mean sub-contracting.

42. Prohibition of Child Labour engagement

The contractor/contractual Agencies must not engage any Child Labour during the course of execution of the contract work within the meaning and scope of the Child Labour Prohibition & Regulation Act-1986 and its relevant Act and Rules amended from time to time by the Govt. of India.

43. Implementation of CMPF/EPF

The tenderer shall have to ensure implementation of CMPF/EPF, if applicable, in respect of the workers deployed by him as detailed in the tender document.

44. Splitting up of the work

The Company does not bind itself to accept the lowest tender and reserves the right to reject any or all the tenders without assigning any reasons whatsoever. The work of "Setting up of Grid Connected 300 MW Ground Mounted Solar PV plant" is not splitable..

45. Settlement of Disputes

Matters relating to any dispute or difference arising out of this tender and subsequent contract Awarded based on this tender, shall be dealt as per Clause No. 19 and 20 - of the 'General Terms and Conditions' of the tender document.

46. Restrictions on Procurement from a bidder of a country which shares a land border with India and on sub-contracting to contractors from such countries.

The guidelines as per order no.F.No.6/18/2019-PPD dt 23/7/2020 of Ministry of Finance, GoI as amended from time to time shall be applicable.

I. Any bidder from a country which shares a land border with India will be eligible to bid in this tender only if the bidder is registered with the Competent Authority.

II. "Bidder" (including the term 'tenderer', 'consultant' or 'service provider' in certain context) means any person or firm or company, including any member of a Joint venture (that is an association of several persons or firms or companies), every artificial juridical person not falling in any of the descriptions of bidders stated herein before, including any agency, branch or office controlled by such person, participating in a procurement process.

III. "Bidder from a country which shares a land border with India" for the purpose of order F.No. 6/18/2019-PPD dated 23.07.2020 means:-

   a. An entity incorporated, established or registered in such a country; **or**
   b. A subsidiary of an entity incorporated, established or registered in such a country; **or**
   c. An entity substantially controlled through entities incorporated, established or registered in such a country; **or**
   d. An entity whose beneficial owner is situated in such a country; **or**

e. An Indian (or other) agent of such an entity; **or**
f. A natural person who is a citizen of such a country; **or**
g. A joint venture where any member of the joint venture falls under any of the above.

IV. "The beneficial owner" for the purpose of (III) above will be as under:

1. In case of a company or Limited Liability Partnership, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person(s), has a controlling ownership interest or who exercises control through other means.

Explanation-

a. "Controlling ownership interest" means ownership of, or entitlement to more than Twenty Five Percent of shares or capital or profits of the company;
b. "Control" shall include the right to appoint the majority of the directors or to control the management or policy decisions, including by virtue of their shareholding or management rights or shareholders agreements or voting agreements;

2. In case of a partnership firm, the beneficial owner is the natural person(s) who, whether acting alone or together, or through one or more juridical person, has ownership of entitlement to more than fifteen percent of capital or profits of the partnership;
3. In case of an unincorporated association or body of individuals, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person, has ownership of or entitlement to more than fifteen percent of the property or capital or profits of such association or body of individuals.
4. Where no natural person is identified under (1) or (2) or (3) above, the beneficial owner is the relevant natural person who holds the position of senior managing official.
5. In case of a trust, the identification of beneficial owner(s) shall include identification of the author of the trust, the trustee, the beneficiaries with fifteen percent or more interest in the trust and any other natural person exercising ultimate effective control over the trust through a chain of control or ownership.

V. An Agent is a person employed to do any act for another, or to represent another in dealings with third person.

VI. The successful bidder shall not be allowed to sub-contract works to any contractor from a country which shares a land border with India unless such contractor is registered with the competent Authority.

Note:

1. (a) The intending bidders must submit the Undertaking as Annexure-VIII in compliance to order no.F.No.6/18/2019-PPD dt 23/7/2020 and as amended from time to time of Ministry of Finance, GoI.

AND

(b) Valid registration from competent authority (if applicable). Registration should be valid at the time of submission of bid and at the time of acceptance of bids.

2. Guidelines issued by GoI regarding registration with Competent Authority and regarding exclusion from restriction may please be referred.

The laws applicable to this contract shall be the laws in force in India. The District Court where the subject work is executed or High Court of Kolkata shall have exclusive jurisdiction in all matters arising under this contract.

If the bidder is a subsidiary of a company, the experience and resources of the holding company or its other subsidiaries will not be taken into account. However, if the bidder is a holding company, the experience and resources of its wholly owned subsidiaries will be taken into consideration.

47. Integrity Pact (applicable).

Bidders are required to submit the Pre-Contract Integrity Pact duly signed & witnessed as per enclosed format, Annexure-VIII**,** along with the bid Part-I/cover-I. This will be signed by the authorized signatory of the bidder (s) with name, designation and seal of the company. Bidder(s) who do not sign the pact shall be disqualified from participation in the bid process.

Code of Integrity for Public Procurement (CIPP)

Bidders are required to accept the CIPP as available in the Bid document (Annexure -IV) online at e-procurement portal of CIL. This will be signed by the authorized signatory of the Bidder (s) with name, designation and seal of the Company at time of execution of formal agreement. In case of Partnership Firms/JV/CONSORTIUM all partners shall sign at the time of agreement.

Name, address and contact No. of the Independent External Monitor (IEM) nominated for this tender:

Sl. No.	Name	Address	E-mail ID	Mobile No.
1.	Mr. Nirmal Kaur, IPS (Retd.)	House No. 8, Plot-615, Road Jawahar Nagar, Mango, Jams Jharkhand - 832110	nirmalkaur1983@gmail.com	9304795041
2.	Shri O.P. Singh, IPS (Retd.)	M-6, First Floor, Green Park Extension, New Delhi - 110016	ops2020@gmail.com	9818564455

3.	Shri. K. D. Tripathi, IAS(Retd.)	A-5, Sector-19, Noida, UP - 201301	tripathikd.1958@gmail.com	9868506966

48. Insurance

48.1 To the extent specified in the Contract Agreement, the Contractor shall at its expense take out and maintain in effect or cause to be taken out and maintained in effect, during the performance of the Contract, the insurances set forth below in the sums and with the deductibles and other conditions. The identity of the insurers and the form of the policies shall be subject to the approval of the Owner, who should not unreasonably withhold such approval.

48.2 During the Contract period including O&M period, i.e., during Construction & O&M period, all insurance related expenses shall be borne by the Contractor. The goods supplied under the Contract shall be fully insured against the loss or damage incidental to manufacture or acquisition, transportation, storage and delivery in such a manner that Owner shall not incur any financial loss, as long as the plant continues to remain under the custody of the Contractor. During O&M period also (after the Construction period is over), the insurances shall be in the scope of the Contractor.

48.3 In case of any loss or damage or pilferage or theft or fire accident or combination of the said incidents etc. under the coverage of insurance, the Contractor shall lodge the claim as per rules of insurance. Any FIR required to be lodged to local Police Station shall be the responsibility of the Contractor.

48.4 The Contractor shall arrange to supply/ rectify/ recover the materials without waiting for settlement of the insurance claim and even if the claim is unsettled for timely completion of the project. The final financial settlement with the insurance company shall rest upon the Contractor.

48.5 In case of any delay of the project attributable to the Contractor, the Contractor himself in consultation with Owner/EMPLOYER shall take the extension of insurance. Any financial implications shall be borne by the Contractor.

48.6 The Contractor should arrange for providing insurance coverage to its workmen under Workmen's Compensation Act or similar Rules and Acts as applicable during execution of work for covering risk against any mishap to its workmen. The Contractor shall also undertake a Third-Party Insurance and shall at all times keep Owner indemnified against any Third-Party claims and shall arrange to settle them at the earliest. CIL will not be liable for any such loss or mishap.

48.7 All other insurance like – transit insurance (Marine/ Cargo/ others as applicable), Construction All Risk, Erection All Risk, workmen compensation, fire, third party liability, insurance against theft, Contractor's Equipment, machinery breakdown policy, business interruption insurance, Property damage Insurance & Environmental risk insurance as required during the Construction and O&M period of the Plant shall be in the contractor's scope & shall borne by the Contractor.

48.8 Owner shall be named as co – insured under all insurance policies taken out by the Contractor, except for the workmen compensation, third party liability and Owner's liability insurances. All insurers' rights of subrogation against such co – insured for losses or claims arising out of the performance of the contract shall be waived under such policies.

48.9 All the insurance cover taken for the construction and O&M period shall be seamless in nature & preferably taken from the same insurance company. The insurance is to be suitably taken for the activity/ act which is required to cover all the risks associated to the activity / act. The Contractor shall be responsible to take suitable insurance till the completion of the O&M contract and indemnify the EMPLOYER/Owner from all associated risks whatsoever.

48.10 The Contractor shall be responsible to take suitable insurance(s) and claim management during and till the completion of the O&M contract and indemnify the Owner from all associated risks whatsoever.

49. <u>Various Types of Insurance to be taken by Contractor during Construction & O&M period:</u>

49.1 Employees State Insurance (ESI) Act

A. The Contractor agrees to and does hereby accept full and exclusive liability for the compliance with all obligations imposed by the Employee State Insurance Act 1948 and the Contractor further agrees to defend, indemnify and hold EMPLOYER/ Owner harmless for any liability or penalty which may be imposed by the Central, State or Local authority by reason of any asserted violation by Contractor or Sub-Contractor of the Employees' State Insurance Act, 1948, and also from all claims, suits or proceeding that may be brought against the EMPLOYER/ Owner arising under, growing out of or by reasons of the work provided for by this Contractor, by third parties or by Central or State Government authority or any political sub- division thereof.

B. The Contractor agrees to fill in with the Employee's State Insurance Corporation, the Declaration Forms, and all forms which may be required in respect of the Contractor's or Sub-Contractor's employees, who are employed in the Work provided for or those covered by ESI from time to time under the Agreement. The Contractor shall deduct and secure the agreement of the Sub-Contractorto deduct the Employee's contribution as per the first schedule of the Employee's State Insurance Act from wages and affix the Employees Contribution Card at wages payment intervals.

C. The Contractor shall remit and secure the agreement of Sub-Contractor to remit to the Employee's State Insurance Corporation Account, the Employee's contribution as required by the Act. The Contractor agrees to maintain all cards and Records as required under the Act in respect of employees and payments and the Contractor shall secure the agreement of the Sub-Contractor to maintain such records. Any expenses incurred for the contributions, making contributions or maintaining records shall be to the Contractor's or Sub-Contractor's account.

49.2 Workmen Compensation and EMPLOYER's/Owner’s Liability Insurance

Insurance shall be effected for all the Contractor's employees engaged in the performance of this Contract. If any of the work is sublet, the Contractor shall require the Sub-Contractor to provide workman's Compensation and Owner’s liability insurance for the latter’s employees if such Employees are not covered under the Contractor's Insurance.

49.3 Accident or Injury to Workmen

The EMPLOYER/ Owner shall not be liable for or in respect of any damages or compensation payable at law in respect or in consequence of any accident or injury to any workman or other person in the Employment of the Contractor or any Sub-Contractor and the Contractor shall indemnify and keep indemnified the EMPLOYER/ Owner against all such damages and compensation (save and except and aforesaid) and against all claims, demands, proceeding, costs, charges and expenses, whatsoever in respect or in relation thereto.

49.4 Transit/Cargo Insurance

In respect of all items to be transported by the Contractor to the Site of Work and any consequential risks, the cost of transit insurance shall be borne by the Contractor and the quoted price shall be inclusive of this cost.

Covering loss or damage occurring, while in transit from the supplier's or manufacturer's works or stores until arrival at the Site, to the Facilities (including spare parts therefor) and to the construction equipment to be provided by the Contractor or its Subcontractors.

Amount	Deductible Limits	Parties Insured	From	To
110% of the Ex-works value of supply	Nil	Contractor and Owner	Ware House	Ware House + 60 Days

49.5 Deleted.

49.6 Comprehensive Automobile Insurance

This insurance shall be in such a form as to protect the Contractor against all claims for injuries, disability, disease and death to members of public including EMPLOYER's/ Owner's men and damage to the property of others arising from the use of motor vehicles during on or off the site operations, irrespective of the EMPLOYER ship of such vehicles.

49.7 Group Personal Insurance

The Contractor shall take full responsibility to take all precautions to prevent loss or damage to the works or part thereof for any reasons whatsoever (except for reasons which are beyond control of the Contractor or act of God, e.g. flood, riots, war, earthquake, etc.) and shall at his own cost repair and make good the loss/damage to the work so that on completion, the work shall be in good order and condition and in conformity with the requirements of the contract and instructions of the Engineer-in-charge, if any:

a) The Contractor shall at all times during the pendency of the contract indemnify the company against all claims, damages or compensation under the provisions of the Workmen's Compensation Act and shall take insurance policy covering all risk, claims, damages or compensation payable under the Workmen's Compensation Act or under any other law relating thereto.

b) The Contractor shall pay directly the ex-gratia amount of [Rs 15 lakhs or such other amount as decided by the Company from time to time] to the same dependent as per the terms of the contract or through insurance company by availing Group Personal Accident Insurance Policy for all its worker before commencement of the contract, which shall be renewed periodically to cover the entire duration of the contract. No reimbursement shall be made on this account by CIL/ Subsidiaries.

   In order to comply with the above provisions, Contractor shall immediately on receipt of letter of acceptance / work order shall obtain group personal accident insurance in respect of the workmen engaged in mining activities to assure such payment of Rs 15 lakhs* in case of death in accident within project premise within 30 days. A proof to such effect shall be produced to the satisfaction of the management before commencement of the work. However, the responsibility of payment of special relief / ex-gratia amount shall be exclusively with the Contractor. If the Contractor fails to disburse the special Relief / Ex-gratia within the due date, the subsidiary concerned may make the payment to the eligible dependent as mentioned herein above.

   However, such amount shall be recovered from the Contractor from his dues either in the same and / or other subsidiaries /CIL.

c) The Contractor shall ensure that the insurance policy/policies are kept alive till full expiry of the contract by timely payment of premiums and shall not be cancelled without the approval of the company and a provision is made to this effect in all the policies, and similar insurance policies are also taken by his sub-Contractors if any. The cost of premiums shall be borne by the Contractor and it shall be deemed to have been included in the quoted rate.

d) In the event of Contractor's failure to effect or to keep in force the insurance referred to above or any other insurance which the Contractor is required to effect under the terms of the contract, the company may effect and keep in force any such insurance and pay such premium/premiums as may be necessary for that purpose from time to time and recover the amount thus paid from any moneys due by the Contractor. The Contractor shall whenever required produce before Engineer-in-charge the policy or policies of insurance and receipt of payment of the current premium. This insurance shall protect the Contractor against all claims arising from injuries, disabilities, disease or death of member of public or damage to property of others due to any act or omission on the part of the Contractor, his agents, his employees, his representatives and Sub-Contractor’s or from riots, strikes and civil commotion.

49.8 Module Performance Insurance:

To ensure faithful performance of PV modules, Contractor must submit insurance before dispatch with a coverage of minimum 6 % of 60% of the total Contract Price for 25 years, with the SPD as its beneficiary. However, the Contractor may also submit the insurance with a coverage of minimum 6% of the total order value of the Solar PV Modules envisaged under the contract, subjected to submission of the required documents (invoices, receipts, Purchase Order etc.). Any financial implication encountered due to insurance shall be borne by the Contractor. The

Contractor's insurance liabilities pertaining to the scope of works are detailed out in elsewhere in contract Document.

I. The module should be insured as per the following clauses and are to be complied: In the case of domestic manufacturers, insurance shall be taken from the list of insurers as per Annexure of the Circular of MNRE, issued vide OM Dated 07.01.2020 with regard to Insurance Products for Solar Power Plants.

II. In case of insolvency of the contractor, the SPD under the terms of the insurance policy against Module Performance and Warranty shall be entitled to raise a claim against the Module Warranty Insurance Policy and in order to benefit from the coverage provided by the aforementioned policy. The Contractor shall be responsible for maintaining the coverage provided under the Module Warranty Insurance Policy at all times, at its cost and expense.

III. Further, the Contractor to note that SPD requires the following to be complied while covering the Warranty/Guarantee/Performance of the supplied goods under the insurance:

a) Single Insurance Policy for Product Warranty/Guarantee and performance before dispatch of the first lot of PV Modules Insurance.

b) The Insurance Policy shall be valid for a minimum period of twenty-five (25) years from the date of receipt of last batch/lot of equipment at site.

c) The premium charges, recurring charges, any other expenditure under the Insurance Policy shall be covered by the Contractor.

d) The insurer must continue to compensate end users for warranty claims for the product quality and/or performance even if contractor ceases to exist as an independent operating company.

e) The insurance shall be non-cancellable by the insurer and shall provide third party bankruptcy rights.

f) Coverage under the insurance policy shall be immediate, without any waiting period.

49.9 The Contractor shall also arrange suitable insurance to cover following during the O&M Period:

a) Machinery Breakdown: Electrical & or machinery breakdown of any machinery or other equipment resulting in costly repairs or even replacement of the solar panel.
b) Business Interruption: Cover for period of operational downtime i.e., covering the cash flow of the solar business as a result of an insured peril, for example fire or storm damage, machinery breakdown or equipment failure.

c) Property Damage: The insurance should cover material damage due to external causes such as fire, theft, vandalism, sabotage, hail damage, snow load, lightning strike, overload, operational mistakes, clumsiness, negligence & theft.
d) EMPLOYERs Liability: Provides cover against the risk of accident from usual workplace risks such as working at height & manual handling during construction & O&M period.
e) Environmental Risk Insurance: Environmental damage coverage indemnifies solar system owners of the risk of either environmental damage done by their development or pre-existing damage on the development site.

49.10 ANY OTHER INSURANCE REQUIRED UNDER LAW OR REGULATIONS OR BY OWNER:

Contractor shall also carry and maintain any and all other insurance(s) which he may be required under any law or regulation from time to time without any extra cost to Owner. He shall also carry and maintain any other insurance which may be required by the Owner.

Amount	Deductible Limits	Parties Insured	From	To
To be indicated by the contractor	Nil	Contractor, and Owner	Receipt at Site	Upto Defect Liability period

49.11 Damage to Property or to any Person or any Third Party Contractor shall be responsible for making good to any loss or any damage to structures and properties belonging to the Owner or being executed or procured or being procured by the Owner or of other agencies within in the premises of all the work of the Owner, if such loss or damage is due to fault and/ or the negligence or willful acts or omission of the Contractor, his employees, agents, representatives or Sub-Contractors. The Contractor shall take sufficient care in moving his plants, equipment and materials from one place to another so that they do not cause any damage to any person or to the property of the EMPLOYER/ Owner or any third party including overhead and underground cables and in the event of any damage resulting to the property of the Owner or of a third party during the movement of the aforesaid plant, equipment or materials the cost of such damages including eventual loss of production, operation or services in any plant or establishment as estimated by the EMPLOYER/ Owner or ascertained or demanded by the third party shall be borne by the Contractor. Third party liability risk shall be INR 1 (One) Lakh for single accident and limited to INR 10 (Ten) Lakhs.

The Contractor shall indemnify and keep the EMPLOYER/ Owner harmless of all claims for damages to property other than EMPLOYER's/ Owner's property arising under or by reason of this agreement, if such claims result from the fault and/ or negligence or willful acts or omission of the Contractor, his employees, agents, representative of Sub-Contractor.

50. <u>Mobilization Advance (Optional)</u>:

50.1 A maximum of 10% of the Supply Contract value may be paid as mobilization advance subject to submission of Bank Guarantee for 110% advance amount.

50.2 Mobilization Advance against supply of equipment shall be released as per provision mentioned in Payment Terms. (in SCC).

50.3 **The mobilization advance of 10% shall be proportionately adjusted from the running bills of the contractor during initial 70% payment of "Supply contract".**

Though the 'Mobilization Advance' shall be given interest free but the interest shall be charged as per the rate of CIL's borrowing rate under cash credit arrangement as varying from time to time to be compounded quarterly, on delayed recoveries either due to the late submission of bill by the Contractor or any other reason attributable to the Contractor besides the reason giving rise to encashment of BG as stated in the Clause 50 of NIT - 'Mobilization Advance'.

In addition to the above, interest will be charged as per aforesaid rate on Mobilization Advance in case the contract is terminated due to default of the Contractor.

50.4 The value of Bank Guarantee may be reduced to the extent such advance is recovered by the company subject to the conditions that the value of Bank Guarantee amount at any time is more than the recoverable outstanding advance. Bank Guarantee shall be irrevocable and from a Nationalized Bank/Scheduled Bank.

50.5 Part Bank Guarantee" (BGs) against the Mobilization Advance shall be taken in as many numbers as the proposed recovery instalments and shall be equivalent to 110% of the amount of each instalment.

50.6 In case of "Machinery and Equipment advance", insurance and hypothecation to the employer shall be ensured.

50.7 Mobilization advance will be given in instalments and subsequent instalments will be released after getting satisfactory utilization Certificate from the contractor for the earlier instalments.

SECTION -II: GENERAL TERMS AND CONDITIONS OF CONTRACT

1.0 DEFINITIONS:

i. The word "Company" or "Employer" or "Owner" wherever occurs in the conditions, means the Coal India Limited, represented at the headquarters of the Company by the or his authorized representative or any other officer specially deputed for the purpose.

ii. The word "Principal Employer" wherever occurs, means the authorized representative or any other officer specially deputed by the Company for the purpose.

iii. The word "Contractor"/"Contractors" wherever occurs means the successful Bidder/Bidders who has/have deposited the necessary Earnest Money and has/have been given written intimation about the acceptance of tender and shall include legal representative of such individual or persons composing a firm or a Company or the successors and permitted assignees of such individual, firm or Company, as the case may be.

iv. "The Site" shall mean the site of the contract work including land and any building and erections thereon and any other land allotted by the Company for Contractor's use.

v. 'Tender Accepting Authority (TAA)/ Awarding Authority' shall mean the management of the Company and includes an authorized representative of the Company or any other person or body of persons empowered in this behalf by the Company to approve the Tender. Tender Accepting Authority (TAA)/Awarding Authority at any time after the award of tender till the finalization of contract shall be construed as the authority as per the prevalent DoP of CIL.

Note: Interpretation of Tender Accepting Authority (TAA)/ Awarding Authority as above is applicable for the existing and future contracts.

vi. A 'Day 'shall mean a day of 24 hours from midnight to midnight.

vii. "Engineer-In-Charge/Designated Officer-in-charge" who is of an appropriate seniority will be responsible for supervising and administering the contract, certifying payment due to the Contractor, valuing variations to the contract, awarding extension of time and valuing compensation events. Engineer-In- Charge/Designated Officer-in-charge may further appoint his representatives i.e. another person/ Project Manager or any other competent person and notify to the Contractor who is directly responsible for supervising the work being executed at the site, on his behalf under the Delegation of Powers of the Company. However, overall responsibility, as far as the contract is concerned will be that of the Engineer-In-Charge/Designated Officer-in-charge.

viii. The 'Contract' shall mean the Notice Inviting Tender, the tender as accepted by the Company and the formal agreement executed between the Company and the Contractor together with

the documents referred to therein including General Terms and Conditions, Special Conditions, if any, schedule of quantities with rates and amounts, Schedule of work. Until the formal agreement is signed between the Owner and the Contractor, LOA/Work Order together with Contract Document, shall constitute the Contract.

ix. The 'Works' shall mean the works required to be executed in accordance with the contract or parts thereof as the case may be and shall include all extra or additional or any work of emergent nature, which in the opinion of the Engineer-In-Charge, become necessary during the progress of the works to obviate any risk or accident or failure or become necessary for security.

x. 'Schedule of Rates' referred to in these conditions shall mean the standard schedule of rates prescribed by the Company and the amendments issued from time to time.

Note: -Functional Directors of Subsidiaries to approve the Schedule of Rates for Coal Transportation, wagon Loading, etc.

xi. 'Contract price' shall mean

a) in the case of lump sum contracts the total sum for which tender is accepted by the Company.
b) in the case of other types of contracts, the total sum arrived at based on the individual rates quoted by the tenderer for the various items shown in the 'Bill of quantities' of the tender documents as accepted by the Company with or without any alteration as the case may be.

xii. 'Written notice' shall mean a notice or communication in writing and shall be deemed to have been duly served if delivered in person to the individual or to a member of the firm or to an office of the Corporation/Company for whom it is intended, or if delivered at or sent by registered mail to the last business address known to him who gives the notice.

2.0 CONTRACT DOCUMENTS:

The following documents shall constitute the contract documents:

(i) Articles of Agreement,
(ii) Notice Inviting Tender and Instruction to Bidders,
(iii) Conditions of Contract, including General Terms and Conditions, Additional Terms and Conditions, Special Conditions, if any etc. forming part of the Agreement,
(iv) Letter of Acceptance of Bid indicating deviations, if any, from the Conditions of Contract incorporated in the Bid/Tender document issued to the Bidder,
(v) Scope of works/Bills of Quantities,
(vi) Finalized work programme,
(vii) Integrity Pact as applicable as decided by different Subsidiary Companies
(viii) Guidelines on Debarment of firms from Bidding,
(ix) Code of Integrity for Public Procurement.

(x) Any other document, if required.

2.1 After acceptance of tender the Contractor shall be deemed to have carefully examined all Contract Documents to his satisfaction. If he shall have any doubt as to the meaning of any portion of the Contract Documents, he shall before signing the Contract, set forth the particulars thereof, and submit them to the Owner in writing in order that such doubt may be removed. The Owner will provide such clarifications as may be necessary in writing to the Contractor. Any information otherwise obtained from the Owner or the Engineer shall not in any way relieve the Contractor of his responsibility to fulfill his obligations under the Contract.
2.2 The Contractor shall enter into a Contract Agreement with the Owner within 60 (sixty) days from the date of 'Acceptance of Tender' or within such extended time as may be granted by the owner. The performance Bank Guarantee for the proper fulfillment of the contract shall be furnished by the contractor in the prescribed form within twenty one (21) days of 'Acceptance of tender'. The performance Guarantee shall be as per terms prescribed in clause 4.0 of General Terms and Conditions of Contract herein after.
2.3 The owner, after the issue of the letter of Acceptance of Tender, will send one copy of the final agreement to the contractor for his scrutiny and approval.
2.4 The agreement, unless otherwise agreed to, shall be signed within 60 days of the issue of the letter of Acceptance of tender, at the office of the owner on a date and time to be mutually agreed. The contractor shall provide for signing of the contract, performance guarantee in copies as required, appropriate power of attorney and other requisite materials. In case it is agreed mutually that the contract is to be signed beyond the stipulated time, the bid guarantee submitted with the tender will have to be extended accordingly.
2.5 The agreement will be signed in six originals and the contractor shall be provided with one signed original and the rest will be retained by the owner. None of these documents shall be used by the contractor for any purpose other than this contract and the contractor shall ensure that all persons employed for this contract strictly adhere to this and maintain secrecy, as required of such documents.
2.6 The contractor shall provide free of cost to the owner all the engineering data, drawings and descriptive materials submitted with the bid, in at least six (6) copies to form a part of the contract immediately after issue of letter of acceptance.
2.7 Subsequent to signing of the contract, the contractor at his own cost shall provide the owner with at least six (6) true copies of agreement within thirty (30) days after the signing of the contract.
2.8 The date of commencement shall be reckoned from the expiry of 30 days from the issue of letter of acceptance and submission of Performance Security or seven days after handing over the site for the first activity as per PERT network chart, whichever is later.
2.9 The laws applicable to this contract shall be the laws in force in India. The courts of Kolkata shall have exclusive jurisdiction in all matters arising under this contract.

3.0 DISCREPANCIES AND ADJUSTMENTS THEREOF:

The documents forming part of the contract are to be treated as mutually explanatory.
3.1 In the event of varying or conflicting provisions made in any of the document/documents forming part of the contract, the Tender Accepting Authority's decision/clarification shall hold good with regard to the intention of the document or contract, as the case may be.

3.2 Any error in description, quantity or rate in schedule or quantities or any omission therefrom, shall not vitiate the contract or release the Contractor from discharging his obligations under the contract including execution of work according to the specifications forming part of the particular contract document.

4.0 SECURITY DEPOSIT:

4.1 Security Deposit shall consist of two parts:

a) Performance Security to be submitted at award of work and
b) Retention Money to be recovered from running bills.

The Security Deposit shall bear no interest.

4.2 Performance Security (first part of Security Deposit) should be 5% of contract amount, and should be submitted within 21 days of issue of LOA, by the successful Bidder in any of the form given below:

- A Bank Guarantee (BG) in the form given in the bid document from any Scheduled Bank. The BG issued by outstation bank shall be operative at its local branch ……. or branch at…….

- Govt. Securities, FDR (Scheduled Bank) or any other form of deposit Stipulated by the owner.

- Demand Draft drawn in favour of Coal India Limited (CIL) on any Scheduled Bank payable at its Branch at …….

However, Company may approve submission of Performance Security beyond 21 days by another 14 days with proper justification on a case to case basis.

The Earnest Money/Bid Security deposited is to be returned to the Contractor after submission of Performance Security. The Earnest Money/Bid Security deposited may be adjusted against the Security Deposit (Performance Security) at Bidder’s option.

Work shall commence only after submission of Security Deposit.
4.3 If Performance Security is provided by the successful Bidders in the form of Bank Guarantee it shall be issued either –

(a) at Bidder's option by a Scheduled Bank,
Or
(b) by a Foreign Bank located in India and acceptable to the Employer. BG of scheduled commercial bank located in India and acceptable to the company should only be accepted. Thus, any BG issued by foreign bank from outside India shall not be accepted.

(c) the validity of the Bank Guarantee shall be for a period of "one year" or "ninety days, beyond the period of contract/extended period of contract (if any)", whichever is more.Bank Guarantee (BG) is to be submitted in the format prescribed by the Company. Bank Guarantee shall be irrevocable and it shall be issued by any Indian Nationalized Bank/Scheduled Bank on Structured Financial Messaging System (SFMS) platform which is payable / enforceable at Kolkata

The paper BG would be delivered by Issuing Bank to the Beneficiary under Speed Post/Registered Post (AD). Original Bank Guarantee shall be accepted from Issuing Bank only. However, the paper BG would be operative only on receipt of a separate advice through SFMS and confirmed by the Advising Bank (i.e. Beneficiary Bank). The confirmation of issuance of BG through SFMS from Advising Bank shall be obtained through electronically as well as print out of the said message from Advising Bank with seal and signature.

Confirmation of Bank Guarantee:

Confirmation of Bank Guarantee through Structured Financial Messaging System (SFMS) will be done as follows:

The bank guarantee issued by the issuing Bank on behalf of Bidder in favour of "CIL" shall be in paper form as well as issued under the "Structured Financial Messaging System". Issuing Bank should send the underlying confirmation message in IFN760COV or IFN767COV message type for getting the BG advised through our bank. Also issuing bank should mention "CIL0066312" in field no. "7037" of IFN760COV or IFN767COV .The message will be sent to the beneficiary bank through SFMS and the date of SFMS confirmation to CIL shall be deemed to be the date of receipt of the BG. The details of beneficiary Bank for issue of BG through SFMS Platform is furnished below:

Name of Beneficiary	Coal India Limited
Unit/Area/Division	Corporate Office
Beneficiary Bank, Branch & Address	ICICI Bank
	Rasoi Court
IFSC Code	ICIC0000006
Account No.	000651000038
Customer ID	066312
Email ID:	

The above particulars are to be incorporated by the Issuing Bank properly while issuing BG under SFMS mode to avoid any problem in future.
Original Bank Guarantee (issued by the Issuing Bank) shall be sent by the Issuing Bank to concerned Department by Registered Post (AD).

Note:
Safe Custody and Monitoring of Securities-
The BG Details after confirmation and acceptance shall be entered in SAP by Associate Finance and its validity expiry shall be monitored through SAP. The BG shall be sent by Associate Finance to Corporate Finance CIL/ Subsidiary for safe custody. Extension of bank guarantees and other instruments, where warranted, should be sought immediately and implemented within their validity period.

For release of BGs, the proposal shall be forwarded by EIC with their recommendations in accordance with the contract conditions, for approval by the Competent Authority with the concurrence of the Finance Division.

In case the successful Bidder fails to submit the Performance Security and Additional Performance Security, if any, within the stipulated time then the award of work may be cancelled with forfeiture of the Bid Security/Earnest Money.

Additionally, the Company shall debar such defaulting Contractor from participating in future tenders in concerned Subsidiary/CIL HQ as per Annexure-XVI – Guidelines on Debarment of Firms from Bidding.
In case of JV/CONSORTIUM/Partnership firm, the debarment shall also be applicable to all individual partners of JV/CONSORTIUM/Partnership firm.

4.4 Retention Money should be deducted at 5% from running on account bills. Total of performance security and Retention Money should not exceed 10% of contract amount or lesser sum indicated in the bid document. Retention Money may be refunded against equivalent Bank Guarantee, on written request of the contractor, on its accumulation to a minimum amount of Rs 25 lakhs. However, Bank Guarantee against retention money shall be with suitable validity based on nature of work which shall be 90 days beyond the defect liability period, but in no case less than the period of one year.
4.5 The Guarantee amount shall be payable to the Employer without any condition whatsoever.
4.6 Performance security/ Retention Money/ security deposit submitted in the form of BG which shall be valid for 90 days after the end date of scheduled completion (12 months for commissioning of the project and 60 months for O&M from next Calendar date of commissioning) and to be extended for minimum period of 1(one) year in one instance which must cover the time period of 90 days beyond completion of Defect Liability period.
4.7 The Performance Guarantee shall cover additionally the following guarantees to the Employer:
(a) The successful bidder guarantees the successful and satisfactory operation of the equipment furnished and erected under the contract, as per the specifications and documents,
(b) The successful bidder further guarantees that the equipment provided and installed by him shall be free from all defects in design, material and workmanship and shall upon written notice from the employer, fully remedy free of expenses to the Employer such defects as developed under the normal use of the said equipment within the period of guarantee specified in the relevant clause of the Conditions of Contract.
4.8 The Contract Performance Guarantee is intended to secure the performance of the entire Contract. However, it is not construed as limiting the damages under clause entitled 'Equipment Performance Guarantee' in section Technical Conditions of Contract and damages stipulated in the other clauses in the bidding documents.
4.9 All Bank Guarantees are to be submitted in the format prescribed by the company in the bid document. Bank Guarantee shall be irrevocable and it shall be from any Scheduled Bank acceptable to the owner. The BG issued by outstation bank shall be operative at its local branch at Kolkata or branch at Kolkata
4.10 The Company shall be at liberty to deduct/appropriate from the Contract Performance Guarantee/Security Deposit such sums as are due and payable by the contractor to the company as may be determined in terms of the contract, and the amount appropriated from the Contract Performance Guarantee/Security Deposit shall have to be restored by Contractor subsequently.
4.11 Performance Security deposit shall be returned to the Contractor after successful completion of 3 (Three) years of Defect Liability Period without any interest. The balance SD i.e. Retention Money shall be released without any interest after successful completion of entire period of the Defect Liability. Any defect/defects in the work, if detected during Guarantee Period/Defect Liability Period shall be rectified or equipment/ system shall be replaced to the satisfaction of the

engineer In-charge within the said defect liability/ operation/ maintenance/guarantee period or its due extension till completion of the rectification/ replacement works as required.
4.12 In case the successful bidder fails to submit the Performance security within the stipulated time then the award of work may be cancelled with forfeiture of the bid security/ earnest money. Additionally, the company shall ban such defaulting contractor as per the Guidelines of Debarment of firms from Bidding. In case of JV/CONSORTIUM/Partnership firm, the debarment shall also be applicable to all individual partners of JV/CONSORTIUM/Partnership firm.
However, debarment shall be done as per Guidelines for Debarment of firms from Bidding.

5. DEVIATIONS/ VARIATIONS IN QUANTITIES:

The quantities given in the “Schedule of Quantities" are based on estimates and are meant to indicate the extent of the work and to provide a uniform basis for tendering and any variation either by addition or omission shall not vitiate the contract.
The variation register may be maintained in SAP in electronic form to have a proper control over variations.
5.1 The company through its Engineer-in-Charge or his representative shall, without radically changing the original scope and nature of the work, under contract, have power to make any alterations in or additions to or substitution of the original specifications, drawings, designs, and instructions that may appear to be necessary or advisable during the progress of the work.
The contractor shall be bound to carry out the work(s) in accordance with the instructions given to him in writing by the Engineer-in-Charge or his representative on behalf of the company. Such altered or additional or substituted work, which shall form part of the original contract, shall be carried out by the contractor on the same terms and conditions in all respects on which they agreed to do the main work and at the same rate/rates as are specified in the contract/ work-order. In case there are changes in ground levels from those shown in the approved drawings, they shall be agreed in writing, jointly by the contractor and EIC.
5.2 The right is reserved to cancel any items of work included in the contract agreement or portion thereof in any stage of execution if found necessary to the work and such omission shall not be a waiver of any condition of the contract nor invalidate any of the provisions thereof.
5.3 If the additional, altered or substituted work includes any class of work for which rate/rates is/are not specified in the contract/work order, rates for such items shall be determined by the Engineer-in-Charge as follows:

a) In the case of percentage tenders, if the rate for the extra item of work executed is available in the company's approved SOR, it will be paid at the schedule rate plus or minus the accepted percentage as per contract.
   However, if the extra item is not available in company’s approved SOR, then the rate for such extra
   item(s) shall be dealt as at (c) below.

b) In case of item rate tenders, the rate for extra item shall be derived from the rate for similar item or near similar item / class of work available in the agreement schedule of work or by analysis of rates as at below and the lower rate out of the above two shall be considered.
In case of composite item rate tenders, where two or more schedule of quantities for similar item
description may form part of the contract; the applicable rates shall be taken from the Schedule of
Quantities of that particular part in which the deviation is involved, failing that at the lowest applicable rate for the similar item of work in the other schedule of quantities.
For derivation of rates based on analysis, the same shall be done by analysis on prevalent market rate
of materials and labour based on standard norms of analysis of rate of C.P.W.D/ N.B.O.

c) In the case of extra item(s) that are completely new, and are in addition to the items contained in the contract, the contractor may within 15 days of receipt of order or occurrence of the item(s) claim rates, supported by proper analysis. The Engineer-in-Charge shall determine the rate(s) by analysis based on prevalent market rate of material and labour and on standard norms of analysis of rate of CPWD / NBO.

d) In case of combined tender with partly item rate for non-schedule items & partly percentage tenders for SOR items, the rate for extra item shall be derived as at (b) & (c) above in case of non-schedule items rates and in case of percentage rates for SOR items the rate for extra item shall be derived as at (a) above.
In case of any difference between the contractor and the Engineer-In Charge as to the fixation of rates, the matter shall be referred to the accepting authority of the company i.e. GM(C) of the company or Staff
Officer(C) for the work awarded at Company Hqrs. level and Area level respectively, whose decision shall be final and binding on the contractor.

5.4 Alteration in the quantities shall not be considered as a change in the condition of the contract nor invalidate any of the provision thereof provided that a deviation estimate / revised estimate / supplementary agreement for the item(s) involved is made. Such approval shall be from appropriate authority.

5.5 Payment for such deviated items [additional/ altered / substituted items of work of the agreement schedule] shall be made in the contractors running on account bills, till the revised estimate / deviation estimate regularizing these items are sanctioned by the competent authority of the company, at the provisional rates and shall not exceed :

a) 75% of the rate recommended by the Engineer-in-Charge to the accepting authority of the company i.e. GM(C) of the company or SO(C) of the Area, if the rate is directly available in the SOR of the company/ if the rate is derived from available rate of BOQ.

b) 50% of the rate recommended by the Engineer-in-Charge to the accepting authority of the company, i.e. GM(C) of the company or SO(C) of the Area , if it is analysed item rates based on prevalent market

c) rates of materials and labour following CPWD / NBO norms.

Total payment for such extra items of work shall not exceed 10% of work order / agreement value / approved deviation estimate value. Also total payment including extra items of work shall not exceed the work order / agreement / approved deviation estimate value.

6. LIQUIDATED DAMAGES FOR DELAY IN COMPLETION

6.1 If the contractor fails to maintain the required progress in terms of the agreed time and progress chart or to complete the work and clear the site on or before the date of completion of contract or extended date of completion, he shall without prejudice to any other right or remedy available under the law to the company on account of such breach, pay as compensation/ Liquidated Damages as mentioned in Special Conditions of Contract (SCC). The aggregate of such compensation/ compensations shall not exceed 10 (ten) percent of the total value as shown in the contract.

This will also apply to items or group of items for which separate period of completion has been specified. The amount of compensation may be adjusted or setoff against any sum payable to the contractor under this or any other contract with the company.

6.1.1 The company, if satisfied, that the works can be completed by the contractor within a reasonable time after the specified time of completion, may allow further extension of time at its discretion with or without the levy of L.D. In the event of extension granted being with L.D, the company will be entitled without prejudice to any other right or remedy available in that behalf, to recover from the contractor as agreed damages equivalent to half percent of the contract value of the works for each week or part of the week subject to a ceiling of 10% of the contract price.

6.1.2 The company, if not satisfied that the works can be completed by the contractor, and in the event of failure on the part of the contractor to complete work within further extension of time allowed as aforesaid, shall be entitled, without prejudice to any other right, or remedy available in that behalf, to rescind the contract.

6.1.3 The company, if not satisfied with the progress of the contract and in the event of failure of the contractor to recoup the delays in the mutually agreed time frame, shall be entitled to terminate the contract.

6.1.4 In the event of such termination of the contract as described in clauses 6.1.2 or 6.1.3 or both, the company, shall be entitled to recover L.D. upto ten percent (10%) of the contract value besides recovery of compensation for damage/loss for termination as provided in 9.4 of General Terms and Conditions of Contract.

6.2 The company may waive the payment of compensation, depending upon merit of the case, on request received from the contractor if the entire work is completed within the date as specified in the contract or as validly extended without stipulating any penalty.

7. QUALITY ASSURANCE:

The Contractor shall carry out and complete the work in every respect in accordance with the contract and shall ensure that the work conforms strictly to the instructions of the Engineer-In-Charge. The Engineer-In-Charge may issue from time to time further detail instructions/directions in writing to the Contractor. All such instructions/directions shall be consistent with the contract documents and should be reasonably inferable therefrom, along with clarifications/explanations thereof, if necessary.

8. MEASUREMENT AND PAYMENT:

Except where any general or detailed description of the work in quantities provides otherwise, measurements of work done shall be taken in accordance with the relevant standard method of measurement as applicable to the schedule of quantities/schedule of work /specification to the contract. In the case of items not covered by any of the aforesaid contract documents, measurement shall be taken in accordance with the relevant standard method of measurement issued by the Indian Standard Institution.

8.1 All items of work carried out by the Contractor in accordance with the provisions of the contract having a financial value shall be entered in the Measurement Book/Log Book, etc. as prescribed by the Company so that a complete record is obtained of all work performed under the contract and the value of the work carried out can be ascertained and determined therefrom.

8.2 Measurements shall be taken jointly by the Engineer-In-Charge or his authorized representative and by the Contractor or his authorized representative.

8.3 Before taking measurements of any work, the Engineer-In-Charge or the person deputed by him for the purpose shall intimate the Contractor to attend or to send his representative to attend the measurement. Every measurement thus taken shall be signed and dated by both the parties on the site on completion of the measurement. If the Contractor objects to any of the measurements, a note to that effect shall be made in the Measurement Book /Log Book and signed and dated by both the parties.

8.4 In the event of failure on the part of Contractor to attend or to send his authorized representative to attend the measurement after receiving the intimation, or to countersign or to record objection within a week from the date of the measurement, the measurement taken by the Engineer-In-Charge or by his authorized representative shall be taken to be the correct measurement of the work done.

8.5 Payment on Account - The Contractor shall submit interim bill/bills for the work carried out/materials provided in accordance with the contract. The Engineer-In- Charge shall then arrange for verification of the bill/bills with reference to the measurements taken or to be taken or any other records relevant for the purpose.

8.6 Payment on account shall be made on the Engineer-In-Charge certifying the sum to which the Contractor is considered entitled by way of interim payment for the work executed as covered by the bill/bills after deducting the amount already paid, the Security Deposit and such other amounts as may be deductible or recoverable in terms of the contract.

8.7 Any certificate given by the Engineer-in-charge for the purpose of payment of interim bill/bills shall not of itself be conclusive evidence that any work/materials to which it relates is/are in accordance with the contract and may be modified or corrected by the Engineer-in-charge by any subsequent certificate or by the final certificate.

8.8 The Company reserves the right to recover/enforce recovery of any overpayments detected after payment as a result of post-payment audit or technical examination or by any other means, notwithstanding the fact that the amount of disputed claims, if any, of the Contractor exceeds the amount of such overpayment and irrespective of the facts whether such disputed claims of the Contractor are the subject matter of arbitration or not. The amount of such overpayments may be recovered from the subsequent bills under the contract, failing that from Contractor's claim under any other contract with the Company or from the Contractor's Security Deposit or the Contractor shall pay the amount of overpayment on demand.

8.9 Amount payable/ repayable for any subsequent change in the Goods and Services Tax (GST) will be made to/ from the Contractors after departmental verification of such changes of tax law issued by statutory authority.

9. TERMINATION, SUSPENSION, CANCELLATION & FORECLOSURE OF CONTRACT:

9.1 Cancellation of Contract-The owner shall, in addition to other remedial steps to be taken as provided in the conditions of contract, be entitled to cancel the contract in full or in part, if the contractor

a) makes default in proceeding with the works with due diligence and continues to do so even after a notice in writing from the Engineer-in-charge, then on the expiry of the period as specified in the notice

   Or

b) commits default/breach in complying with any of the terms and conditions of the contract and does not remedy it or fails to take effective steps for the remedy to the satisfaction of the Engineer-in-charge, then on the expiry of the period as may be specified by the Engineer-in-charge in a notice in writing

Or

c) fails to complete the work or items of work with individual dates of completion, on or before the date/dates of completion or as extended by the company, then on the expiry of the period as may be specified by the Engineer-in-charge in a notice in writing

Or

d) shall offer or give or agree to give any person in the service of the company or to any other person on his behalf any gift or consideration of any kind as an inducement or reward for act/acts of favour in relation to the obtaining or execution of this or any other contract for the company.

Or

e) Shall try to obtain a contract with the company by way of ring tendering or other non-bonafide method of competitive tendering.

Or

f) transfers, sublets, assigns the entire work or any portion thereof without the prior approval in writing from the Engineer-in-charge. The Engineer-in-charge may by giving a written notice, cancel the whole contract or portion of it in default.

9.2 The owner shall in such an event give fifteen (15) days' notice in writing to the contractor of his decision to do so.

9.3 The contractor upon receipt of such notice shall discontinue the work on the date and to the extent specified in the notice, make all reasonable efforts to obtain cancellation of all orders and contracts to the extent they are related to the work terminated and terms satisfactory to the owner, stop all further sub-contracting or purchasing activity related to the work terminated, and assist the owner in maintenance, protection, and disposition of the works acquired under the contract by the owner.

9.4 Termination of Contract-The contract shall stand terminated under the following circumstances unless the owner is satisfied that the legal representatives of the individual

contractor or of the proprietor of the proprietary concern and in the case of partnership the surviving partners, are capable of carrying out and completing the contract and the owner shall in any way not be liable to payment of any compensation to the estate of deceased contractor and/or to the surviving partners of the contractor's firm on account of the termination of the contract.:

a) If the contractor being an individual in the case of proprietary concern or in the case of a partnership firm any of its partners is declared insolvent under the provisions of insolvency act for the time being in force, or makes any conveyance or assignment of his effects or composition or arrangement for the benefit of his creditors amounting to proceedings for liquidation or composition under any insolvency act.
b) In the case of the contractor being a company, its affairs are under liquidation either by a resolution passed by the company or by an order of court, not being a voluntary liquidation proceeding for the purpose of amalgamation or reorganization, or a receiver or manager is appointed by the court on the application by the debenture holders of the company, if any.
c) If the contractor shall suffer an execution being levied on his/their goods, estates and allow it to be continued for a period of 21 days.
d) On the death of the contractor being a proprietary concern or of any of the partners in the case of a partnership concern and the company is not satisfied that the legal representative of the deceased proprietor or the other surviving partners of the partnership concern are capable of carrying out and completing the contract. The decision of the company in this respect shall be final and binding which is to be intimated in writing to the legal representative or to the partnership concern.

9.5 If the contractor is an individual or a proprietary concern and the individual or the proprietor dies and if the contractor is a partnership concern and one of the partners dies, then unless the owner is satisfied that the legal representatives of the individual contractor or of the proprietor of the proprietary concern and in the case of partnership the surviving partners, are capable of carrying out and completing the contract the owner shall be entitled to cancel the contract as to its incomplete part without being in any way liable to payment of any compensation to the estate of deceased contractor and/or to the surviving partners of the contractor's firm on account of the cancellation of the contract.

The decision of the owner that the legal representatives of the deceased contractor or surviving partners of the contractor's firm cannot carry out and complete the contract shall be final and binding on the parties. In the event of such cancellation the owner shall not hold the estate of the deceased contractor and/or the surviving partners of the estate of the deceased contractor and/or the surviving partners of the contractor's firm liable to damages for not completing the contract.

9.6 On cancellation of the contract or on termination of the contract, the Engineer-incharge shall have powers

a) To take possession of the site and any materials, constructional plant, implements, stores, etc. thereon.

b) In such an event, the contractor shall be liable for loss/damage suffered by the employer because of action under this clause and to compensate for this loss or damage, the employer shall be entitled to recover higher of the following:
    i) Forfeiture of security deposit comprising of performance guarantee and retention money at the disposal of the employer.
    Or
    ii) 20% of value of incomplete work (Contract Value minus already executed value of the work).

The amount to be recovered from the contractor as determined above, shall, without prejudice to any other right or remedy available to the employer as per law or as per agreement, will be recovered from any money due to the contractor on any account or under any other contract and in the event of any shortfall, the contractor shall be liable to pay the same within 30 days. In case of failure to pay the same the amount shall be debt payable.

In the event of above course being adopted by the Engineer-in-charge, the contractor shall have no claim to compensation for any loss sustained by him by reasons of his having purchased materials, equipment or entered into agreement or made advances on any account or with a view to the execution of work or performance of the contract. And in case action is taken under any of provision aforesaid, the contractor shall not be entitled to recover or to be paid any sum for any work thereof or actually performed under this contract unless and until the engineer-in-charge has certified in writing the performance of such work and value payable in respect thereof and he shall only be entitled to be paid the value so certified.

The need for determination of the amount of recovery of any extra cost/expenditure or of any loss/damage suffered by the company shall not however arise in the case of termination of the contract for death/demise of the contractor.

9.7 Suspension of Contract- The company shall have power to suspend the progress of the work or any part thereof and the Engineer-in-charge may direct the contractor in writing to suspend the work, for such period and in such manner as may be specified therein, on account of any default on the part of the contractor, or for proper execution of the work for reasons other than any default on the part of the contractor, or on ground of safety of the work or part thereof. In the event of suspension for reason other than any default on the part of the contractor, extension of time shall be allowed by the company equal to the period of such suspension. Any necessary and demonstrable costs incurred by the contractor as a result of such suspension of the works will be paid by the owner, provided such costs are substantiated to the satisfaction of the engineer. The owner shall not be responsible for any liabilities if suspension or delay is due to some default on the part of the contractor or his sub-contractor.

The work shall, throughout the stipulated period of contract, be carried out with all due diligence on the part of the contractor. In the event of termination or suspension of the contract, on account of default on the part of the contractor, as narrated hereinbefore, the security deposit and other dues of this work or any other work done under this company shall be forfeited and brought

under the absolute disposal of the company provided, that the amount so forfeited shall not exceed 10% of the contract value.

9.8 Foreclosure of Contract (in full or in part) - If at any time after acceptance of the tender, the company decides to abandon or reduce the scope of the work for any reason whatsoever the company, through its Engineer-in-charge, shall give notice in writing to that effect to the contractor. In the event of abandonment/reduction in the scope of work, the company shall be liable:

a) to pay the contractor at the contract rates full amount for works executed and measured at site upto the date of such abandonment/reduction in the work.
b) to pay reasonable amount assessed and certified by the Engineer-in-charge of the expenditure incurred, if any, by the contractor on preliminary works at site. e.g. temporary access roads, temporary construction for labour and staff quarters, office accommodation, storage of materials, water storage tanks and supply for the work including supply to labour/staff quarters, office, etc.
c) to pay for the materials brought to site or to be delivered at site, which the contractor is legally liable to pay, for the purpose of consumption in works carried out or were to be carried out but for the foreclosure, including the cost of purchase and transportation and cost of delivery of such materials. The materials to be taken over by the company should be in good condition and the company may allow at its discretion the contractor to retain the materials in full or part if so desired by him and to be transported by the contractor from site to his place.
d) to take back the materials issued by the company but remaining unused, if any, in the work on the date of abandonment/reduction in the work, at the original issued price less allowance for any deterioration or damage caused while in custody of the contractor
e) to pay for the transportation of tools and plants of the contractor from site to contractor's place or to any other destination, whichever is less.

The contractor shall, if required by the Engineer-in-charge, furnish to him books of accounts, papers, relevant documents as may be necessary to enable the
Engineer-in-charge to assess the amount payable in terms of para 9.8 (b), (c) and (e) above, the contractor shall not have any claim for compensation whatsoever either for abandonment or for reduction in the scope of work, other than those as specified above.

10.0 CONTRACT PRICE

The lump sum prices quoted by the contractor in his bid with additions and deletions as may be agreed before signing of the contract, for the entire scope of the work including furnishing and erection of equipment covered under the specifications and documents and shall be treated as the contract price.

11.0 CHANGED QUANTITY

The owner reserves the right to vary the quantities of items or groups of items to be ordered as specified in the accompanying technical specifications, as may be necessary, during the execution of the contract, but such variations unless otherwise specified in the accompanying technical specifications shall be limited to plus or minus twenty percent (20%) of the original quantity ordered.

12.0 DEDUCTIONS FROM CONTRACT PRICE

All costs, damages or expenses which the owner may have paid, for which under the contract the contractor is liable, will be claimed by the owner. All such claims shall be intimated by the owner to the contractor regularly as and when they fall due. Such claims shall be supported by appropriate and certified vouchers or explanations, to enable the contractor to properly identify such claims. Such claims shall be paid by the contractor within fifteen (15) days of the receipt of the corresponding claims and if not paid by the contractor within the said period, the owner may then deduct the amount, from any moneys due or becoming due by him to the contractor under the contract or may be recovered by actions of law or otherwise, if the contractor fails to satisfy the owner of such claims and to recover the amount from any money due to the contractor on any account or under any other contract including contracts awarded by Coal India Ltd. or other subsidiaries and in the event of any shortfall, the contractor shall be called upon to pay the same on demand.

13.0 PACKING, FORWARDING AND SHIPMENT

13.1 The contractor, wherever applicable, shall after proper painting, pack and crate all equipment in such a manner as to protect them from deterioration and damage during rail and road transportation to the site and storage at the site till the time of erection. The contractor shall be held responsible for all damages due to improper packing.

13.2 The contractor shall notify the owner of the date of each shipment from his works, and the expected date of arrival at the site for the information of the owner.

13.3 The contractor shall also give all shipping information concerning the weight, size and content of each packing including any other information the owner may require.

13.4 The following documents shall be sent by registered post to the owner within 3 days from the date of shipment, to enable the owner to make progressive payments to the contractor: the payment shall be made only after receipt and acceptance of material at site in good condition. Application for payment in the standard format of the owner (3 copies), Invoice (6 copies), Packing list (6 copies), Pre-dispatch clearance certificate, if any (3 copies), Test certificate, wherever applicable (3 copies),

13.5 The contractor shall prepare detailed packing list of all packages and containers, bundles and loose material forming each and every consignment dispatched to site. The contractor shall further be responsible for making all necessary arrangements for loading, unloading and other handling right from his works up to the site and also till the equipment is erected, tested and commissioned. He shall be solely responsible for proper storage and safe custody of all equipment.

14.0 DEMURRAGE, WHARFAGE, ETC.

All demurrage, wharfage and other expenses incurred due to delayed clearance of the material, or any other reason shall be to the account of the contractor.

15.0 LIABILITY FOR ACCIDENTS AND DAMAGES

Under the contract, the contractor shall be responsible for loss or damage to the plant until the plant is taken over in accordance with clause entitled 'Taking Over' in section technical terms and conditions of contract of this volume.

16.0 FORCE MAJEURE

16.1 Force majeure is herein defined as any cause which is beyond the control of the contractor or the owner as the case may be which they could not foresee or with a reasonable amount of diligence could not have foreseen and which substantially affect the performance of the contract, such as: (a) natural phenomena, including but not limited to floods, draughts, earthquakes and epidemics: (b) acts of any government, including but not limited to war, declared or undeclared, priorities, quarantines, embargoes, provided either party shall within fifteen (15) days from the occurrence of such a cause notify the other in writing of such causes.

16.2 (a) The successful Bidder/ Contractor will advise, in the event of his having resort to this clause by a registered letter duly certified by the local chamber of commerce or statutory authorities, the beginning and end of the cause of delay, within fifteen days of the occurrence and cessation of such Force Majeure condition. In the event of delay lasting over two months, if arising out of Force Majeure, the contract may be terminated at the discretion of the company.

(b) For delays arising out of Force Majeure, the successful Bidder/ Contractor will not claim extension in completion date for a period exceeding the period of delay attributable to the causes of Force Majeure and neither company nor the successful Bidder/ Contractor shall be liable to pay extra costs (like increase in rates, remobilisation advance, idle charges for labour and machinery etc.) provided it is mutually established that the Force Majeure conditions did actually exist.

(c) If any of the Force Majeure conditions exists in the place of operation of the bidder even at the time of submission of bid he will categorically specify them in his bid and state whether they have been taken into consideration in their quotations.

16.3 The contractor or the owner shall not be liable for delays in performing his obligations resulting from any force majeure cause as referred to and/or defined above. The date of completion will, subject to hereinafter provided, be extended by a reasonable time even though such cause may occur after contractor's performance of his obligations has been delayed for other causes.

17.0 Extension of date of completion

17.1 On happening of any events causing delay as stated hereinafter, the contractor shall intimate immediately in writing the Engineer-in-charge:

a. due to any reasons defined as Force Majeure.

b. non-availability of stores which are the responsibility of the owner to supply

c. non-availability or breakdown of tools and plant to be made available or made available by the owner

d. delay on the part of the contractors or tradesmen engaged by the owner not forming part of the contract, holding up further progress of the work

e. non-availability of working drawings/work program in time, which are to be made available by the company during progress of the work

f. any other causes which, at the sole discretion of the company is beyond the control of the contractor.

17.2 A "Hindrance Register" shall be maintained by both the Company and the Contractor at site to record the various hindrances, as mentioned above, encountered during the course of execution.

17.3 The contractor may request the company in writing for extension of time within 15 days of happening of such event causing delay stating also, if practicable, the period for which extension is desired. The company may, considering the eligibility of the request, give a fair and reasonable extension of time for completion of the work. Such extension shall be communicated to the contractor in writing by the company through the Engineer-in-charge within 1 month of the date of receipt of such request. The contractor shall however use his best efforts to prevent or make good the delay by putting his endeavors constantly as may be reasonably required of him to the satisfaction of the Engineer-in-charge.

17.4 Interim extension of time may also be granted by the Engineer -In-charge during the course of execution, on written request for extension of time within 15 (fifteen) days of happening of such events as stated above, reserving the company's right to impose/ waive liquidated damages at the time of granting final extension of time as per contract agreement.

17.5 When the period fixed for the completion of the contract is about to expire, the question of extension of the contract may be considered at the instance of the Contractor or the Company or the both. The extension will have to be by party's agreement, expressed or implied.

17.6 In case the Contractor does not apply for grant of extension of time within 15 (fifteen) days of hindrance occurring in execution of the work and the Company wants to continue with the work beyond the stipulated date of completion for reason of the work having been hindered, the Engineer-in-charge at his sole discretion can grant interim extension of time even in the absence of application from the Contractor. Such extension of time granted by the Engineer-in-charge is valid provided the Contractor accepts the same either expressly or implied by his actions before and subsequent to the date of completion. Such extension of time shall be without prejudice to Company's right to levy compensation under the relevant clause of contract.

17.7 All interim extensions of time shall be granted by Tender Accepting Authority limited to Director (Tech) for works approved by Chairman/FDs/Board and Area GM for area works and all final extension of time shall be granted by Tender Accepting Authority limited to Chairman/ CMD of CIL/ Subsidiary. Effort should be made to complete the work within the original contract period or extended period.

18.0 PAYMENT

18.1 The payment to the contractor for the performance of the works under the contract will be made by the owner as per the guidelines and conditions specified herein. All payment made during the contract shall be on account payments only. The final payment will be made on completion of all the works and on fulfillment by the contractor of all his liabilities under the contract. The payment to the contractor will be made through Electronics Mode.

18.2 CURRENCY OF PAYMENT All payments under the contract shall be in Indian Rupees only.

18.3 DUE DATES FOR PAYMENT Owner will make progressive payment as and when the payment is due as per the terms of payment set forth in the accompanying technical specifications. Payment will become due and payable by the owner within thirty 30) days from the date of receipt of contractor's bill/invoice/debit note by the owner, provided the documents submitted are complete in all respects.

18.4 PAYMENT SCHEDULE The contractor shall prepare and submit to the engineer for approval, a break-up of the contract price. This contract price break-up shall be interlinked with the agreed detailed PERT network of the contractor setting forth his starting and completion dates for the various key phases of works prepared as per condition of this section. while preparing the PERT network, the supply of P&M Equipment shall be linked to construction of respective Civil and Structural Works. Any payment under the contract shall be made only after the contractor's price breakup is approved by the engineer. The aggregate sum of the contractor's price break-up shall be equal to the lump sum contract price.

18.5 INTERIM PAYMENTS

18.5.1 The contractor shall submit running bill for the payment in the prescribed proforma of the owner to be supplied in due course at the time of payment.

18.5.2 Each such running bill shall state the amount claimed and shall set forth in detail, in the order of the payment schedule, particulars of the works including the works executed at site and of the equipment shipped/brought on to the site pursuant to the contract up to the date mentioned in the bill and for the period covered since the last preceding certificate, if any.

18.5.3 Every interim payment claim shall indicate the contract value of the works executed up to the date mentioned in the running bill, provided that no sum shall be included in any running bill in respect of the works that, according to the decision of the engineer, does not comply with the contract, or has been performed, at the date of certificate prematurely.

18.6 TERMS OF PAYMENTS

18.6.1 Payment: Any payment to the Contractor before the final payment shall be treated as interim payment towards the total contract value. The Contractor may at intervals of not less than one month submit claims/ bills for payment on account of work done after proper scrutiny and certification of the same by the Employer. The progressive payment shall be made in respect of the following:

a) Supply Contract
b) Works Contract
c) O&M Contract

All such payments shall be made by the Employer online within a month from the date of the submission of claims/bills. Payment will also be governed by Clauses of 4.0 of General Terms & Conditions of Contract. Any sum due from the Contractor shall be deducted from the first or next subsequent on account of payments as the case may be, in general the procedure of payment shall be followed will be as mentioned in Special Conditions of Contract (SCC).

19.0 Settlement of Disputes with the Contractor

It is incumbent upon the contractor to avoid litigation and disputes during course of execution. However, if such disputes take place between the contractor and the department, effort shall be made first to settle the disputes at the company level.

The contractor should make request in writing to the Engineer-in-charge for settlement of such disputes/ claims within 30 (thirty) days of arising of the cause of dispute/ claim failing which no disputes/ claims of the contractor shall be entertained by the company.

Effort shall be made to resolve the dispute in two stages:

In first stage dispute shall be referred to GM(Solar), CIL. If difference still persist the dispute shall be referred to a committee constituted by the owner. The committee shall have one member of the rank of Director of the company who shall be chairman of the committee.

If differences still persist, then matter shall be resolved through conciliation. Conciliation:

The party initiating conciliation shall send a written invitation to the other party to conciliate and proceedings shall commence when the other party accepts the initiations to conciliation. The parties may agree on the name of a sole conciliator or each party may appoint one conciliator. The conciliation shall assist the parties to reach an amicable settlement of their dispute. When the parties sign the settlement agreement, it shall be final and binding on the parties. The conciliator shall authenticate the settlement agreement and furnish a copy thereof to each party.

If differences still persist, the settlement of the dispute shall be resolved in the following manner: Disputes or differences relating to the interpretation and application of the provisions of commercial contract(s) between Central Public Sector Enterprise (CPSEs) / Port Trusts inter se and also between CPSEs and Government Departments/ Organizations (excluding disputes relating to Railways, Income Tax, Customs & Excise Department), shall be taken up by either party for its resolution through Administrative Mechanism for Resolution of CPSEs Disputes (AMRCD) as mentioned in DPE OM No. 05/003/2019-FTS-10937 dated 14th December 2022 and the decision of AMRCD on the said dispute will be binding on both the parties. In case of parties other than above Agencies, the redressal of the dispute may be sought through Arbitration (THE ARBITRATION AND CONCILIATION ACT, 1996 as amended by AMENDMENT ACT of 2015).

20.0 A Settlement of Disputes through Arbitration

(i) Normally, there should not be any scope of dispute between the employer (department) and the contractor after entering into a mutually agreed valid contract. However, due to various unforeseen reasons, disputes may arise during the progress of the contract between the employer (department) and the contractor. Therefore, the conditions governing the contract shall contain suitable provision for settlement of such disputes / differences binding on both the parties.

(ii) Mode of settlement of such disputes/differences shall be through Arbitration. However, when a dispute/difference arises, then, depending on the position of the case, either the employer (department) or the contractor shall give notice to the other party of its intention to commence arbitration. The applicable arbitration procedure will be as per the Arbitration and Conciliation Act, 1996 as amended by Amendment Act of 2015.

(iii) Venue of Arbitration: The venue of arbitration shall be the place from where the contract has been issued.

(iv) Applicable Law: The contracts shall be interpreted in accordance with the laws of the Union of India.

(v) Legal Advice: While processing a case for arbitration, the purchase organization is to take legal advice, at appropriate stages from competent authorities viz their Legal Department.

(vi) Following clause shall be included in the General Conditions of the Contract (GCC): Sole Arbitration Clause: In the event of any question, dispute or difference arising under these terms & conditions or any condition contained in this contract or interpretation of the terms of, or in

connection with this Contract (except as to any matter the decision of which is specially provided for by these conditions), the same shall be referred to the sole arbitration of a person, appointed to be the arbitrator by the Chairman, CIL/ CMD of Subsidiary Company (as the case may be). The award of the arbitrator shall be final and binding on the parties of this Contract.

(a) In the event of the Arbitrator dying, neglecting or refusing to act or resigning or being unable to act for any reason, or his/her award being set aside by the court for any reason, it shall be lawful for the Chairman, CIL / CMD of Subsidiary Company (as the case may be) to appoint another arbitrator in place of the outgoing arbitrator in the manner aforesaid.

(b) It is further a term of this contract that no person other than the person appointed by the Chairman, CIL / CMD of Subsidiary Company (as the case may be) as aforesaid should act as arbitrator and that, if for any reason that is not possible, the matter is not to be referred to Arbitration at all. Subject as aforesaid, Arbitration and Conciliation Act, 1996 as amended by Amendment Act of 2015, and the rules thereunder and any statutory modification thereof for the time being in force shall be deemed to apply to the Arbitration proceedings under this clause. The venue of arbitration shall be the place from which the contract is issued or such other place as the Chairman, CIL / CMD of Subsidiary Company (as the case may be) at his discretion may determine.

(vii) Contracts with Partnership firm/ JV/Consortium: A partner is the implied authority to bind the firm in a contract coming in the purview of the usual business of the firm. The implied authority of a partner, however, does not extend to enter into arbitration agreement on behalf of the firm. Therefore, while entering into a contract with partnership firm /JV/Consortium care should be taken to obtain consent of all the partners to the arbitration agreement. A suitable clause for obtaining consent of all the partners to the arbitration agreement shall be included in the General Conditions of the Contract (GCC).

(viii) In cases where CIL/ Subsidiary has challenged an arbitral award and as a result, the amount of the arbitral award has not been paid, 75% of the arbitral award (which may include interest up to date of the award) shall be paid by CIL/ Subsidiary to the contractor/ concessionaire against a Bank Guarantee (BG). The BG shall only be for the said 75% of the arbitral award as above and not for the interest which may become payable to CIL/ Subsidiary should the subsequent court order require refund of the said amount. The payment may be made into a designated Escrow Account with the stipulation that the proceeds will be used first, for payment of lenders' dues, second, for completion of the project and then for completion of other projects of CIL/ Subsidiary as mutually agreed/ decided. Any balance remaining in the escrow account subsequent to settlement of lenders' dues and completion of projects of CIL/ Subsidiary may be allowed to be used by the contractor/ concessionaire with the prior approval of the lead banker and CIL/ Subsidiary. If otherwise eligible and subject to contractual provisions, retention money and other amounts withheld may also be released against BG. The only circumstances in which such payment need not be made is where the contractor declines, or is unable, to provide the requisite bank guarantee and/or fails to open an escrow account as required. Persons responsible for not adhering to are liable to be held personally accountable

for the additional interest arising, in the event of the final court order going against the procuring entity.

(ix) Arbitration /court awards should be critically reviewed. In cases where there is a decision against CIL/Subsidiary the decision to appeal should not be taken in a routine manner, but only when the case genuinely merits going for the appeal and there are high chances of winning in the court/ higher court. There is a perception that such appeals etc. are sometimes resorted to postpone the problem and defer personal accountability. Casual appealing in arbitration / court cases has resulted in payment of heavy damages / compensation / additional interest cost, thereby causing more harm to the exchequer, in addition to tarnishing the image of the Government.

(x) Legal department of CIL/Subsidiary should monitor the success rate of appealing against arbitration awards. There should be a clear delegation to empower officials to accept arbitration / court orders. A special board / committee may be set up by legal department of CIL/ Subsidiary to review the case before an appeal is filed against an order. Arbitration /court awards should not be routinely appealed without due application of mind on all facts and circumstances including realistic probability of success. The board / committee or other authority deciding on the matter shall clarify that it has considered both legal merits and the practical chances of success and after considering the cost of, and rising through, litigation / appeal / further litigation as the case may be, it is satisfied that such litigation / appeal /further litigation cost is likely to be financially beneficial compared to accepting the arbitration / court award.

SECTION – III: SPECIAL CONDITIONS OF CONTRACT (SCC)

SPECIAL CONDITIONS OF CONTRACT (SCC)

The following Special Conditions of Contract (SCC) shall supplement the General Conditions of Contract (GCC). Wherever there is a conflict, the provisions herein shall prevail over those in the GCC. The corresponding Clause number(s) of the GCC is/ are indicated in parentheses.

SCC No.	GCC Clause Ref. No. (If Applicable)	Details/ Description/ Special Conditions
1.	Definitions	**The Employer/Owner is:** **Coal India Limited,** Coal Bhawan Premise No-04 MAR, Plot No-AF-III, Action Area-1A, Newtown, Rajarhat, Kolkata-700163 Kind Attn.: Telephone Nos.: - Fax No.: - Email: -
2.		**The Engineer-in-Charge**: "**Shall be intimated to the successful bidder"**
3.		**The Time for Commissioning for the cumulative capacity of 300 MW Ground mounted Solar PV Power Plant along with DC Overloading at Khavda Solar Park along with other associated equipment as per this tender document in total shall be 12 (Twelve) Months from the Date of the Notification of Award NOA/LOA/LOI. The commencement of work should be within 30 days from the Date of the Notification of Award NOA/LOA/LOI.**

		Further Contractor is also to provide Operation & Maintenance Contract of Solar Photo Voltaic Plant for a period of 05 (Five) years from the date of Operational Acceptance of the Plant.

Section	Clause	Aspect	Specific Terms
-	-	Location of Site	Add following to the existing clause regarding the Site Visit: 1. The proposed solar powered plants are to set up at Khavda Solar Park. 2. Prospective Bidders are advised to visit the site to study the actual conditions and go through the plans/ drawings connected to the present scope of work including power evacuation system, including conditions, availability of water etc. and get acquainted with the same before attending Pre-bid meeting. 3. The Bidder at the Bidder's own responsibility, cost and risk shall inspect and examine the site and its surrounding, and shall satisfy themselves fully before submitting bids as to the form and nature of the site, the geological conditions decisive for the success of the project, the means of access to the site, the loading and unloading facilities etc. In general, the Bidders shall themselves obtain all necessary information as to risks, contingencies, and other circumstances susceptible to influence or affect their bids. 4. Although certain information is provided in Scope of work of this tender document, it should be checked by the Bidders, any neglect or failure to obtain or confirm such information will not relieve the Bidders from any liability or responsibilities to carry out the works according to the contract. CIL will assist the

			Bidders in obtaining the data required but will not assume responsibility either for the data obtained or for their completeness. 5. Bidders shall acquaint themselves on their own responsibility with laws and regulations in India under which the work is to be performed including those which may influence, in general or in detail, design, supply, transportation, erection, operation of the equipment and requirement of manpower. Any failure or neglect to do so will not absolve the potential Contractor from his contractual obligation. 6. It is specially emphasized that it shall be the responsibility of the Bidders to have themselves familiarized with the prevailing conditions and that no claim relating thereto for additional payment or adjustment of a Contract price will be acceptable after the submission of their Bid. 7. It shall be deemed that the tenderer has visited the site/area and got fully acquainted with the working conditions and other prevalent conditions and fluctuations thereto whether he visits the site/area or not and has taken all the factors into account while quoting his rates. 8. Prospective Bidders are advised to carefully read the Tender documents along with Annexures, understand them in the proper perspective and then fill the Technical Bid Format, Commercial Bid Format and Price Bid Format (SOR). 9. In connection with the site visit, the bidder shall submit an Undertaking along with the bid. 10. Cutting of trees, bushes and vegetation from site (including permission from local authorities) and disposal thereof. The site should be maintained in vegetation free condition during erection stage (at any point of time) i.e., up to start of O&M Contract.

--	--	Completion Schedule	• The time of completion and Commissioning of the Plant is 365 days, i.e. 12 months from the date of issue of LOA from the employer. The O&M Contract Period is for 5 years from the COD of the project. • The Contractor shall inform the Owner at least thirty (30) days advanced written notice of the date on which it intends to synchronize the Project to the grid.
2	6	Liquidated Damages for Delay and Underperformance	**Delay in Commissioning and COD** If the COD of the project is delayed beyond 12 Months from the date of LOA, then unless such failure is due to Force Majeure (as defined in the relevant clauses) or due to CIL's DEFAULTS, ½% (Half percent) of the total contract price per week of delay or part on pro rata Basis of non-commissioned capacity (Total Capacity – commissioned Capacity in multiple of 50 MW) thereof subject to a maximum of 10% of total contract price will be deducted for such delay as LD. **Maximum applicable Liquidated Damages for Delay in Commissioning** : The upper ceiling for total liquidated damages shall be maximum 10% of the total Contract Price. **Underperformance** • For each Contract Year, the Contractor shall demonstrate "Actual Energy Delivered" at the Metering Point as compared to the contracted CUF of the corresponding year: • If for any Contract Year, it is found that the "Actual Energy Delivered" is less than the contracted CUF for the corresponding year, the Contractor shall pay the compensation to the Company is the following manner:

			a) Equivalent to PPA tariff which is INR 2.55 per kWh of under-generation if the actual CUF is within 85% of the contracted CUF of that corresponding year. **b)** Equivalent to 2 times of PPA tariff which calculates to INR 2.55 x 2 per kWh of under-generation quantum below 85% of Contracted CUF of that corresponding year in addition to (a) above applicable upto 85%. ***Example:*** *Contracted CUF of any year = X* *Actual CUF of that year = Y* *Case-1:* *If Y is within X and 0.85X, then applicable LD = 1 time of PPA tariff for the shortfall of energy generation at CUF X - energy generation at CUF Y.* *Case-2:* *If Y is below 0.85X, applicable LD = 2 times of PPA tariff for the shortfall of energy generation equivalent to CUF (0.85 X – Y) + 1 time of PPA tariff for energy generation equivalent to CUF (0.15 X)* • The same shall be recovered from payment yet to be made by the Company to the Contractor and/ or from the Bank Guarantees available with the Company. • This compensation shall not be applicable in events of Force Majeure identified under this Tender affecting supply of solar energy from the Project.

			Maximum applicable Liquidated Damages for underperformance: The upper ceiling for total liquidated damages shall be maximum 10% of the total Contract Price. *The same will be over and above the 10% ceiling of LD applicable for delay in commissioning.*
2	6	Documents for Extension of Time request	The following documents shall form the principal basis for consideration of Extension of Time with or without LD, levy of Liquidated Damages and settlement of extra claims during the execution of contract: 1. The joint recordings in "Hindrance Register" and "Weekly Review Register". 2. Records of Technical Coordination Meetings. 3. Records of Contract Review Meetings, 4. Written notices issued by the "Engineer-in-Charge" or his authorized representative to the Contractor in the relevant period. "
1	1	Contract Performance Security	Unconditional and irrevocable individual Bank Guarantees issued by any Nationalized Banks in the manner as mentioned below. The Contract Performance Security shall be in the form of Bank Guarantee only and shall be in the currency of the Contract and will be issued in the name of the Owner as **"Coal India Ltd**". The Contract Performance Security against this Contract need to be furnished as mentioned below: 1. The value of the Contract Performance Security shall be 5% (Five percent) of the Contract Value (i.e., total sum of the Supply & Service Contract). This Performance security will be valid for a total period of 75 Months (12 Months Project

			commissioning period) + prescribed O & M Period, i.e., 60 Months + 03 Months additional) from the date of its issuance. The successful bidder can submit Contract Performance Security with initial validity of 36 months and the same may be extended after every 36 months till completion of the total 75 months period. 2. The Contract Performance Security shall be towards faithful performance of the contractual obligations and performance of equipment. 3. In case of any default or failure of the Contractor to comply with the requirements of any of the Obligations covered under this Tender Document and/ or Contract Agreement shall constitute sufficient grounds for forfeiture of the entire Contract Performance Security, in such cases, the liability on account of GST will be borne by the contractor. 4. Further, any delay beyond 30 (Thirty) days shall attract delay charges @ 1.25% per month on the total Contract Performance Security amount, calculated on pro-rata basis accordingly. However, total project completion period shall remain same. Part Security shall not be accepted. Further, Owner at its sole discretion may cancel the Contract Agreement/ NOA & forfeit 100% of EMD inclusive of GST, in case Contract Performance Security is not submitted within 45 (Forty-Five) days from issuance of NOA/LOA/LOI. **Contract Performance Security submitted shall be released to the Contractor without any interest not later than 75 (Seventy-Five) days after the successful completion of the complete O&M period (5 Years) subject to the approval and acceptance of the O&M period deliverables.**

2	6	Event of Default	**Contractor's Default:** The occurrence and/or continuation of any of the following events, unless any such event occurs as a result of a Force Majeure Event or a breach by imp of its obligations under this Agreement, shall constitute a Contractor Event of Default: (i) the failure to commence supply of power up to the Contracted Capacity, by the end of the period specified in Section-6 Special Conditions of Contract of this tender, or failure to continue supply of Contracted Capacity after COD throughout the O&M period, or if a) the Contractor assigns, mortgages or charges or purports to assign, mortgage or charge any of its assets or obligations related to the EPC contract for this solar Power Project in contravention of the provisions of this Agreement; or b) the Contractor transfers or novates any of its rights and / or obligations under this agreement, in a manner contrary to the provisions of this Agreement; except where such transfer • is in pursuance of a Law; and does not affect the ability of the transferee to perform, and such transferee has the financial capability to perform, its obligations under this Agreement or

			• is to a transferee who assumes such obligations under this Agreement and the Agreement remains effective with respect to the transferee; (ii) if (a) the contractor becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of thirty (30) days, or (b) any winding up or bankruptcy or insolvency order is passed against the contractor, or (c) the contractor goes into liquidation or dissolution or has a receiver or any similar officer appointed over all or substantially all of its assets or official liquidator is appointed to manage its affairs, pursuant to Law, provided that a dissolution or liquidation of the contractor will not be a contractor Event of Default if such dissolution or liquidation is for the purpose of a merger, consolidation or reorganization and where the resulting company retains creditworthiness similar to the contractor and expressly assumes all obligations of the contractor under this Agreement and is in a position to perform them; or (iii) the contractor repudiates this Agreement and does not rectify such breach within a period of thirty (30) days from a notice from CIL in this regard; or (iv) except where due to any CIL's failure to comply with its material obligations, the contractor is in breach of any of its material obligations pursuant to this Agreement, and such material breach is not rectified by the Contractor within thirty (30) days of receipt of first notice in this regard given by CIL (v) occurrence of any other event which is specified in this Agreement to be a material breach/ default of the contractor.

			(vi) Failure or refusal by the Contractor to perform any of it's material obligations under this contract • **Company's Default:** The occurrence and the continuation of any of the following events, unless any such event occurs as a result of a Force Majeure Event or a breach by the contractor of its obligations under this Agreement, shall constitute the Event of Default on the part of defaulting Company: (i) The Company fails to pay (with respect to a Monthly Bill or a Supplementary Bill), for a period of ninety (90) days after the Due Date and the contractor is unable to recover the amount outstanding to the contractor through the Letter of Credit, (ii) The Company repudiates this Agreement and does not rectify such breach even within a period of sixty (60) days from a notice from the Contractor in this regard; or (iii) except where due to any Contractor's failure to comply with its obligations, The Company is in material breach of any of its obligations pursuant to this Agreement, and such material breach is not rectified by the Company within sixty (60) days of receipt of notice in this regard from the Contractor to Company; or if • The company becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of sixty (60) days, or • any winding up or bankruptcy or insolvency order is passed against the Company, or • The Company goes into liquidation or dissolution or a receiver or any similar officer is appointed over all or substantially all of its assets or official liquidator is appointed to manage its affairs, pursuant to Law, provided that it shall not constitute a Company Event of Default, where such dissolution or liquidation of Buyer or Company is for the purpose of a merger,

			consolidation or reorganization and where the resulting entity has the financial standing to perform its obligations under this Agreement and has creditworthiness similar to Company and expressly assumes all obligations of Company and is in a position to perform them; or; (iv) Occurrence of any other event which is specified in this Agreement to be a material breach or default of the Company.
--	--	Power Evacuation	Power Evacuation shall be through tie transformers at voltage level of corresponding CTU substation, which is identified as per "Metering Point". The project should be designed for delivery of energy at 220 / 400 / 765 KV Sub-station of CTU (KPS 2) at Khavda i.e. at CTU Periphery through 33 / 400 KV internal pooling sub-station of the solar park to be developed by GIPCL (SPPD). The SPPD has secured connectivity and LTA from CTU for Khavda Solar Park. The Successful Bidder shall connect their power project to 220 / 400 / 765 KV Substation through 33/400 KV internal pooling sub-station of the solar park to be developed by SPPD by laying 33 kV cable upto low voltage bus bar of Pooling Sub-station. The entire cost of transmission including cost of construction of line, maintenance, etc. from the project up to the delivery/ interconnection point will be borne by the Successful Bidder. The transmission of power up to the point of interconnection as well as upto delivery point and energy accounting infrastructure shall be the responsibility of the successful bidder at its own cost. All expenses including transmission & wheeling charges and losses (during O&M period) between the Project and the Delivery Point shall be paid by the Successful Bidder without any reimbursement by CIL. The Successful Bidder shall not be entitled to deemed generation in case of any

			delay in grant of connectivity. The Successful Bidder shall comply with the CERC regulations on Forecasting, Scheduling and Deviation Settlement, as applicable. Bidder has to apply for First Time Charging (FTC) approval for its installed capacity as per prescribed procedure by Western Region Load Dispatch Centre (WRLDC)/CEA/CERC. All the necessary compliance at 33 kV level, i.e. Study Reports/Models, additional equipment for reactive power support etc as required by the WRLDC shall be in the scope of bidder. First Time Charging obligation is to be solely fulfilled by bidder and for any non-compliance of bifdder and delay in FTC, CIL will not be responsible. (As per CEA guidelines for RE generators considering 0.95 PF, the Reactive power Requirement for 100 MW plant would be 33 MVAr.). However, as per CEA / WRLDC / MNRE guidelines amended time to time, if Reactive Power compensation is further required at common pooling station of 400 KV level, it shall be provided by Solar Project Park Developer (SPPD) for which bidder shall co-ordinate with SPPD so as to ensure that there is no delay in FTC clearance in case of projects that are ready for commissioning.
--	--	Hindrance Register	• Record of Hindrances / events that lead to slow/ stoppage of smooth execution of work shall be maintained in "Hindrance Register". • The Contractor shall maintain the Register where reasons for delay may be recorded from time to time and at the time of occurrence of the hindrance and get it duly certified by the Engineer-in-Charge of the Company or his authorized representative.

1	32	Handing Over	• After Commissioning of the Project by the Contractor, the Contractor to intimate the same to the Company and subsequently, appropriate authorities from the Company will check the Project as per terms and conditions of the Contract and will give punch points to the Contractor, which shall be attended by the Contractor. Further after commissioning, the Contractor shall submit the following to the Company: I. All as- Built Drawings; II. Detailed Engineering Document with detailed specification, schematic drawing, circuit drawing and test results, manuals for all deliverable items, Operation, Maintenance & Safety Instruction Manual and other information about the project; III. Bill of material; and IV. Inventory of spares at projects Site. V. Copies of all warranties/guarantees. • After Commissioning, the Contractor to perform Operation & Maintenance for a period as mentioned in the Tender document. • Prior to the completion of the O&M period, the Company shall conduct a plant audit by self or the third party as per the Company's discretion, and any defects identified during such audits or inspection shall be rectified by the Contractor at its own cost prior to handing over. • If the Employer is satisfied with the completion of O&M of Solar Photo Voltaic Project as the provisions of the Contract, the Employer shall issue to the Contractor a Taking Over Certificate as a proof of final acceptance of the entire Solar Photo Voltaic Project. Such certificate shall not relieve the Contractor of any of its obligation which otherwise survive, by the terms and conditions of the Contract after issuance of such certificate.

			• Upon successful fulfilment of all the obligation of the Contractor, the Employer shall require the Contractor to furnish a "No Claim Certificate " as per the format enclosed at Appendix XIII. • The final closing of the contract shall be effected after the Defect Liability Period is successfully completed and the Contract Performance Security of the Contractor is returned/ discharged.
-	-	Change in Law	• The term Change in Law shall refer to the occurrence of any of the following events pertaining to this project only after last date of submission of this tender including (i) the enactment of any new law; or (ii) an amendment, modification or repeal of an existing law; or (iii) the requirement to obtain a new consent, permit or license; or (iv) any modification to the prevailing conditions prescribed for obtaining an consent, permit or license, not owing to any default of the contractor; or (v) any change in the rates of any Taxes including any duties and cess or introduction of any new tax made applicable for setting up the solar power project and supply of power from project which have a direct effect on the Project. • However, Change in Law shall not include (i) any change in taxes on corporate income or (ii) any change in any withholding tax on income or dividends distributed to the shareholders of the Contractor. • In the event of occurrence of any of events as provided under Article which results in any increase/ decrease in the Project Cost (i.e. the cost incurred by the Contractor towards supply and services only for the Project concerned, upto the Actual Commissioning Date of the last part capacity or Scheduled Commissioning Date/extended Scheduled Commissioning Date, whichever is earlier), the Contractor/ Company shall be entitled for compensation by the other party, as the case may be.

			• However, in case of change in rates of safeguard duty, GST and basic customs duty after last date of submission of this tender and resulting in change in Project Cost, then such change will be treated as 'Change in Law' and the quantum of compensation payment on account of change in rates of such duties and shall be provided to the affected party by the other party. • It is clarified that, any introduction of new tax/duty/cess made applicable for setting up the solar power project and supply of power from the Solar Power project by the Contractor which have a direct effect on the Project, resulting in change in Project Cost, will also qualify under "Change in Law" as per timeline and procedure indicated herein. • It is further clarified that, applicability of Safeguard Duty on "Solar Cells whether or not assembled in modules or panels" which is till 29.07.2021, if gets extended and has a direct effect on the Project, resulting in change in Project Cost, such extension will also qualify under "Change in Law" as per timeline and procedure indicated herein. **Notification of Change in Law** • In case of any decrease or increase in project cost occurs due to Change in Law and the Contractor wishes to claim a Change in Law under this Article, it shall give notice to the CIL of such Change in Law as soon as reasonably practicable (but no later than 30 days from the date of occurrence of such Change in Law). • Any notice service shall provide, amongst other things, precise details of the Change in Law and its effect on the Project Cost, supported by documentary evidences including Statutory Auditor Certificate to this effect so as to establish one to one correlation and its impact on the Project Cost.

2	10	Progress Report of Work	• The authorized representative of the Contractor shall review the progress of the Project work every fortnight on a prefixed day at project site with the Company or its representative as per the network and record the minutes. • The Contractor shall submit a weekly progress report on execution of works conforming to bar/ PERT Chart and format provided by the Company. The Contractor shall be required to attend all weekly site progress review meetings organized by the 'Engineer-in-Charge' or his authorized representative. The deliberations in the meetings shall inter alia include the weekly program, progress of work (including details of manpower, tools and plants deployed by the contractor vis-a-vis agreed schedule), inputs to be provided by Employer, delays, if any, and recovery program, specific hindrances to work and work instructions by Employer. In case of any slippage(s) or delay in execution of work reasons for such delay along with details of hindrances will be submitted by the Contractor along with modified Bar/ PERT Chart mentioning the action plan being taken to keep the due date of completion of project unchanged. If required, the Contractor shall use additional manpower to keep the due date of completion of Project unchanged. • The minutes of the weekly meetings shall be recorded in triplicate in a numbered register available with the 'Engineer-in-Charge', or his authorized representative. These recordings shall be jointly signed by the Engineer-in-Charge or his authorized representative and the Contractor and one copy of the signed records shall be handed over to the Contractor.
-	-	Inspection and Testing	• The Company or its authorized representative including appointed Consultant for the project shall have, at all times, access to the Contractor's premises and also shall have the power to inspect and examine the materials and workmanship of project work during its manufacture, shop assembly and testing. If part of the plant is required to be manufactured in the premises other than the Contractor's, the

			necessary permission for inspection shall be obtained by the Contractor on behalf of the Company or its duly authorized representative. • The Contractor shall offer following Test / Inspection to the Company: I. The Company may depute its Engineer or representative or hire an agency for Third-Party Inspection, for pre-dispatch inspection at the manufacturing facility of the Contractor all items under this Tender Document as per applicable standards, approved QAP and documents. Samples for testing shall be drawn randomly in presence of the Company/ inspecting agency from the lot offered for inspection. After Test/Inspection of the Items at factory, the Contractor is to submit the inspection & test reports to the Company for review. After review of the inspection & test reports, the Company will give dispatch clearance in writing. The Contractor shall not dispatch any item without dispatch clearance from the Company, in writing. II. The Company may depute its Engineer or representative or third party inspection agency for inspection during manufacture and in assembled condition prior to dispatch in accordance with the standard practice/ QAP of the manufacturer and applicable Standards, at no additional cost to the Company for demonstration and performing the test/inspection. The Contractor shall raise inspection call with internal test reports in advance for all items like PV Modules, MMS, cables, SJBs, Inverters, Transformers, HT & LT switchgears, DC system, Switchyard equipment, earthing system, SCADA, RMU etc. III. Upon delivery of the photovoltaic modules on site, they shall be sampled randomly and tested for performance through an approved testing agency assigned by the Company. The result of such testing agency shall be binding to both the parties and shall be considered final performance measurement report for the guarantee / warrantee conditions of this contract.

			• In case of underperformance or rejection of the photovoltaic modules during above inspection or during operational lifetime of project, the Company shall notify the Contractor of such underperformance or rejection by email or in writing. I. Consecutively, the Contractor shall immediately replace such PV modules by supplying a new PV module of similar specification conforming to the required performance criteria and warranty to the Company within a period of 10 days from the date of intimation by email or written notice. II. Upon receipt of the new PV module, the Contractor shall arrange to collect the rejected/defective photovoltaic module from site. III. The cost of transportation of the PV modules from the supplier to the site of CIL, and return shall be borne by the Contractor. • The Company shall have the right to serve notice in writing to the Contractor on any grounds of objections, which he may have in respect of the work. The Contractor has to satisfy the objection, otherwise, the Company at his liberty may reject all or any component of plant or workmanship connected with such work. • The Contractor shall issue request letter to the Company or his authorized representative for testing of any component of the plant, which is ready for testing at least fifteen (15) days in advance from the date of actual date of testing at the premises of the Contractor or elsewhere. When the inspection and the tests have been satisfactorily completed at the Contractor's works, the Company shall issue a certificate to that effect. However, the Owner at its own discretion may waive the inspection and testing in writing under very special circumstances. In such case, the Contractor may proceed with the tests which shall be deemed to have been made in the Company's presence, and it shall forthwith forward six (6) sets of duly certified copies of test results and certificates to the Company for approval of the Company. The Contractor, on receipt of written acceptance from the Company, may dispatch the equipment for erection and installation.

			• For all tests to be carried out, whether in the premises of the Contractor or any Subcontractor or the supplier, the Contractor, shall provide labor, materials, electricity fuel, water, stores, apparatus and instruments etc. free of charge as may reasonably be demanded to carry out such tests of the plant in accordance with the Contract. The Contractor shall provide all facilities to the Company or its authorized representative to accomplish such testing. • The Company or his authorized representative shall have the right to carry out inward inspection of the items on delivery at the Site and if the items have been found to be not in line with the approved specifications, shall have the liberty to reject the same. • If the Company desires, testing of any component(s) of the plant be carried out by an independent agency, the inspection fee, if any, shall be paid by the Owner. However, the Contractor shall render all necessary help to the Company whenever required free of charge. • The Contractor has to provide the necessary testing reports to the Company as and when required. • Neither the waiving of inspection nor acceptance after inspection by the Company shall, in anyway, absolve the Contractor of the responsibility of supplying the plant and equipment strictly in accordance with specification and drawings etc. • If any item is not found conforming to standards during test / inspection, the same shall be replaced / rectified by Contractor without any cost to the Company and shall be re-offered for inspection. • The work is subject to inspection at all times and at all places by the Company. The Contractor shall carry out all instructions given during inspection and shall ensure that the work is carried out according to the relevant codes of practice

			• Decision of the Company in regard to the quality of work and materials and performance to the specifications and drawings shall be final.
--	--	Authorized Test Centers	• The PV modules, inverters, transformers, panels, wires, etc. deployed in the power plants shall have valid test certificates for their qualification as per IEC/ BIS Standards by one of the reputed labs of the respective equipment (preferably NABL Accredited Test Centres) in India. In case of module or other equipment for which such Test facilities may not exist in India, test certificates from reputed ILAC Member Labs abroad or from test reports as per industry best practices in India will be acceptable.
-	-	Terms of Payment	All payment shall be made against invoices raised in line with the approved billing break up under individual heads of Supply, Works and O&M works. **A. The payment for the Supply Portion - First Contract (Supply Contract) shall be made as per the following terms and conditions:** Mobilization advance (OPTIONAL) can be claimed by the contractor within a time period of 30% of the original Schedule Contract Period along with requisite conditions as per Clause 50 of NIT. 10% of the value of Supply Contract can be claimed as Mobilization Advance payable in 2 instalment as follows: (i) 1st installment: At the time of placing of material order with submission of necessary supporting document. (ii) 2nd Installment: At the time of inspection of material with submission of necessary supporting document.

			The mobilisation advance of 10% shall be proportionately adjusted from the running bills of the contractor during initial 70% payment of "Supply contract". (a) Sixty percent (60%) payments (if mobilization advance is availed)/ Seventy percent (70%) payments (if mobilization advance is not availed)/ shall be paid on Pro rata basis against supply, receipt and acceptance of Materials at site on submission of documents , Contractor's detailed invoice & packing list identifying contents of each shipment, evidence of dispatch (GR/ LR copy), Manufacturer's/ Contractor's Guarantee certificate of Quality, submission of the certificate by the Executing Agency's authorized representative that the item(s) have been received and MDCC (Material Dispatch Clearance Certificate) issued by EMPLOYER's authorized representative in original. * *In case the mobilization advance is availed by the Contractor and no progress/work is executed at site till the commissioning period or if the contract is terminated due to default of contractor as mentioned under the Contract/tender, thereby not adjusting the advance amount timely, the entire advance amount will be recovered from the Contractor along with one-year SBI MCLR rate. Reference of SBI MCLR rate shall correspond to the rate as on 1st April of each year.* (b) Ten percent (10%) price of each item quoted in supply shall be paid after installation of each item on Unit rate basis and certification of the same by the Project Manager.

			(c) Ten percent (10%) price of supply of the Plant and Equipment shall be payable after successful Commissioning of part capacity (**i.e., in block of minimum 50 MW**) and on acceptance/ certification by the Project Manager of such part commissioning. (d) Five percent (5%) price of supply of the plant and Equipment shall be payable on successful completion of Performance Guarantee tests and certification of the same by the Project Manager. (e) Five percent (5%) price of supply of the plant and equipment against shall be payable after Final take over and certification of the same by the Project Manager. ***Additional condition for release of last 2 bills of 5% each totaling to 10% of Supply Contract Value:*** *In case PBG submitted by the bidder has not been enchased for delay LD, then no additional BG is required from the Bidder.* *In case PBG submitted by the bidder has been encahsed for delay LD in part of full, bidder has to furnish the additional BG falling short from the remaining PBG amount*. **B. The payment for the Service Portion - Second Contract (Works Contract) shall be made as per the following terms and conditions.** **80% of the price** of the Civil and Structural works shall be payable on pro-rata basis after completion of installation of equipment of the Solar Power Plant and certification of the same by the Project Manager. **Ten percent (10%)** price of the Civil and Structural works shall be payable after successful Commissioning of part capacity (i.e., in block of minimum 50MW) and on acceptance/certification by the Project Manager of such part commissioning.

			Five percent (5%) price of the Civil and Structural works shall be payable on successful completion of Performance and Guarantee tests as specified and certification of the same by the Project Manager. **The final five percent (5%)** price of the Civil and Structural works shall be payable after Final take over and certification of the same by the Project Manager. ***Additional condition for release of last 2 bills of 5% each totaling to 10% of Works Contract Value:*** *In case PBG submitted by the bidder has not been enchased for delay LD, then no additional BG is required from the Bidder.* *In case PBG submitted by the bidder has been encahsed for delay LD in part of full, bidder has to furnish the additional BG falling short from the remaining PBG amount.* **C. For the Third Contract (Operation & Maintenance Part), the payment shall be made as detailed below: -** (a) Operation and Maintenance of the entire Project payment will be released on quarterly basis at the end of every quarter for each year till 05 (Five) years. The bills will be calculated on pro-rata basis based on the capacity commissioned. In case of any default, Non-Performance or breach of contractual conditions of the O&M contract during the O&M period, the penalties/deductions, if applicable will be liable to be deducted from the Quarterly O&M payments first & then from the Contract Performance Security D. The required ESI/PF Challans/any other mandatory compliance will also be provided by the Contractor during any of the Service (Services + O&M) related payments.

			E. All the payment shall be released from Owner's Head Office upon submission of Original Documents like MDCC, delivery challan, warranty certificate, LR, WCC, MRN, commissioning certificate, handing over certificate, Insurance, PF, ESI, etc. as required and mentioned against each Milestone payment, duly certified by the authorized representative of the EMPLOYER/Owner.
-	-	Payment Procedure	• Subject to any deduction which the Employer may be authorized to make under this Contract, and or to any additions or deductions provided for this Contract, the Contractor shall be entitled to payment as follows: I. All payments shall be made in Indian Rupees (INR), unless otherwise specified in the LOA/Contract Agreement. All payment shall be made on the basis of actual measurement for the quantified items as per schedule of works. II. The Contractor shall submit the Tax Invoice for claim in three copies with relevant GST details and all supporting documents as per the Contract condition to the Employer. After due verification and recommendation, the Employer shall process verified bills for release of payment. Payments shall be released in 30 (Thirty) days by A/c payee cheque / RTGS/ NEFT or any other mode as communicated by the Employer from date of submission of clear invoice. III. The Contractor shall give complete shipping information concerning the weight, size, content of each package including any other information the Employer, may require. a. For offshore supplies by the Contractor, following documents shall be air-mailed to the Employer within (7) days from the date of shipment. The advance copy of these documents shall be sent through e-mail: i. Insurance certificates (6 copies) ii. Bill of lading (5 non-negotiable copies) iii. Invoice (6 copies) iv. Packing list (6 copies)

			v. Test certificate (3 copies) vi. Certificate of Origin (six copies) vii. One copy of the packing list shall also be enclosed in each case. viii. O & M Manuals &/or Catalogues b. For onshore supply, the following documents shall be submitted through registered post to the Employer within 3 days from the date of shipment, the advance copy of these documents shall be sent through e-mail. i. Invoice (4 copies) ii. LR copies iii. Packing list (4 copies) iv. Test Certificate (3 copies) v. One copy of the packing list shall also be enclosed in each case. vi. O & M Manuals &/or Catalogues IV. The Contractor shall submit the Tax Invoice for the work executed showing separately GST and any other statutory levies in the Tax Invoice. V. Any discrepancy and delay, which result in demurrage and other charges for the consignment (for incomplete/incorrect documentation) will be to the account of the Contractor. All the formalities for custom clearance are in the Contractor's scope. VI. All taxes and deductions shall be applicable as per prevailing statutory rules and provisions in force. VII. In case the Contractor fails to submit the invoice with all the required documents to process payments, the Employer reserves the right to hold the payment of the Contractor against such invoices.

-	-	Warranty/ Guarantee	• The Plant shall perform as per the Guaranteed Performance indicated by the Bidder in its Bid. • PV modules used in the project must be warranted by the module Manufacturer/OEM for peak output wattage, which should not be less than 90% at the end of 10 years and 80% at the end of 25 years. • All plant equipment and components and overall workmanship of the grid solar power plants shall be warranted for a minimum of 5 years except solar PV Modules for which product warranty shall be for 5 years and performance warranty shall be for 25 years. • The Contractor shall ensure that the goods supplied under the Contract are new, unused and of most recent or current models and incorporate all recent improvements in design and materials unless provided otherwise in the Contract. • At the end of Contract period, the Contractor's liability shall cease. CIL shall be entitled to the benefit of such warranty given to the Contractor by the original contractor or manufacturer or supplier of such goods. • During the Contract period, the Contractor shall be responsible for any defects in the work due to faulty workmanship or due to use of substandard materials in the work. Any defects in the work during the Contract period shall therefore, be rectified by the Contractor without any extra cost to CIL within a reasonable time as may be considered from the date of receipt of such intimation from CIL failing which CIL shall take up rectification work at the risk and cost of the Contractor.
--	--	Project Management Consultant and	• A Project Management Consultancy (PMC) or Third-Party Inspection agency (TPI) may be appointed by the Company, at its sole discretion, to conduct any kind of inspection regarding procurement, fabrication, installation, hook-up, quality, execution, commissioning, operation and maintenance during the span of the

		Third-Party Inspection Agency	Project. The Contractor shall provide necessary access and coordination to conduct such inspections. The Contractor shall provide all necessary access and cooperation for inspection by any National or State agency.
--	--	Power and Water Supply during Construction	• The Contractor shall arrange for the temporary Power Supply at the site for construction purpose at its own cost. • Cost of water shall be as per prevailing rate and to be borne by the Contractor. Contractor has to arrange water. • Cost of electricity required during construction shall be payable by the Contractor. For construction, temporary connection from Distribution Company shall be arranged by the Contractor as per applicable tariff. • The Company shall not provide facility for storage of material, and accommodation for labors at site. The Contractor shall make his own arrangement for the same.
--	--	Shift Work	• To achieve the required rate of progress in order to complete the Facilities within the Time for Completion, the Contractor may carry on the work round the clock, in multiple shifts per day, as may be necessary. The Contractor shall however be responsible to comply with all applicable laws in this regard. • No additional payment will be made on account of round the clock working in multiple shifts. • Wherever the work is carried out at night adequate lighting of working areas and access routes for pedestrians or vehicles shall be provided by the Contractor at his cost. Sufficient notice should be given by the Contractor to the Employer regarding the details of works in shifts so that necessary supervision should be provided.
--	--	Transportation of Materials by Road	• In case, the Contractor decides to transport the Plant and Equipment and the Contractor's Equipment by road, then such Plant and Equipment and the Contractor's Equipment must necessarily be transported through a registered

<table>
<tr><td></td><td></td><td></td><td>common carrier as per Carriage by Road Rules 2011 of Central Government of India.</td></tr>
<tr><td>--</td><td>--</td><td>Contractor’s obligations</td><td>• Subsequent to successful completion of Guarantee Test, the Contractor shall be responsible for completion of all pending obligations within the stipulated timelines as mentioned hereunder:
<table>
<tr><th>S. No</th><th>Contractor’s Obligation</th><th>Timelines</th></tr>
<tr><td>01</td><td>Any inputs regarding Scope Change</td><td>Within 01 month from the date of successful completion of Guarantee Test</td></tr>
<tr><td>02</td><td>Submission of pending Engineering Documents/Drawings including O&M Manuals.</td><td>Within 01 month from the date of successful completion of Guarantee Test</td></tr>
<tr><td>03</td><td>Contractor’s compliance to all the pending points recorded in writing by the Employer</td><td>Within 01 month from the date of successful completion of Guarantee Test</td></tr>
</table></td></tr>
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					during Performance Guarantee Test.		
				04	Any other obligations of the Contractor set forth in the Contract	Within 01 month from the date of successful completion of Guarantee Test.	
--	--	Incentive for Surplus Generation	• In case of surplus generation from the said solar PV plant after fulfilling the desired demand of CIL, if the surplus energy generated is agreed to be consumed by the respective discoms at a mutually agreed tariff, the selected EPC player will be eligible to receive an incentive for the same. However, the incentives will be provided as per a mutually agreed rate between the selected EPC player and CIL.				
2	1	Definitions	• "Actual Energy Delivered" means the net energy in kilo-watt hour (kWh) from the Project as measured at the Metering Point at Grid/delivery point. • "Applicable Law" means any statute, law, regulation, ordinance, notification, rule, regulation, judgment, order, decree, bye-law, approval, directive, guideline, policy, requirement or other governmental restriction or any similar form of decision of, or determination by, or any interpretation or administration having the force of law in the Republic of India and the State Government, by any Government Authority or instrumentality thereof, whether in effect as of the date of this Contract or thereafter. • "Appropriate Commission" shall mean Electricity Regulatory Commission unless otherwise stated; • "Bid" shall mean the bid submitted by the Bidder in response to this Tender. • "Bidder" shall mean Bidding Company or a Bidding Individual submitting the Bid. Any reference to the Bidder includes Bidding Company / Bidding Individual				

			including its successors, executors and permitted assigns severally, as the context may require; • "Capacity Utilization Factor (CUF)" shall have the same meaning as provided in CERC (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2009 as amended from time to time; However, for avoidance of any doubt, it is clarified that the CUF shall be calculated on the Contracted Capacity as per following formula: In any Contract Year, if 'X' MWh of energy has been metered out at the Delivery Point for 'Y' MW Project capacity, CUF= (X MWh/(Y MW*8766)) X100%; "CERC" means Central Electricity Regulatory Commission. • "Change in Law" shall have the meaning ascribed thereto in this Tender document. • "Chartered Accountant" shall mean a person practicing in India or a firm whereof all the partners practicing in India as a Chartered Accountant(s) within the meaning of the Chartered Accountants Act, 1949. • "Commercial Operation Date (COD)" shall be the date on which the commissioning certificate is issued by GEDA upon successful commissioning of the full capacity of the Project including the DC to AC ratio as quoted by the bidder. • "Commissioning": The Solar Power Project will be considered as commissioned if all equipment as per rated project capacity has been installed and energy has gone into the grid and witnessing of such generation of electricity by representatives authorized by DISCOM/ GETCO/ CTU. • "Completion" means that the Facilities (or a specific part thereof where specific parts are specified in the Scope of Work) have been completed operationally and structurally and put in a tight and clean condition and that all work in respect of

			Commissioning of the Facilities or such specific part thereof has been completed as per the Scope of Work. • "Completion Certificate" shall mean the certificate to be issued by the owner or his representative when the works have been completed to his satisfaction. • "Contract" or "Contract Agreement" means the Contract signed between the Company (CIL) and the Contractor to execute the entire Scope of Work as given in this RFP document. • "Contracted Capacity" shall mean 300 MW AC power contracted with GUVNL for supply by CIL at the Delivery Point from the Solar Power Project. It is to clarify that in any 15 minute time block during the entire term of PPA, the injected power shall not exceed the Contracted AC Capacity. Provided that in case the supply of power at delivery point exceeds the contracted capacity in any time block, such excess energy shall be considered as inadvertent energy and no payment shall be made for such excess energy. • "Contracted CUF" shall mean the % capacity utilization factor of the project measured at the Delivery Point as specified in the Contract. • "Contractor" means the person(s) whose bid to perform the Contract has been accepted by the Company and is named as such the Contract Agreement, and includes the legal successors or permitted assigns of the Contractor. • "Contractor's Equipment" means all plant, facilities, equipment, machinery, tools, apparatus, appliances or things of every kind required in or for installation, completion and maintenance of Facilities that are to be provided by the Contractor, but does not include Plant and Equipment, or other things intended to form or forming part of the Facilities. • "Day" means calendar day of the Gregorian/English calendar.

			• "Delivery Point"/" Inter-connection Point" shall be the point or points of inter-connection of project with CTU Grid i.e. CTU Periphery at which Electricity shall be delivered. • All expenses, including transmission / wheeling charges and losses upto Delivery Point including on account of any Change in Law event, shall be paid by the Successful Bidder without any reimbursement by GUVNL. All expenses including wheeling charges and losses in relation to the transmission and distribution beyond the Delivery Point shall be borne by GUVNL • "Defect Liability Period" means the period of validity of the warranties given by the Contractor, during which the Contractor is responsible for defects with respect to the Facilities (or the relevant part thereof) as provided in Defect Liability clause hereof. Defect Liability Period shall be for a duration upto the end of the O&M period or as for any duration extended by the mutual agreement of both the parties. • "Effective Date" for this Contract shall mean the date of commencement of work • "Facilities" means the Plant and Equipment to be supplied and installed, as well as all the Installation Services to be carried out by the Contractor under the Contract for enabling the installation, construction, testing and commissioning of the Solar Power System(s). • "Government Authority" means Government of India, any state government or any governmental department, commission, board, body, bureau, agency, authority, undertaking, court or other judicial or administrative body or any sub-division or instrumentality thereof, central, state, or local, having jurisdiction over the Contractor, the Facility, or the performance of all or any of the services, obligations or covenants of Contractor under or pursuant to this Contract or any portion thereof.

			• "Guarantee Test(s)" means the Performance Guarantee test(s) specified in the Technical Specifications to be carried out to ascertain whether the Facilities or a specified part thereof is able to attain the Functional Guarantees. • "Installation Services" means all those services ancillary to the supply of the Plant and Equipment for the Facilities, to be provided by the Contractor under the Contract; e.g., transportation and provision of marine or other similar insurance, inspection, expediting, Site preparation works (including the provision and use of Contractor's Equipment and the supply of all civil, structural and construction materials required), installation, Commissioning, carrying out guarantee tests, operations, maintenance, the provision of operations and maintenance manuals, training of Company's personnel etc. • "Interconnection Facilities" shall mean the facilities from the Project up to the grid connection point for scheduling, transmitting and metering the electrical output in accordance with the Long Term Open Access and which shall include, without limitation, all other transmission lines and associated equipment, transformers, relay and switching equipment and protective devices, safety equipment and RTU, Data Transfer and Acquisition facilities for transmitting data, the Metering System required for supply of power as per the terms of the Terms and conditions of the LTOA . • "Metering Point" shall mean the point at 400KV side of 400/765 KV Khavda PS-II (KPS II) Pooling Sub-Station of CTU. However, one more metering system is to be installed at 33 KV side of 400/33 KV Internal Pooling Sub-station where power from the Solar Power Project is injected for measuring export / import from each project. Energy recorded in the meter placed at CTU Substation shall be apportioned to each project in the proportion of energy recorded in the meters

			placed at Pooling Substation. All line losses upto the metering point (400 KV) will be to the account of the Solar Power Developers. • "MNRE" means Ministry of New and Renewable Energy, Government of India. • "Month" means shall mean a period of thirty (30) days from (and excluding) the date of the event, where applicable, else a calendar month of the Gregorian/English calendar. • "O&M" means Operations and Maintenance. • "Project" or "Solar Power Project" or "Solar Project" is defined as the 300 MW(AC) Grid-Connected Solar Photovoltaic Power Plant proposed to be located in the State of Gujarat, and having a separate control system, metering and a single or multiple point(s) of injection into the grid at Delivery/Metering point at CTU substation or in case of sharing of transmission lines, by separate injection at pooling point. This includes all units and auxiliaries such as water supply, treatment or storage facilities; bay/s for transmission system in the switchyard, dedicated transmission line up to the Delivery Point and all the other assets, buildings/structures, equipment, plant and machinery, facilities and related assets required for the efficient and economic operation of the power generation facility; whether completed or at any stage of development and construction or intended to be developed and constructed for the purpose of supply of power as per this Agreement;. • "Plant Capacity" or "Project Capacity" shall mean the Contracted Capacity of the Project measured at the Delivery Point. • "Prudent Utility Practices" shall mean those practices, methods, techniques and standards, that are generally accepted for use in electric utility industries taking into account conditions in India, and commonly used in prudent electric utility engineering and operations to design, engineer, construct, test, operate and maintain

			equipment lawfully, safely, efficiently and economically as applicable to power stations of the size, service and type of the Project, and that generally conform to the manufacturers' operation and maintenance guidelines. • "RFP document" or "Tender document" or "Tender" shall mean this bidding document issued by the Company including all attachments. • "Site" means the land and other places upon which the Facilities are to be installed, and such other land or places as may be specified in the Contract as forming part of the Site. • "Solar Power System(s)" means the solar photovoltaic grid interactive power system(s) to be established at the site specified in the Tender Document. • "Subcontractor", including vendors, means any person to whom execution of any part of the Facilities, including preparation of any design or supply of any Plant and Equipment, is sub-contracted directly or indirectly by the Contractor, and includes its legal successors or permitted assigns. • "Successful Bidder" means the bidder who has been awarded the Contract and described as Contractor for the "Project". • "Time for Completion" shall be the date on or before which Commissioning of the Facility has to be achieved to the satisfaction of the Company and such date is specified in NIT. • "Year" means a period of 12 full consecutive months or 365 consecutive days. • "Goods and Services Tax" or "GST" means taxes or cess levied under the Central Goods and Services Tax Act, Integrated Goods and Services Tax Act, Goods and Services Tax (Compensation to States) Act and various State/Union Territory Goods and Services Tax Laws and amendments thereof and applicable cesses, if

			any under the laws in force (hereinafter referred to as relevant GST Laws), which shall be fully complied with by Bidders.

SECTION – IV: SAFETY CODE

1.0 GENERAL PROVISIONS:

1.1 **Housekeeping:**

a) The contractor shall be primarily responsible for maintaining Good housekeeping and safety standards in the workplace;

b) Loose materials that are not required for use shall not be placed or left behind so dangerously as to obstruct workplaces or passageways;

c) All projecting nails shall be removed or bent to prevent injury;

d) Equipment, tools and small objects shall not be left lying unattended or unsecured from where they could fall or cause a person to trip;

e) Scrap, waste or rubbish shall not be allowed to accumulate in the site as these combustibles can create serious fire hazards and affect safe working;

f) Workplaces and passageways that become slippery owing to spillage of oil or other causes shall be cleaned up or strewn with sand, ash or the like;

g) Portable equipment shall be returned after use to their designated storage place.

1.2 **Means of access and egress**

shall consist of

a) Adequate and safe means of access and egress shall be provided in all workplaces;

b) The means of access and egress shall be maintained in a safe condition;

1.3 **Lighting and ventilation**

a) All practical measures shall be taken to prevent smoke, fumes etc. from obscuring any workplace or equipment at which any worker is engaged;

b) Adequate and suitable artificial lighting shall be provided where natural lighting is not sufficient as per IS 3646 (Part II). The artificial lighting so provided shall not cause any incidental any danger, including that of producing glare or disturbing shadows;

c) To prevent danger to health from air contamination by dust generated during grinding, cleaning, spraying or manipulation of materials as also to provide protection against dangerous gases, fumes, vapours, mist, etc. effective arrangements shall be made for ventilation;

d) Workers shall be provided with suitable respiratory protective equipment, if it is not technically possible to have uncontaminated air. To this end, a study by a competent person shall be made to decide on the due protection. Sufficient illumination at all times for maintaining safe working conditions shall be provided where building workers are required to work or pass, and for passageways, stairways and landings such illuminations shall not be less a than 0.5 foot candles at the floor level;

e) Where natural lighting is not adequate to prevent danger, adequate and suitable lighting shall be provided as per IS: 3646 – Part II;

f) Artificial lighting shall not cause any danger due to a brightness greater than 10 foot candles per square inch, except where the angle of inclination from the eye to the source or the part pf the fitting as

the case may be exceeds 200, including that of producing glare or disturbing shadows;

g) Where necessary to prevent danger to health from air contamination by dust from the grinding, cleaning, spraying, or manipulating of materials or objects, arrangements shall be made to limit the concentration of the pollutants by thorough ventilation, and dust generated due to movement of earthmoving machinery and other construction equipment, by spray of water in the area from time to time;

h) Adequate ventilation by the circulation of fresh air shall be maintained in such places where the concentration of pollutants is likely to affect the health of the workers;

i) Special care shall be taken to ventilate the workplace where gas cutting, welding or other operations involving generation of dangerous fumes, vapours, mists, gases etc is likely;

j) Where it is technically not possible to eliminate dust or noxious or harmful fumes or gases sufficiently to prevent injury to the health of the workers, the contractor shall provide suitable respiratory equipment like dust mask or gas/fume mask or breathing apparatus or other suitable respiratory equipment.

1.4 **Dangerous and harmful environment:**

a) When an internal combustion engine exhausts into confined space or excavation or tunnel or any other workplace where neither natural ventilation nor artificial ventilation system is adequate to keep the carbon monoxide content of the atmosphere below fifty parts per million, adequate and suitable measures shall be taken at such workplace in order to avoid exposure of building workers to health hazards;

b) No building worker shall be allowed to enter any confined space or tank or trench or excavation wherein there is given off any dust fumes or other impurities of such nature and to such extent as is likely to be injurious or offensive to the building worker or in which explosives, poisonous, noxious or gaseous material or other harmful articles have been carried or stored or in which dry ice has been used as a refrigerant, or which has been fumigated or in which there is a possibility of oxygen deficiency, unless all practical steps have been taken to remove such dust, fumes or other impurities and dangers

which may be present and to prevent any further ingress thereof, from such workplace or tank or trench or excavation;

c) No worker shall be allowed to enter any such space unless a responsible person has certified it safe and fit for the entry of such building workers.

1.5 **Fumes/gases due to Welding and gas-cutting operations:**

When welding or cutting operations are carried out in a confined space:

a) Adequate ventilation, by means of exhaust fans or forced draught, as the condition may require, shall be constantly provided; otherwise enough quantity of air shall be circulated by means of air compressors to dilute the contaminant within permissible limits;

b) Workers shall take necessary precautions to prevent unburned combustible gas or oxygen from escaping inside a tank or vessel or other confined space;

c) Welding or cutting operations on any container that has held explosives or where inflammable gases may have been generated, shall be undertaken after the container has been thoroughly cleaned by steam or other effective means; and

d) Gas-test shall be carried out ensure that the confined space is completely free from combustible gases and vapours.

e) Dust, gases, fumes

f) Concentration of dust, gases or fumes shall be prevented by providing suitable means to control their concentration within the permissible

limit so that they may not cause injury or create health hazard to a building worker;

g) For protection against such hazardous substances, besides efficient and effective means of control, personal protective equipment like dust masks, breathing apparatus, other respiratory appliances, goggles, as the case may be, shall be provided.

1.6 **Excessive noise:**

a) Adequate measures shall be taken against the harmful effects of an excessive noise;

b) Use of earplugs/muffs and anti-vibration gloves shall be ensured to protect the workers from the impact of exposure to such dangers;

c) The noise level in no case shall exceed as prescribed in the concerned Rules and exposure in excess of 115 dBA over the period of a quarter of an hour cannot be permitted.

1.7 **Corrosive substances:**

a) All corrosive substances, including alkalis and acids, shall be stored and used by a person dealing with such substances at a building or other construction work in such a manner that it does not endanger the building worker and suitable protective equipment shall be provided by the employer to a building worker during handling or use of such substances at a building or other construction work and in case of spillage of such substances on the building worker, immediate remedial measures shall be taken;

b) While protection of the body could be ensured by use of corrosion resistant apparel/overalls, suitable goggles, gloves, apron, gum boots etc. shall be made available to all concerned personnel;

c) To deal with an accidental spillage of a corrosive substance on the body of a worker, the facility of eyewash fountain or water shower, as the case may be, shall be installed, within the easy reach of the workplace.

d) Eye protection:

e) Suitable personal protective equipment for the protection of eyes shall be provided and used by the building worker engaged in operations like welding, cutting, chipping, grinding or similar operations which may cause hazard to his eyes;

f) Goggles or face shield or welding screen with suitable shade of glass/filters etc shall be provided for the protection of the eyes.

1.8 **Overhead protection:**

g) It shall be ensured that at the building or other construction site, overhead protection is erected along the periphery of every building under construction that shall be of fifteen meters or more in height when completed;

h) Overhead protection shall not be less than two meters wide and shall be erected at a height not more than five meters above the base of the building and the outer edge of such overhead protection shall be one hundred fifty millimeters higher than the inner edge thereof or shall be erected at an angle of not more than twenty degrees to its horizontal sloping into the building;

i) It shall be also ensured that at the building and other construction work that any area exposed to risk of falling material, articles or objects is roped or cordoned off or otherwise suitably guarded from inadvertent entry of persons other than building workers at work in such area.

1.9 **Lifting and carrying of excessive weight:**

a) No building worker lifts by hand or carries overhead or over his back or shoulders any materials, articles, tools or appliances exceeding in weight the maximum limits as set out in the following table unless aided by any other building worker or a mechanical device;

b) No worker aided by other workers, lift by hand or carry overhead or over their back or shoulders any materials, articles, tools or other appliances exceeding in weight the sum total of the maximum limits as prescribed in the concerned Rules, unless aided by a mechanical devices.

1.10 **Protections against fall of persons –**

a) All scaffolds/working platforms at height of two metres or more shall be fenced;

b) All guard-rails for the fencing of floor openings, gangways, elevated workplaces shall be made of sound material, good construction and possess adequate strength and be between 1 m and 1.5 m above platform level, consist of two rails (two ropes or chains may be used if they are sufficiently taut) and supporting stanchions;

c) Intermediate rails, ropes or chains shall be midway between the top and lower of edges of the top rail;

d) Sufficient number of stanchions or standard poles or uprights shall be maintained to ensure the required stability and resistance;

e) Guard-rails shall be free from sharp edges and be maintained in good repair;

f) Floor openings through which persons could fall, shall be guarded by covering or fencing;

g) If the means of protection is removed to allow the passage of persons or goods or other purpose, the same shall be replaced as soon as possible, while making temporary arrangements for reasonable degree of safety in the meanwhile;

h) Covers for floor opening shall be safe to walk on and if vehicles operate thereon it shall be safe for the same. This will require the contractor to have prior assessment of expected loads;

i) Cover for floor opening shall be secured by hinges, grooves, stops or other effective means against sliding, falling down or lifting out or any other inadvertent displacement;

j) Covers for any openings shall not constitute any hindrance to traffic and, as far as practicable, be flush with the floor;

k) If covers constitute as grids, the bars shall be spread not more than 5 cm apart;

l) Elevated workplaces at more than 2 m above the floor or ground shall be protected on all open sides by guardrails. It is commonly observed that fragile barricade tapes are used as a substitute of a strong and dependable fencing. This practice is prohibited. The barricade tapes can be used as markers/route guide only;

m) Elevated workplaces shall be provided with safe means of access and egress such as stairs, ramps or ladders according to suitability;

n) Persons employed at elevated workplaces or other situations at more than 2m from which they may fall, shall be protected by means of adequate safety nets, or platforms, or be secured by safety belts with the lanyard properly anchored above the head level of the user. All possible effort shall be made to have strong and dependable mechanical arrangement.

1.11 **Protection against fall of objects and materials:**

a) Materials and objects such as scaffolding materials, waste materials or tools shall not be thrown up or down from heights, as they are liable to cause injury;

b) If materials and other objects cannot be safely lowered from heights, adequate precautions such as the provision of fencing, lookout men or barriers shall be provided to protect any person from injury.

1.12 **Protection against entry of unauthorized persons:**

a) Construction zones in the site and built up areas alongside main traffic routes shall be barricaded;

b) Unauthorized persons shall not be allowed access to construction sites and visitors shall be provided with the required protective equipment and it be ensured that they use them effectively.

1.13 **Head protection and other protection apparel:**

Every building worker who is required to –

a) Pass through or working within the areas where there is hazard of his being struck by falling objects or materials, shall be provided with safety helmets of the type approved and tested in accordance with the national standards;

b) Work in water or in wet concrete or in other similar work, shall be provided with suitable waterproof;

c) Work in rain or in similar wet condition, shall be provided with waterproof coat with hat;

d) Workers using or handling of alkalis, acid or other similar corrosive substances shall be provided with appropriate protective equipment in accordance with the approved standards;

e) Every building worker engaged in handling sharp objects or materials at a building or other constriction work, which may cause hand injury, shall be provided with suitable hand gloves in accordance with the approved standards.

1.14 **Stability of structures:**

a) No wall, chimney or other structure or part of a structure shall be left unsupported in such condition that it may fall, collapse or weaken due to wind pressure, vibration or due to any other reason. Entry of persons into such locations where tall structures are being built shall be regulated without a let up.

1.15 **Safety of Structures and equipment and other safety concerns**

a) Safety of structures like scaffoldings, platforms, gangways/walkways, towers, stairs, ladders, ramps, safety in excavation, formwork, falsework, demolition work, storage, handling and use of explosives,

inflammable substances and hazardous materials, gas cutting and welding, use of electricity etc.; and equipment viz. construction machinery, crushers and batching plant, boiler and other pressure vessels, transport and material handling equipment, lifting appliances, vehicles etc., shall be operated and maintained as per approved norms and –

b) They shall be made of sound material and of good construction, free from patent defects, provided with adequate safe guards, properly maintained, periodically inspected and strong enough to withstand safely the loads and stresses to which they may be subjected;

c) They shall carry enough factor of safety bearing in mind that the possibility of their abuse, which otherwise shall be prevented by constant and adequate supervision, cannot be ruled out altogether;

d) It is incumbent on the contractor to ensure that only competent and authorized persons operate the equipment or attend to electrical and mechanical systems and repair of faults or breakdowns etc.

e) Working in the confined space may involve certain serious hazards. Strict adherence to the conditions of Permit-to-work issued for the purpose is required;

f) Control of energy sources shall be ensured through Log-out/Tag-out practices.

1.16 **Slipping, tripping, cutting, drowning and falling hazards:**

a) The contractor shall keep all passageways, platforms and other places free from accumulations of dust, debris or similar material and from other obstructions that may cause tripping;

b) Any sharp projections or protruding nails or similar projections which may cause any cutting hazard to a building workers shall be removed or otherwise made safe by taking suitable measures;

c) No contractor shall allow any building worker at construction work to use the passageway, or a scaffold, platform or any other elevated working surface which is in slippery and dangerous condition and shall ensure that water, grease, oil or other similar substances which may cause the surface slippery, be removed or sanded/saw-dusted or covered with suitable material to make it safe from slipping hazard;

d) Wherever building workers are exposed to the hazarded of falling into water, they shall be provided with rescuing arrangement from such hazard and if it is considered necessary, well equipped boat or launch manned with trained personnel shall be provided by the contractor at the site of such work;

e) Every open side or opening into or through which a building worker, vehicle or lifting appliance or other equipments may fall at a building or other construction work shall be covered or guarded suitably to prevent such fall except where free access is necessary by reasons of their nature of the work;

f) Wherever building workers are exposed to the hazards of falling from height while employed on such work they shall be provided by the employer with adequate equipment or means for saving them from such hazards, Such equipments or means shall be in accordance with the standards as laid down;

g) Whenever there is a possibility of falling of any martial, equipment or building worker at a construction site relating to a building or other

construction work, adequate and suitable safety net shall be provided in accordance with the above stipulation;

2.0 SAFETY IN MATERIAL HANDLING AND WASTE DISPOSAL

2.1 **GENERAL PROVISIONS:**

a) All building materials stored in tiers shall be stacked, racked, blocked, interlocked or otherwise secured safely to prevent sliding, falling or collapse and in an orderly manner to avoid obstruction of any passageway at the place of work. Piles of materials shall be stored or stacked in such a manner as to ensure their stability;

b) Maximum safe load limits of floors within buildings and structures in kg/cm2 shall be conspicuously posted in all storage areas, except for floor or slab on gradient. Maximum safe load shall not be exceeded. Material or equipment shall not be stored upon any floor or platform in such quantity as to exceed its safe carrying capacity;

c) Ailes and passageways shall be kept clear to provide for the free and safe movement of material handling equipment or persons. Such areas shall be kept in good repair;

d) When a difference in road or working levels exist, means such as ramps, blocking or grading shall be used to ensure the safe movement of vehicles between two levels;

e) Material stored inside buildings under construction shall not be placed within 2 m of any hoist way or inside floor openings nor within 3.2 m of exterior wall which does not extend above the top of material stored;

f) Persons employed required to work on stored material in silos, hoppers and similar storage areas shall be equipped with lifelines and safety belts;

g) Non-compatible materials shall be segregated in storage;

h) Bagged materials shall be stacked by stepping back the layers and cross-keeping the bags at least every 10 bags high;

i) Materials shall not be stored on scaffolds or runways in excess of supplies needed for immediate operations;

j) Bricks stacks shall not be more than 2.2 m in height. When a loose brick stack reaches a height of

k) 1.3 m it shall be tampered back 5 cm in every foot of height above the 1.25 m level;

l) When masonry blocks are stacked higher than 2 m, the stack shall be tapered back on half block per tier above the 2 m level;

m) Material or equipment shall not be stored or placed so close to any edge of a floor or platform as to endanger the safety of persons below or working in the vicinity. Where stacking, unshackling, stowing or unstaring of construction material or article, or handling in connection therewith cannot be safely carried out unaided, reasonable measures to guard against accident or dangerous occurrences shall be taken by shoring or otherwise to prevent any danger likely to be caused by such handling;

n) Stacking of material or article shall be made on firm foundation not liable to settle and such material or article and shall not overload the floor on which such stacking is made;

o) The material or articles shall not be stacked against partition or walls o f a warehouse or stores unless it is known that such partition or the

wall is of sufficient strength to withstand the pressure of such materials or articles;

p) The materials or articles shall not be stacked to such a height and in such a manner as would render the pile of such stack unstable and cause hazards to the building workers or the public in general;

q) Where the building workers are on stack exceeding one point five meters in height, safe means of access to the stack shall be provided;

r) All stacking or unshackling operations shall be performed under the supervision of a responsible person for such stacking or unstacking;

s) The stacking of construction materials or articles shall not be made near the site of excavation, shaft, pit or any other such opening;

t) Stacks that may lean heavily or become unstable or collapse are barricaded shall be avoided;

u) Structural steel, poles, pipe, bar stock and other cylindrical materials, unless racked, shall be stacked and blocked so as to prevent sliding, spreading or tilting.

2.2 **LUMBER:**

a) Used lumber shall have all nails withdrawn before stacking;

b) Lumber shall be stacked on level and solidly supported sills;

c) Lumber piles shall not exceed 6 m in height provided that lumber is handled manually, shall not be stacked more than 5 m height;

d) Lumber shall be so stacked as to be stable and self-supporting.

2.3 STACKING OF CEMENT AND BAGS CONTAINING OTHER MATERIALS:

a) The cement or other material in bags shall be stacked in a header and stature-wise in rows alternately in not more than 10 numbers and there will be circulation of space of at least 600 mm in between two such rows;

b) While removing bags from the stack pile the stability of such stack pile shall be ensured;

c) Bags containing cement or lime shall be stored on a firm ground;

d) The materials like bricks, tiles or blocks shall also be stored on a firm ground;

e) Reinforcing steel shall be stored according to its shape, size and length and stack of reinforcing steel kept as low as possible;

f) No pipe shall be stored on rack or in stack where such pipe is likely to fall by rolling;

g) The angle of repose shall be maintained where loose materials are stacked;

h) When dust laden material is to be stored or handled, measures shall be taken to suppress the dust produced by such storing or handling and suitable personal protective equipment supplied to and used by the building workers working for such storing or handling.

2.4 DISPOSAL OF DEBRIS AND WASTE MATERIAL:

a) It shall be ensured that debris is

b) Handled and disposed of by a method, which does not cause danger to the safety of a person and not allowed to accumulate so as to constitute a hazard;

c) Kept sufficiently moist to bring down the dust under control;

d) Not thrown inside or outside from any height of such building or other construction work;

e) Brought down by suitable means/chutes provided for the purpose and on completion of work, leftover building material, article or other substance or debris shall be disposed off as soon as possible to avoid any hazard to any traffic or person;

f) Whenever materials are dropped more than 6 m to any point lying outside the exterior walls of the building an enclosed chute of wood, or equivalent material shall be used;

g) When debris is dropped through holes in the floor without the use of chutes, the area where the material is dropped shall be completely enclosed with barricades not less than 1.1 m high and not less than 1.9 m back from the edge of the opening above. Signs warning of the hazard of falling material shall be posted at each level;

h) All scrap lumber, waste material and rubbish shall be removed from the immediate work area as the work progresses;

i) Disposal of waste material or debris as per the guideline issued by CPCB in compliance of Rule 10 sub-rule 1(a) of C & D Waste Management Rules, 2016).

j) All bio-degradable material shall be disposed off in the pit for making compost. Pellets can also be made from bio-degradable material

k) All solvent wastes, oil rags and flammable liquids shall be kept in fire resistant covered containers until removed from the work site.

2.5 HANDLING GAS CYLINDERS:

a) Gas cylinders shall not be lifted on bare slings. For lifting the cylinders, cage of suitable size shall be used and all cylinders shall be horizontally positioned in it. Such cage shall have fencing in such a way that there is no possibility of fall of cylinders from this cage.

2.6 RIGGING EQUIPMENT FOR MATERIAL HANDLING:

a) Rigging equipment for material handling shall be inspected prior to use in each shift as necessary during its use to ensure that it is safe. Defective rigging equipment shall be removed from service;

b) Rigging equipment shall not be loaded in excess of its recommended safe working load, as prescribed in the Indian standards;

c) Rigging equipment, when not in use, shall be removed from the immediate work area so as not to present a hazard to persons engaged in the area;

d) Special custom designed grabs, hooks, clamps, or other lifting accessories, for such units as modular panels, prefabricated structures and similar materials, shall be marked to indicate the safe working loads shall be proof tested prior to use 125% of their rated load;

e) Welded alloy steel chain slings shall have permanently affixed-durable identification standing size, grade, rated capacity and manufacturer.

2.7 FENCING OF MOTORS ETC

a) All motors, cogwheels, chains and friction gearings, flywheels, shafting and the other dangerous and moving parts of machinery (whether or not driven by mechanical power) and steam pipes shall be securely fenced and the fencing of dangerous parts of machinery not removed while such machinery is in motion or in use;

b) No part of any machinery which is in motion and which is not securely fenced, shall be examined, lubricated, adjusted or repaired except by a person skilled and trained for such examination, lubrication, adjustment or repairs and machine parts cleaned only when such machine is stopped;

c) When a machine is stopped for servicing or repairs, adequate measures shall be taken to ensure that such machine does not restart inadvertently and not only tag-out sign is required; it is also essential that an active system of isolating the power be applied.

2.8 PROTECTION AGAINST LIGHTNING

a) Where necessary, installations shall be protected against lightning, provided further that;

b) No bare conductors or bare current-carrying parts of equipment be permitted to be installed unless adequate precautions are taken to prevent direct pr indirect contact;

c) Only flame-proof equipment and conductors shall be installed at places where explosives or inflammable substances are stored, handled or used or where explosive atmosphere exits;

d) Persons competent and authorized only shall attend to electrical breakdowns and other operational faults and give or restore power to

an equipment and such persons shall be easily identifiable by their dress or special helmet worn;

e) It will constitute a standard practice to switch off portable tools while shifting from one place to another or while leaving them behind unattended;

f) The contractor shall ensure that a system is in place to always keep tools well maintained.

2.9 VEHICULAR TRAFFIC

a) Whenever any building or other construction work is being carried on, or is located in close proximity to a road or any other place where any vehicular traffic may cause danger to building workers, it shall be ensured that such building or other construction work is barricaded and suitable warning signs and lights displayed or erected to prevent such danger and if necessary, a request in writing made to the concerned authorities to control such traffic;

b) All vehicles used at construction site shall comply with the requirements of the Motor Vehicles Act, 1988 (59 of 1988) and the Rules made hereunder;

c) The driver of a vehicle of any class or description operating at a construction site shall hold a valid driving license under the Motor Vehicles Act. 1988 (59 of 1988).

d) USE OF SAFETY BELT OR OTHER FALL ARREST SYSTEMS:

e) Wherever any work at a height of 3 m or more is carried out, use of a suitable fall arrest system is mandatory if the workplace has already

not been provided with an otherwise reliable means of protection for preventing the fall of persons from that height, provided further that:

f) Safety belt, lanyard, life lines and devices for the attachment of such life lines shall conform to the approved standards;

g) Every building worker shall be supplied with safety belt and safety life lines for his protection and such building worker shall use such belts and life lines during the performance of his work;

h) All building workers using safety belt and safety life lines shall have the knowledge of safe use and maintenance of such belts and life lines and shall be supplied with necessary instructions for its use;

i) The responsible person for supervising the use of safety belts and safety lifelines shall inspect and ensure that such safety belts and lifelines are fit for use before taking them into use.

2.10 SAFETY NET AND ITS USE

a) Every safety net shall be of adequate strength, made of sound material and suitable for use and conform to the approved standards;

b) The responsible person for maintenance of safety nets and their use shall ensure safe fixing of such safety nets and provide such safety nets with suitable and sufficient anchorage so that the purposes for which such safety net is intended for use is served;

c) Use of multi-layer safety net to be ensured to avoid fall of material/objects.

2.11 STORAGE OF SAFETY BELTS AND NETS, ETC:

a) Proper arrangement shall be made for the safe storage of safety belts, safety lifelines and safety nets when they are not in use and are protected against mechanical damage, damages from chemicals and damages from biological agents.

2.12 SAFETY HELMETS AND SAFETY FOOTWEAR

a) The Engineer in-charge may declare whole or part of a site as the hardhat area and in such an eventuality it shall be the responsibility of the contractor to provide safety helmet of the approved quality to all personnel engaged in construction and erection work, including the visitors to the site;

b) Accordingly, wherever safety footwear is required for the safety of the personnel, the contractor shall provide the same of the approved type free of charge.

3.0 WELDING AND GAS CUTTING OPERATIONS

A. GAS WELDING:

3.1 GENERAL PROVISIONS:

a) All welders shall be provided with fire resistant protective clothing and equipment, such as fire resistant gauntlets and aprons, helmets and goggles with suitable filter lenses and its usage shall be ensured;

b) The welders shall not be allowed to wear clothing that is not free from grease, oil and other flammable material;

c) Adequate precautions shall be taken to protect persons working or passing near welding operations from dangerous sparks and radiation;

d) When welding or cutting is being done on materials containing toxic or harmful substances or liable to produce toxic or harmful fumes, adequate precautions shall be taken to protect workers from the fumes, either by

e) Exhaust ventilation, or

f) Respiratory protective equipment;

g) Arrangement shall be made so that welding sparks do not fall down on the persons working below or material, which are combustible in nature and may be damaged with such sparks.

h) The oxygen pressure for welding shall always be high enough to prevent acetylene flowing back into the oxygen cylinder;

i) Acetylene shall not be used for welding at a pressure exceeding 1 atmosphere gauge;

j) Adequate precautions shall be taken to prevent:

k) Fire being stated by sparks,

l) Slag or hot metal; and

m) Damage to fibre ropes from heat, sparks, slag or hot metal;

n) Precautions shall be taken to prevent flammable vapours and substances from entering the working area;

3.2 **WELDING AT PLACES WITH FIRE RISKS:**

a) Unless adequate precautions are taken, no welding or cutting operations shall be allowed near the place where combustible materials are stored, or near materials or plant where explosive or flammable dusts, gases or vapours are likely to be present or given off. If hot work permit system exists at the site, the same shall be followed;

b) Combustible materials and structures that cannot be removed from the vicinity of welding operations shall be shielded by asbestos or protected by other suitable means.

3.3 **WELDING IN CONFINED SPACE:**

a) When welding or cutting operations are being carried out in a confined space;

b) Adequate ventilation, by means of exhaust fans or forced drought as the condition may require, shall be constantly provided; otherwise

enough quantity of air shall be flown in by means of compressors to dilute the pollutants;

c) No blow pipe shall be left unattended inside a tank or vessel or other confined space during meal break or other interruption of the work;

d) The worker shall take all necessary precautions to prevent unburned combustible gas or oxygen from escaping inside a tank or vessel or other confined space; and

e) When necessary to prevent danger, an attendant shall watch the welders from outside.

3.4 **WELDING ON CONTAINERS FOR EXPLOSIVE OR FLAMMABLE SUBSTANCES:**

a) Welding or cutting operations on containers in which they are explosives or flammable substances shall not be allowed;

b) Welding or cutting operations on any container that has held explosive or where flammable gases may have been generated, shall only be undertaken,

c) After the container has been thoroughly cleansed by steam or other effective means; and

d) Found by air tests to be completely free from combustible gases and vapours; or

e) After the combustible gas in the container has been completely replaced by an inert gas or by water;

f) If an inert gas is used as laid down in clause 4.2.3, after the vessel has been filled with gas, the gas shall continue to flow slowly into it thorough out the welding or cutting operations;

g) Before starting any welding operations on, or otherwise applying heat to, closed or jacketed containers or other hollow parts, such containers or parts shall be adequately vented in suitable manner.

3.5 **GAS CYLINDERS**

a) Gas cylinders shall be inspected, stored, handled and transported in conformity with the requirements of Gas Cylinders Rules, 1981;

b) When in use, cylinders shall be held in upright positions by straps, collars or chains;

c) Devices referred to in clause 6.2 shall be such that the cylinders can be rapidly removed in an emergency;

d) Welders shall not temper with or attempt to repair safety devices and valves on gas cylinders;

e) When acetylene cylinders are coupled, flash back arrestor shall be inserted between the cylinder and the coupler block, or between the coupler bock and the regulator;

f) Only acetylene cylinders or approximately equal pressure shall be coupled;

g) No gas shall be taken from a cylinder unless a pressure reducing regulator has been attached to the valve;

h) Only the right pressure reducing regulator shall be used for the gas in the cylinder;

i) Cylinder valves shall be kept free from gases, grease, oil, dusts and dirt;

j) Leaky cylinders charged with acetylene or liquefied fuel gas shall be taken into the open air at a safe distance from any open flame or sparks.

3.6 **HOSE**

a) Only hose especially designed for welding and cutting operations shall be used to connect an oxy- acetylene torch to gas outlet;

b) Hose lines for oxygen and for oxy-acetylene shall be of different colours and preferably of different size;

c) Hose connections shall be sufficiently light to withstand without leakage a pressure twice thee maximum delivery pressure of the pressure regulators in the system;

d) Care shall be taken that hose does not become kinked or tangled, stepped on or run-over or otherwise damaged;

e) Any length of hose in which a flashback has burned, shall be discarded;

f) No hose with more than one gas passage shall be used;

g) Only soapy water shall be used for testing hose for leaks.

3.7 **TROCHES**

a) When torches are being changed, the gases shall be shut off at the pressure reducing regulators and not by crimping hose;

b) Torches shall be lit with friction lighters or other safe source but not with matches.

c) Electric welding equipment:

d) Welding machines shall be controlled by a switch mounted on or near the machine framework that, when opened, immediately cuts off the power from all conductors supplying the machine;

e) Welding circuit shall be so designed as to prevent the transmission of high potential from the source of supply to the welding electrodes;

f) The maximum open circuit voltage shall be in accordance with Indian Standards;

g) Electrode conductors or cables shall not be excessive in length and shall not be longer that necessary to perform the work;

h) Return conductors shall be taken directly to work and securely connected mechanically and electrically to it or to the work bench, floor etc. and to an adjacent metallic object;

i) Cable shall be supported so as not to create dangerous obstruction;

j) Motors, generators, rectifiers and transformers in arc welding or cutting machines, and all current carrying parts, shall be protected against accidental contact with uninsulated live parts;

k) Ventilating slots in transformer enclosures shall be so designed that no live part is accessible through any slot;

l) Frames of arc welding machines shall be effectively earthed;

m) In hand-operated arc welding machines, cables and cable connectors used in arc welding circuits shall be effectively insulated on the supply side;

n) The outer surface electrode holders of hand-operated arc welding machines, including the jaw so far as practicable, shall be effectively insulated;

o) Electrode holders of hand-operated arc-welding machines shall, if practicable, be provided with discs or shields to protect the operator's hands from the heat of the arcs;

p) Only heavy-duty cable with unbroken insulation shall be used;

q) Circuit connections shall be waterproof;

r) When lengths of cable have to be joined, only insulated connectors shall be used on the earth line and the electrode holder line;

s) Connections to welding terminals shall be made at distribution boxes, socket outlets, etc. by bolted joints;

t) Welding terminals shall be adequately protected against accidental contact by enclosures, covers or other effective means;

u) Electrode holder shall

v) Have adequate current capacity;

w) Be adequately insulated to prevent shock, short-circuiting or flashovers.

3.8 **OPERATIONS**

a) Arc welding and cutting operations that are carried on at places where persons other than the welders are working or passing shall be enclosed by means of suitable stationary or mobile screens;

b) Walls and screens of both permanent and temporary protective enclosures shall be provided to absorb harmful rays from the welding equipment and prevent reflection, and if necessary, be painted or otherwise treated for the purpose;

c) When arc welding is done in damp confined spaces;

d) Electrode holders shall be completely insulated; and

e) The welding machines shall be outside the confined space;

f) Welders shall take adequate precautions

g) To prevent any part of their body from completing an electric circuit

h) To prevent contact between any part of the body and the exposed part of the electrode, or electrode when in contact with metal; and

i) To prevent wet or damaged clothing, gloves and boots from touching any live part;

j) Welding circuits shall be switched off when not in use;

k) Electrodes shall only be inserted in the holder with insulating means such as insulating gloves;

l) Electrode and return leads shall be adequately protected against damage;

m) Live parts of electrode holders shall be inaccessible when they are not in use;

n) Electric arc-welding equipment shall not be left unattended with current switched on.

4.0 SAFETY IN THE USE OF ELECTRICITY

4.1 **GENERAL PROVISIONS**

a) Before commencement of any building or other construction work, adequate measures shall be taken to prevent any worker from coming into physical contact with any electrical equipment or apparatus, machines or live electrical circuit which may cause electrical hazard during the course of his employment and suitable warning signs shall be displayed and maintained at conspicuous places in Hindi and in local language understood by the majority of the building workers;

b) In workplaces where the exact location of underground electric power line is not known, the building workers using jack hammers, crow bars or other hand tools which may come in contact with a live electrical line shall be provided with approved insulated protective gloves and footwear;

c) As far as practicable, no wiring or cable, which may come in contact with water or which may be mechanically damaged or which may result in electric shock shall be left on ground or;

d) All electrical appliances and current carrying equipment used shall be made of sound material and adequately earthed;

e) All temporary electrical installations shall be provided with earth leakage circuit breakers;

f) It is required that all portable power-driven hand tools are provided with double insulation to secure a high degree of protection from electrical hazards;

g) Electrical installations shall comply with the requirements of any law for the time being in force, especially the Indian Electricity Act/Rules in particular with specific reference to the following:

- All parts of installations shall be of standard construction not lower, from the safety point of view, than the national standards, as applicable. All parts of electrical installations shall be so constructed, installed and maintained so as to prevent electrical fires, explosion and shock;
- Earthing of metal work of electrical equipment, other than the parts which carry current, shall be provided and will conform to Electricity Act and IS: 3042 – 1966 (code of practice for earthing);

h) All parts of electrical installation shall be adequate size and characteristics for the work they may be called upon to do and in particular they shall:

- Be of adequate mechanical strength to withstand working conditions in construction operations; and
- Be not liable to damage by water, dust or electrical, thermal or chemical action to which they me subjected to in construction operations;

i) All parts of electrical installations shall be so constructed, installed and maintained as to prevent the danger of electric shock; fire and external explosion;

j) It shall be made impossible for circuit breakers to be opened or closed inadvertently, by gravity or by mechanical impact;

k) Before operation of OCBs, oil level must be checked and the event of short, extra quantity must be filled;

l) Use of rubber gloves and rubber gum boots of tested quality where electric shock is likely to occur shall be provided, but these shall not be considered as providing adequate protection against the risk of electric shock in lieu of inbuilt safety arrangement in the system;

m) First-aid boxes, instruction for restoration of persons affected by electric shock shall be made;

n) Arrangement shall be made for sufficient number of CO2/chemical powder type fire extinguishers/sand buckets etc.;

o) No electrical circuits shall ever be overloaded to the dangerous extent or beyond the rated capacity;

p) In confined areas, only 24 volt supply shall be used for every equipment, including hand-held portable tools and hand lamps;

q) All electrical appliances and outlets shall be clearly marked to indicate their purpose and voltage.

4.2 **FUSES**

a) Fuses shall bear markings indicating their rated current, whether they are of the fast or slow- breaking type and, as far as practicable, and their rated breaking capacity. Fuses as per need and of correct rating shall be used in the circuit;

b) Effective measures shall be taken to ensure that persons removing or inserting fuses will not be endangered, in particular by any adjacent live parts;

c) In case of blow of fuses only after finding out and correcting of the fault, new fuses shall be provided in the circuit.

4.3 SWITCHES

a) All switches shall be of enclosed type and so installed and earthed as to prevent danger in their operation;

b) Use of switches, which may connect or disconnect circuit through gravity, shall not be used.

4.4 MOTORS

a) All motors shall be equipped with a switch;

b) When a motor can be cut off from more than one place, where practicable, a stopping device shall be installed in the immediate vicinity of the motor;

c) Motors shall be so installed as to ensure that they can be adequately cooled;

d) Motors shall be effectively protected against over current;

e) Whenever the motors installed are in the open area where there is the possibility of fall of liquid corrosives or otherwise, it shall be suitably protected with covering;

f) Earthing shall be connected to all motors, generators etc. as prescribed in the Indian Electricity Rules, amended from time to time.

4.5 CONNECTIONS

a) At points where conductors are joined, branched or led into apparatus, they shall be: Mechanically protected, and Properly maintained;

b) Conductors shall be joined, branched or led into an apparatus through junction boxes, bushings, glands or equivalent connecting devices;

c) Junction boxes or plug-out-socket couplings shall be used for joining cables wherever practicable;

d) When parts of conductors are joined together, or conductors are joined to one another or to an apparatus, the attachment shall be made by screwing, clamping, soldering, riveting, brazing, crimping, or equivalent means. Loose connections shall not be provided in any case;

e) Cable joints, junction boxes and connectors shall be protected as far as practicable, against traffic, fall of ground, water and other sources of damage;

f) Whenever armoured cables are joined, the junction boxes shall be bridged by a suitably conducive bond between the armouring of the cables.

4.6 TRANSPORTABLE AND PORTABLE ELECTRICAL EQUIPMENT:

a) The supply of electricity to portable apparatus shall not exceed 250v;

b) Hand-held and portable machines shall be equipped with a built-in switch to switch off power in case of emergency;

c) Hand-held electrically operated tools shall be provided with built-in switch to disconnect the circuit when the tool is not being used;

d) Portable electrical tools, unless flameproof, shall not be used in flammable or explosive atmosphere;

e) Only three-core cable shall be used for single-phase operated tools with the third core connected to earth

4.7 HAND LAMPS

a) Hand lamps shall be equipped with strong cover of glass or other transparent material;

b) Portable lamp holders shall have:

- All current –carrying part s enclosed;
- Insulated handle; and
- They shall operate at 24 v;

4.8 INSPECTION, MAINTENANCE

a) All electrical equipment shall be inspected before it is taken into use to ensure that it is suitable for its purpose of use;

b) At the beginning of every shift every person using electrical equipment shall make a careful external examination of the equipment and conductors for which he is responsible, especially flexible cables;

c) Periodic inspections, testing, maintenance of all electrical equipment is to be made and record of test of transformer oil and pit earthing shall be maintained;

d) Electrical conductors and equipment shall be repaired by the electrician only as far as practicable, no work shall be done live conductors or equipment;

e) Before any work is begun on conductors or equipment that does not have to remain live;

f) The current shall be switched off;

g) Adequate precautions shall be taken to prevent the current from being switched on again;

h) The conductors or the equipment shall be tested to ascertain that they are dead;

i) The conductor and equipment shall be earthed and short-circuited; and

j) Neighbouring live parts shall be adequately protected against accidental contact;

k) After work on conductors and equipment, the current shall only be switched on again on the orders of a competent person;

l) Electricians shall be provided with adequate tools, and person protective equipment, such as rubber gloves, mats etc.;

m) All conductors and equipment shall be considered to live unless there is certain proof to the contrary.

4.9 WORK IN THE VICINITY OF ELECTRICAL INSTALLATION

a) When work is to be done in the neighborhood of electrical conductors or installations, the contractor shall ascertain the voltage carried and the works shall not be allowed to reach to unsafe distance from them;

b) When any excavation is to be made or any bore-holed sunk, the contractor shall ascertain whether there are any underground conductors, in or in dangerous proximity to, the zone of operations;

c) No work shall be done in dangerous proximity to a conductor or an installation until it has been made dead;

d) Before work begins, work permit shall be obtained from the Engineer in-charge if live electricity lines/circuit are passing in close vicinity;

e) Before the current is restored, the contractor shall ensure that no work remain on the work site;

f) If conductor or an installation in the neighbourhood of which work is io be done can not be made dead, special precautions shall be taken and special instructions given to the workers so as to prevent danger by adequately enclosing or fencing;

g) If mobile equipment has to be employed in the neighbourhood of conductors or installations that cannot be made dead, its movement shall be so controlled as to keep it as a safe distance from them.

5.0 SAFETY IN THE USE OF HAND TOOLS AND POWER-OPERATED TOOLS

5.1 **GENERAL PROVISIONS**

a) All hands and power tools and similar equipment, shall be maintained in safe condition.

b) When power operated tools are designed to accommodate guards, they shall be equipped with such guards, when in use;

c) Belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains and other reciprocating, rotating or moving parts of the equipment shall be similarly guarded;

d) Personnel using hand and power tools and exposed to the hazard of falling, flying, abrasive, and splashing objects, or exposed to harmful dusts, fumes, mists, vapours, or gases shall be provided with the particular personal protective equipment necessary to protect them from the hazards;

e) All hand-held powered platen sanders, grinders, grinders with wheels of 5 cm or less, routers, planers, laminate trimmers, nibblers, shears, scroll saws and jigsaws with blade shanks of 0.5 cm wide or less shall be equipped with only a positive on-off control.

f) All hand-held powered drills, tappers, fastener drivers, horizontal, vertical or angle grinders with wheels greater than 5 cm in diameter, disc sanders, belt sanders, reciprocating saws, saber saws and other operating powered tools shall be equipped with a momentary contact on control provided that turnoff can be accomplished by a single motion of the same finger or fingers that turn it on.

5.2 **HAND TOOLS**

a) The contractor shall not issue or permit the use of unsafe hand tools;

b) Wrenches including adjustable pipe end and socket wrenches shall not be used when saws are sprung to the point that slippage occurs;

c) Impact tools such as drift pins, wedges and chisels shall be kept free of mushroomed heads;

d) The wooden handles of tools shall be kept free of splinters or cracks and shall be kept tight on the tools.

5.3 POWER OPERATED TOOLS

a) Electric power operated tools shall be either of the approved double-insulated type or shall be grounded;

b) The use of electric cords for hoisting or lowering loads shall not be permitted;

c) Pneumatic power tools shall be secured to the hose or whip by some positive means to prevent the tool from becoming accidentally disconnected;

d) Safety clips or retainers shall be securely installed or maintained on pneumatic impact (percussion) tools to prevent attachments from being accidentally expelled;

e) All pneumatically riveting machine staplers and other similar equipment provided with automatic fastener feed, which operate at more than 7 kg/cm2 pressure at the tool a safety device on the muzzle to prevent the tool from ejecting the fasteners unless the muzzle is in contact with the work surface;

f) Compressed air shall not be used for cleaning purposes except when the pressure is reduced to less than 2 kg/cm2 and that too with effective chip guarding. The 2 kg/cm2 pressure requirement does not apply to concrete form, mill scale and similar cleaning purposes;

g) The manufacturer's safe operating for hoses, pipes, valves, filters and other fittings shall not be exceeded;

h) Only personnel who has been trained in the operation of the particular tool shall be allowed to operate power-actuated tools;

i) The tool shall be tested each day before loading to see that the safety devices are in proper working condition. The method of testing shall be accordance with the manufacturer's recommended procedure;

j) Any tool found not in proper working order, or that which develops a defect during use, shall be immediately removed from service and not used until properly repaired;

k) Tools shall not be loaded until just prior to the intended firing time. Neither loaded nor empty tools are to be pointed at any other person. Hands shall be kept clear of the open barrel end;

l) Loaded tools shall not be left unattended;

m) Fasteners shall not be driven into very hard or brittle materials including, but not limited to, cast iron, glazed tiles, surface hardened steel, glass block, live rock, face brick or hollow tiles;

n) Driving into materials that can be easily penetrated shall be avoided unless backed by a substance that will prevent the pin or fastener from passing completely through and creating a flying missile hazard on the other side;

o) No fastener shall be driven into a palled area caused by an unsatisfactory fastening;

p) Only non-sparking tools shall be used in an explosive or flammable atmosphere;

q) All tools shall be used with the correct shield, guard or attachment as recommended by thee manufacturer.

5.4 ABRASIVE WHEELS AND TOOLS

a) All grinding machines shall be supplied with sufficient power to maintain the spindle speed at safe levels under all conditions of normal operation;

b) Grinding machines shall be equipped with suitable safety guards;

c) The maximum angular exposure of the grinding wheel periphery and sides shall not be more than 900, except that when the work requires contact with the wheel below the horizontal plane of the spindle, the angular exposure shall not exceed 1200. In either case, the exposure shall begin not more than 650 above the horizontal plane of the spindle. Safety guards shall be strong enough to withstand the bursting of the wheel;

d) Floor and bench-mounted grinders shall be work-rests, which shall be rigidly supported and readily adjustable. Such work-rests shall be kept at a distance not to exceed 5 mm from the surface of the wheel;

e) Cup type wheels used for external grinding shall be protected by either revolving cup guard or a band type guard;

f) When safety guards are required, they shall be mounted as to maintain proper alignment with the wheel and the guard and the guard and its fastening shall be adequate strength to retain the fragments of the wheel in case of accidental breakage. The maximum angular exposure of the grinding wheel periphery and sides shall not exceed 1800;

g) Portable abrasive wheel used for internal grinding shall be provided with suitable safety flanges;

h) When safety flanges are required, they shall be used only with wheels designed to fit the flanges. Only safety flanges, of a type and design and properly assembled so as to ensure that the pieces of the wheel will be retained in case of accidental breakage, shall be used;

i) All abrasive wheels shall be closely inspected and ring tested before mounting to ensure that they are free from cracks or defects;

j) Grinding wheels shall fit freely on the spindle and shall not be forced on. The spindle nut shall be tightened only enough to hold the wheel in place;

k) All employees using abrasive wheels shall be protected by suitable eye protection equipment.

5.5 WOODWORKING TOOLS

a) All fixed power driven woodworking tools shall be provided with a disconnect switch that can either be locked or tagged in the off-position;

b) The operating speed shall be attached or otherwise permanently marked on all circular saws over 0.5 m in diameter or operating at

over 3000 peripheral rpm. Any saw so marked shall not be operated at a speed other than that marked on the blade. When a marked saw is retensioned for a different speed, the marking shall be corrected to show the new speed;

c) Automatic feeding devices shall be installed on machines wherever the nature of the work will permit. Feeder attachments shall have the feed rolls or other moving parts covered or guarded so as to protect the operator from hazardous points;

d) All portable power driven circular saws shall be equipped with guards above and below the base plate or shoe. The upper guard shall cover the saw to the depth of the teeth, except for the minimum arc required to permit the base to be tilted for bevel cuts. The lower guard shall cover the saw to the depth of the teeth, except for the minimum arc required to allow proper retraction and contact with the work. When the tool is withdrawn from the work, the lower guard shall automatically and instantly return to the covering position.

6.0 SAFETY IN THE USE OF LADDERS AND STAIRS

6.1 **GENERAL ASPECTS OF SAFETY RELATED TO USE OF LADDERS**

a) Every ladder or step-ladder used in building or other construction work shall be of good construction, made of sound material and of adequate strength for the purpose for which such ladder or step-ladder is used;

b) When a ladder is used as a means of communication, such ladder shall be lashed to a fixed structure so that while working on such ladder it does not slip;

c) A ladder or step ladder shall not stand on loose bricks or other loose packing and have a level and firm footing;

d) No ladder shall be used which has a missing or defective rungs or rungs, which depend for support solely on nails, spikes or other similar fixing.

6.2 **MATERIALS FOR LADDERS**

a) Shall be constructed with upright of adequate strength and are made of straight-grained wood, free from defects and having the grain of such wood running length wise;

b) Shall have rungs made of straight-grained wood free for defects and mortised or securely notched into the upright, reinforcing metal ties, if wedges shall not secure the tenors of such ladders;

c) Where it is required, in case of use of fixed ladders, sufficient foot-hold and hand-hold shall be provided for use by the building worker;

d) Every ladder shall be -

- Secured so as to prevent undue swaying;
- Equally and properly supported on each of its upright;
- So used as not to cause undue sagging; and
- Placed as nearly as possible at an inclination of four in one;

e) The use of all ladders and stepladders shall conform to the approved standards;

f) Wooden ladders shall be constructed with uprights of adequate strength as well as rungs made of wood free from visible defects and having the grains of the wood in the ladders running lengthwise and rungs mortised or rebutted into the uprights;

g) Uprights and rungs of metal ladders shall have a cross-section adequate to prevent dangerous deflection, shall be equal and not less than 25 cm or more than 35 cm;

h) Rungs of metal ladders shall be kept clean so as to prevent them from becoming slippery;

i) Portable ladders shall not exceed 9 m in length;

j) Every ladder or run of ladders rising to a height exceeding 9 m shall be provided with an intermediate landing, providing further that the intervals between landings shall not exceed 9 m. The landings shall be of suitable size and protected by railings;

k) Defective ladders that cannot be satisfactorily repaired shall be tagged Not Fit For Use and destroyed;

l) Wooden ladders shall not be painted, but oiled or covered with clean varnish or other transparent preservatives;

m) Metal ladders shall be protected against corrosion by being coated with rust-proof paint or by other means unless they are made of non-corrosive metals;

n) Every ladder shall rise at least 1 m above the highest point to be reached and have one of the uprights continued to that height to serve as a hand-rail at the top;

o) Ladders shall not stand on loose bricks or other loose packing but have a level and firm footing so that they are equally supported on each upright;

p) Every ladder shall be securely fixed so that it cannot move from its top and bottom points of rest and if it cannot be secured at the top, it shall be securely fastened at the base and if fastening at the top is also impracticable, it shall have a man stationed at the foot holding the end to prevent it from slipping;

q) Where a run of two or more ladders connects different floors, the ladders shall be staggered and a protective landing with the smallest practicable opening shall be provided at each floor;

r) A ladder having only one upright or a missing or dangerously defective rung shall not be used;

s) When a ladder is placed in position, the distance between the foot of a ladder and the base of the structure against which it rests shall be about one-quarter of its length;

t) Workers using ladders shall leave at least one hand free for climbing up and down, face the ladder, avoid wearing slippery footwear and avoid carrying heavy or bulky loads;

u) A ladder shall not be placed in front of a door that opens towards it unless the door is fastened or locked or guarded;

v) A ladder shall not be placed against a window frame unless the ladder is fitted with a board at the top so that the applied load is safely distributed over the frame;

w) Metal ladders shall not be used in the vicinity of live electrical equipment;

x) Adequate means shall be provided to prevent displacement of the ladder set up in public thoroughfare or where persons, vehicles etc. may accidentally collide with it.

6.3 PORTABLE STEPLADDERS

a) The length of portable stepladders shall not exceed 6 m and their back legs shall be adequately braced;

b) Stepladders exceeding 1.5 m in length shall have two or more cross-ties;

c) The spread between the front and back legs shall be restricted by means of hinged metal flat bars or high-grade fibre or other effective means;

d) When in the open position, treads of stepladders shall be horizontal.

6.4 PORTABLE TRESTLE LADDERS

a) The height of the trestle ladders shall not exceed 5.5 m;

b) The spread between the front and back legs shall be restricted by means of hinged metal flat bars or high-grade fibre or other effective means;

c) The front and back legs shall be joined at the top by bolted steel hinges of adequate dimensions or other effective means;

d) Both legs of trestle ladders shall be equipped with sufficient number of steel crossties.

6.5 EXTENSION LADDERS

a) The length of extension ladders shall not exceed 15 m;

b) Extension ladders shall be equipped with an effective lock and guide brackets by which the ladder can be extended, retracted or locked in any position;

c) The rungs of overlapping sections shall coincide so as to form double treads and shall be equipped with one or more extension ropes;

d) Extension ropes shall be securely anchored and run over suitable pulleys.

6.6 MECHANICAL LADDERS

a) Mechanical ladder is that ladder, which is a mechanically extendable ladder, mounted on a wheeled frame;

b) Mechanical ladder shall be equipped with guard-rails and toe-boards and a cage of heavy-gauge steel mesh;

c) If mechanical ladder has no railed platform or cage, workers using it shall be secured by suitable safety belt;

d) Mechanical ladders shall not be moved, while a person is on them, unless they have specially designed to ensure that perfect stability is maintained during movement.

6.7 FIXED LADDERS

a) Uprights of fixed ladders shall be at least 40 cm and shall be set an angle of 150 to the vertical;

b) Clearance at the back of the rungs shall be at least 15 cm and no obstruction within 75 cm of the face of the ladder;

c) There shall be at least 7.5 cm clearance between the ladder and the nearest fixed object;

d) When it is necessary for a ladder to pass closely through a hole in a platform or a floor, the edges of the hole shall be padded so as to prevent injury to the users;

e) The length of the runs of fixed ladder shall not exceed 9 m;

f) Landing platform shall be provided for each 9 m or fraction thereof;

g) As far as practicable, runs shall be staggered;

h) Runs from which a person could fall from more than 6 m shall be enclosed in a cage of heavy-gauge mesh or hoops;

i) Fixed ladders shall be firmly bolted or welded in position.

6.8 **STAIRS**

a) Stairs shall be of adequate strength to withstand safely the loads that they will have to carry;

b) Stairs used for the purpose of construction work shall have a clear width of at least 60 cm;

c) Stairs made of perforated material shall not have openings exceeding 1.2 cm in width;

d) No step of a stairway shall depend for its support solely on nails, spikes, screws or other similar fixing;

e) No stairway with missing or dangerously defective steps shall be used;

f) Every stairway that is at an angle of less than 300 from the vertical shall be provided with a secure handhold at the top landing place, either by extending one upright for at least 1 m or by other effective means;

g) Movable and removable stairs shall be adequately secured in the position of use;

h) In all building structures permanent stairs shall be constructed as soon as practicable;

i) When work on a building has progressed to a height of more than 18 m above the ground and it has not been practical to construct the permanent stairs, sufficient number of stairs shall be provided to ensure safe access to the working levels.

7.0 SAFETY IN THE USE OF LIFTING APPLIANCES & GEARS

7.1 **CONSTRUCTION AND MAINTENANCE OF LIFTING APPLIANCES:**

a) All lifting appliances, including their parts and working gear, whether fixed or movable, and any plant or gear used in anchoring or fixing of such appliances -

b) Shall be of sound construction, sound material, and of adequate strength to serve the purpose for which these are to be used and all such appliances shall be free from patent defects, and

c) Maintained in good repair and working condition;

d) Every drum or pulley around which the rope of any lifting appliance is carried, shall be of adequate diameter and sound construction in relation to such rope;

e) Any rope that terminates at the winding drum of lifting appliance shall be securely attached to such drum and at least three dead turns of such rope remain on such drum in every operating position of such lifting appliance;

f) The flange of a drum projects twice the rope diameter beyond the last layer of such rope and if such rope and if such projection is not available, other measures like anti-slackness guards shall be provided to prevent such rope from coming off such drum;

g) Every lifting appliance shall be provided with adequate and efficient brakes which shall be:

h) Capable of preventing fall of suspended load (including any test load),

i) Effectively controlling such load while it is being lowered, acting without shock and shall be attached with shoes that can be easily removed for running and which shall be simple and have easily accessible means of adjustment;

j) Provided that nothing contained above shall apply to steam-winch that can be operated as safely as with brakes.

7.2 **CONTROLS OF EVERY LIFTING APPLIANCE SHALL BE SO;**

a) Situated that the driver of such appliance at his stand or seat has ample room for operating and has an unrestricted view of building or other construction work, as far as practicable, and that he remains clear of the load and the ropes, and that no load passes over him;

b) Positioned with due regard to ergonomic considerations for proper operation of such appliance;

c) Located that the driver of such appliance remains above the appliance and shall have upon them or adjacent to them clear markings to indicate their purpose and mode of operations;

d) Provided, where necessary, with a suitable locking device to prevent accidental movement or displacement and shall move, as far as practicable, in the direction of the resultant load movement;

e) Wherever automatic brakes are provided, they shall automatically come to the neutral position in case of power failure.

7.3 **TEST AND PERIODICAL EXAMINATION**

a) Test: all lifting appliances including all parts and gears thereof, whether fixed or movable, shall be tested and examined by a competent person before being taken into use for the first time or after it has undergone any alteration or repairs liable to affect its strength or stability or after erection on a site and also once at least in every five years, in the manner as specified;

b) Examination: all lifting appliances shall be thoroughly examined by a competent person at least in every twelve months and where the competent person making such examination forms the opinion that the lifting appliance cannot continue to function safely, he shall forthwith give notice in writing of his opinion to the contractor.

7.4 AUTOMATIC LOAD INDICATOR

a) Cut-out shall be provided which automatically arrests the movement of the lifting parts of every crane if the load exceeds the safe working load, wherever possible;

b) Wherever the above provisions cannot be applied and if it is not possible to install an automatic safe load indicator, in that case, provision of a table showing the safe working loads at the corresponding inclinations or radii of the jib on the crane shall be considered sufficient.

7.5 INSTALLATION:

a) Fixed lifting appliances shall be installed by a competent person in a manner that

b) Such appliances cannot be displaced by the load, vibration or other influences;

c) The operator of such appliance is not exposed to danger from loads, ropes or drums;

d) The operator can either see over the zone of operation or communicate with all loading and unloading points by signal, or other communication system;

e) Adequate clearance is provided between parts or loads of lifting appliances and between the fixed objects such as walls and posts, or electrical conductors;

f) The lifting appliances; when exposed to wind loading, are given sufficient additional strength, stability and rigidity to withstand such loading safely;

g) No structural alterations or repairs are made on any part of the lifting appliances that affect the safety of such appliances without obtaining the opinion of the competent person to this effect.

7.6 WINCHES

a) Winches shall not be used if their control levers operate with excessive friction or play;

b) Double gear winches shall not be used unless a positive means of locking the gearshift is provided;

c) There shall be no load other than the fall and the hook assembly on the winch while changing gears on a two-gear winch;

d) Adequate protection shall be provided to the winch operator against abnormal weather;

e) Temporary seats or shelters for winch operators that may pose hazard to the winch operator or any other building workers shall not be allowed to be used;

f) Control levers shall be secured in the neutral position and, whenever possible, the power shall shut off if the winch is left unattended.

7.7 **IN USE OF EVERY STEAM-WINCH**

a) Measures shall be taken to prevent escaping steam from obscuring any part of the construction site or other workplace or from otherwise hindering or injuring any building worker;

b) Extension control levers which tend to fall off their own weight shall be counter-balanced;

c) Winch operators shall not be permitted to use the which control extension levers except for short handles on wheel type controls and that such levers shall be of adequate strength, secure and fastened with metal connections at the fulcrum and at the permanent control lever;

d) In use of every electric winch, no building worker shall be permitted to transfer, alter or adjust electric control circuits in case of any defect in such winch;

7.8 **ELECTRIC WINCHES SHALL NOT BE USED FOR BUILDING WORK WHERE**

a) The electromagnetic brake is unable to hold the load; or

b) One or more control points either hoisting or lowering are not operating properly.

7.9 **BUCKETS:**

a) It shall be ensured that tip-up buckets are equipped with a device that effectively prevents accidental tipping.

7.10 **IDENTIFICATION AND MARKING OF SAFE WORKING LOAD:**

a) Every lifting appliance and loose gear shall be clearly marked for its safe working load and identification by stamping or other suitable means;

b) Every derrick (other than derrick crane) shall be clearly marked for its safe working load when such derrick is used either in single purchase with lower block or in union purchases in all possible block positions;

c) The lowest angle to the horizontal, to which the derrick may be used, shall be legibly marked;

d) Every lifting appliance having more than one working load shall be fitted with effective means to enable the operator to determine safe working load at each point under all conditions of use;

e) Means to ascertain the safe working load for lifting gears under such conditions in which such gears may be used shall be provided to enable a worker using such gears and such means safely, which shall comprise:

f) Marking of the safe working load in plain figures or letters upon the sling or upon a tablet or ring of durable material attached securely thereto in case of chain slings; and

g) The means specified or notices so exhibited as can be easily read by any concerned building worker stating the safe working load for the various sizes of the wire rope slings used.

7.11 LOADING OF LIFTING APPLIANCES AND LIFTING GEARS

a) No lifting appliance, lifting gear or wire rope shall be used in an unsafe way and in such a manner as to involve risk to life of building workers and they are not loaded beyond their safe working load except for testing purposes under the direction of a competent person in the manner as specified in schedule;

b) No lifting appliance and lifting gear, or any other material-handling appliance shall be used if the Inspector having jurisdiction under the Building and Other construction (regulation of employment and conditions of service) Act/Rules is not satisfied with reference to a certificate of test or examination or to an authenticated record maintained as provided under the Rules or if in his view the lifting appliance, lifting gear or any other material handling appliance is not safe for use in building or other construction work;

c) No pulley block shall be used unless the safe working load and its identification are clearly marked on such block.

7.12 OPERATOR'S CAB OR CABIN SHALL

a) Be made of fire resistant material;

b) Have a suitable seat, a foot rest and protection from vibration;

c) Afford the operator an adequate view of the area of operation;

d) Afford the necessary access to working parts in the cab;

e) Afford the operator adequate protection against the weather;

f) Be adequately ventilated; and

g) Be provided with a suitable fire extinguisher.

7.13 **OPERATION OF LIFTING APPLIANCES:**

a) Operator of every crane or lifting appliance shall possess adequate skill and training in the operation of the particular lifting appliances, provided further that

b) No person under eighteen years of age shall be in control of any lifting machine, scaffold winch, or give signals to the operator;

c) Precaution shall be taken by the trained operator to prevent lifting appliance from being set in motion inadvertently;

d) The operation of lifting appliances shall be governed by signals in conformity with the approved standards;

e) The operator's attention shall not be distracted while he is working;

f) No crane, hoist, winch or other lifting appliance or any part of such crane, hoist, winch or other lifting appliance shall, except for testing purposes, be loaded beyond the safe working load;

g) During the hoisting operation, effective precaution shall be taken to prevent any person from standing or passing under the load in such operation;

h) Operator shall not leave lifting appliance unattended while power is on or the load is suspended to such appliance;

i) No person shall ride on a suspended load of any lifting appliance;

j) Every part of a load in course of being hoisted or lowered shall bee adequately suspended and supported to prevent danger;

k) Every receptacle used for hoisting bricks, tiles, slates or other material shall be suitably enclosed as to prevent the fall of any such material;

l) The hoisting platform shall be enclosed when loose material or loaded wheel barrows are placed directly on such platform or lowering such materials or wheel barrows;

m) No material shall be raised, lowered or slewed with any lifting appliance in such a way as to cause sudden jerks to such appliance;

n) In hoisting a barrow, any wheel of such barrow shall not used be as a means of support unless adequate steps have been taken to prevent the axle of such wheel from slipping out of its bearing;

o) Long objects like planks or girders shall be provided with tag line to prevent any possibility of danger while raising or lowering such objects;

p) During the process of landing or material, a building worker shall not be permitted to lean out into empty space for finding out the loading and unloading of such material;

q) When hoisting of load is done in an enclosed space, neither the lifting material nor the boom shall project outside the enclosed space;

r) Adequate steps shall be taken to prevent a load, in the course of being hoisted or lowered from coming into contact with any object to avoid any displacement of such load and appropriate appliances provided and used for guiding heavy loads when raising or lowering heavy

loads to avoid crushing of hands of building workers during such raising or lowering of loads.

7.14 HOISTS

a) Hoist towers shall be designed according to the relevant national standards;

b) Hoist shafts shall be provided with rigid panels or other adequate fencing at the ground level on all sides of such shafts and at all other levels on all sides of the access to such shafts while the walls of hoist shafts, except at approaches, extend at least two meters above the floor or platform of access to such shifts;

c) Approaches to hoist shall be adequately lit and provided with gates that shall be guarded to maintain visibility at least of two meters height; and equipped with a device, which requires such gate to be closed before the platform of such hoist can leave the landing, and prevents the gate from being opened unless such platform is at the landing;

d) The guides of hoist platforms shall offer sufficient resistance to bending and to bucking in the case of jamming, by providing a safety catch;

e) Overhead beams and their supports are capable of holding the total maximum live and dead loads that such beams and supports will be required to carry, with a safety factor of at least five;

f) A clear space shall be provided –

- Above the highest stopping place of a cage or platform to allow sufficient unobstructed travel of such cage or platform in case of over-winding and
- Below the lowest stopping place of such cage or platform;

g) Adequate covering shall be provided above the top of hoist shafts to prevent materials from falling into such shifts;

h) Outdoor hoist towers shall be erected on adequately firm foundations and securely braced, guyed and anchored;

i) A ladder way shall extend from the bottom to the top of every outdoor hoist tower in case no other ladder way exists within easy reach and such ladder way shall comply with the relevant national standards;

j) The rated capacity of a hoisting engine shall at least be one and a half times the maximum load that such engine will be required to move;

k) All gearing on a hoisting engine shall be securely enclosed;

l) Steam piping of hoisting engine shall be adequately protected against accidental contact of such piping with a building worker;

m) Electrical equipment of a hoisting engine shall be effectively earthed;

n) A hoist shall be provided with suitable devices to stop a hoisting engine as soon as the platform of such hoist reaches its highest stopping place;

o) A hoisting engine shall be protected by suitable cover against weather and falling objects;

p) A hoisting engine set up in a public thoroughfare shall be completely enclosed;

q) All exhaust steam pipes shall discharge steam in such a manner that the steam so discharged does not scald any person or obstruct the operator's view;

r) The motion of a hoist shall not be reversed without first bringing it to rest to avoid any harm from such reverse motion;

s) A hoist not designed for the conveyance of persons shall not be set in motion from the platform of such hoist;

t) Pawls and ratchet wheels of a hoist, requiring disengagement of such pawls from such ratchet wheels, before the platform of such hoist is lowered, shall not be used;

u) A platform of a hoist shall be capable of supporting such maximum load that such platform may carry with a safety factor of at least three;

v) A platform of a hoist shall be equipped with suitable safety gear which can hold such platform with its maximum load in case its hoisting rope breaks;

w) On platform of a hoist, the wheel barrows or truck shall be efficiently blocked in safe positions;

x) A cage of a hoist or platform where the building workers are required to enter into such cage or to go on such platform at landing levels, shall be provided with a locking arrangement to prevent such cage or platform from moving during the time a worker enters or leaves such cage or platform;

y) The sides of platform of a hoist which are not used for loading or unloading, shall be provided with toe-board and enclosures of a wire mesh or any other suitable means to prevent the fall of any part of a load from such platform, further provided that

- The platform of a hoist, which has any probability of falling of any part of a load from it, shall be provided with an adequate covering to prevent such fall;
- The counter weights of a hoist consisting of an assemblage of several parts shall be so constructed that such parts shall be rigidly connected together;
- The counter weights of a hoist shall run between guides;

z) At every level of work the building workers shall be provided with adequate platforms for performing such work;

aa) A legible notice in Hindi as well as in a local language shall be displayed in a conspicuous place of the platform of a hoist and that such notice shall state the maximum carrying capacity of such hoist in kilograms on the hoisting engine;

bb) On a hoist authorized and certified for the conveyance of the persons on the platform or in the cage and such notice shall state the maximum number of persons to be carried on such hoist at one time;

cc) On a hoist carrying goods and other materials such notice shall state that such hoist is not meant for carriage of persons.

7.15 FENCING AND MEANS OF ACCESS TO LIFTING APPLIANCES

a) Safe means of access shall be provided to every part of lifting appliances;

b) The operator's platform on every crane or tip driven by mechanical power shall be securely fenced and provided with safe means of access and where access to such platform is by a ladder, the sides of such ladder shall extend to a height reasonable beyond such platform or some other suitable handhold shall be provided in the platform;

c) The handling place on such platform shall be maintained free from obstruction and slipping; and

d) In case the height of such ladder exceeds six meters, the resting platforms shall be provided on such ladder at every six meters of its height and where the distance between last platform so provided and the top end of such ladder is more than two meters then on such top end.

7.16 **RIGGING OF DERRICKS:**

a) Every derrick shall have current and relevant rigging plans and any other information necessary for the safe rigging of such derrick and its gear.

7.17 **SECURING OF DERRICK FOOT:**

a) Appropriate measures shall be taken to prevent the foot of a derrick from being lifted out of its socket or supports.

7.18 **CONSTRUCTION AND MAINTENANCE OF LIFTING GEAR**

a) Every lifting gear shall be –

- of good design and construction, sound material and adequate strength to perform the work for which it is used;
- free from patent defects; and
- properly maintained in good repair and working order;

b) Components of the loose gear, at the time of its use, shall be renewed if one of its dimensions at any point has decreased by ten per cent or more;

c) A chain shall be withdrawn from use when it is stretched and increased in length which exceeds five per cent of its length or when a link of such chain is deformed or is otherwise damaged or defects in the welds have appeared on it;

d) Rings, hooks, swivels and end links attached to a chain shall be of the same materials as that of such chain;

e) The voltage of electric supply to any magnetic lifting device shall not fluctuate by more than plus or minus 10%.

7.19 TEST AND PERIODICAL EXAMINATION OF LIFTING GEARS

a) A lifting gear shall be initially tested for the manufacturer by a competent person in a manner specified as per schedule annexed before taking into use or after undergoing any substantive alterations which renders its any part liable to affect its safety and such gear alter such test shall subsequently be retested for the use of its owner at least once in every five years;

b) A lifting gear in use shall thoroughly examined once at least in every twelve months by a competent person;

c) A chain in use shall be thoroughly examined at least once every month by a responsible person for its use;

d) Certificates of initial and periodical test and examinations of loose gears shall be obtained in the form annexed.

7.20 **ROPES**

a) No rope shall be used for building or other construction work unless –

- It is of good quality and free from patent defects; and
- In the case of wire rope, it shall be tested and examined by a competent person in the manner annexed;

b) Every wire rope of lifting appliance or lifting gear used for building or other construction work shall be inspected by a responsible person for such use, once at least in every there month;

c) Provided that after if any such wire is broken in such rope, the responsible person shall thereafter inspect it once at least in every month and ensure that;

d) No wire rope shall be used for building or other constructing work if in any length of eight diameters of such wires, the total number of visible broken wires exceed ten per cent of the total number of wires in such rope, or such rope shows signs of excessive wear, corrosion or other defects which in the opinion of the person who inspects it, is unfit for use;

e) Eye splices and loops of ropes for the attachment of hooks, rings and other such parts to wire rope shall be made with suitable thimble;

f) A thimble or loop splice made in any wire rope sling shall conform to the following standards, namely:

- Wire rope sling shall have at least three tucks with full strand of rope and two tucks with one-half of the wires cut out of each of such strand in all cased, such strands shall be tucked against the lay of the rope;
- Protruding ends of such strands in any splice of wire rope slings shall be covered or treated so as to leave no sharp points;
- A fiber rope or a rope sling shall have at least four tucks, tail of such tuck being whipped in a suitable manner; and
- A synthetic fiber rope or rope sling shall have at least four tucks with full strands followed by further tuck with one-half filaments cut out of each of such strand and final tuck with one-halt of the remaining filaments cut out from such strands. Any portion of the splices containing such tucks, with reduced number of filaments, shall be securely covered with suitable tape or other materials;

g) Provided further that nothing contained above shall apply where any other form of splice, which may be shown to be as efficient as the splice with above standards, shall be used.

7.21 HEAT TREATMENT OF LIFTING GEARS

a) All chains other than bridle chains attached to derricks and all rings, hooks, shackles and swivels used in hoisting or lowering of such derricks shall be effectively annealed under supervision of a competent person and at the following intervals, namely:

- Such chains, rings, hoods, shackles and swivels which are not more than twelve and a half millimeter of length annealed at least once in every six months; and
- All other such chains rings hooks shackles and swivels shall be so annealed at least once in every twelve months;

b) Provided that the clause (a) above shall not apply to -

c) Pitched chins, working on sprocket or sprocket wheels;

d) Rings, hooks and swivels permanently attached to pitched chains, pulley blocks or weighing machines, and

e) Hooks and swivels having ball bearings or other case hardened parts;

f) A chin or a loose gear made of high tensile steel or alloy steel shall be plainly marked with a mark indicating that it is so made;

g) No chain or loose gear made of high tensile steel or alloy steel shall be subjected to any form of heat treatment except where such treatment is necessary for the purpose of repair of such chain or loose gear and that such repair shall be made under the direction of the competent person;

h) That the wrought iron gear, the past history of which is not traceable, shall be suspected of being heat treated at incorrect temperature shall be normalized before using it on any building or other construction work.

7.22 **CERTIFICATE TO BE ISSUED AFTER ACTUAL TESTING AND EXAMINATION ETC:**

a) A competent person shall issue a certificate after actual testing or examination of the apparatus specified and record of such test or examination shall be maintained for inspection.

7.23 REGISTER OF PERIODICAL TEST, EXAMINATION AND CERTIFICATION THEREOF

a) A register in the form annexed shall be maintained and particulars of such test and examination of lifting appliances, lifting gears and heat treatment as required shall be entered in such register;

b) Certificate in respect of each of the following shall be obtained from a competent person:

c) i) In cases of initial and periodical test and examination of the lifting appliances such as Winches, Derricks and their accessory gears, Cranes or Hoists and their accessory gears;

d) In case of test, examination and re-examination of loose gears;

e) In case of test and examination of wire ropes;

f) In case of heat treatment and examination of loose gears;

g) In case of annual thorough examination of the loose gears, except where required particulars of such exemption have been enclosed in the register referred to in Form annexed and such certificates are attached to the register referred to as above and certificates kept at such construction site in case such register and certificate relate to lifting appliances, loose gear and wire ropes and

h) Produced on demand and retained for at least five years after the date of the last entry made in such register;

i) No lifting appliance or lifting gear in respect of which an entry is required to be made in register referred to above and certificate of test and examination are required to be attached in such register in the manner as specified, shall be used for building or other construction work unless the required entries have been made in such register and certificates.

7.24 VACUUM AND MAGNETIC LIFTING GEAR

a) No vacuum lifting gear, magnetic lifting gear or any other lifting gear where the load on it is held by adhesive power, shall be used while workers are performing operations beneath such gear;

b) A magnetic lifting gear used in connection with building or other construction work shall be provided with an alternative supply of power, such as batteries, which may come into operation immediately in the event of failure of the main power supply;

c) No building worker shall work within the swinging zone of the lifting gear or load or building or other construction material suspended to such lifting gear.

7.25 KNOTTING OF CHAINS AND WIRE ROPES:

No chain or wire rope with a knot in it shall be used in building or other construction work.

7.26 CARRYING OF PERSONS BY MEANS OF LIFTING APPLIANCES ETC.

a) No building worker shall be raised, lowered or carried by a power driven lifting appliance, except

- On the drive's platform in the cage of a crane; or

- On as hoist; or
- On an approved suspended scaffold;

b) Provided that a building worker may be raised, lowered or carried by a power driven lifting appliance:

c) In circumstances where the use of a hoist or of a suspended scaffold shall not reasonably be practicable, or

d) On an aerial cableway or aerial ropeway, provided further that the following requirements are met:

e) That the appliance referred to above can be operated from one position only and that

f) Any winch used in connection with the appliance shall also comply with the requirements as laid down above.

g) The appliance referred to above shall not carry any person except:

h) In a chair or cage,

i) In a skip or other receptacle at least three feet deep which shall be suitable for safe carriage of a person and any such chair, cage, skip or other receptacle shall be made of good construction, sound material, and adequate strength and properly maintained with suitable means to prevent any occupant therein from falling out of it and shall be free from any material or tools which may interfere with the handhold or foothold of such occupant or otherwise endanger him; and

j) Those suitable measures shall be taken to prevent the chair, cage skip or other receptacle from spinning or tipping in a manner dangerous to any occupant therein.

7.27 HOISTS CARRYING PERSONS

a) No building worker shall be carried with the help of a hoist unless it is provided with a cage which:

- Is so constructed as to prevent, when its gates are shut, any building worker carried by such hoist from falling out of it or from being trapped between any part of such cage and any fixed structure or other moving part of such hoist or from being struck by articles or materials falling down the hoist way on which such hoist is moving; and

- Is fitted on each of its side from which access is provided to a landing place with a gate which has efficient interlocking or other devices to secure so that such gate cannot be opened except when such cage is at a landing place and that such cage cannot be moved away from any such place until such gate is closed;

b) Every gate in the hoist way enclosure of such hoist used for carrying persons shall be fitted with efficient interlocking or other devices to secure so that such gate cannot be opened except when the cage of such gate is at the landing place and that such cage cannot be moved away from the landing place until such gate is closed;

c) In every hoist used for carrying building workers there are provided with suitable and efficient automatic devices to ensure that the cage of such hoist comes to rest at a point above the lowest point to which such gave may travel.

7.28 ATTACHMENT OF LOADS

a) When a sling is used to hoist long materials, a lifting beam shall be used to space the sling legs for proper balance and when a load is suspended at two or more points with slings, the eyes of the lifting legs of such slings shall be shackled together and such shackled or eyes of the shackled slings shall be placed on the hook or the eyes of such lifting legs shall be shackled directly to the hoisting block, ball or balance beam, as the case may be;

b) Every container or receptacle used for raising or lowering stone, bricks tiles, slates or other similar objects shall be so enclosed with the hoist as to prevent the fall of such objects;

c) A loaded wheel barrows placed directly on a platform of a hoist for raising or lowering of such wheel barrows shall be so secured that such wheel barrows cannot move and such platform shall be enclosed to prevent the fall of the contents kept in such wheel barrows;

d) Landings of hoists shall be so designed and arranged that building workers on such hoist be not required to lean out into empty space for loading and unloading on any material from such hoist.

7.29 TOWER CRANES

a) No person other than the operator trained and capable to work at heights shall be employed to operate tower cranes;

b) The ground on which a tower crane stands shall have adequate bearing capacity;

c) Bases for tower cranes and trucks for rail mounted tower cranes shall be firm and leveled and such cranes erected at a reasonably safe

distance from excavations and operated within gradient limits as specified by the manufacturer of such cranes;

d) Tower cranes shall be sited where there is a clear space available for erection, operation and dismantling of such cranes;

e) Tower cranes shall be sited in such a way that the loads on such cranes shall not be handled over any occupied premises, public thoroughfares, railways or near power cables, other than construction works for which such cranes are used;

f) Where two or more tower cranes are sited and operated, every care shall be taken to ensure positive and proper communication between operators of such cranes to avoid any dagger or dangerous occurrences;

g) Tower cranes shall not be used for loading magnet, or demolition ball service, piling operation or other similar operations which could impose excessive load stresses on the crane structure of such cranes;

h) The instruction of the manufacturer of a tower crane and standard safe practices regarding such cranes shall be followed while operating or using such cranes.

7.30 QUALIFICATION OF OPERATOR OF LIFTING WINCHES AND OF SIGNALER ETC.

a) No person shall be employed to drive or operate a lifting appliance whether driven by mechanical power or otherwise or to give signals to driver of operator of such lifting appliance or to work as an operator of a rigger or derricks unless he is

- Sufficiently competent and reliable;
- Possesses the knowledge of he inherent risks involved in the operation of lifting appliance;
- Medically examined periodically as specified and
- Is above eighteen years of age.

8.0 SAFETY IN THE USE OF TRANSPORT, EARTHMOVING EQUIPMENT & OTHER CONSTRUCTION MACHINERY

8.1 **EARTHMOVING EQUIPMENT AND VEHICLES**

a) All vehicles and earthmoving equipment shall be made of good material, proper design and sound constructional and be sufficiently strong for the purpose for which such equipment are properly used in accordance with standard safe operating practices;

b) Provided that the truck or trailer employed for transporting freight containers shall be of the size sufficient to carry the containers, without over hanging and provided with twist locks conforming to approved standards, at all the four corners of each of such use by an authority under the relevant law for the time being in force and is inspected by a responsible person, at least once in a month and record of such inspection shall be maintained:

c) All transport or earth moving equipment and vehicles shall be inspected at least once a week by a responsible person and in case any defend is noticed in such equipment or vehicle it shall be immediately taken out of use;

d) Power trucks and tractors shall be equipped with effective brakes, headlights and tail lamps and maintained in good repair and working order;

e) Side stanchions on power trucks and trailers for crying heavy and long objects shall be

- Of sound construction and free from defects;

- Provided with tie chains attached to the top across the loads for preventing such stanchions from spreading out; and
- Kept in position while loading and unloading;

f) Safe gangways provided for to and fro movement of building workers engaged in loading and unloading of lorries, trucks, trailers and wagons;

g) Trucks and other equipment shall not be loaded beyond their safe capacity and carry workers engaged in loading and unloading of lorries, trucks trailers and wagons in an unsafe condition;

h) Handles of trucks shall be so designed as to protect the hands of the building workers working on such trucks, or such handles provided with knuckle guards;

i) No unauthorized person shall ride the transport equipment employed in such work;

j) A driver of a transport equipment shall maneuver such equipment under the direction of a signaler;

k) Adequate precaution such as isolating the electric supply or erecting overhead barriers of a safe height shall be taken when earth moving equipment or vehicles are required to operate in dangerous proximity to any live electric conductor;

l) Vehicles and earth moving equipment shall not be left on a slope with the engine of such vehicles or equipment running;

m) All earth moving equipment, vehicles or other transport equipment shall be operated only by such person who are adequately trained and

possess such skills as required for safe operation of such equipment, vehicle or other transport equipment.

8.2 POWER SHOVELS AND EXCAVATOR

a) A shovel or an excavator whether operated by steam or electric or by internal combustion, shall be constructed, installed, operated, tested and examined as per approved standards;

b) Excavator equipped for use as a mobile crane shall be examined and tested in accordance with the requirements for such mobile cranes as laid down by the manufacturer; and

c) Fitted with an automatic safe working load indicator;

d) Buckets or grabs of power shovels shall be propped to restrict the movement of such buckets or grabs while being repaired or while the teeth of such buckets or grabs are being changed.

8.3 BULLDOZER

e) Operator of every such bulldozer before leaving the dozer shall take the following steps:

f) Apply the brakes;

g) Lower the blade and sipper and

h) Put the shift lever into neutral;

i) Dozer left on level ground at the close of the work for which such bulldozer is used;

j) The blade of a bulldozer kept low when such bulldozer is moving uphill;

k) The bulldozer blades not used as brakes except in an emergency.

8.4 SCRAPERS

a) A tractor and scraper shall be joined by safety line at the time of its operation;

b) The scraper bowls shall be propped while blades of such scraper are being replaced;

c) A scraper moving downhill shall not be left in gear.

8.5 MOBILE ASPHALT LAYERS & FINISHERS

a) A mixture elevator shall be located within a wooden or sheet metal enclosure with a window for observation, lubrication and maintenance;

b) Bitumen scoops shall have adequate covers;

c) When asphalt plants are working on public road, adequate traffic control shall be established on such road and the building workers working with such plant provided with reflective jackets;

d) A sufficient number of fire extinguishers shall be kept in readiness at such workplace where fire hazards may exist;

e) The materials shall be loaded on the elevator after the drying drain has warmed up of such elevator;

f) No open light shall be used for ascertaining the level of asphalt;

g) Inspection opening shall not be opened till there is a pressure in the boiler, which may cause injury to building workers.

8.6 PAVERS:

Pavers shall be equipped with guards suitable to prevent building workers from walking under the skip of such pavers.

8.7 **Road rollers:**

Before a road roller is used on the ground, such ground shall be examined for its bearing capacity and general safety, especially at the edges of slopes such as embankment on such grounds and shall not be moved downhill with the engine out of gear.

8.8 **GENERAL SAFETY IN RESPECT OF POWERED CONSTRUCTION MACHINERY**

a) Every vehicle or earthmoving equipment shall be equipped with -

- Silencers;
- Tail lights
- Power and hand brakes;
- Reversing alarm; and
- Search light for forward and backward movement, which are required for safe operation of such vehicle or earthmoving equipment;

b) The cab of vehicle or earthmoving equipment shall bee kept at least one meter from the adjacent face of a ground being excavated;

c) When cranes of shovel are traveling, the boom of such crane or shovel shall be in the direction of such travel and the bucket or scoop attached to such crane or shovel raised and without load except when such traveling is downhill.

9.0 9.0 SAFETY IN THE PROVISION OF RUNWAYS AND RAMP

9.1 USE OF RUNWAYS AND RAMPS:

a) Runway or ramps shall not be less than 430 mm in width and constructed of not less than 25 mm thick planking or any other material of adequate strength to withstand the required load, supported substantially in relation to the span and braced with such runway or ramp, and design and construction of such runway or ramp shall be in accordance with the approved standards;

b) Every runway or ramp located more than 3 m above the floor or ground shall be on open sides and provided with a guardrail of adequate strength and height of not less than 1 m.

c) Use of runways and ramps by vehicles:

- All runways and ramps shall be of sound construction, strength and securely braced and supported;
- Every runway or ramp for the use of transport equipment like trailers, trucks or heavier vehicles shall have a width of not less than 3.7 m and provide with timber curbs or any other material of adequate strength with not less than 200 mm by 200 mm in width placed parallel to, and secured to, the sided of such runway or ramp and such runways or ramps or ramps shall be designed in accordance with the approved standards.

9.2 SLOPE OF RAMPS:

Every ramp shall have a slope not exceeding one in four and the total rise of a continuous ramp used by building workers carrying material or using wheelbarrows shall not exceed 3.7 m, unless broken by horizontal landing of at least 1.2 m in length.

9.3 USE OF RUNWAYS OR RAMPS BY WHEELBARROWS, ETC.

Every runway or ramp used for wheelbarrows and carts or hand trucks shall not be less than 1 m width and constructed of not less than 50 mm thick planking, and supported and braced suitably for such use;

Every runway or ramp located more than 3 m above the floor or ground shall be provided on the open sides with suitable guardrails of adequate strength.

10.0 SAFETY IN HANDLING AND USE OF EXPLOSIVES

10.1 **GENERAL PROVISIONS:**

a) The use of explosives shall be carried out in a safe manner to avoid injury to any person and under the direct supervision of a responsible person;

b) No person other than authorized and competent one shall be allowed to handle and use explosives;

c) Before using any explosive, necessary warning and danger signals shall be erected, at conspicuous places of such use to warn the building workers and the general public of the danger involved in such use.

d) No person other than authorized and competent one shall be allowed to handle and use explosives.

e) Smoke, open lamps, other type of hot or heat producing items and sparks shall be prohibited in or near explosives magazines or while explosives are being handled, transported or used.

f) No person shall be allowed to handle or use explosives while under the influence of intoxicating liquors or dangerous drugs.

g) The explosives shall be accounted for at all times. No explosives or blasting agents shall be abandoned.

h) No fire shall be fought where the fire is in the imminent danger of contact with explosives. All employees shall be removes to a safe area and the fire area shall be guarded against intruders.

i) Employees authorized to prepare explosive charges or conduct blasting operations shall use every reasonable precaution including but not limited to

visual and audible warning signals, flags, or barricades to ensure employee safety.

j) Due precautions shall be taken to prevent accidental discharge of electric blasting caps from current induced by induced voltage, lightning, adjacent power lines, dust storms, or other sources of extraneous electricity or otherwise. These precautions shall include:

- Short-circuiting of detonators in holes, which have been primed and shunted until wired into the blasting circuit.
- The suspension of all blasting operations and removal of persons from the blasting area during the approach and progress of an electric storm.

k) The prominent display of adequate signs, warning against the use of radio transmitters, on all roads within 1000 ft of blasting operations. Whenever adherence to the 1000 ft distance would create an operational handicap, a competent and expert person shall be consulted to evaluate the particular situation, and an alternative provided, which are adequately designed to prevent any premature firing of electric blasting of caps. A description of any such blasting shall be reduced to writing and shall be certified as meeting the purposes of this subdivision by the competent person consulted. The description shall be maintained at the construction site during the duration of the work, and shall be available for inspection.

l) Empty boxes and paper and fiber packing materials, which have previously contained high explosives, shall not be used again for any purpose, but shall be destroyed by burning at an approved location.

m) Explosives, blasting agents and blasting supplies that are obviously deteriorated or damaged shall not be used.

n) Delivery and issue of explosives shall only be made authorized persons into authorized magazines or approved temporary storage or handling areas.

o) Blasting operations in the proximity of overhead power lines, communication lines, utility services, or other services and structures shall not be carried on until the operators and/or owners have been notified and measures for safe control have been taken. In such situations controlled blasting shall be restored to.

p) All loading and firing shall be directed and supervised by competent persons thoroughly experienced in this field.

q) Loaded boreholes shall not be left unattended after the end of the shift.

r) Suitable and sufficient means of egress to ground level shall be provided in all cases of excavations, trenches, all other places where explosives are handled above or below ground level.

s) At an appropriate time before the final blasting warnings, workers in the area shall be removed to a designated safe place.

t) An unmistakable, audible, final warning shall be sounded one minute prior to the detonation of explosives; after completion, when the person in charge has established that safe conditions prevail, an “all clear” shall be sounded.

u) To prevent persons entering any danger zone during blasting operations notices shall be given to all concerned.

v) Notices referred above shall indicate:

w) that explosives are in use;

x) the audible warning sound and the “all clear” and state when they will be sounded; and

y) the warning flags in use, including an “all clear” flag.

z) Precautions against lightning shall be provided in accordance with the Indian Electricity Act and Indian Explosives Act and Rules and regulations framed there under.

aa) Package containing explosives shall not be dragged, dropped or handled roughly.

bb) Non-sparking tools shall be used to open keys.

cc) The explosives shall not be carried in the box or otherwise on any individual.

dd) Nothing shall be inserted in the open end of the blasting cap except fuses.

ee) Deteriorated or damages explosives shall not be used but shall be disposed or destroyed strictly in accordance with the approved methods and in the doing so the manufacturers or the appropriate authority's instructions shall be followed.

ff) lightning shall be in accordance with Indian Electricity Act/Rules

10.2 TRANSPORTATION OF EXPLOSIVES

a) Keep safe distance and to use non-sparking tools while opening packages containing explosives;

b) Stop the use of explosives and handling thereof while the weather conditions are not suitable for such use or handling;

c) Due precautions shall be taken to prevent accidental discharge of electric blasting caps from current induced by induced voltage, lightning, adjacent power-lines, dust storms or other sources of extraneous electricity or otherwise. These precautions shall include –

d) Suspension of all blasting operations and evacuation of persons;

e) All warning signs shall be displayed within 200 m of blasting operations and in case putting up a sign at 200 m is impractical, the contractor shall consult the Engineer-in-charge for alternatives;

f) All loading and firing shall be directed and supervised by competent persons thoroughly experienced in the field;

g) To prevent persons entering any danger zone during blasting operations, notices shall be given to all concerned;

h) In addition to these provisions, all measures and precautions that are required to be observed for use, handling, storing or transportation of

explosives under the Rules framed under the Explosives Act, 1884 (4 of 1884) shall be observed;

i) All the relevant statutory provisions, local laws and rules and regulations shall be complied with.

j) Where the magazine is located near the construction site and blasting operation continues daily, actual requirement of explosives shall be drawn from the magazine and transported to the site. Any leftovers shall be returned to the magazine each time after the blast. In case of work at scattered places and for a small duration, portable magazines shall be used and kept within a fence in safe place and properly guarded.

k) For carrying higher quantity (more than 5 kg of explosives) specially designed insulated containers shall be used. These containers shall be constructed of finished wood not less than 5cm thick or plastic not less than 6mm thick or pressed fibre not less than 10mm thick. There shall be no metal parts (not even nails, bolts, screws etc.) and the containers shall be provided with suitable non-conductive carrying device, such as rubber, leather or canvas handle or strap.

l) Vehicles to be used for transportation explosives shall be in good working condition and shall have a tight wooded or non-sparking metal (copper, brass and the like) floor with sides and ends high enough to prevent the explosives from failing off the vehicle. In open bodied vehicles, the explosives shall be covered with a waterproof and fibre tarpaulin.

m) Electrical wiring in vehicle shall be fully insulated so as to prevent the danger of short- circuiting and at least two fire extinguishers of carbon dioxide type shall be carried. The vehicle shall be properly marked indicating adequate warning to the public in regard to the nature of cargo.

n) No metals except approved metal truck shall be allowed to come in contact with cases of explosives, metal, flammable, or corrosive substance shall not be transported with explosives. As far as possible, transportation of any material along with explosives shall be prohibited.

o) Smoking shall be prohibited in the vehicle carrying explosives.

p) No unauthorized person shall be allowed in the vehicle, carrying explosives.

q) Loading and unloading of explosives shall be done carefully.

r) Explosives and detonators or blasting caps shall not be permitted to be transported in the same vehicle.

s) Detonators and other explosives for blasting shall be transported to the site of work in the original containers or in securely locked separate non-metallic containers and shall not be carried loose or mixed with other materials.

10.3 STORAGE OF EXPLOSIVES AND BLASTING AGENTS

a) Explosives and related materials shall be stored in approved facilities.

b) Blasting caps, electric blasting caps, detonating primers, and primed cartridges shall not be stored in the same magazine with other explosives or blasting agents.

c) Smoking and open flames shall not be permitted within 50 feet of explosives and detonators storage magazine.

d) No Explosives or blasting agents shall be permanently stored in any underground area until the area has been developed to the point where at lease two modes of exit have been provided.

e) Permanent underground storage magazine shall be at least 300 feet from any shaft or other active under ground working area.

f) Permanent underground magazines containing detonators shall not be located closer than 50 feet to any magazine containing other explosives or blasting agents.

10.4 **DRILLING AND LOADING**

a) Before planning out the drilling operations for blasting purposes, nature of stratum and the over burden shall necessarily be examined to avoid possibilities of landslides after blasting.

b) The face or rock shall be carefully examined before drilling to determine the presence of unfired explosives. No attempt shall be made to drill at a site if un-detonated explosives are suspected. In such case the boreholes shall be thoroughly cleaned before a cartridge is

c) inserted. Wooden tamping rods (not pointed, but cylindrical throughout) shall be used in the charging the holes. The cartridge will be on the top.

d) The borehole shall be carefully checked for length, presence of water dust, etc. with a wooden temping pole or a measuring tape before loading.

e) Surplus explosives shall not be stacked near working areas during loading/unloading.

f) The line of detonating fuse extending into a borehole shall be cut from the spool before loading the remainder of the charge.

g) A bore shall not be loaded with explosives after springing (enlarging the hole with explosives) or upon completion of drilling without making sure it is cool and it does not contain any hot smoldering material. Temperatures in excess of 65o C are dangerous.

h) A bore near another hole loaded with explosives shall not be sprung.

i) No force shall be used for inserting cartridges or any explosives into a bore hold or pass any obstruction in a borehole.

j) No force shall be used for inserting a blasting cap or an electric blasting cap into explosive. The cap shall be inserted into a hole made with a pickers designed for the purpose. A hitch of the electric blasting cap leading wire shall be made on the primer cartridge so as to prevent pulling out the electric blasting cap from the explosive charge. In case of fuse, the fuse shall be tied to the explosive cartridge so that the blasting cap is not pulled out. Care shall be taken so that the blasting cap is not pulled out. Care shall be taken so that the electric blasting cap, leading wire or the length of the fuse does not get damaged during loading of the charge.

k) No attempt shall be made to slit, drop, deform or abuse the primer.

l) Blasting caps or electric blasting caps shall not be connected to detonating fuse except by methods recommended by the manufacturers of caps.

m) Explosive cartridge shall not be cut, nor explosive removed from the cartridge for use.

n) Metallic devices of any kind shall not be used in tamping. Wooden tamping tools with not exposed metal parts except non-sparking metal connectors for jointed poled shall be used. Violent tamping shall be avoided. Primer shall not be tamped.

o) Care shall be taken to confine the explosives in the bore hold with sand, earth clay or other suitable combustible stemming material.

p) Kinking or injuring of fuse or electric blasting cap wires shall be avoided when tamping.

10.5 **ELECTRICAL SHOT-FIRING CIRCUIT**

a) In deciding the sizes of wires, fuses, circuits, blasting switches, etc., instructions issued by the manufacturers of these articles shall be followed, if they do not contradict with Indian Explosives Act or framed under it.

b) No person shall attempt to uncoil the wires and open out the short-circuited bare leading wires of the electric blasting cap during approach of dust storm or near any source of large charge of static electricity or near a radio transmitter. The manufacturer of the cap or the Inspectorate of Explosives shall be consulted regarding the distance from the transmitter beyond which electric short firing shall be conducted.

c) Firing circuit shall be kept completely insulated from the ground of the other conductors, such as wires, rails, pipes or other paths or stray current.

d) There shall not be any electric live wires or cables of any kind near electric blasting caps or other explosives except at the time and for the purpose of firing the blast.

e) All electric blasting caps shall be tested singly and also when connected in a circuit in series using only an approved type of circuit continuity tester or ohmmeter.

f) No attempt shall be made to use in the same circuit either electrical blasting caps made by more than one manufacturer or electric blasting caps of different design or function even if made by the same manufacturers unless such use is approved by the manufacturers.

g) No attempt shall be made to fire a circuit of electric blasting caps with less than the minimum current specified by the manufacturer of that electric blasting cap.

h) Care shall be taken to ensure that all wire ends to be connected are bright and clean.

i) The electric cap wires or leading wires shall be kept short circuited until ready to fire.

j) When energy for blasting is taken from power circuits the voltage shall not exceed 220v. The wiring controlling arrangements shall conform to the following:

k) The blasting switch shall be strictly according to the specifications, externally operated double-throw switch, which when locked in the open

position will short circuit and ground the leading wires. The switch shall be installed at the location where the firing is to be controlled.

l) A ‘safety’ switch of the same type as the blasting switch shall be installed between the blasting switch and the firing circuit and lead lines, at a distance not to exceed 180cm from the blasting switch.

m) Both the safety switch and the blasting switch shall be locked in the open position immediately after the shot and before any person is permitted to return to the blasting area. Key to the switches shall remain in the possession of the blaster at all times.

n) Rubber covered or other adequately insulated copper wires in good condition shall be used for firing lines and shall have solid cores of appropriate gauge. Sufficient firing line shall be provided to permit the blaster to be located at a safe distance from the blast. Single conductor lead lines shall be used.

o) Blasting operations in the proximity of overhead power lines, communication lines, utility lines, or other structures shall not be carried on until the operator or the owner, or both of such lines as been notified and precautionary measures deemed necessary, have been taken.

p) All holes loaded on a shift shall be fired on the same shift.

q) As far as possible, blasting shall be carried out using suitable exploder with 25 per cent excess capacity. Electric power from the mains shall be used only when it is absolutely necessary.

10.6 **SHOT-FIRING WITH SAFETY FUSE**

a) The fuse shall be carefully handled to avoid damaging the covering. In very cold weather the fuse shall be slightly warmed before using so as to avoid cracking the waterproofing.

b) Short fuse shall not be used. The length of a fuse shall not be less than 120cm. The rate of burning of the fuse shall be known and it would be necessary to make sure that it will take sufficient time in burning so as to enable all persons to reach a place of safety. The burning rate of the fuse shall not be more than 60 cm/min.

c) The fuse shall not be cut until the operation to insert the fuse into a blasting cap is ready. The fuse shall be cut off about 2.5 to 5 cm to ensure a dry end. It shall be cut squarely across with a clean and sharp blade. The fuse shall be seated lightly against the cap charge and care shall be taken to avoid twisting after it has been placed in position.

d) Blasting caps shall not be crimped by any means except by a cap crimper designed for the purpose. It shall be necessary to make sure that the cap is squarely crimped to the face.

e) The fuse shall be lighted with a fuse lighter designed for the purpose. If a match is used, the fuse shall be slit at the end and the match head held in then slit against the power core and then the match head rubbed against an abrasive surface to light the fuse.

f) The fuse shall not be lighted until sufficient stemming has been placed over the explosives to prevent sparks of live match heads from coming into contact with the explosives.

g) The explosives shall not be held in hands when lighting the fuse.

10.7 **UNDERGROUND WORK**

a) Only permissible explosives and in the manner as specified by the appropriate authority shall be used.

b) Excessive quantities of explosives shall not be taken underground at any time. Black blasting powder or pellet powder shall not be used with any other explosive in the same borehole.

10.8 **BEFORE AND AFTER FIRING**

a) Before firing, sufficient warning shall be given to enable the people working in the area to get off the danger zone. The danger zone shall be suitable cordoned off and flag men posted at important points.

b) No loose materials, such as tools, drilling implements etc. Shall be left on the rock surfaces to be blasted.

c) Blasting in the open shall be carried out during the fixed hours every day or on fixed days in the week. This information shall be amply publicized and the following precautions observed:

- On the project sites, where blasting operations are carried out, daily blasting hours shall be clearly printed on the sign-boards on all the roads approaching that area.
- Road closing barriers should be provided to close the traffic on these roads, at least 400 meters away when the firing is to take place.

d) The beginning of the firing shall follow loud sirens and similarly loud sirens shall succeed the completion of the firing.

e) The shot-firer shall not be allowed to return to the blasting site after firing, until at least 5 min have elapsed. In case of electric shot firing, the shot holes shall be examined after firing and in case of misfire no person shall be allowed to approach the blasting site for at lease 5 min. In case of shot firing with safety fuse, utmost care shall be taken to count the number to ensure that all the shots have fired and in the event of misfire, no person shall be allowed to approach the blasting site for at least 30 min. In any case, a careful inspection for the remaining un-detonated explosive shall be made after firing the shots. All misfired shot holes shall be cross-marked. No other person than those duly authorized shall approach the holes until one of the following operations has been performed in respect of each of the misfired holes:

f) If the misfire is due to a faulty cable or faulty electrical connection the defect shall be remedied and the shot fired.

g) The stemming shall be floated out by use of water or air jet from hose until the hole has been opened to within 60 cm of the charge, whereupon water will be siphoned or pumped out, then a fresh new charge placed and duly detonated. Or

h) A careful search shall be made of unexploded material in the debris of the charge.

i) If a shift charge is unavoidable, the person in-charge of one shift before leaving the work shall inform the person relieving him for the next shift of any cases misfired and shall point out their position duly cross marked and also state clearly what action has to be taken in the matter.

Note: The rules are made considering statutory provisions and other National/International standards. However, if any statutory provision

overruling these laws is made, the statutory provisions shall overrule the CIL Rules.

11.0 SAFETY IN EXCAVATION & TUNNELING WORK

A. SAFETY IN EXCAVATION

11.1 GENERAL PROVISIONS

j) Before undertaking any activity, the soil shall be tested and in case of availability of any explosive gas, necessary arrangements must be made to remove/dilute such gases and in case they are found to be toxic or poisonous, the workplace must be purged and continuous ventilation maintaining the contamination below the permissible level ensured;

k) The position of underground installations such as sewers, water pipes and electrical cables shall be verified and in case of their existence, they must be isolated;

l) If they cannot be isolated or removed or shutdown, they shall be fenced, hung up or otherwise protected. On every part likely to be visited by persons or where transport vehicles ply, the area shall be suitably fenced, guarded or barricaded to prevent fall of persons, vehicles or livestock into the excavated area;

m) Warning signs shall be erected and the in the night hours the area shall be illuminated to warn pedestrians and vehicular traffic;

n) Arrangements shall be made to prevent external vibrations due to rail/road traffic;

o) Blasting shall be carried out in accordance with the norms applicable in this regard. Special care shall be taken to control the impact of vibrations/tremor caused by blasting to protect excavations from cave-ins;

p) Arrangements shall be made to save other buildings/structures in the affected zone or in the vicinity of the area of excavation, from collapse;

11.2 **SHORING AND TIMBERING**

a) Site of excavations, where workers are exposed to danger from moving ground, shall be made safe by maintaining due slope not exceeding the angle of repose of different types of soil or otherwise by shoring, portable shields or other effective means;

b) All trenches in the soil, other than rock or hard compact soil more than 1.5 m deep into which men enter, shall be securely shored and timbered under the supervision of a competent person and only the trained workers shall be allowed to substantially alter or dismantle the shoring or timbering;

c) All struts, braces and walls in excavation shall be adequately secured so as to prevent their accidental displacement;

d) In all excavations in soft or fissured rock or hard soil exceeding 2 m in depth, except those which are sloped to within 1.5 m of the bottom into which men enter, shall be securely shored and timbered;

e) Where the sides of the excavations are sloped as outlined above, but not within the 1.5 m of the bottom, vertical sides shall be shored and the shoring shall extend at least 30 cm above the vertical sides. When open spaced sheathing is used, a toe-board shall be provided to prevent material rolling down the slope and falling into the excavated.

11.3 **SHEATHING**

a) The sheathing should be placed against the side of the trench so that length of each piece of sheathing is vertical. It should be held securely in place against the wales by ensuring that sheathing is kept firmly pressed against the wall of the trench. Where the trench excavated is loose, sandy or soft soil or soil which has been previously excavated or soil which is under hydrostatic pressure, each piece of sheathing shall be driven into the bottom of the trench so as to firmly hold it in place;

b) Where two or more pieces of sheathing are used one above another, the sheathing shall be so arranged that the lower pieces of sheathing shall overlap the lowest wales supporting the piece of sheathing next above it. These pieces of sheathing shall be firmly driven into the soil and securely supported by wales and struts, as the trench is made deeper.

11.4 **WALES**

The wales shall be parallel to the bottom or the proposed bottom of the trench. Each wale shall be supported on cleats spiked to the sheathing or by posts set on the wales next below it and in the case of the lowest wale on the bottom of the trench itself. Where necessary, wedges may be provided between a wale and the sheathing it supports so that roughly uniformity is given to all individual pieces of sheathing.

11.5 **STRUTS**

a) Struts shall be horizontal and at right angles to the wales or sheathing supported thereby. Struts shall be cut to the proper length required to fit in tightly between the wales. Where necessary, the struts shall be held securely in place by wedges, driven between the struts and the wales;

b) Struts shall be placed on cleats spiked or bolted to the posts supporting the Wales.

11.6 LOOSE SITE MATERIALS:

a) No loose material shall be kept very close to the excavation creating possibility of its fall into the excavated area. A safe distance of at least 1 m shall be maintained.

11.7 PLANT & MACHINERY:

Movement of vehicles and heavy equipment shall be kept at a distance least equal to the depth of the excavation or at least 6 m for excavation deeper than 6 m and the workers shall be provided with proper tools.

11.8 MEANS OF ACCESS

a) For trenches deeper than 1.5 m, safe means of access and egress shall be provided at intervals of every 15 m. Where it is not possible to provide safe means of access and egress as above, ladders shall extend from the bottom of the trench to at least 90 cm above the ground;

b) Walkways, runways and sidewalks shall be kept clear of excavated materials or other obstructions and no side walls shall be undermined-undercut unless it is capable of carrying a minimum live load of 125 lbs per square feet;

c) If planks are used for raising walkways, runways or sidewalks, they should be parallel to the length of the walk and fastened together against displacement;

d) Lone worker shall not be allowed to work in the excavated area.

11.9 INSPECTIONS:

A competent person shall make inspections every day and necessary measures shall be taken to safeguard against possible cave-ins or slide or collapse of the excavations.

11.10 NOTIFICATION OF INTENTION TO CARRY OUT EXCAVATION AND TUNNELING WORK

a) Within thirty days, prior to the commencement of such excavation or tunneling work, the contractor shall inform in writing the detailed layout plans, method of construction and schedule of such excavation or tunneling work to the Engineer in-charge of CIL;

b) In case compressed air is used in such excavation or tunneling work or any work incidental to or required for such excavation or tunneling work, the technical details and drawings of all man-locks and medical-locks together with names and addresses of all construction medical officers duly qualified and so appointed by such contractor for the purpose of such excavation or tunneling work shall be sent to the Engineer in-charge.

11.11 PROJECT ENGINEER

a) The contractor undertaking any excavation or tunneling work shall appoint a Project Engineer for safe operation of such projects;

b) Such Project Engineer shall exercise overall control of the operations and the activities at such project and be responsible for carrying out the activities safely.

11.12 RESPONSIBLE PERSON

a) The contractor undertaking excavation or tunnel ling work at construction site of a building or other construction work shall appoint a responsible person for safe operation of such excavation or tunneling work;

b) The name and addresses of such responsible persons shall be forwarded to the Engineer in- charge;

c) Duties and responsibilities of the responsible person referred to above person shall include

d) To carry out smoothly such excavation or tunneling work;

e) To inspect and rectify any hazardous situation relating to such excavation or tunneling work;

f) To take remedial measures to avoid any unsafe practice or conditions relating to such excavation or tunneling work.

11.13 **WARNING SIGNS AND NOTICES**

a) Suitable warning signs or notices, required for the safety of building workers carrying out the work of an excavation or tunneling, shall be displayed or erected at conspicuous places in Hindi and in language understood by the majority of such building workers at such excavation or tunneling work;

b) Such warning signs and notices with regard to compressed air working shall include:

c) The danger involved in such compressed air work;

d) Fire and explosion hazards;

e) The emergency procedures for rescue from such danger or hazards.

11.14 **REGISTER OF EMPLOYMENT**

a) The contractor shall ensure that at a construction site of a building or other construction work where an excavation or tunneling work is being carried

on, a register of employment of building workers carrying out such excavation or tunneling work is maintained and produced on demand;

b) Periods of work of such excavation or tunneling work shall be maintained in a register on day- to-day basis and such register shall be produced on demand.

11.15 **ILLUMINATION**

a) All contractors carrying out excavation or tunneling work at a construction site of a building or other construction work shall provide for emergency generators on such construction site to ensure adequate illumination at all work places where such excavation or tunneling work is being carried out;

b) In case of power failure, all workplaces where excavation or tunneling works are carried out shall be adequately illuminated

11.16 **PNEUMATIC TOOLS:**

Supply lines to pneumatic tools used within a tunnel are fitted with water trap or safety chain or safety wire, as the case may be.

11.17 **STABILITY OF STRUCTURE DURING GENERAL EXCAVATION & TUNNELING:**

a) The contractor shall ensure that where there is any doubt as to the stability of any structure adjoining the workplace or other areas to be excavated or where tunneling work is to be carried out –

- The Project Engineer shall arrange for measures like underpinning, sheet piling, shoring, bracing or other similar means to support such structure and to prevent injury to any building worker working adjacent

to such structure or damage to property or equipment adjacent to such structure;

- Where any building worker engaged in excavation is exposed to hazard of falling or sliding material or article from any bank or side of such excavation which is more than 1.5 m above his footing, such worker shall be protected by adequate piling and bracing against such bank or side;

b) The excavation and its vicinity shall be checked by a responsible person after every rain, storm or other occurrences carrying hazards and in case a hazard is noticed at such checking, adequate protection against slides and cave-in to prevent such hazard shall be provided;

c) Temporary sheet piling installed for the construction of a retaining wall after excavation shall not be removed, except on the advice of the responsible person after an inspection carried out by such responsible person;

d) Where banks of an excavation are undercut, adequate shoring shall be provided to support the material or article overhanging such bank;

e) Excavated material shall not be stored at least 0.5 m from the edge of an open excavation or trench and the banks of such excavation or trench shall be stripped of loose rocks and other materials which may slide, roll or fall upon a building worker working below such bank;

f) Adequate and suitable warning signs shall be put-up at conspicuous places at the excavation work to avoid any person falling into the excavations or trenches;

g) The responsible person shall ensure at the excavation that no building worker is permitted to work where such building worker may be struck or endangered by the excavation machinery or material or article used in such excavation.

11.18 **SAFE ACCESS AND EGRESS:**

Ladders, staircases or ramps are provided, as the case may be, for safe access to and egress form excavation where the depth of such excavation exceeds one point 1.5 m and such ladders, staircases or ramps comply with the relevant national standards.

11.19 **TRENCHES**

a) A trench or excavation shall be protected against falling of a person by suitable measures if the depth of such trench or excavation exceeds 1.5 m and such protection shall be an improved protection in accordance with the design and drawing of a Professional Engineer, where such depth exceeds 4 m;

b) Where the depth of a trench requires two lengths of sheet piling, one above the other, the lower piling shall be set inside the bottom strings or wales of the upper piling and such sheet piling shall be driven down and braced as the excavation continues;

c) All metal sheet piles used in excavation or a trench shall be welded end-to-end and secured by other similar means.

11.20 **POSITIONING AND USE OF MACHINERY:**

a) Any machinery used in excavation and tunneling work shall be positioned and operated in such a way that such machinery will not endanger the operator of such machinery or any other person in the vicinity.

11.21 **BREATHING APPARATUS:**

a) Suitable breathing apparatus shall be provided to a building worker while working in compressed air environment for his use at excavation or tunneling work and such breathing apparatus shall be maintained in good working condition at all times.

11.22 **SAFETY MEASURES FOR TUNNELING OPERATIONS**

a) Where there is a danger of falling or sliding of material from the roof face or wall of a tunnel, adequate measures such as shoring, supporting by means of rock bolts, segments or steel sets shall be taken for the safety of building workers;

b) The excavated areas shall be made safe by use of suitably designed and installed steel sets, rock bolts or similar other safe means;

c) The responsible person shall examine and inspect the workplaces in a tunnel before the commencement of work in such tunnel and at regular intervals thereafter to ensure safety of the building workers in such tunnel;

d) The portal areas of a tunnel with loose soil or rock, likely to cause injury to a person shall be adequately protected with supports.

11.23 **SURROUNDINGS OF A SHAFT**

a) Surroundings of a shaft used in excavation or tunnel work shall be protected from being washed away by construction of sufficient height;

b) Where a building worker is required to enter a shaft at an excavation or tunneling work, safe means of access shall be provided for such entry;

c) Every shaft at excavation or tunneling work shall be provided with a steel casing, concrete piping, timber shoring or other materials of adequate strength for the safety of building workers working in such shaft;

d) Such casing and bracing shall be provided to shafts at an excavation or tunneling work according to the appropriate design for such casing and bracing;

e) A reinforced concrete raft and beam shall be provided around the opening of a shaft at an excavation or tunneling work if the ground surrounding such opening is unstable or unsafe.

11.24 **LIFT FOR SHAFT:**

Lift shall be provided for transport of building workers and materials or articles at an excavation or tunneling work required to descend more than 50 m in a shaft.

11.25 **MEANS OF COMMUNICATION**

a) Reliable and effective means of communication such as telephone or walkie-talkie shall be provided and maintained in working order for arranging better and effective communication at an excavation or tunneling work at the following locations, namely:

- Working chamber of an excavation;
- Intervals of hundred meters along the tunnel;
- Working chamber side of a man lock near the door of such man lock;
- Interior or each chamber of a man lock;
- Location conspicuous lock attendant’s situation;
- A compressor plant;
- A first-aid station, and
- Outside the portal or the top of a shaft;

Such number of bells and whistles shall be made available at all times at the locations as are necessary for the safety of persons at such locations.

11.26 **SIGNALS:**

a) The standard audio or video signals shall be used in excavation or tunneling work and conspicuously located or displayed near entrance to the workplace and in such other locations as may be necessary to bring such signals to notice of all building workers employed in such excavation or tunneling work.

11.27 **CLEARANCES**

The minimum lateral clearances of 0.5 m shall be maintained between any part of a vehicle and any fixture or any equipment used in an excavation or tunneling work after allowing the throw or swing of such fixture or equipment;

The overhead clearance for a locomotive drive at excavation or tunneling work shall not be less than 1.20 m above the seat of such driver and not less than 2 m above the platform where such driver stands or of any other dimension in accordance with the approved standard.

11.28 **SHELTERS:**

The adequate number of shelters for the safeguard of the building workers are provided where, in the course of working, they are liable to be struck by a moving vehicle or other material handling equipment in a tunnel.

11.29 **USE OF INTERNAL COMBUSTION ENGINE:**

No internal combustion engine shall be used underground in excavation or tunneling work unless such engine is so constructed that the air entering the engine gets cleared before entry and the engine emits no fumes or sparks.

11.30 **INFLAMMABLE OILS:**

Inflammable oils with the flash point below the working temperature that is likely to be encountered in a tunnel shall not be used in excavation or tunneling work.

11.31 **COUPLING AND HOSES:**

All high-pressure hydraulic hoses and couplings shall be adequately protected against any possible damage in excavation or tunneling work.

11.32 **HOSE INSTALLATION:**

All hydraulic lines and plants working at a temperature exceeding 750 c shall be protected by adequate insulation or otherwise against accidental human contact in excavation or tunneling work.

11.33 **FIRE RESISTANT HOSES:**

No fire hydraulic hoses other than fire resistant hydraulic hoses are used when hydraulically activated machinery and equipment are employed in tunnels.

11.34 **FLAMEPROOF EQUIPMENT:**

Only flameproof equipment of appropriate type as per approved standards shall be used where there is a danger of flammable or explosive atmosphere being prevalent inside the tunnel.

11.35 **STORING OF OIL AND FUEL UNDERGROUND:**

All oils, greases or fuels stored underground in excavation or tunneling work shall be kept in tightly sealed containers and in fire resistant areas at safe distances away from explosive and other flammable chemical and appropriate flameproof installation shall be used in such storage areas.

11.36 **USE OF GASES UNDERGROUND**

a) Petrol or liquefied petroleum gas or any other flammable substances shall not be used or stored inside the tunnel except with the prior approval of the Project Engineer;

b) After the use of the petroleum or liquefied petroleum gas, or highly inflammable substances, all remaining petroleum or liquefied petroleum gas or highly inflammable substances shall be removed immediately from such tunnel;

c) No oxy-acetylene gas shall be used in a compressed air environment in excavation or tunneling work.

11.37 **WATER FOR FIRE FIGHTING**

a) Adequate number of water outlets shall be provided on excavation or tunneling work and readily made accessible throughout the tunnel for fire fighting purposes and such water outlets shall be maintained for effective fire lighting;

b) All air locks shall be equipped with fire fighting facilities at excavation or tunneling work;

c) An audible fire alarm shall be provided to warn the building workers whenever a fire breaks out on an excavation or tunneling work;

d) Adequate number and types of fire extinguishers, in accordance with relevant national standards, shall be provided and made readily available to fight any outbreak of fire at an excavation or tunneling work;

e) Fire extinguishers with vaporizing liquids and high pressure carbon dioxide shall not be used in tunnels or other confined spaces;

f) The instructions regarding steps to be followed to fight outbreak of fire, at an excavation or tunneling work, written in Hindi or local language understood by the majority of the building workers employed on such excavation or tunneling work, shall be displayed at conspicuous and vulnerable places of such excavation or tunneling work.

11.38 **FLOODING**

a) Water tight bulkhead doors shall be installed at the entrance of a tunnel to prevent flooding during a tunneling work where more than one tunnel is driven from a shaft;

b) All necessary measures shall be taken to ensure that no building worker is trapped in any isolated section of a tunnel when any bulkhead door of such tunnel is closed;

c) Where there is likelihood of flooding or water rushing into a tunnel during a tunneling work, arrangements shall be made for immediate starting of water pumps to take out water of such flooding or water rushing and for giving alert signals to the building workers and other persons to keep them away from danger.

d) Airtight steel curtains shall be provided in areas liable to flooding at tunneling work and in case of descending tunnels, such curtains shall be provided in the top half of such tunnels to ensure the retention of pockets of air for rescue purpose.

11.39 **REST SHELTERS**

a) Where building workers employed in a compressed air environment in a tunneling work are required to remain at the work site for one hour or more

after de-compression from pressure exceeding one bar, adequate and suitable facilities shall be provided for such building workers to rest;

b) Every man-lock, medical-lock and any other facility inside these locks in a tunneling work shall be maintained in a clean state and in good repairs;

c) A first-aid room shall be provided and readily available at a construction site of a tunneling work;

d) Each man-lock attendant at the station shall be provided with a first-aid box.

11.40 **PERMISSIBLE LIMIT OF EXPOSURE OF CHEMICALS**

a) The working environment in a tunnel or a shaft in which building workers are employed shall not contain any of the hazardous substances in concentrations beyond the permissible limits;

b) The responsible person referred to shall conduct necessary test before the commencement of a tunneling work for the day and at suitable intervals as fixed by the Engineer in-charge, to ensure that the permissible limits of exposure are not exceeded and a record of such test shall be maintained and made available for inspection.

11.41 **VENTILATION:**

All working areas in a free air tunnel shall be provided with the approved ventilation system and the fresh air supplied in such tunnel shall not be less than 6 m^3 per minute for each building worker employed underground in such tunnel and the free air-flow movement inside such tunnel not less than 9 m^3 per minute.

11.42 **AIR SUPPLY INTAKE POINT:**

The air intake points for all air compression shall be located at places where such intake air does not get contaminated with dust, fumes, vapor and exhaust gases or other contaminants.

11.43 **EMERGENCY GENERATORS**

Every compressed air system in a tunnel shall be provided with emergency power supply system for maintaining continued supply of compressed air in such compressed air system, which shall be capable of operating air compressor and ancillary systems of such compressed air system;

The emergency power supply system shall be maintained and made readily available at all times.

11.44 **AIR MAINS:**

Every air-main supplying air to the working chamber, man-lock or medical-lock used at an excavation or tunneling work shall be protected against accidental damage and where it is not practicable to provide such protection, a stand-by air-main shall be provided.

11.45 **BULKHEAD AND AIR LOCKS**

a) A bulk head or air tight diaphragms retaining compressed air, when used within a tunnel or a shaft, shall be constructed to withstand the maximum pressure at 1.25 the maximum working pressure of such bulk head or diaphragm and such bulk head or diaphragm shall be tested before its each use by a responsible person to ensure that such bulk head or diaphragm is in proper working order;

b) Such responsible person shall keep the record of each test and such record shall be produced for inspection.

c) The bulk head or diaphragm shall be made of sound material of adequate strength, which shall be able to withstand the maximum pressure on which they are subjected to at any time of their use;

d) A bulkhead anchorage and air lick shall be tested at its work place at an excavation or tunneling work immediately after their installation at such place.

11.46 **DIAPHRAGM:**

All diaphragms, which are in the form of horizontal decks across a shaft used at excavation or tunneling work, shall be securely anchored.

11.47 **PORTABLE ELECTRICAL HAND TOOLS:**

All portable electrical hand tools and inspection lamps used underground or in a confined space shall be operated at a voltage not exceeding 24 V.

11.48 **CIRCUIT BREAKER**

Adequate numbers of differential ground fault circuit breakers shall be installed for every electrical distribution system and its sub-systems used at an excavation or tunneling;

Work and the sensitivity of each of circuit breaker shall be adjusted in accordance with the requirement set out in accordance with the approved standards;

No semi-enclosed fuse unit shall be used in underground place.

11.49 **TRANSFORMER:**

The contractor shall ensure no transformer is used in any section of a tunnel under compressed air unless such transformer is of the dry type and conforms to the approved standards.

11.50 **LIVE WIRES:**

There shall be no exposed live wire in working areas at an excavation or tunneling work which are accessible to building workers other than those authorized to work on such live lines.

11.51 **WELDING SETS:**

All welding sets used in a tunnel shall be of adequate capacity and of suitable type, duly approved.

11.52 **QUALITY AND QUANTITY**

Every working chamber at an excavation or tunneling work where compressed air is used, the supply of such air shall be maintained at not less than 0.3 m^3 per minute per person working therein;

A reserve supply of compressed air shall be made available at all times for man-locks and medical locks used at a tunneling work;

The air supplied in a compressed air environment at a tunneling work shall be, as far as practicable, free from contaminants, namely, dust, fumes and other toxic substances.

11.53 **WORKING TEMPERATURE:**

The temperature in any working chamber at an excavation or tunneling work where building workers are employed shall not exceed 29^0 c and the arrangement shall be maintained for kipping records in which the temperatures measured by dry bulb and wet bulb inside such working chamber once in every hour and for producing such records for inspection on demand.

11.54 **MAN-LOCKS AND WORKING IN COMPRESSED AIR ENVIRONMENT**

a) Man-locks used at a tunneling work shall be of adequate strength, made of sound material and designed to withstand any pressure, internal or external, to which it may be subjected in the normal use or in an emergency;

b) Doors of man-locks at an excavation or tunneling work shall be made of steel and used at a tunneling work for keeping the work airtight and devices shall be provided for sealing the doors when such locks are under pressure. The anchorage of a man-lock used at tunneling work shall have adequate strength to withstand the pressure exerted by air on the man-lock. There shall be adequate room available for the workers for working in the man-locks;

c) Where work is carried out in any compressed air tunnel, a Man-lock in accordance with the approved standards shall be used;

d) Where a man-lock is used, safety Instructions in Hindi and in local language understood by majority of building workers employed there, shall be displaced at conspicuous places;

e) Except in an emergency, compression and de-compression operations shall be carried out in a man-lock and in an emergency any material-lock may be used;

f) A record of compression and de-compression shall be kept in writing and produced for inspection on demand;

g) Material lock shall be used with the permission of the Engineer in-charge where it is impracticable to install both the man-lock and the material-lock at;

h) The man-lock at tunneling work shall not be used for any purpose other than compression or de-compression of building workers;

i) No de-canting of building workers at tunneling work shall be carried

j) out without prior approval of the Engineer in-charge except in an emergency;

k) In case a building worker collapses or is taken ill during his de-compression in a man-lock, the lock attendant of such man-lock shall raise the pressure to a level equal to the maximum pressure which that building worker was exposed to in the working chamber prior to such de-compression and such lock attendant shall immediately report the matter relating to such collapse to the medical lock attendant and medical officer on duty;

l) A building worker who had previously received training with a trained building worker to work in a compressed air environment at tunneling work shall be employed to work independently in such a compressed air environment;

m) A building worker who had undergone three de-compressions from a pressure exceeding one bar in a period of eight hours at tunneling work shall not be allowed to enter a compressed air environment except for the purpose of carrying out rescue work;

n) A building worker employed in a compressed air environment for a period of eight hours in a day at tunneling work shall not be employed again in such environment unless he has spent not less than twelve consecutive hours of rest at atmospheric pressure;

o) No building worker shall be engaged in a compressed air environment at a pressure, which exceeds three bars at a tunneling work unless prior permission, in writing, has been obtained from the Engineer in-charge;

p) No building worker shall be employed in a compressed air environment for more than fourteen consecutive days in a month;

q) A register of employment of all building workers in compressed air environment shall be maintained;

r) An identification badge shall be supplied to a building worker employed in compressed air environment;

s) The badge of a building worker shall contain particulars of his name, location of the medical-lock allotted to him for work, the telephone number of the Construction Medical Officer concerned for his treatment and the instructions in case of his illness of unknown and doubtful causes;

t) Record of all identification badges supplied to building shall be kept in a register;

u) Every building worker whose name appears in the register shall wear the badge supplied to him at all times during his duty hours;

v) Suitable warning signs shall be displayed in the compressed air for the prohibition of the following, namely:

w) Use of alcoholic drinks;

x) Use and carrying of lighters, matches or other sources of ignition;

y) Smoking; and

z) No entry to person who has consumed alcoholic drink

11.55 **SAFETY INSTRUCTION:**

All building workers employed in compressed air environment at tunneling work shall follow the instructions issued for their safety in the course of such employment.

11.56 **MEDICAL-LOCK**

a) A suitably constructed medical lock shall be maintained at tunneling work where building workers are employed in a working chamber at a pressure exceeding one bar;

b) Where more than one hundred building workers are employed in a compressed air working environment exceeding one bar at tunneling work, one medical-lock is provided for every one hundred building workers or part thereof and such medical lock shall be situated as near as possible to the main-lock used at such tunneling work.

12.0 SAFETY IN PILING WORK

12.1 **GENERAL PROVISION**

a) All pile driving equipment shall be of good design and sound construction, taking into account the ergonomic principles and properly maintained;

b) A pile driver shall be firmly supported on a heavy timber sill, concrete bed or other secured foundation;

c) In case a pile driver is required to be erected in dangerous proximity to an electrical conductor, all necessary precautions shall be taken to ensure safety;

d) The hoses of steam and air hammer shall be securely lashed to such hammer so as to prevent them from whipping in case of connection or break;

e) Adequate precaution shall be taken to prevent the pile driver from over turning and hammer from missing the pile;

f) A responsible person for inspecting pile-driving equipment shall inspect such equipment before taking it into use and takes all appropriate measures as required for the safety of building workers before commencing piling work by such equipment;

g) Where there is any question of stability of a structure for its adjoining areas to be piled, such structure shall be supported, where necessary, by underpinning, sheet pilling, shoring, and bracing or by other means to ensure safety and stability of such structure and to prevent injury to any person.

12.2 **PROTECTION OF OPERATOR:**

The operator of every pile driving equipment shall be protected from falling objects, steam, cinders or water by substantially covering or otherwise or by other means.

12.3 INSTRUCTION TO AND SUPERVISION OF BUILDING WORKERS WORKING ON PILE-DRIVING EQUIPMENT:

Every building worker working on a pile driving equipment shall be given instructions regarding safe work procedure to be followed in piling operation and shall be supervised by a responsible person throughout such work.

12.4 ENTRY OF UNAUTHORIZED PERSON:

The contractor shall ensure at a construction site of a buildings or other construction work that all piling areas where pile-driving equipment is in use are effectively cordoned off to prevent entry of unauthorized persons.

12.5 INSPECTION AND MAINTENANCE OF PILE DRIVING EQUIPMENT

a) Pile-driving equipment shall not be taken into use until it has been inspected by a responsible person and found to be safe for such use;

b) A responsible person for such inspection at suitable intervals to ensure safety to the building worker working on such equipment shall inspect pile driving equipment in use;

c) All pile lines and pulley blocks shall be inspected by a responsible person before the beginning of each shift of piling operations.

12.6 OPERATION OF PILE-DRIVING EQUIPMENT

a) Only experienced and trained building worker shall operate pile driving so as to avoid any probable danger from such operation;

b) Pile-driving operations shall be governed generally prevalent and accepted signals so as to prevent any probable danger from such operations;

c) Every building worker employed in pile driving operation or in the vicinity of such pile driving operation shall wear ear protection and safety helmet or hardhat and safety shoes;

d) Piles shall be prepared at a distance, at least equal to twice the length of the longest pile, from the place of pile-driving operations;

e) When a pile driver is not in use, the hammer of such pile driver shall be blocked at the bottom of the heads of such pile driver.

12.7 **WORKING PLATFORM ON PILING FRAMES:**

Where a structural tower supports the lead of a pile driver, leads at which it is necessary for the building workers to work and such platforms except on the hammer of such pile driver or lead sides of such platform and where such platforms cannot be provided with such railing and toe boards, a safety belt shall be provided to each such building worker.

12.8 **PILE TESTING**

a) The testing of pile shall be conducted under the supervision of a responsible person for such testing;

b) All practicable measures like displaying of waning notices, barricading the area and other similar measures shall be taken to protect the area where the pile testing is carried out;

c) Entry to a pile testing area shall be prohibited to general public to ensure safety.

12.9 **PILING, SHORING AND BRACING**

a) Planks used for sheet piling in excavation or tunneling work shall be of sound material with adequate strength;

b) Shores and braces used in excavation or tunneling work shall be of adequate dimensions and so placed as to be effective for their intended purposes;

c) Earth supported shores or braces used in excavation or tunneling work shall bear against a footing of sufficient area and stability to prevent the shifting of such shores or braces.

13.0 SAFETY IN THE ERECTION, USE AND DISMANTLING OF SCAFFOLDS

13.1 **SCAFFOLD CONSTRUCTION**

a) Every scaffold and every component thereof shall be of adequate construction, made of sound material and free from defects and safe for the purposes for which it is intended for use;

b) In case bamboo is used for scaffolding, such bamboo shall be of suitable quality, good condition, free from protruding knots and stripped off to avoid any injury to building workers during handling such bamboo;

c) All metal scaffolds used in building or other construction work shall conform to the approved standards;

13.2 **SUPERVISION BY A RESPONSIBLE PERSON:**

No scaffold shall be erected, added, altered or dismantled except under the supervision of a responsible person.

13.3 **Maintenance**

a) The scaffold used in building or other construction work shall be maintained in good repairs and the measures taken against its accidental displacement or any other hazard;

b) No scaffold or part thereof shall be partly dismantled and allowed to remain in such a condition unless –

c) The stability or safety of the remaining portion of such scaffold has been ensured by a responsible person for the safety of such scaffolds;

d) In case the remaining part of such scaffold cannot be used by the building workers, necessary warning notice written in Hindi and in a language

understood by the majority of the building workers that such scaffold is unfit for use, shall be displayed at the place where such scaffold is erected.

13.4 STANDARDS, LEDGERS, PUTLOGS

a) Standards of a scaffold shall be plumb, where practicable, fixed sufficiently close together to secure the stability of such scaffold having regard to all the possible working situations and conditions for the intended use of such scaffold, spaced, as close as practicable, to ensure safety and stability of such scaffold;

b) Adequate measures are taken to, prevent displacement of a standard of a scaffold either by providing sole plate or a base plate, as necessary;

c) Ledgers of metal scaffold are placed at vertical intervals with due regard to safety and stability of such scaffold;

d) Bamboo ledgers are kept as nearly as possible and are placed and fastened to the standards of a scaffold with due regard to the stability of such scaffold.

13.5 WORKING PLATFORM

a) Working platform shall be provided around the face or edge of a building adjoining at every upper most permanent floor of such building under construction and at any level where construction work of such building is carried out;

b) A platform shall be designed to suit the number of building workers to be employed on each bay of a scaffold work on such platform and the materials or articles and tools to be carried with them in such bay;

c) The safe working load and the number of building workers to be employed in each bay of a scaffold shall be displayed for the information of all the building workers employed at such construction site.

13.6 BOARD, PLANK AND DECKING

a) Board, plank and decking used in the construction of a working platform shall be of uniform size and strength and shall be capable of supporting the load and number of building workers keeping in view the safety of such building workers;

b) Metal decking, which forms part of a working platform, shall be provided with non-skid surface;

c) No board or plank which forms the working platform shall be projected beyond its end support unless it is effectively prevented from tripping or lifting and board, plank or decking shall be fastened and secured;

d) At any one time, not more than two working platforms per bay, shall be used to support building workers or materials or articles at such bay;

e) Adequate measures shall be taken to prevent injury which may be caused by falling material and objects by using safety nets or other suitable means;

f) Concrete, other debris or materials shall not be allowed to accumulate at any platform on a scaffold;

g) Where a work is to be done at the end of a wall, working platform at such workplace shall be faced or, wherever practicable, at least 0.6 m beyond the end of such wall.

13.7 REPAIR OF DAMAGED SCAFFOLD

a) No building worker shall be permitted to work on a scaffold that has been damaged or wakened unless adequate safety measures have been taken to ensure the safety of such building worker;

b) Necessary warning signs shall be displayed at such places where repairs of scaffold are undertaken.

13.8 **OPENING**

a) There shall be no opening in any working platform except for allowing access to such working platform;

b) Wherever opening on a platform is unavoidable, necessary measures for protection against failing of objects or building workers from such platform shall be taken by providing suitable safety nets, belts or any other similar means;

c) Access from one working platform to another platform on a scaffold, if required, shall be provided with suitable and safe ladder for the use of building workers working on such platforms;

d) Every opening or shaft in the floor shall be provided with suitable means to protect the fall of a person or material by providing suitable fencing or railing of height not less than 900 mm.

13.9 **GUARDRAILS:**

Every side of a working platform from which a person is liable to fall shall be provided with suitable and safe guardrails and toe board of adequate strength to prevent fall of any building worker, material or tools from such platform.

13.10 **SCAFFOLD USED BY BUILDING WORKERS OF DIFFERENT EMPLOYERS**

a) Where a scaffold or a part of a scaffold is used, which has previously been used by another employer for his building workers, such scaffold or part thereof shall be used only after its inspection and examination by a responsible person for ensuring that such scaffold or part thereof is safe and fit for such use;

b) If any rectification, alteration or modification in a scaffold or part thereof, needed to suit its use, shall be made in consultation with the responsible person.

13.11 **PROTECTION AGAINST ELECTRIC POWER LINE:**

The contractor shall ensure that all necessary and practical measures for protection are taken to prevent any building worker, working on a scaffold, from coming into contact with the electric wires or dangerous equipment.

13.12 **SCREENING NET AND WIRE NETS:**

Where a scaffold is erected in an area where the construction activities may pose hazards to pedestrians or vehicular traffic nearby from the falling of objects, wire nets or screening nets shall be used to envelope such scaffold.

13.13 **TOWER SCAFFOLD**

a) The height of every tower scaffold used in building or other construction work shall not be more than eight times the lesser to the base dimension of such scaffold;

b) A tower scaffold shall be lashed to a building or a fixed structure before being used by the building workers;

c) Any tower scaffold which can be moved or castered shall be –

- Constructed with due regard to the stability and, if necessary, adequately weighted at the base;
- Used only on plain and even surface; and
- Has casters provided with positive locking devices to hold such scaffold in position;

d) No building worker shall remain on board scaffold or leave behind tools and material when it is being shifted from one position to another position.

13.14 GEAR FOR SUSPENSION OF SCAFFOLD

a) Chains, ropes or lifting gears used for suspension of a scaffold shall be of adequate strength, made of sound material and suitable for the purpose of their use and maintained in good repairs;

b) Chains, wires, ropes or metal tubes used for the suspension of a scaffold shall be:

- Properly and securely fastened to every anchorage point and to the scaffold ledgers of other main supporting members used for the support of such scaffold; and
- So positioned as to ensure stability of the scaffold.

13.15 TRESTLE SCAFFOLD AND CANTILEVER SCAFFOLD

a) No trestle scaffold shall be constructed with more than three tiers or if its working platform is more than 4.5 m above the ground or floor or other surface upon which such scaffold is erected;

b) Trestle scaffold shall be designed by professional engineer and shall have the approval of the Engineer in-charge before being taken into use.

c) No trestle scaffold shall be erected on a suspended scaffold;

d) No cantilever or jib scaffold shall be used unless it is adequately supported, fixed and anchored on opposite side of its support and have out triggers of adequate length and, where necessary sufficiently, supported and braced to ensure safety and stability of such scaffold;

e) No working platform resting on bearers let into a wall at one end and without other support shall be used unless such bearers are of adequate strength, braced through the wall and securely fastened on the other side.

13.16 SCAFFOLD SUPPORTED BY BUILDING

a) No part of a building shall be used as support or part of a scaffold unless such part of the building is made of sufficient strength and made of sound material to afford safe support;

b) Overhanging eaves gutters shall not be used for supporting scaffold;

c) Suspended scaffold shall be made of in accordance with the approved standards before being used by the building workers.

13.17 USE OF WINCHES AND CLIMBERS FOR SUSPENDED SCAFFOLD

a) No scaffold shall be raised or lowered by winches or climbers unless such scaffold is made of sound material, adequate strength and has been tested and certified safe for use of winches or climber by a competent person before being taken into use;

b) All suspended scaffolds counter-balanced by counter weights shall be of approved types before being taken into use for building or other construction work;

c) The working platform of a suspended scaffold shall be securely fastened to the building or structure as to be safe and to prevent such platform from swing;

d) The safe working load that a suspended scaffold can carry, shall be displayed where such scaffold is being used.

13.18 SAFETY DEVICES FOR SUSPENDED SCAFFOLD

a) Every suspended scaffold, raised or lowered by the winches or climbers, shall be provided at each of its suspension point with a safety rope with automatic safety device mounted on each of such rope so that such safety rope with such automatic safety device support the platform of such scaffold in the event of failure of the primary suspension wire ropes, winches, climbers or any part of the mechanism used for raising or lowering such suspended scaffold;

b) Provided that the clause (a) shall not apply -

- Where the platform of such scaffold is supported at two independent suspension wire rope at or near each end of such platform so that in the event of failure of one of such suspension wire rope, the other wire rope is capable of sustaining the weights of such platform and its load and prevent it from tilting; or

- Where a system is incorporated which operates automatically to support the platform of such scaffold and its load in the event of failure of the primary suspension wire rope of such scaffold.

14.0 SAFETY IN THE ERECTION OF STRUCTURAL FRAME & FORMWORK

14.1 **GENERAL PROVISION**

a) The trained building worker under the direct supervision of a person, responsible for structural frame and formwork, shall be employed for erection of such structural frame or formwork, dismantling of building and structure and performance of and engineering work formwork, false work and shoring work;

b) Adequate measures shall be taken to guard against hazards arising from any temporary state of weakness or unsuitability of a structure.

14.2 **FORMWORK, FALSE WORK AND SHORING**

a) Formwork and false work shall be so designed, constructed and maintained that such formwork and false work are able to support the load that may be imposed on them;

b) Such formwork shall be so erected that working platform, means of access, bracings, means of handling and stabilizing could easily be fixed with such formwork.

14.3 **ERECTION OR DISMANTLING OF STEEL AND PREFABRICATED**

a) Erection or dismantling of any pre-fabricated structure shall be made safe against danger by using appropriate means such as ladders, gangways or fixed platforms, buckets, boatswains chair or other appropriate means suspended from lifting appliances, safety harness, life lines, catch nets or catch platforms, power-operated mobile working platforms etc.;

b) The work of erection or dismantling of buildings or structures or formwork or false work or shoring or any other civil engineering work shall be

carried out by trained building workers under the supervision of a person responsible for such work;

c) Steel or prefabricated structures shall be so designed and made that such structures can be safely transported or erected; and weight of each unit of such structures shall be clearly marked on such unit;

d) The design of each such part shall maintain stability of each part of the structures referred to in clauses above when erected, and to prevent danger, the design shall explicitly take into account –

e) The relevant conditions and methods of attachment in the operations of stripping, transport, storing and temporary support during erection of such parts;

f) Safeguards, such as provision of railings with working platforms, and for mounting such railings and platforms easily on the structural steel or prefabricated parts;

g) The hooks and softer devices built in or provided on the structural steel or prefabricate parts that are required for lifting and transporting such parts shall be so shaped, dimensioned and positioned to withstand the stresses to which such hooks or other devices are subjected;

h) Prefabricated parts made of concrete shall not stripped or erected before such concrete has set and hardened sufficiently to the extent provided for in the plans, and such parts are examined by the responsible person for any sign of damage before their use;

i) Store-places shall be so constructed that –

j) There shall be no risk of structural steel of prefabricated parts falling or overturning;

k) Storage conditions shall generally ensure stability and avoid damage having regard to the method of storage and atmospheric conditions; and

l) Racks shall be set on firm ground and designed so that units cannot move accidentally in such store-places;

m) Structural steel or pre-fabricated parts shall not be subjected to stresses prejudicial to their stability while they are stored or transported or raised or set down;

n) Tongs, clamps and other appliances for lifting structural steel and prefabricated part shall be:

o) In such shape and dimensions as to ensure a secure grip without damaging and marked with the maximum permissible load in the most unfavourable lifting conditions; and

p) Structural steel or pre-fabricated parts shall be lifted by such methods and appliances that prevent them from spinning accidentally;

q) Structural steel or pre-fabricated parts shall be provided with railings and working platforms before raising such parts to prevent any danger of falling of building workers, materials or articles at the time of any work with such parts;

r) All reasonably practical measures shall be taken to avoid injury to building workers, building structure or equipment while structural steel or pre-fabricated parts are handled or stored or transported or raised or lowered;

s) Structures shall not be worked on during violent storms or high winds or any other such hazardous situation;

t) The risk of falling to which building workers, moving on high or sloping girders, may be exposed is limited by all means of adequate collective protection or by the use of a safety harness which shall be well secured to a sufficiently strong supports;

u) Structural steel parts, which are to be erected at a great height, shall, as far as practicable, be assembled on the ground;

v) When structural steel or pre-fabricated parts are being erected, a sufficiently extended area underneath the workplace shall be barricaded or guarded;

w) Steel trusses, which are being erected, shall be adequately shored, braced or guyed until they are permanently secured in position;

x) Structural members shall not be forced into place by the hoisting machine while any building worker is in such a position that he is likely to be injured by such operation.

14.4 **FORMWORK**

a) All formwork shall be properly designed keeping in view the safety of building workers, buildings or structures;

b) A responsible person for structural frame and formwork shall –

c) Inspect and examine the material, timber, structural steel and scaffolding for its strength and suitability before being taken into use;

d) Lay-down procedures to cover all stages of such structural frame and formwork;

e) Supervise such structural frame and formwork;

f) Take all necessary steps or measure to correct any situation with a view to prevent accident or dangerous occurrence during performances of such structural frame and formwork.

14.5 **DE-SHORING**

a) When shoring is removed, sufficient props shall be left in place of such shoring to prevent any possible hazard; and

b) Deshoring shall be adequately braced and tied together with support to prevent any hazard.

15.0 SAFETY IN CONCRETE WORK

15.1 **GENERAL PROVISIONS REGARDING USE OF CONCRETE**

a) All construction with the use of concrete or reinforced concrete shall be based on plans including specification of steel and concrete and other material to be used in such construction –

- Giving technical details regarding methods for safe placing and handing of such materials and indicating the type, quality and arrangement of each part of a structure of such construction; and
- Explaining the sequence of steps to be taken for completion of such construction;

b) Formwork and shores used for concrete work shall be structurally safe and properly braced or tied together so as to maintain position and shape of formwork or shores;

c) Formwork structure used shall have sufficient catwalks and other secure access for inspection of such structure if such structure is in two or more tiers;

d) No machinery or any object should fall below by using wire nets, screen nets etc.

15.2 **PREPARATION AND POURING OF CONCRETE AND ERECTION OF CONCRETE STRUCTURE**

a) A building worker handling cement or concrete shall –

- Wear close-fitting clothing, gloves, helmet or hardhat, safety goggles, proper footwear and respirator or mask to protect himself from danger in such handling;

- Keep as much of his body covered as is required to protect himself from danger in such handling;
- Take all necessary precautions to keep cement and concrete away from his skin in such handling;

b) Lime pits shall be fenced or enclosed and filled and emptied by such devices, which do not require workers to go into the pit;

c) Moving parts of the elevators, hoists screens bunkers, chutes, grouting equipment used for concrete work and of other equipment used for storing, transport and other handling ingredients of concrete shall be securely fenced to avoid contact of building workers with such moving parts;

d) Screw conveyors used for cement, lime and other dusty materials shall be completely enclosed.

15.3 **BUCKETS**

a) Concrete buckets used with cranes or aerial cableways shall be free from projections from which accumulations of concrete could fall;

b) Movements of concrete buckets shall be governed by signals necessary to avoid any danger by such movements.

15.4 **PIPES AND PUMPS**

a) A scaffolding carrying a pipe for pumped concrete shall be strong enough to support such pipe at a time when such pipe is filled with concrete or water or any other liquid and carry the combined load of the all the building workers who may be on such scaffold at such time, safely;

b) Every pipe for carrying pumped concrete shall be –

- Securely anchored at its end point and at each curve on it;
- Provided near the top of such pipe with an air release valve;
- Securely attached to a pump nozzle by a bolted collar or other adequate means;

c) The operation of concrete pumps shall be governed by standard signals;

d) Building workers employed around a concrete pump shall wear safety goggles;

15.5 **MIXING AND POURING OF CONCRETE**

a) The concrete mixture shall not contain any material, which may unduly affect the setting of such concrete, weaken such concrete or corrode steel used with such concrete;

b) When dry ingredients of concrete are being mixed in confined spaces such as silos –

- The dust shall be exhausted at the time of such mixing and
- In case the dust the dust cannot be exhausted, as specified, the workers shall wear respirators at the time of such mixing;

c) When concrete is being tipped from buckets, building workers shall be kept out of the range of any kickbacks of such buckets;

d) Loads shall not be dumped or placed on settling concrete.

15.6 CONCRETE PANELS AND SLABS

a) All parts of a concrete panel or concrete slab shall be hoisted uniformly;

b) Concrete panels shall be adequately braced in their final positions and such bracings shall remain in such positions until such panels are adequately supported by other parts of the construction for which such panels are used;

c) Temporary bracings of concreter panels shall be securely fastened to prevent any part of such panels from falling when such panels are being moved.

15.7 STRESSED AND TENSIONED ELEMENTS

a) Building workers shall not stand directly over jacking equipment while stressing of concrete girders and beams is being done;

b) A pre – stressed concrete unit shall not bee handled except at points on such unit and by the devices specified for such work by the manufacture of such devices;

c) During transport, pre-stressed concrete girders or concrete beams shall be kept upright by bracing or other effective means;

d) Anchor fittings for pre-tensioned strands of pre-stressed concrete girders of concert beams are kept in a safe condition in accordance with the instruction of manufacturer of such anchor fittings;

e) Building workers shall not stand behind jacks or in line with tensioning elements and jacking equipment during tensioning operations of pre-stressed concrete girders of concrete beams;

f) Building workers do not cut wires of pre – stressed concrete girders or concrete beams under tension before such concrete used of such girder or beams is sufficiently hardened.

15.8 VIBRATORS

g) A building worker, who is in good physical condition, shall operate vibrators used in concreting work;

h) All practical measures shall be taken to reduce the amount of vibration transmitted to the operators working in concreting work and

i) When electric vibrators are used in concreting work

j) Such vibrators shall be earthed;

k) The leads of such vibrators shall be heavily insulated; and

l) The current shall be switched off when such vibrators are not in use.

15.9 INSPECTION AND SUPERVISION

a) A person responsible for a concreting work shall supervise the erection of the formwork, shores, braces and other supports used for such concreting work, make a through inspection of every formwork to ensure that such formwork is safe, regularly inspect the formwork, shores, braces, reshores and other supports during the placing of concrete, keep all records of inspections referred to above at the workplace relating to such inspection and produce them for inspection upon the demand.

b) Any unsafe condition, which is discovered during the inspections, shall be remedied immediately.

15.10 **BEAMS, FLOORS AND ROOFS**

a) Horizontal and diagonal bracings shall be provided in both longitudinal and transverse direction as may be necessary to provide structural stability to formwork used in concreting work and shores used in such concreting work shall be properly seated on top and bottom and secured in their places;

b) Where shores used in concreting work rest upon the ground, base plates shall be provided for keeping such shores firm and in level;

c) Where the floor to ceiling height of a concreting work exceeds 9 m or where the formwork deck used in such concreting work is supported by shores constructed in two or more tiers, or where the dead, live and impact loads on the formwork used in such concreting work exceed 700 kilogram per m2, the structure of such formwork shall be designed by a professional engineer in the relevant field and the specifications and drawings of such formwork kept at such construction site and produced on demand.

d) Where a professional engineer designs the structure of the formwork used in concreting work, such engineer shall be responsible for the supervision of construction and the stability of such structure.

15.11 **STRIPPING**

a) Stripping of formwork used in concreting work shall not commence until the concrete on such formwork is fully set, examined and certified to this effect by the responsible person and record of such examination and certification is maintained;

b) Stripped forms in concreting work shall be removed or stock piled promptly after stripping from all areas in which building workers are required to work or pass;

c) Protruding nail, wire ties and other formwork accessories not required for subsequent concreting work shall be pulled, cut or otherwise made safe.

15.12 **RE-SHORING**

a) Re-shoring used in concreting work shall be provided to a slab or beam for its safe support after its stripping or where such slab or beam is subjected to superimposed loads due to construction above such slab or beam;

b) The provisions applicable to shoring in a concreting work shall also be applicable to reshoring in such work or pass.

16.0 SAFETY IN CONSTRUCTION, REPAIR & MAINTENANCE OF STEEP ROOFS

16.1 **WORK ON STEEP ROOFS:**

All practicable measures shall be provided to protect the building workers against sliding when carrying outwork on steep roofs.

16.2 **CONSTRUCTION AND INSTALLATION OF ROOFING BRACKETS**

a) Roofing brackets shall be constructed to fit the pitch of steep roof and such brackets shall be used to provide level working platform;

b) Roofing bracket shall be secured in its place by nailing pointed metal projections attached to the underside of such bracket and securely driven into a steep roof on which it is used or secured by a rope passed over the ridgepole and tie of such roof.

16.3 **CRAWLING BOARDS**

a) All crawling boards used for work on steep roofs shall be of adequate strength, made of sound material and of the type approved for the purpose of their use;

b) Crawling boards shall be kept in good repairs and inspected by a responsible person before being taken into use;

c) Crawling boards shall be secured to a steep roof on which it is used by ridge hooks or other effective means;

d) A firmly fastened lifeline of adequate strength shall bee strung beside each crawling board throughout its length while using such crawling boards.

17.0 SAFETY IN CATCHES PLATFORMS, HOARDINGS & CHUTES

17.1 **CATCH PLATFORM**

a) Catch platform shall not be used for storage of material or as a working platform;

b) Catch platform shall at least be of 2 m wide and inclined so that the position of outer edge of such platform is 1500 mm higher than the inner edge;

c) The open end of catch platform shall be properly fenced to the height not less than 1 m.

17.2 **HOARDINGS:**

Hoardings shall be constructed when the Registering Authority / Assistant Labour Commissioner considers it necessary for protection of building workers and directs such employer to construct such hoardings**.**

17.3 **CHUTES, ITS CONSTRUCTION AND USE**

a) Wooden or metal chutes which are at an angle of more than 450 to the horizontal and used for the removal of materials shall be closed on all sides except at their openings used for receiving or discharging of materials or articles;

b) All openings of chutes except their top openings shall be closed when not in use;

c) Every chute –

d) Shall be constructed of sound material, adequate strength and suitable for the purpose it is intended for use;

e) Exceeding 12 m in height shall be constructed in accordance with the design and drawings of professional engineer for such;

f) A suitable warning notice shall be displayed at conspicuous locations, written in Hindi and in a local language, at the discharge end of every chute;

g) Shall be cleared when debris has accumulated to a height, which can pose danger to building worker, but such clearance shall be done in no case less frequently than once a day.

18.0 SAFETY IN WORK ON OR ADJACENT TO WATER

18.1 **TRANSPORT OF WORKERS BY WATER**

a) When any building worker has to proceed to or from any workplace by water for purposes of carrying on a building or other construction work, proper measures shall be taken to provide for his safe transportation and vessels used for such purpose shall be in charge of a responsible person, properly equipped for safe navigation and maintained in good condition;

b) Maximum number of persons which can be safely carried in a vessel shall be marked plainly and conspicuously on such vessel and such number shall not be exceeded during use of such vessel for carrying persons;

c) Adequate protecting shall be provided to the building workers in such vessel from inclement weather;

d) Such vessel shall be manned by adequate and experienced crew;

e) In case the bulwarks of such vessel are lower than 60 cm from the level of the deck of such vessel, the open edge of such bulwarks shall be fitted with suitable fencing to a height of at least 1 m above such deck and the post and stanchions and similar parts used in such fencing shall not be spaced more than 2 m;

f) The number of life buoys on deck of such vessel shall at least be equal to the number of crew members of such vessel and shall not be less than two;

g) All life buoys on deck of such vessel shall be kept in good state of maintenance and so placed that if such vessel sinks then they will remain afloat and one of such buoys shall be within the immediate reach of the Steersman of such vessel and another is situated after part of such vessel; and

h) The position of the steersman of the vessel shall be such that he has a reasonably free view of all sides.

18.2 **PREVENTION FROM DROWNING**

a) Where, on or adjacent to the workplace of any contraction site, there is water into which a building worker employed for work on such site, in the course of his employment, may fall and has the risk of drowning, suitable rescue equipment shall be provided and kept in an efficient state of ready use and measures shall be taken to arrange for the prompt rescue of such building worker from the danger of drowning and where there is a special risk of such fall from the edge of adjacent land or from a structure adjacent to or above the water, or from floating stage on such water, secure fencing shall be provided near the edge of such land, structure or floating stage, as the case may be, to prevent such fall, and such fencing may be removed or allowed to remain unerected for the time and to the extent necessary for the access of building workers to such work or the movement of material for such work;

b) For handling rescue equipment, at least two persons knowing diving should be available at such sites.

19.0 SAFETY IN COFFERDAMS & CAISSONS

19.1 **EVERY COFFERDAM AND CAISSON SHALL BE**

a) Of good construction, sound material and of adequate strength, provided with adequate means for workers to reach safely at the top of such cofferdam or caisson in the event of an in rush of water and safe means of access to every place where workers shall be employed;

b) Work relating to construction, positioning, modification, dismantling of cofferdams or caissons shall be carried out under the supervision of a responsible person and inspected by the responsible person at the specified intervals;

c) A worker shall be allowed to work in a cofferdam or caisson after such cofferdam or caisson has been inspected and found safe by responsible person within such preceding period as approved and a record of such inspection maintained.

19.2 **WORK IN COMPRESSED AIR IN A COFFERDAM OR CAISSON SHALL BE**

a) Carried out in accordance with the procedure laid down;

b) Carried out by such building workers who have completed eighteen years of age and are medically examined and found fit for the work;

c) Carried out under the supervision of a responsible person;

d) If the work in cofferdam or caisson is carried out in shifts, a record of the time spent by each worker in each such shift for carrying out the wok shall

be maintained in a register with particulars or time taken for the compression of such building worker, if any;

e) At every work site or project in a cofferdam or caisson, where workers are employed to work in compressed air environment, a construction medical officer assisted by a nurse or trained first-aid attendant, shall be available at all times and there shall be one standby reserve compressor to meet the emergency.

19.3 **PRESSURE PLANT AND EQUIPMENT**

a) Pressure plant and equipment for which it is used shall be –

- Properly maintained in good repairs and working condition and fitted with a suitable safety valve or other effective device to provide maximum safe discharge pressure from being exceeded at any time; a suitable pressure gauge with a dial range not less than 1.5 time and not exceeding twice the maximum working pressure, easily visible and designed to show at all times, the internal pressure in kilogram per square centimeter and marked with the maximum safe working pressure, a suitable stop valve or valves by which the pressure plant or the system of the pressure plant may be isolated from the source supply of pressure or otherwise;

b) Every pressure plant or equipment shall be thoroughly examined by the competent person, externally, once in every period of six months; internally, once in every period of twelve months; and by hydraulic test, once in a period of four years.

20.0 SAFETY IN DEMOLITION WORK

20.1 **PREPARATION**

a) All glass or similar material or article in exterior openings shall be removed before commencing any demolition work and all water, steam, electric, gas and other similar supply lines put off and suitably capped and the concerned department of the appropriate authority informed and permission obtained wherever required before commencing;

b) Wherever it is necessary to maintain water, gas or electric line or power during such demolition, such line shall be so located or protected with substantial coverings so as to protect it from damage and to afford safety to the building workers and the general public.

20.2 **PROTECTION OF ADJACENT STRUCTURES**

a) Examination of walls etc. of adjacent structures –

b) During demolition process, the contractor shall examine the walls of all structures adjacent to the structure to be demolished to determine the thickness, method of support to such adjacent structures and;

c) In case, such employer has reason to believe that any of such adjacent structure is unsafe or may become unsafe during such demolition process, he shall not perform demolition activity unless stability to such unsafe adjacent structu4e from collapsing has been taken. All roads and open spaces adjacent to the site of demolition work shall be closed or suitably protected by bracketing.

20.3 **DEMOLITION OF WALLS, PARTITIONS, ETC.**

a) Any demolition of walls or partitions shall be proceeded in a systematic manner as per the standard safe operating practices approved and all work above each tier of any floor beams shall be completed before the safety of the supports of such beam is impaired;

b) Masonry shall be neither loosened nor permitted to fall in such masses or volume or weight as to endanger the structural stability of any floor or structural supports;

c) No wall chimney or other structure or part of a structure shall be left unguarded in such a condition that it may fall, collapse or weaken due to wind pressure or vibration;

d) In the case of demolition of exterior walls by hand, safe footing shall be provided for the workers employed in, such walls or partitions, which are to be demolished by hand shall be not left standing more than one storey high above the uppermost floor on which persons are working.

20.4 **METHOD OF OPERATION:**

The contractor shall ensure that debris, bricks and other materials or articles are removed by means of chutes, buckets or hoists and through openings in the floors.

20.5 **ACCESS TO FLOOR**

a) Safe access to and egress from every building shall be provided at all times in the course of demolition by means of entrances hallways, stairways or ladder runs which shall be so protected as to safeguard the workers using such means from falling material or articles;

b) Demolition of structural steel etc. shall be demolished column by column and tier by tier and every structural member, which is being demolished, shall not be under any stress, and such structural member shall be suitably

lashed to prevent it from any uncontrolled swinging, dropping or falling or falling;

c) Large structural members shall not be thrown or dropped from the building, but carefully lowered by adopting suitable safe method;

d) Where a lifting appliance like a derrick is used for demolition, the floor on which such lifting appliance rests shall be completely planked over or supported and such floor shall be of adequate strength to sustain bearing load for such lifting appliance and its operation.

20.6 **STORAGE OF MATERIAL OR ARTICLE**

a) No materials or articles shall be not stored or kept on platform, floor or stairways of a building being demolished, provided that this clause shall not apply to the floor of a building when such floor is of such strength as to support safely the load to be superimposed by storing such material or articles;

b) No access to any stairway or passageway shall be affected or blocked by storing any material or article;

c) Suitable barricades shall be provided so as to prevent materials or articles from sliding or rebounding into any space used by the workers.

20.7 **FLOOR OPENINGS:**

Every opening used for the removal of debris from every floor which is not closed to access, except the top or working floor, shall be provided with an enclosure from such floor to its ceiling, or such opening is so barricaded that no building worker shall access to within a horizontal distance of 6.0 m from such opening through which debris is being dropped.

20.8 **INSPECTION:**

A person responsible for demolition work shall make continuous inspections during demolition process so as to detect any hazard resulting from weakened or deteriorated floors or walls or loosened materials or articles, and that no building worker shall be permitted to work where such hazard exist unless remedial measured like shoring or bracing shall be taken to prevent such hazards.

20.9 **WARNING SIGNS, BARRICADES, ETC.**

a) Barricades and warning sign shall be erected along every side throughout the length and breadth of a building or other construction work to be demolished to prevent unauthorized persons from entering into the during demolition operations;

b) During the demolition of an exterior masonry wall or a roof from a point more than 12 m above the adjoining ground level of such wall or roof, if persons below such wall or roof are exposed to falling objects, suitable and safe catch platform shall be provided and maintained at a level not more than 6 m below the working level except where an exterior built-up scaffold is provided for safe and adequate protection of such persons;

c) Suitable and standard warning signs shall be displayed or erected at conspicuous places or position at the workplace;

20.10 **MECHANICAL METHOD OF DEMOLITION**

a) The following requirements shall be fulfilled in case the mechanical method of demolition like use of swinging weight, clamshell bucket, power shovel, bulldozer or other similar mechanical methods are used for the purpose of demolition namely –

b) The building or structure or structure or remaining portion thereof shall be not more than 12 m in height;

c) Where a swinging weight is used for demolition, a zone of such demolition having a radius of at least 1.5 times the height of the structure of portion thereof being demolished shall be maintained around the points of impact of such swinging weight;

d) Where a clamshell bucket is being used for demolition, a zone of demolition shall be maintained within eight metres of the liner of travel of such bucket;

e) Where other mechanical methods are being used to affect total or partial collapse of a building or other construction work, there shall be maintained, in the area into which the affected portion of such building or other construction work may fall, a zone of demolition at least 1.5 times the height of such affected portion thereof; and

f) No person other than building workers or other persons essential to the operation of demolition work shall be permitted to enter a zone of demolition, which shall be provided with substantial barricades.

21.0 FIRE EXTINGUISHERS & OTHER APPLIANCES OF FIRE FIGHTING

21.1 **FIRE EXTINGUISHERS & OTHER MEANS OF PREVENTION AND PROTECTION**

a) Every contractor shall have a fire protection and prevention plan developed and implemented keeping in view the following:

- The specific work practices requiring fire control measures;
- Response measures to be taken in case of fire;
- Equipment required;
- Personnel requirements and responsibilities;
- Schedules of daily and weekly inspection;
- Open flames and fires are prohibited in all underground construction;
- Readily visible signs to be posted in the fire prone/inflammable/explosive areas prohibiting smoking use of open flames and other hot work.
- A system of Permit-to-Work.

b) For the protection of the workers from the outbreak of fire, the contractor shall Provide, maintain and regularly inspect the Fire extinguishing equipment, which shall be sufficiently provided to extinguish any probable fire;

Suitability of portable fire extinguishers			
Class of fire	**Type of extinguisher**		
	Water	**DCP**	**CO2**
A	**Yes**	**Yes**	**Yes**
B	**No**	**Yes**	**Yes**
C	**No**	**Yes**	**Yes**
D	**No**	**Yes**	**Yes**
Electrical	**No**	**Yes**	**Yes**

c) Ensure availability of an adequate supply of water at ample pressure;

d) Make available Adequate number of trained persons required to operate the fire extinguishing equipment;

e) Properly maintain Fire extinguishing equipment and inspect them at regular intervals of not less than once in a year by the responsible person and a record of such inspections maintained;

f) Portable fire extinguishers provided in the operator's cabin of earthmoving machinery, material handling systems, construction equipment etc. shall be regularly inspected, maintained and replenished/refilled;

g) The operators and the helpers of such equipment shall be trained in the methods operating the equipment and fighting the fire effectively;

h) All combustion engine power equipment shall be so located that the exhausts are well away from combustible material;

i) No smoking shall be allowed at or in the vicinity of operations, which constitute fire hazards and shall be conspicuously posted with No smoking or open flame signs;

j) In the flammable environment as described in IS: 9570, the electrical fittings and equipment shall be of flame proof type conforming to IS: 2206 & IS; 2148;

k) Arrangements shall be made to contain sparks generated during welding, cutting or other operations and spark shall not be allowed to fall down on combustible material kept below; All means of exit shall be kept free of obstruction at all times;

l) Appropriate type of fire extinguishers according to IS: 5698 shall be kept in fully charged condition at the places which have potential risk of fire;

m) The contractor shall educate his or his sub-contractors' men working in the vicinity of fire risk, on how to operate these equipment and know in particular circumstances which type of extinguishers is to be used;

n) The contractor shall take full responsibility for the upkeep and replenishment/refilling of the fixed and portable fire extinguishers.

SECTION – V: FORMAT OF FORMS AND ANNEXURES

Annexure-I

FORMAT FOR LETTER OF BID

(To be uploaded by the Bidder on his Letter Head during submission of bid online)

To,
The Tender Committee
Coal India Limited

Sub: BID for the Work "Setting up of Grid Connected 300 MW Ground Mounted Solar PV plant at Khavda, Gujarat ".

NIT No.: ……. DATED:-

Tender Id No:…….

Dear Sir,

This has reference to above referred bid. I/we have read and examined the conditions of contract, Scope of Work, technical specifications, BOQ and other documents carefully.

I /We am/are pleased to submit our bid for the above work. I/We hereby unconditionally accept the bid conditions and bid documents in its entirety for the above work and agree to abide by and fulfil all terms and conditions and specifications as contained in the bid document.

I/we here by submit all the documents as required to meet the eligibility criteria as per provision of the bid notice/document.

I/We hereby confirm that this bid complies with the Bid validity, Bid security and other documents as required by the Bidding documents.

If any information furnished by me/us towards eligibility criteria of this bid is found to be incorrect at any time, penal action as deemed fit may be taken against me/us for which I/We shall have no claim against CIL.

Until a formal agreement is prepared and executed, this bid and your subsequent Letter of Award (LOA)/Work shall constitute a binding contract between us and Coal India Limited.

Should this bid be accepted, we agree to furnish Performance Security within stipulated date and commence the work within stipulated date. In case of our failure to abide by the said provision, Coal India Limited shall, without prejudice to any other right or remedy, be at

liberty to cancel the letter of award/ work order and to forfeit the Earnest Money and also debar us from participating in future tenders for a minimum period of 12(twelve) months.

Annexure-II

PROFORMA FOR UNDERTAKING

We solemnly declare that:

1. I/We am/are submitting Bid for the work 'Setting up of Grid Connected 300 MW Ground Mounted Solar PV plant at Khavda, Gujarat' against Tender id No. ..... Dated…… and I/we offer to execute the work in accordance with all the terms, conditions and provisions of the bid.

2. All information furnished by us in respect of fulfilment of eligibility criteria and qualification information (General Qualification criteria, Technical Qualification Criteria and Financial Qualification Criteria), General Terms and Conditions of the Contract, Additional Terms and Conditions of the Contract and Special Conditions of the Contract of this Bid is complete, correct and true.

3. The Company is not banned/debarred/blacklisted by other Central Public Sector Enterprises (CPSEs)/Government Entities as on the original scheduled date of tender opening.

4. Copy of documents, credentials and documents submitted along with this Bid are genuine, authentic, true and valid.

5. I/ We hereby authorize department to seek references / clarifications from our Bankers.

6. We hereby undertake that we shall register and obtain license from the competent authority under the contract labour (Regulation & Abolition Act) as relevant, if applicable.

7. I/We have not been debarred by any procuring entity for violation of Preference to Make in India (as applicable) vide Order No. P-45021/2/2017-PP (BE-II) dated 16.09.2020, issued by Govt. of India as amended from time to time

8. l/We do not have relationship with any other participating bidders, directly or through common third parties, that puts us in a position to have access to information about or influence on the bid of another Bidder.

9. l/We or any of my/our affiliate has/have not participated as consultant in the preparation of the design or technical specification of the contract that is the subject of the bid.

10. If any information and document submitted is found to be false/ incorrect at any time, department may cancel my/our Bid and action as deemed fit may be taken against me/us, including termination of the contract, forfeiture of all dues including Earnest Money and banning of our firm and all partners of the firm etc. as per Annexure-XVI – Guidelines on Debarment of Firms from Bidding.

Annexure-III

MANDATE FORM FOR ELECTRONIC FUND TRANSFER / INTERNET BANKING PAYMENT.

1. Name of the Bidder :……

2. Address of the Bidder : ……
…….

City……. Pin Code……

E-mail Id ……

Permanent Account Number …….

3. Particulars of Bank:

Bank Name		Branch Name	
Branch Place		Branch City	
Pin Code		Branch Code	
MICR No.			
(Digital Code number appearing on the MICR Band of the cheque supplied by the Bank. Please attach Xerox copy of a cheque of your Bank for ensuring accuracy of the Bank Name, Branch Name and Code Number.			

RTGS CODE																				

Account Type	Savings							Current						Cash Credit						
Account Number(as appearing in the Cheque Book.																				

4. Date from which the mandate should be effective.

I hereby declare that the particulars given above are correct and complete. If any transaction is delayed or not effected for reasons of incomplete or incorrect information. I shall not hold Company responsible. I also undertake to advise any change in the particulars of my account to facilitate updation of records for purpose of credit of amount through SBI Net / RTGS transfer/NEFT. I agree to discharge responsibility expected of me as a participant under the scheme. Any bank charges levied by the bank for such e-transfer shall be borne by us.

Place :
Date :

Signature of the Party / Authorised Signatory

Certified that particulars furnished above are correct as per our records.

Banker's Stamp
Date :

(Signature of the Authorised official from the Bank)

Annexure- IV

PROFORMA FOR DECLARATION TOWARDS CODE OF INTEGRITY FOR PUBLIC PROCUREMENT TO BE ACCEPTED UNCONDITIONALLY BY BIDDER/S

(To be signed on Plain Paper)

To Tender Inviting Authority,

……

Sub: Declaration towards CIPP by

Bidder Ref:

NIT No.:

Tender Id No:

Dear Sir,

I, Sri, ……, proprietor, representative, partner of ……I / We, _____Proprietor/ Partner / Legal Attorney /Director/ Accredited Representative of M/s ……. Solemnly declare that:

1. I/we have read and examined the conditions of Code of Integrity for Public Procurement in respect to this contract as laid down in the General Terms and Conditions.

2. Without prejudice to and in addition to the rights of the Procuring Entity to other penal provisions as per the bid documents or contract, if the Tender Inviting Authority comes to a conclusion that a (prospective) bidder/contractor/ Supplier/ consultant/ service provider, directly or through an agent, has violated this code of integrity in competing for the contract or in executing a contract, actions deemed fit as per the punitive actions recommended in the tender document may be taken against me/us.

3. In-case the contract is awarded to me/us, I/we will submit a signed copy of Code of Integrity for Public Procurement, signed by All Partners/Authorized Signatory of the Bidder.

(For & On behalf of the Principal)
(Office Seal)

(For & On behalf of Bidder/ Contractor)
(Office Seal)

Place ----------

Date ----------

Witness 1:

Witness 2:

(Name & Address)

(Name & Address)

Code of Integrity for Public Procurement (CIPP)

1. Introduction

   Public procurement is perceived to be prone to corruption and ethical risks. To mitigate this, the officials of Procuring Entities involved in procurement and the bidders/ contractors must abide by the following Code of Integrity for Public Procurement (CIPP). All Procuring officials may be asked to submit sign declarations to this effect while processing PR on ERP of CIL. To implement it uniformly and mandatorily, this undertaking shall be in-built in the PR format in ERP of CIL. The bidders/ contractors should be asked to sign a declaration about abiding by a Code of Integrity for Public Procurement (including sub-contractors engaged by them) during submission of bid, with a warning that, in case of any transgression of this code, it would be liable for punitive actions such as cancellation of contracts, banning and blacklisting or action in Competition Commission of India, and so on.

2. Code of Integrity for Public Procurement

   Procuring authorities as well as bidders, contractors and consultants should observe the highest standard of ethics and should not indulge in the following prohibited practices, either directly or indirectly, at any stage during the procurement process or during execution of resultant contracts:

   i) "Corrupt practice": making offers, solicitation or acceptance of bribe, rewards or gifts or any material benefit, in exchange for an unfair advantage in the procurement process or to otherwise influence the procurement process or contract execution;

   ii) "Fraudulent practice": any omission or misrepresentation that may mislead or attempt to mislead so that financial or other benefits may be obtained or an obligation avoided. This includes making false declaration or providing false information for participation in a tender process or to secure a contract or in execution of the contract;

   iii) "Anti-competitive practice": any collusion, bid rigging or anti-competitive arrangement, or any other practice coming under the purview of The Competition Act, 2002, between two or more bidders, with or without the knowledge of the procuring entity, that may impair the transparency, fairness and the progress of the procurement process or to establish bid prices at artificial, non-competitive levels;

   iv) "Coercive practice": harming or threatening to harm, persons or their property to influence their participation in the procurement process or affect the execution of a contract;
   v) "Conflict of Interest"-A Bidder may be considered to have a Conflict of Interest with one or more parties in this bidding process, if:

      a) they have controlling partner(s) in common; or

      b) they receive or have received any direct or indirect subsidy/financial stake from any of them; or

      c) they have the same legal representative/agent for purposes of this bid; or

      d) they have business relationship with each other, directly or through common third parties, that puts them in a position to have access to information about or influence on the bid of another Bidder; or

e) a Bidder or any of its affiliate participated as a consultant in the preparation of the design or technical specification of the contract that is the subject of the bid; or

f) in case of a holding Company having more than one Subsidiary/Sister Concern having common business ownership/management only one of them can bid. Bidders must proactively declare such sister/common business/management in same/similar line of Business;

all such Bidders having a Conflict of Interest, shall be disqualified.

The Bidders shall comply the above provision of "Conflict of Interest" and submit an undertaking with respect to Clause No. 27 in NIT.

Earnest Money deposited by such defaulting Bidders shall be forfeited and they shall be debarred from participating in future tenders in concerned Subsidiary/CIL HQ for a period of 12(twelve) months from the date of issue of such letter.

In case of JV/CONSORTIUM/Partnership firm, the debarment shall also be applicable to all individual partners of JV/CONSORTIUM/Partnership firm.

vi) "Obstructive practice": materially impede the procuring entity's investigation into allegations of one or more of the above mentioned prohibited practices either by deliberately destroying, falsifying, altering; or by concealing of evidence material to the investigation; or by making false statements to investigators and/ or by threatening, harassing or intimidating any party to prevent it from disclosing its knowledge of matters relevant to the investigation or from pursuing the investigation; or by impeding the procuring entity's rights of audit or access to information;

3. Obligations for Proactive Disclosures

i) Procuring authorities as well as bidders, contractors and consultants, are obliged under Code of Integrity for Public Procurement to suo-moto proactively declares any conflicts of interest (coming under the definition mentioned above – pre-existing or as and as soon as these arise at any stage) in any procurement process or execution of contract. Failure to do so would amount to violation of this code of integrity; and

ii)Any bidder must declare, whether asked or not in a bid document, any previous transgressions of such a code of integrity with any entity in any country during the last three years or of being debarred by any other procuring entity. Failure to do so would amount to violation of this code of integrity.

iii) To encourage voluntary disclosures, such declarations would not mean automatic disqualification for the bidder making such declarations. The declared conflict of interest may be evaluated and mitigation steps, if possible, may be taken by the procuring entity. Similarly voluntary reporting of previous transgressions of Code of Integrity elsewhere may be evaluated and barring cases of various grades of debarment, an alert watch may be kept on the bidder's actions in the tender and subsequent contract.

4. Punitive Provisions

Without prejudice to and in addition to the rights of the procuring entity to other penal provisions as per the bid documents or contract, if the procuring entity comes to a conclusion

that a (prospective) bidder/ contractor directly or through an agent, has violated this code of integrity in competing for the contract or in executing a contract, the procuring entity may take appropriate measures including one or more of the following:

i) If his bids are under consideration in any procurement

a) Forfeiture or encashment of bid security;

b) calling off of any pre-contract negotiations; and

c) rejection and exclusion of the bidder from the procurement process

ii) If a contract has already been awarded

a) Cancellation of the relevant contract and recovery of compensation for loss incurred by the procuring entity;

b) Forfeiture or encashment of any other security or bond relating to the procurement;

c) Recovery of payments including advance payments, if any, made by the procuring entity along with interest thereon at the prevailing rate;

iii) Provisions in addition to above:

a) / debarment of the bidder from participation in future procurements of the procuring entity for a period not less than one year;

b) In case of anti-competitive practices, information for further processing may be filed, with the Competition Commission of India;

c) Initiation of suitable disciplinary or criminal proceedings against any individual or staff found responsible.

Annexure- V

PROFORMA OF BANK GURANTEE FOR CONTRACT PERFORMANCE SECURITY

To

……..

……..

Re: Bank Guarantee in respect of Contract No…….…..,Dated……. Between …….. (Name of the company) and ……. (Name of the Contractor)

WHEREAS

…….. (Name and address of the Contractor) (herein after called "the Contractor") has entered into a contract made as per letter of acceptance……. dated.……. (herein after called the said contract) with …… (name of the Company) (hereinafter called "the Company") to execute ……. (name of the contract and brief description of work) on the terms and conditions contained in the said Contract.

It has been agreed that the Contractor shall furnish a Performance Security in the shape of Bank Guarantee from a Scheduled Bank for a sum of Rs……. as security for due compliance and performance of the terms and conditions of the said Contract.

We…… (name of the Bank) having its Branch/Office at……. ….. have, at the request of the Contractor, agreed to furnish this Bank Guarantee by way of Performance Security.

NOW, THEREFORE, we the…… Bank (herein after called The Bank) hereby, unconditionally and irrevocably, guarantee and affirm as follows:

The Bank do hereby irrevocably guarantee and unconditionally agree with the Company that if the Contractor shall in any way fail to observe or perform the terms and conditions of the said Contract or shall commit any breach of its obligation thereunder, the Bank shall on its mere first written demand, and without any objection, demur and without any reference to the Contractor, pay to the Company the said sum of …… or such portion as shall then remain due with interest without requiring the Company to have recourse to any legal remedy that may be available to it to compel the Bank to pay the sum, or failing on the Company to compel such payment by the Contractor.

Any such demand shall be conclusive as regards the liability of the Contractor to the Company and as regards the amount payable by the Bank under this Guarantee. The Bank shall not be entitled to withhold payment on the ground that the Contractor has disputed its liability to pay or has disputed the quantum of the amount or that any arbitration proceeding or legal proceeding is pending between the Company and the Contractor regarding the claim.

The Bank further agree that the Guarantee shall come into force from the date hereof and shall remain in force and effect till the period that will be taken for the performance of the said Contract which is likely to be ……. day of …….. but if the period of Contract is

extended either pursuant to the provisions in the said Contract or by mutual agreement between the Contractor and the Company, the Bank shall renew the period of the Bank Guarantee failing which it shall pay to the Company the said sum of ……..…. or such lesser amount of the said sum of …… as may be due to the Company and as the Company may demand.

This Guarantee shall remain in force until the dues of the Company in respect of the said sum of …….and interest are fully satisfied and the Company certifies that the Contract has been fully carried out by the Contractor and discharged the guarantee.

The Bank further agrees with the Company that the Company shall have the fullest liberty without consent of the Bank and without affecting in any way the obligations hereunder to vary any of the terms and conditions of the said contract or to extend time for performance of the said contract from time to time or to postpone for any time or from time to time any of the powers exercisable by the Company against the Contractor and to forebear to enforce any of the terms and conditions relating to the said Contract and the Bank shall not be relieved from its liability by reason of such failure or extension being granted to the Contractor or to any forbearance, act or omissions on the part of the Company or any indulgence by the Company to the Contractor or any other matter or thing whatsoever which under the law relating to sureties would but for this provision have the effect or relieving or discharging the Guarantor.

The Bank further agrees that in case this Guarantee is required for a longer period and it is not extended by the Bank beyond the period specified above, the Bank shall pay to the Company the said sum of ……. ….. or such lesser sum as may then be deemed to the Company and as the Company may require.

This Bank Guarantee shall also be operative at our ……. Branch located at .....(detailed address), from whom, confirmation regarding issue of this guarantee or extension/renewal thereof shall be made available on demand. Any notice by way of request, demand or otherwise hereunder may be sent by post/e-mail/Fax addressed to the bank branch / operative branch, which shall be deemed to be a sufficient demand notice. Bank shall effect payment thereof forthwith. The details of outstation Bank issuing the Bank Guarantee are as below.

i) Complete Postal Address with PIN Code

ii) Branch Code

iii) IFSC Code –

iv) SWIFT –

v) Telephone No. –

vi) Fax No. –

vii) Email ID –

The details of Local Operating Branch of the Bank issued the Bank Guarantee are as below.

i) Complete Postal Address with PIN Code

ii) Branch Code

iii) IFSC Code –

iv) SWIFT –

v) Telephone No. –

vi) Fax No. –

viii) Email ID –

Whenever there is change in postal address and/or other details of this branch issued the guarantee and/or the operative branch, we .....(the issuing bank) will ensure to intimate respective Area, being the beneficiary, of such changed address, telephone number, fax number and e-mail ID.

Notwithstanding anything contained herein the liability of the Bank under this Guarantee is restricted to Rs……. The guarantee shall remain in force till the day ……*……. of ……*……. and unless the guarantee is renewed or claim is preferred against the Bank on or before the said date all rights of the Company under this guarantee shall cease and the Bank shall be relieved and discharged from all liabilities hereunder except as provided in the preceding Clause.

* The date of guarantee shall cover a period of minimum one year or 90 days beyond the date of completion whichever is more.

This guarantee will not be discharged due to the change in the constitution of the Bank or the Contractor.

The Bank has under its constitution power to give this Guarantee and Sri……. who has signed it on behalf of the Bank has authority to do so.

Signed and sealed this……. day of…….at……

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)

(Name)

(Designation)

(Code number)

(Address)

"The Bank Guarantee as referred above shall be operative at our branch at……. payable at…….(NIT shall specify town/city of the operative Branch. Bank Guarantee shall specify name of the branch with address of the specified town/city)

NOTE: - The department shall ensure extension of guarantee period in case of extension of time.

Annexure- VI

PROFORMA OF BANK GUARANTEE FOR MOBILISATION/

LUMP -SUM ADVANCE.

M/s. Coal India Limited
Coal Bhawan Premise No-04 MAR, Plot No-AF-III, Action Area-1A,
Newtown, Rajarhat, Kolkata-700163

Dear Sir,
In consideration of Coal India Limited having its Registered Office at Coal Bhawan Premise No-04 MAR, Plot No-AF-III, Action Area-1A, Newtown, Rajarhat, Kolkata-700163 (hereinafter called "the Company" which expression shall unless repugnant to the subject or context includes its successors and assigns) having agreed under the terms and conditions of the Contract No…… dated……. Entered into between Coal India Limited and M/s having its Registered Office at …… (hereinafter called "the Contractor" to make mobilisation advance/lump-sum advance to the tune of Rs…… subject to submission of the Bank Guarantee for equal amount from any Nationalised/ Schedule Bank , We …… Bank (hereinafter referred to as the said Bank) hiving it is Registered Office at …….. do hereby undertake and agree to pay the Company to the extent of Rs……. on demand stating that the amount claimed by the Company is due and payable by the contractor for the reasons of non-refund and or non-recovery of the amount with interest thereon and to unconditionally pay the amount claimed by the company on such demand without any demur to the extent aforesaid.

2. We, ……. Bank agree that the Company shall be the sole judge as to whether the said Contractor has failed/neglected in refunding the amount advanced by the Company and/or extent of loss and damages caused to or suffered by the Company on account of the amount advanced not being recovered in full and non-utilisation of the said advanced amount or part thereof for the purpose of performance of the contract and interest payable thereon and the decision of the company in this behalf shall be final and binding on us.

3) We, the said Bank further agree that the Guarantee herein contained shall remain in full force and effect upto …… and any claim received after the said date shall in no case bind the Bank.

4) The Company shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee or indemnity from time to time vary any of the terms and conditions of the said contract or to extend the time of performance by the said contractor or to postpone any time

and from time to time any of the powers exercisable by it against the said contractor and either to enforce or to forbear from enforcing any of the terms and conditions governing the said contract or securities available to the company and the said Bank shall not be released from its liability under these presents.

5. Notwithstanding anything contained herein the liability of the said Bank under this Guarantee is restricted to Rs…….. (amounting to 110% of total advance amount) and this Guarantee shall come into force from the date hereof and shall remain in full force and effect till …… unless the written demand or claim under this Guarantee is made by the Company with us on or before ……. all rights of the Company under this Guarantee shall cease to have any effect and we shall be relieved and discharged our liabilities hereunder.

6. We, the said Bank lastly undertake not to revoke this Guarantee during its currency except with the previous consent of the company in writing and agree that any change in the constitution of the said contractor or the said Bank shall not discharge our liability hereunder.

7. This guarantee issued by Sri…….. who is authorized by the Bank.
Under jurisdiction of …… court only.

Annexure-VII

PROFORMA OF JOINT VENTURE AGREEMENT

(On Non-Judicial Stamp paper of appropriate value as per provision of the Stamp Act applicable in the concerned state)

This Joint Venture(JV)/Consortium agreement is made on this ……..day of…….

AMONGST/BETWEEN

M/s……, having its registered Office at ……..... Represented by Shri……. (Name and Designation) of M/s……..., who has power of Attorney to enter into JV/Consortium with……...and sign all documents/ agreements on behalf of M/s…… (hereinafter referred to as" ……")

AND

M/s……, having its registered Office at ……... Represented by Shri…….(Name and Designation) of M/s……..., who has power of Attorney to enter into JV/Consortium with……...and sign all documents/agreements on behalf of M/s…… (hereinafter referred to as"……").

AND

M/s……, having its registered Office at ……... Represented by Shri…….(Name and Designation) of M/s……..., who has power of Attorney to enter into JV/Consortium with……...and sign all documents/agreements on behalf of M/s…… (hereinafter referred to as"……").

The expressions M/s …….. and M/s……and M/s ……..shall, wherever the context admits, mean and include their respective legal representatives, successors-in-interest and assigns and shall collectively be referred to as "JV/Consortium /Parties" and individually as "JV/Consortium Partner/Party".

WHEREAS M/s…….and M/s…… and M/s ……..agreed to form a JV/Consortium in order to join their forces to obtain best results from the combinations of their individual resources of technical and management skill, finance and equipment for the benefit of the project and in order to submit the Bid for the work of "…….....……
……" (Hereinafter referred to as "Project") under…….. (Name of Company) (hereinafter referred to as "the Principal Employer").

The Parties hereby enter into this JV/Consortium Agreement (hereinafter referred to as "JV/Consortium agreement") to jointly prepare and submit the Bid for the Project and in the event of securing the Project from the Employer, to execute the Project in accordance with the Contract Terms and Conditions, to the satisfaction of the Principal Employer.

NOW THEREFORE, the parties, in consideration of the mutual premises contained herein, agree as follows:

1) FORMATION AND TERMINATION OF THE JV/CONSORTIUM.

The parties under this Agreement have decided to form a JV/Consortium to submit the Bid for the above Project and execute the Contract with the Principal Employer for the Project, if qualified and awarded.

a) The name and style of the JV/Consortium shall be "……." (hereinafter called the "JV/Consortium")

b) The Head Office of the JV/Consortium shall be located at……. and the site office will be located at the site of the Project.

All communication regarding the Project will be made to…… Telephone Nos…….

c) Neither of the parties of the JV/Consortium shall be allowed to assign, pledge, sell or otherwise dispose all or part of its respective interests in the JV/Consortium to any party including the existing partner of the JV/Consortium.

d) The terms of the JV/Consortium shall begin as on the date first set forth above and shall terminate on the earliest of the following dates.

i) The JV/Consortium fails to obtain qualification from the Employer.

ii) The Contract for the Project is not awarded to the JV/Consortium.

iii) The Employer cancels the Project.

iv) Either Party commits material breach of this Agreement and fails to cure such breach within the period designated by the non-defaulting Party.

v) Both parties agree to terminate this Agreement in writing.

vi) The Project is completed including defects liability period to the satisfaction of the Employer and all the parties complete any and all duties, liabilities and responsibilities under or in connection with the Contract and the JV/Consortium agreement.

2) LEAD PARTNER.

M/s……. shall be the Lead Partner of the JV/Consortium and is In-charge for performing the contract management. M/s……. shall be attorney of the parties duly authorized to incur liabilities and receive instructions for and on behalf of any and all partners in the JV/Consortium and also all the partners of the JV/Consortium shall be jointly and severally liable during the bidding process and for the execution of the contract as per contract terms with the employer in accordance with the power of attorney annexed. All JV/Consortium Partners M/s……., M/s……. M/s……. nominate and authorize Shri……. (name and designation) of M/s…… to sign all letters, correspondence, papers & certificates and to submit the Pre-qualification Application / Bid documents for and on behalf of the JV/Consortium.

3) REPRESENTATIVE OF THE PARTNERS OF THE JV/CONSORTIUM.

Each constituent party of the JV/Consortium appoints the following personnel as the representative of the relevant party with full power of attorney from the Board of Directors of the concerned Company, or from the partners of the entity, or from the proprietor.

JV/CONSORTIUM	Name	Position in the respective Company Partners
M/s……	…….	……..
M/s……	…….	…….
M/s …… …	……	…….

4) PARTICIPATION SHARE & WORK RESPONSIBILITIES.

4.1 The parties agree that their respective participation share (hereinafter called 'Participation Share') in the JV/Consortium shall be as follows:

M/s…….:	……..…..% (……..per cent)
M/s…….:	……..…..% (……..per cent) and
M/s……..	……..…..% (…….per cent)

4.2 The Parties shall share the rights and obligations, risk, cost and expenses, working capitals, profits or losses or others arising out of or in relation to execution of the Project individually or collectively.

4.3 The parties shall jointly execute the works under the Project as an integrated entity and allocate responsibilities as regards division of work between themselves by organizing the adequate resources for successful completion of the Project. However, all parties shall remain jointly and severally responsible for the satisfactory execution of the Project in accordance with the Contract terms and conditions.

5) JOINT AND SEVERAL LIABILITIES.

All partner of JV/Consortium shall be liable jointly and severally during the Prequalification and Bidding process; and in the event the contract is awarded, during the execution of the Contract, in accordance with Contract terms.

6) WORKING CAPITAL

During the execution of work/service, the requirement of Working Capital shall be met individually or collectively by the JV/CONSORTIUM partners.

7) BID SECURITY:

Bid Security, Performance Security and other securities shall be paid by the JV/Consortium except as otherwise agreed.

8) PERSONNEL & EQUIPMENT

Team of Managers / Engineers of all the partners of the JV/Consortium will form part of the core management structure and assist in execution of the project. The list of personnel and equipment proposed to be engaged for the Project by each Party will be decided by the management committee.

9) NON-PERFORMANCE OF RESPONSIBILITY BY ANY PARTY OF JV/CONSORTIUM.

a) As between themselves, each Party shall be fully responsible for the fulfillment of all obligations arising out of its scope of the work for the Project to be clarified subject to the Agreement between the Parties and shall hold harmless and indemnified against any damage arising from its default or nonfulfilment of such obligations.

b) If any Party fails to perform its obligations described in this Agreement during the execution of the Project and to cure such breach within the period designated by the non-defaulting party, then the other party shall have the right to take up work, the interest and responsibilities of the defaulting party at the cost of the defaulting party.
c) Stepping into the shoes of the existing partner of JV/Consortium with all the liabilities of the existing partner from the beginning of the contract with the prior approval of Company.

d) Notwithstanding demarcation or allotment of work of between/amongst JV/Consortium partners, JV/Consortium shall be liable for non-performance of the whole contract irrespective of their demarcation or share of work.

e) In case bid being accepted by Company, the payments under the contract shall only be made to the JV/Consortium and not to the individual partners.

10) BANK A/C.
Separate Bank A/c. shall be opened in the name of the JV/Consortium in a scheduled or Nationalized Bank in India asper mutual Agreement and all payments due to the JV/Consortium shall be received only in that account, which shall be operated jointly by the representative of the Parties hereto. The financial obligations of the JV/Consortium shall be discharged through the said JV/Consortium Bank Account only and also all the payments received or paid by Company to the JV/Consortium shall be through that account alone.

11) LIMIT OF JV/CONSORTIUM ACTIVITIES.
The JV/Consortium activities are limited to the bidding and in case of award, to the performance of the Contract for the Project according to the conditions of the Contract with the Employer.

12) TAXES.
Each Party shall be responsible for its own taxes, duties and other levies to be imposed on each party in connection with the Project. The taxes, duties and other levies imposed on the JV/Consortium in connection with the Project shall be paid from the account of the JV/Consortium.

13) EXCLUSIVITY
The Parties hereto agree and undertake that they shall not directly or indirectly either individually or with other party or parties take part in the Bid for the said Project. Each party further guarantees to the other party hereto that this undertaking shall also apply to its subsidiaries and companies under its direct or indirect control.

14) MISCELLANEOUS:

a. Neither party of the JV/Consortium shall assign, pledge, sell or otherwise dispose all or part of its respective interests in the JV/Consortium to all third party without the Agreement of the other party in writing.
b. Subject to the above Clause, the terms and conditions of this agreement shall be binding upon the parties, the Directors, Officers, Employees, Successors, Assigns and Representatives.

15) APPLICABLE LAW
This agreement shall be interpreted under laws and regulations of India.

IN WITNESS Whereof the parties hereto have hereunder set their respective hands and seals the day, month, year first above written.

For ……..	For……..
Signature _____	Signature _____
(Name & Address)	(Name & Address)
(Official Seal)	(Official Seal)
Place ……..	Place……..
Date ……	Date …….
Witness	Witness
Signature ……..	Signature ……
(Name & Address)	(Name & Address)

Annexure-VIII

PRE CONTRACT INTEGRITY PACT
(To be signed on plain paper)

General

This pre-bid pre-contract Agreement (hereinafter called the Integrity Pact) is made on…….day of the month of ……20…, between, on one hand, Coal India Limited/Subsidiary Cos. acting through Shri …….., Designation of the officer, (hereinafter called the "BUYER / Principal", which expression shall mean and include, unless the context otherwise requires, his successors in office and assigns) of the First Part and M/s. ……..represented by Shri……, Chief Executive Officer (hereinafter called the "BIDDER/Seller/Contractor" which expression shall mean and include, unless the context otherwise requires, his successors and permitted assigns) of the Second Part.

WHEREAS the BUYER proposes to execute ……(Name of the work) and the BIDDER/Seller is willing to offer/has offered the Services and

WHEREAS the BIDDER is a private Company / public Company / Government undertaking/ partnership/ proprietorship/ JV/Consortium constituted in accordance with the relevant law in the matter and the BUYER is a Ministry/ Department of the Govt. of India/ PSU performing its functions on behalf of the President of India.

NOW, THEREFORE,

To avoid all forms of corruption by following a system that is fair, transparent and free from any influence/prejudiced dealings prior to, during and subsequent to the currency of the contract to be entered into with a view to: -

Enabling the BUYER to complete the desired work at a competitive price in conformity with the defined specifications by avoiding the high cost and the distortionary impact of corruption on public procurement and Enabling BIDDERs to abstain from bribing or indulging in any corrupt practice in order to secure the contract by providing assurance to them that their competitors will also abstain from bribing and other corrupt practices and the BUYER will commit to prevent corruption, in any form, by its officials by following transparent procedures.

The parties hereto hereby agree to enter into this Integrity Pact and agree as follows:

Section 1 – Commitments of the Principal

(1) The Principal commits itself to take all measures necessary to prevent corruption and to observe the following principles: - a. No employee of the Principal, personally or through family members, will in connection with the tender for, or the execution of a contract, demand, take a promise for or accept, for self or third person, any material or immaterial benefit which the person is not legally entitled to. b. The Principal will, during the tender process treat all Bidder(s) with equity and

reason. The Principal will in particular, before and during the tender process, provide to all Bidder(s) the same information and will not provide to any Bidder(s) confidential / additional information through which the Bidder(s) could obtain an advantage in relation to the tender process or the contract execution. c. Principal will exclude from the process all known prejudiced persons. (2) If the Principal obtains information on the conduct of any of its employees which is a criminal offence under the IPC/ PC Act, or if there be a substantive suspicion in this regard, the Principal will inform the Chief Vigilance Officer and in addition can initiate disciplinary actions.

Section 2 - Commitments of the Bidder(s)/ Contractor(s)

(1) The Bidder(s) / Contractor(s) commit themselves to take all measures necessary to prevent corruption. The Bidder(s) / Contractor(s) commit themselves to observe the following principles during participation in the tender process and during the contract execution.

a. The Bidder(s) / Contractor(s) will not, directly or through any other person or firm, offer, promise or give to any of the Principal's employees involved in the tender process or the execution of the contract or to any third person, any material or other benefit which he/ she is not legally entitled to, in order to obtain in exchange any advantage of any kind whatsoever during the tender process or during the execution of the contract.
b. The Bidder(s) / Contractor(s) will not enter with other Bidders into any undisclosed agreement or understanding, whether formal or informal. This applies in particular to prices, specifications, certifications, Subsidiary contracts, submission or non-submission of bids or any other actions to restrict competitiveness or to introduce cartelisation in the bidding process.
c. The Bidder(s)/ Contractor(s) will not commit any offence under the relevant IPC/ PC Act; further the Bidder(s) / Contractor(s) will not use improperly, for purposes of competition or personal gain, or pass on to others, any information or document provided by the Principal as part of the business relationship, regarding plans, technical proposals and business details, including information contained or transmitted electronically.
d. The Bidder(s) / Contractors(s) of foreign origin shall disclose the name and address of the Agents/ representatives in India, if any. Similarly, the Bidder(s) /Contractors(s) of Indian Nationality shall furnish the name and address of the foreign principals, if any. Further details as mentioned in the "Guidelines on Indian Agents of Foreign Suppliers" shall be disclosed by the Bidder(s) / Contractor(s). Further, as mentioned in the Guidelines all the payments made to the Indian agent/ representative have to be in Indian Rupees only. Copy of the "Guidelines on Indian Agents of Foreign Suppliers" shall be as per the provisions at Annexure-A.
e. The Bidder(s) / Contractor(s) will, when presenting their bid, disclose any and all payments made, is committed to or intends to make to agents, brokers or any other intermediaries in connection with the award of the contract.
f. Bidder(s) / Contractor(s) who have signed the Integrity Pact shall not approach the Courts while representing the matter to IEMs and shall wait for their decision in the matter.

(2) The Bidder(s) / Contractor(s) will not instigate third persons to commit offences outlined above or be an accessory to such offences.

Section 3 - Disqualification from tender process and exclusion from future contracts

If the Bidder, before contract award, has committed a transgression through a violation of Section 2 or in any other form such as to put his reliability or credibility as Bidder into question, the Principal is entitled to disqualify the Bidder from the tender process or to terminate the contract, if already signed, for such reason.
(1) If the Bidder / Contractor / Supplier has committed a transgression through a violation of Section 2 such as to put his reliability or credibility into question, the Principal is also entitled to exclude the Bidder / Contractor / Supplier from future contract award processes. The imposition and duration of the exclusion will be determined by the severity of the transgression. The severity will be determined by the circumstances of the case, in particular the number of transgressions, the position of the transgressors within the Company, hierarchy of the Bidder and the amount of the damage. The exclusion will be imposed for a minimum of 6 months and maximum of 3 years.
(2) A transgression is considered to have occurred if the Principal, after due consideration of available facts and evidences within his / her knowledge concludes that there is a reasonable ground to suspect violation of any commitment listed under Section 2 i.e "Commitments of Bidder(s) / Contractor(s)".
(3) The Bidder accepts and undertakes to respect and uphold the Principal's absolute right to resort to and impose such exclusion and further accepts and undertakes not to challenge or question such exclusion on any ground, including the lack of any hearing before the decision to resort to such exclusion is taken. This undertaking is given freely and after obtaining independent legal advice.
(4) If the Bidder / Contractor / Supplier can prove that he has restored / recouped the damage caused by him and has installed a suitable corruption prevention system, the Principal may revoke the exclusion prematurely.

Section 4 - Compensation for Damages

(1) If the Principal has disqualified the Bidder(s) from the tender process prior to the award according to Section 3, the Principal is entitled to demand and recover the damages equivalent to Earnest Money Deposit/ Bid Security.
(2) If the Principal has terminated the contract according to Section 3, or if the Principal is entitled to terminate the contract according to Section 3, the Principal shall be entitled to demand and recover from the Contractor liquidated damages of the Contract value or the amount equivalent to Performance Bank Guarantee.

Section 5 - Previous transgression

(1) The Bidder declares that no previous transgressions occurred in the last three years with any other Company in any country conforming to the anticorruption approach or with any Public Sector Enterprise in India that could justify his exclusion from the tender process.
(2) If the Bidder makes incorrect statement on this subject, he can be disqualified from the tender process or action can be taken as per the procedure mentioned in "Guidelines on Debarment of firms from Bidding ".

Section 6 - Equal treatment of all Bidders / Contractors / Sub-Contractors

(1) In case of Sub-contracting, the Principal Contractor shall take the responsibility of the adoption of Integrity Pact by the Sub-Contractor.

(2) The Principal will enter into agreements with identical conditions as this one with all Bidders and Contractors.
(3) The Principal will disqualify from the tender process all bidders who do not sign this Pact or violate its provisions.

Section 7- Criminal charges against violating Bidder(s)/Contractor(s)/ Sub-Contractor(s)

If the Principal obtains knowledge of conduct of a Bidder, Contractor or SubContractor, or of an employee or a representative or an associate of a Bidder, Contractor or Sub-Contractor which constitutes corruption, or if the Principal has substantive suspicion in this regard, the Principal will inform the same to the Chief Vigilance Officer.

Section 8 - Independent External Monitor

(1) The Principal appoints competent and credible Independent External Monitor for this Pact after approval by Central Vigilance Commission. The task of the Monitor is to review independently and objectively, whether and to what extent the parties comply with the obligations under this agreement.

(2) The Monitor is not subject to instructions by the representatives of the parties and performs his/ her functions neutrally and independently. The Monitor would have access to all Contract documents, whenever required. It will be obligatory for him / her to treat the information and documents of the Bidders/Contractors as confidential. He/ she reports to the Chairman, Coal India Limited / CMD, Subsidiary Companies

(3) The Bidder(s) / Contractor(s) accepts that the Monitor has the right to access without restriction to all Project documentation of the Principal including that provided by the Contractor. The Contractor will also grant the Monitor, upon his/ her request and demonstration of a valid interest, unrestricted and unconditional access to their project documentation. The same is applicable to Sub-Contractors.

(4) The Monitor is under contractual obligation to treat the information and documents of the Bidder(s) / Contractor(s) / Sub-Contractor(s) with confidentiality. The Monitor has also signed declarations on 'NonDisclosure of Confidential Information ' and of 'Absence of Conflict of Interest'. In case of any conflict of interest arising at a later date, the IEM shall inform Chairman, Coal India Limited / CMD, Subsidiary Companies and recuse himself / herself from that case.

(5) The Principal will provide to the Monitor sufficient information about all meetings among the parties related to the Project provided such meetings could have an impact on the contractual relations between the Principal and the Contractor. The parties offer to the Monitor the option to participate in such meetings.

(6) As soon as the Monitor notices, or believes to notice, a violation of this agreement, he/ she will so inform the Management of the Principal and request the Management to discontinue or take corrective action, or to take other relevant action. The Monitor can in this regard submit non-

binding recommendations. Beyond this, the Monitor has no right to demand from the parties that they act in a specific manner, refrain from action or tolerate action.

(7) The Monitor will submit a written report to the Chairman, Coal India Limited / CMD, Subsidiary Companies within 8 to 10 weeks from the date of reference or intimation to him by the Principal and, should the occasion arise, submit proposals for correcting problematic situations.

(8) If the Monitor has reported to the Chairman, Coal India Limited / CMD, Subsidiary Companies, a substantiated suspicion of an offence under relevant IPC/ PC Act, and the Chairman, Coal India Limited / CMD, Subsidiary Companies has not, within the reasonable time taken visible action to proceed against such offence or reported it to the Chief Vigilance Officer, the Monitor may also transmit this information directly to the Central Vigilance Commissioner.

(9) The word 'Monitor' would include both singular and plural. Section 9 - Pact Duration This Pact begins when both parties have legally signed it. It expires for the Contractor 12 months after the last payment under the contract, and for all other Bidders 6 months after the contract has been awarded. Any violation of the same would entail disqualification of the bidders and exclusion from future business dealings.

If any claim is made / lodged during this time, the same shall be binding and continue to be valid despite the lapse of this pact as specified above, unless it is discharged / determined by Chairman Coal India Limited / CMD, Subsidiary Companies.

Section 10 - Other provisions

(1) Changes and supplements as well as termination notices need to be made in writing. Side agreements have not been made.

(2) If the Contractor is a partnership or Joint Venture (JV/CONSORTIUM), this agreement must be signed by all partners or JV/CONSORTIUM members.

(3) Should one or several provisions of this Agreement turn out to be invalid, the remainder of this Agreement remains valid. In this case, the parties will strive to come to an Agreement to their original intentions.

(4) Issues like Warranty / Guarantee etc. shall be outside the purview of IEMs.

(5) In the event of any contradiction between the Integrity Pact and its Annexure, the Clause in the Integrity Pact will prevail.

Section 11- Facilitation of Investigation

In case of any allegation of violation of any provisions of this Pact or payment of commission, the BUYER or its agencies shall be entitled to examine all the documents including the Books of Accounts of the BIDDER and the BIDDER shall provide necessary information and documents in English and shall extend all possible help for the purpose of such examination.

Section 12- Law and Place of Jurisdiction

This Pact is subject to Indian Law. The place of performance and jurisdiction is the seat of the BUYER.

Section 13- Other Legal Actions.

The actions stipulated in this Integrity Pact are without prejudice to any other legal action that may follow in accordance with the provisions of the extant law in force relating to any civil or criminal proceedings.

(For & On behalf of the Principal) (For & On behalf of Bidder/ Contractor)

(Office Seal) (Office Seal)

Place ----------
Date ----------

Witness 1:
(Name & Address)

Witness 2:
(Name & Address)

ANNEXURE- A

Guidelines for Indian Agents for Foreign supplier (Part of Integrity Pact)

5. Authorized Indian Agent of a foreign manufacturer or indigenous manufacturer is also eligible to quote on behalf of its principal against the tender, in case manufacturer as a matter of corporate policy does not quote directly. However, in such case, authorized Indian Agent shall have to upload scanned copy of tender specific Manufacturer's Authorization, signed and stamped by the manufacturer to quote against the CIL Tender, indicating the Tender Reference No. and date along with the offer. The authorized Indian Agent is to upload scanned copies of details in respect of its organization along with the copies of document like certificate of incorporation / registration etc. alongwith the offer. The firm (Indian Agent) should be in existence for 3 years on the date of tender opening, irrespective of date of appointment as Indian Agent.
   In case an Indian Agent is participating in a tender on behalf of one manufacturer, it is not allowed to participate / quote on behalf of another manufacturer in this tender or in a parallel tender for the same item. Further, in a tender, either manufacturer can quote or its authorized Indian Agent can quote but both are not allowed to participate/ quote in the same tender. Also, one manufacturer can authorise only one agent to quote in the same tender. All the bids, not quoted as per the above guidelines, will be rejected.

6. The Foreign manufacturer must indicate the name & address of its agent in India. It should also indicate the commission payable to them and the specific services rendered by them. The Indian Agency commission will be payable only on FOB prices of goods and it should be quoted as a percentage of the FOB price. In case, the foreign manufacturer does not have any Indian Agent, it should be clearly mentioned in the bid. In terms of Integrity Pact, the Bidder has also to disclose all payments to agents, brokers or any other intermediaries. The amount of agency commission payable to Indian Agent should not exceed 5% or what is specified in agency agreement, whichever is lower.

7. In addition to above A certificate that no commission is payable by the principal supplier to any agent, broker or any other intermediary against this contract other than percentage as indicated in BOQ (not exciding 5% of FOB) of FOB value of the contract to Indian Agent. This certificate forms a part of letter of credit.

8. The payment of Indian Agency Commission, if any, involved, may be considered in case of necessity, subject to compliance of the Government of India guidelines issued from time to time. The name of the Indian Agent with their full address and the quantum of Agency commission if any, payable shall have to be mentioned in the offer by the foreign manufacturer. The following documents shall be submitted by the Bidder in case of contract with foreign principals involving Indian agents:

   a. Foreign principal's pro-forma invoice or any other authentic document indicating the commission payable to the Indian agent, nature of after sales service to be rendered by the Indian Agent and the precise relationship between the Principal and the Agent and their mutual interest.

b. Copy of the agency agreement if any with the foreign principal stating the precise relationship between them and their mutual interest in the business. However, if all the details given in Para – (i) are complied with, the requirement of submission of document mentioned at Para – (ii) may be waived.

9. Agency commission, if any, shall be paid in equivalent Indian Rupees.

Annexure-IX

PROFORMA FOR EXECUTION OF AGREEMENT

STAMP PAPER

(of appropriate value as per Stamp Act)

This agreement is made on ……. day of …….. between (Name of Company) having its registered office at …… (hereinafter called the 'COMPANY' which expression shall, unless repugnant to the subject or context, include its successors and assignees) of the one part and (Name of the Contractor) carrying on business as a (partnership/ proprietorship/ Ltd. Co. etc.) firm under the name and style …… (hereinafter called the 'said Contractor' which expression shall, unless the context requires otherwise include them and their respective heirs, executors, administrators and legal representatives) of the other part.

Whereas the Company invited tenders for the work of "…… …… ……..." and whereas the said Contractor/ Firm submitted tender for the said work and deposited a sum of Rs…….. as Earnest Money and whereas the tender of the said contract has been accepted by the Company for execution of the said work.

NOW THIS AGREEMENT WITNESSETH AS FOLLOWS:

1) In this agreement words and expressions shall have the same meaning as are respectively assigned to them in the tender papers hereinafter referred to.

2) The following documents which are annexed to this agreement should be deemed to form and be read and construed as part of this agreement viz.

i) Annexure-A Tender Notice (Page .. to ..)

ii) Schedule –A General Terms & Conditions, Special Conditions and General Technical Specification (Page …. to …) and

Safety Code.

iii) Schedule-B The probable Quantities and Amount (Page … to …)

iv) Schedule-C Negotiation letters –

iv) Schedule-D Letter of Award/Work Order (Page .. to ..)

v) Schedule-E Drawings (Page .. to ..)

3) In consideration for the payment of the sum of Rs……(W/O Value; both in words and figures) or such other sum as may be arrived at under the clause of the specification relating to Payment by items measurements at unit prices by the Company, the said Contractor shall, subject to the terms & condition contained herein execute and complete the work as described and to the extent of probable quantities as indicated in Schedule B with such variations by way of alteration, addition to or reduction from the said works.

4) The company has received a sum of Rs..... towards Contract Performance Security Deposit (1st part of Security Deposit) in the form of Demand Draft / Certified Cheque/ B.G./ *other form (details to be furnished)*.

5) The said contractor hereby covenants with the company that the company shall deduct at 5% of R/A Bills as Retention Money (2nd part of security deposit) as per the terms & condition of the tender/ contract.

IN WITNESS WHEREOF THE parties herein have set their hands and seals the date and year above written.

1 Partner. Signature

2 Partner Signature

On behalf of M/S……..

The Contractor, as one of the constituted attorney,

In the presence of –

1. Name _____ Signature

Address :

Occupation :

Signed by Sri …….on behalf of Signature
(Name of Company) in presence of -

a) Name : Signature
b) Address: .

Annexure-X

PROFORMA FOR UNDERTAKING

(To be uploaded by the Bidder on his Letter Head during submission of bid online)

I / We, ..., Proprietor/Partner/Legal Attorney/Director/ Accredited Representative of M/S. ....., solemnly declare that:

1. Myself/Our Partners/Directors don't has/have any relative as employee of Coal India Limited.

OR

The details of relatives of Myself/Our Partners/Directors working as employee of Coal India Limited is as follows:

a) Name of the employee
b) Place of posting
c) Department
d) Designation
e) Type of relation - Wife/Husband/ Father/ Step-Father/Mother / Step-Mother/ Son/Step-son/ Son's wife / Daughter / Daughter's Husband / Brother/ Step-Brother/ Sister / Stet-Sister.

2. *I/We hereby confirm that we have registration with CMPF / EPF Authorities. We shall make necessary payments as required under law.

Or

*I/We hereby undertake that we shall take appropriate steps for registration as relevant under CMPF / EPF authorities, if applicable. We shall make necessary payments as required under law.

* Delete whichever is not applicable.

3. ** I/We have not been banned or delisted by any Govt., or Quasi Govt. Agencies or PSUs.

Or

**I / *We* ……..have been banned by the organization named "_____" for a period of…… year/s, effective from ……. to……..…..

** Delete whichever is not applicable.

4.We,…… ……..(Name of Partners of Partnership Firm/Joint Venture), partners of ……..(Name of Partnership Firm/Joint Venture) hereby consent to abide by the provisions of Clause 19 and 20 of General Terms and Conditions pertaining to arbitration.

(Applicable in case of Partnership firm/Joint Venture)

5. We certify that the works/services offered by us against the tender for the work "……(Name of work)" against NIT No/Tender ID. ..... Dated……, meet the minimum local content requirement and has local content:

   * Equal to or more than 50% (Select this, in case of Class-I Local Suppliers) i.e……% (indicating the percentage of local content)

   * More than 20% but less than 50% (Select this, in case of Class-II Local Suppliers) i.e……% (indicating the percentage of local content)

   *Delete whichever is not applicable.

6. The NEEGG of the offer is 28% CUF (minimum 73,58,40,000 units) at the Delivery Point for the first year. The degradation in NEEGG quoted for any year is not more than 0.5% of that quoted for the previous year.

Year	CUF (in percentage)	Net Electrical Energy Generation Guarantee (in kWh)
Year 1		
Year 2		
Year 3		
Year 4		
Year 5		

7. Certificate regarding compliance to order no.F.No.6/18/2019-PPD dt 23/7/2020 as amended from time to time of Ministry of Finance, Dept of Expenditure, Public Procurement Division with respect to restrictions on procurement of goods, services or works from a bidder of a country which shares a land border with India and on sub-contracting to contractors from such countries - I/we have read the Clause regarding restrictions on procurement from a bidder of a country which shares a land border with India and on sub-contracting to contractors from such countries; I/we certify that I am/ we are not from such a country or, if from such a country, has/have been registered with the Competent Authority and will not sub-contract any work to a contractor from such countries unless such contractor is registered with the Competent Authority. I hereby certify that I/we fulfil all requirements in this regard and I am/ we are eligible to be considered.

   (Where applicable, evidence of Competent Authority shall be attached along with this undertaking.)

3. If any information and document submitted is found to be false/ incorrect at any time, department may cancel my/our Bid and action as deemed fit may be taken against me/us, including termination of the contract, forfeiture of all dues including Earnest Money and banning of our firm and all partners of the firm etc. as per Annexure-XVI – Guidelines on Debarment of Firms from Bidding.

Annexure-XI

ILLUSTRATIVE COMPUTATION OF EVALUATED BID VALUE (EBV)

The Evaluated Bid Value (EBV) shall be calculated using the following parameters: Parameters Quoted by the Bidder:

i. Quoted Supply Price (in INR),
ii. Quoted Works Price (in INR),
iii. Quoted O&M Price for each year during the O&M period (of 5 years) (in INR),

Parameters assumed constant for evaluation of each Bidder:

The Evaluated Bid Value (EBV) shall be calculated using the abovementioned parameters as follows:

Step 1		Quoted total Supply Price (in INR)
Step 2		Quoted total Works Price (in INR)
Step 3		Total of 5 years of O&M Cost quoted by the Bidder (in INR)
Step 4	ADD	Summation of Supply Price, Works Price and Total of O&M Price for 5 years (in INR) (sum of Step 1 to 3)

The Evaluated Bid Value (EBV) shall be the Net Present Value (NPV) as calculated above.

Evaluated Bid Value (EBV) = [(Quoted Supply Price) + (Quoted Works Price) + (Total NPV of each year O&M Contract Price of 5 years)]

The Bidder with the lowest EBV in INR shall be the Successful Bidder.

FORMAT FOR SUBMISSION OF PRICE BID

Supply Cost (INR)	Works Cost (INR)	Year	Total of O&M Cost		EBV (INR)
			Yearly Cost (INR)	Total Cost INR)	
(A)	(B)			(C)	F=(A+B+C)
		1			
		2			
		3			
		4			
		5			

EXAMPLE:

The following example will further clarify the methodology of comparison:

Figures Quoted by Bidder 1:

Supply Cost (INR)	Works Cost (INR)	Year	Total of O&M Cost		EBV (INR)
			Yearly Cost (INR)	Total Cost INR)	
(A)	(B)			(C)	F=(A+B+C)
4,03,50,00,000	1,00,00,00,000	1	2,18,00,000	9,65,67,460	5,13,15,67,460
		2	2,04,78,920		
		3	1,92,38,500		
		4	1,80,72,200		
		5	1,69,77,840		

EBV of Bidder 1 is INR 5,13,15,67,460.

Figures Quoted by Bidder 2:

Supply Cost (INR)	Works Cost (INR)	Year	Total of O&M Cost		EBV (INR)
			Yearly Cost (INR)	Total Cost INR)	
(A)	(B)			(C)	F=(A+B+C)
4,18,82,22,000	1,20,00,00,000	1	2,28,90,000	10,13,95,833	5,48,96,17,833
		2	2,15,02,866		
		3	2,02,00,425		
		4	1,89,75,810		
		5	1,78,26,732		

EBV of Bidder 2 is INR 5,48,96,17,833.

EBV of Bidder 1 is lower than Bidder 2.

Bidder with lower EBV in INR shall be L-1. Hence, in the above illustrative computation, Bidder 1 would be preferred as the Successful Bidder (L-1) compared to Bidder 2.

Annexure-XII

FORMAT FOR DETAILED PROJECT SCHEDULE

(to be furnished by the Bidder in the Bid in form of Gantt Chart or PERT Chart)

Sl. No.	Activity	Weeks							
		W1	W2	W3	…	…	…	…	Wn
1.									
2.									
3.									

Note: The Bidder shall ensure that the Project COD is achieved within 365 days (i.e. 12 months) from the date of issue of LOA from the Employer.

Annexure-XIII

NO CLAIM CERTIFICATE
(on company letterhead)

To,
(Contract Executing Officer)

Procuring Entity_____

NO CLAIM CERTIFICATE

Sub: Contract Agreement no. ---------- dated ----------for the supply of ----------

We have received the sum of Rs. (Rupees _____only) in full and final settlement of all the payments due to us for the supply of under the above mentioned contract agreement, between us and……. We hereby unconditionally, and without any reservation whatsoever, certify that with this payment, we shall have no claim whatsoever, of any description, on any account, against Procuring Entity, against aforesaid contract agreement executed by us. We further declare unequivocally, that with this payment, we have received all the amounts payable to us, and have no dispute of any description whatsoever, regarding the amounts worked out as payable to us and received by us, and that we shall continue to be bound by the terms and conditions of the contract agreement, as regards performance of the contract.

Yours faithfully,

Signatures of contractor or Officer authorized to
sign the contract documents on behalf of the
contractor.
(Company stamp)

Date:

Place:

(This certificate shall be accompanied by the Power of attorney of the signatory)

Annexure-XIV

PROFORMA FOR BANK GUARANTEE AGAINST RELEASE OF RETENTION MONEY DEDUCTED FROM RUNNING ON ACCOUNT BILLS.

To …….. ……..

Re: Bank guarantee in respect of contract No……..…… Dated…… between ……. (Name of the …….) And …….. (Name of the Contractor)

WHEREAS
…….. (Name and address of the Contractor) (herein after called "the Contractor") has entered into a contract dated…….(herein after called the said contract) with …… (name of the Company) (hereinafter called "the Company") to execute ……. (name of the contract and brief description of work) on the terms and conditions contained in the said contract.

It has been agreed that the Contractor shall furnish a Bank Guarantee from a Scheduled Bank for a sum of Rs…….. as security for release of equivalent amount of Retention Money/Bid Security as per Terms and Conditions of the said Contract.

We…… (name of the Bank) having its branch/Office at……..….. have, at the request of the Contractor, agreed to furnish this bank Guarantee by way of Bid Security.

NOW, THEREFORE, we the…… Bank (herein after called The Bank) hereby, unconditionally and irrevocably, guarantee and affirm as follows:

The Bank do hereby irrevocably guarantee and unconditionally agree with the Company that if the Contractor shall in any way fail to observe or perform the Terms and Conditions of the said Contract or shall commit any breach of its obligation thereunder, the Bank shall on its mere first written demand, and without any objection, demur and without any reference to the Contractor, pay to the Company the said sum of …… or such portion as shall then remain due with interest without requiring the Company to have recourse to any legal remedy that may be available to it to compel the Bank to pay the sum, or failing on the Company to compel such payment by the Contractor.

Any such demand shall be conclusive as regards the liability of the Contractor to the Company and as regards the amount payable by the Bank under this guarantee. The Bank shall not be entitled to withhold payment on the ground that the Contractor has disputed its liability to pay or has disputed the quantum of the amount or that any arbitration proceeding or legal proceeding is pending between the Company and the Contractor regarding the claim. The Bank further agree that the Guarantee shall come into force from the date hereof and shall remain in force and effect till the period that will be taken for the performance of the said Contract which is likely to be …… day of ……. but if the period of Contract is extended either pursuant to the provisions in the said Contract or by mutual agreement between the Contractor and the Company, the Bank shall renew the period of the Bank Guarantee failing which it shall pay to

the Company the said sum of Rs…….. or such lesser amount of the said sum of Rs……. as may be due to the Company and as the Company may demand.
This Guarantee shall remain in force until the dues of the Company in respect of the said sum of Rs…….. and interest are fully satisfied and the Company certifies that the Contract has been fully carried out by the Contractor and he has discharged the guarantee.

The Bank further agrees with the Company that the Company shall have the fullest liberty without consent of the Bank and without affecting in any way the obligations hereunder to vary any of the Terms and Conditions of the said Contract or to extend time for performance of the said Contract from time to time or to postpone for any time or from time to time any of the powers exercisable by the Company against the Contractor and to forebear to enforce any of the terms & conditions relating to the said Contract and the Bank shall not be relieved from its liability by reason of such failure or extension being granted to the Contractor or to any forbearance, act or omissions on the part of the Company or any indulgence by the Company to the Contractor or any other matter or thing whatsoever which under the law relating to sureties would but for this provision have the effect or relieving or discharging the Guarantor.

The Bank further agrees that in case this Guarantee is required for a longer period and it is not extended by the Bank beyond the period specified above the Bank shall pay to the Company the said sum of Rs…….. or such lesser sum as may then be deemed to the Company and as the Company may require.

This Bank Guarantee shall also be operative at our …… Branch located at .....(detailed address), from whom, confirmation regarding issue of this guarantee or extension/renewal thereof shall be made available on demand.

Any notice by way of request, demand or otherwise hereunder may be sent by post/e-mail/Fax addressed to the bank branch / operative branch, which shall be deemed to be a sufficient demand notice. Bank shall effect payment thereof forthwith.

The details of outstation Bank issuing the Bank Guarantee are as below.
i) Complete Postal Address with PIN Code -
ii) Branch Code -
iii) IFSC Code –
iv) SWIFT –
v) Telephone No. –
vi) Fax No. –
vii) Email ID –

The details of Local Operating Branch of the Bank issued the Bank Guarantee are as below. i) Complete Postal Address with PIN Code -
ii) Branch Code -
iii) IFSC Code –
iv) SWIFT –
v) Telephone No. –
vi) Fax No.

vii) Email ID –

Whenever there is change in postal address and/or other details of this branch issued the guarantee and/or the operative branch, we .....(the issuing bank) will ensure to intimate respective Area, being the beneficiary, of such changed address, telephone number, fax number and e-mail ID.

Notwithstanding anything contained herein the liability of the Bank under this Guarantee is restricted to Rs…….. The Guarantee shall remain in force till the day ……*…….. of ……*…….. and unless the Guarantee is renewed or claim is preferred against the Bank on or before the said date all rights of the Company under this Guarantee shall cease and the Bank shall be relieved and discharged from all liabilities hereunder except as provided in the preceding Clause.

* The date of guarantee shall cover a period of minimum one year or 270 days beyond the date of completion whichever is more.

Any notice by way of request, demand or otherwise hereunder maybe sent by post/e-mail/Fax addressed to the bank branch/operative branch, which shall be deemed to be a sufficient demand notice. Bank shall effect payment thereof forthwith.

This Guarantee will not be discharged due to the change in the constitution of the Bank or the Contractor.

The Bank has under it is constitution power to give this guarantee and Shri …… who has signed it on behalf of the Bank has authority to do so. Signed and sealed this……..day of……..at……

SIGNED, SEALED AND DELIVERED
For and on behalf of the Bank by:
(Signature)
(Name)
(Designation)
(Code number)
(Address)

“The Bank Guarantee as referred above shall be operative at our branch at…….. payable at…….(NIT shall specify town/city of the operative Branch. Bank Guarantee shall specify name of the branch with address of the specified town/city)”

NOTE: - The department shall ensure extension of guarantee period in case of extension of time.

Instructions to Bidders for both the above BGs

NOTES TO BANK GUARANTEES

While issuing the Bank Guarantee, the issuing bank may please note the following.

i) The bank guarantees issued by the issuing bank on behalf of Contractor, supplier, customer in favour of ……Coalfields Limited shall be in paper form as well as Structured Financial Messaging System (SFMS).

ii) ……..(Company name) has chosen ….(Bank name) and ….(Bank name) to act advising/beneficiary bank of …...(Company name). The bank issuing the guarantee can choose either of these banks to send confirmation through SFMS.

iii) The details of beneficiary for issue of bank guarantee in SFMS platform is as furnished as below.

1.	Name and details of the Beneficiary	i	Name	
		ii	Area	
		iii	Name of Bank	
		iv	Bank Account No.	***
		v	Department	**
2.	Beneficiary's Advising Bank, Branch and Address for Confirmation of BGs through SFMS	i	Name of Bank	
		ii	Bank Branch Name	***
		iii	Branch Code	***
		iv	Beneficiary Bank Branch IFSC	***
		v	Beneficiary Bank Addres	***

* Name of the Area/HQ, to which the NIT is concerned, is to be mentioned.
** Name of Department of the Area/ HQ, to which the NIT is concerned, is to be mentioned
*** Details of Bank Account, IFSC Code, Bank Address of the Area/HQ to which the NIT is concerned, is to be mentioned

i) The Supplier / Contractor/ Customers are required to take note of it that above particulars are to be incorporated by the issuing bank properly while issuing the Bank Guarantee under SFMS mode to avoid any future problem in accepting the BGs.

ii) The Guarantor (BG issuing bank) shall send information about issuance of this Guarantee through SFMS gateway to the ….(Bank name) (IFSC-_____) or ….(Bank name) (IFSC-_____), as the case may be, to aid in the process of confirmation of Bank Guarantee.

iii) The Guarantor (BG issuing bank) shall also send information about issuance of this Guarantee to its local operating branch at _____to aid in the process of confirmation as well as claim for encashment of Bank Guarantee.

iv) The Original Bank Guarantee issued by the outstation bank shall be sent by the Issuing Bank to the Concerned Department of Head Quarters or Area of …… Coalfields Limited at …… (as the case may be) by Speed Post /Registered Post (AD).

Annexure-XV

FORMAT FOR PRE-BID QUERIES

Sl. No.	Chapter No.	Clause No.	Page No.	Tender Term	Bidder's Query

Sign with seal

Annexure-XVI

GUIDELINES ON DEBARMENT OF FIRMS FROM BIDDING

CIL and its Subsidiary Companies shall follow the following guidelines for effecting 'Debarment of firms from Bidding' with a contracting entity in respect of Works and Services Contracts.

1. Observance of Principle of Natural Justice before banning the business dealings with any contracting entity.

2. The contracting entity bidder/contractor may be debarred in the following circumstances: -

   i) If Bidder backs out after notification of opening of price bid and if that Bidder is found to be L-1.

   ii) If L-1 Bidder fails to submit PSD, if any and/or fails to execute the contract within stipulated period.

   iii) If L-1 Bidder fails to start the work on scheduled time.

   iv) In case of failure to execute the work as per mutually agreed work schedule.

   v) Continued and repeated failure to meet contractual Obligations:

      a) In case of partial failure on performance, agency shall be debarred from future participation in tenders keeping his present contract alive.

      b) On termination of contract.

   vi) Willful suppression of facts or furnishing of wrong information or manipulated or forged documents by the Agency or using any other illegal/unfair means.

   vii) Formation of price cartels with other contractors with a view to artificially hiking the price.

   viii) The contractor fails to maintain/repair/redo the work up to the expiry of performance guarantee period, when it is specifically brought to his notice.

ix) Contractor fails to use Mobilisation advance given to him for the purpose it was intended.

x) Contractor fails to renew the securities deposited to the department.

xi) The contractor fails to rectify any lapse(s) in quality of the work done within defect liability period.

xii) Transgression of any clause(s) relating to Contractor's obligation defined in the Integrity Pact wherever such Pact exists.

xiii) Any other breach of Contract or misdeed which may cause financial loss or commercial disadvantage to the Company.

3. Such 'Debarment of firms from Bidding, if and when effected, shall be with prospective effect only. The effect of 'Debarment of firms from Bidding' shall be for future tenders from the date of issue of such Order. However, if any contracting entity is debarred after online notification of opening of Price Bid, such a debarment will not be effective for that work.

4. The debarment shall be for a minimum period of one year and shall be effective for the concerned Subsidiary for the tenders invited at Subsidiary level. Similarly, in case of tenders of CIL HQ, debarment shall be for CIL HQ. However, if such 'Debarment of firms from Bidding' has to be made effective for entire CIL and its Subsidiaries then approval of Chairman, CIL shall be required.

5. Once a contracting entity is debarred, it shall be extended to the constituents of that entity, all partners in case of JV/Consortium, all the partners in case of Partnership Firm, owner/proprietor in case of Proprietorship Firm and all the Directors in case of Limited Company. If such debarred owner/Proprietor/ Partner/Director make/form different Firms/entity and attempts to participate in tenders, the same will not be entertained during the currency of such debarment.

6. The above 'Debarment of firms from Bidding' shall be in addition to other penal provisions of NIT/Contract document.

7. Approving Authority: The ‘Debarment of firms from Bidding’ of a contracting entity shall be done with the approval of the Competent Authority as per the details below:

    a) In case the Accepting Authority of the work is Board or Empowered Committee or FDs or CMD of CIL/Subsidiary Company, then the Competent Authority for debarring shall be CMD of CIL/Subsidiary Company.

    b) In case the Accepting Authority of the work is up to the level of Director of CIL/Subsidiary Company, then the Competent Authority for debarment shall be Director of CIL/Subsidiary Company.

8. Appellate Authority shall be one Rank higher than the Competent Authority meant for ‘Debarment of firms from Bidding’. In case the debarment is done with the approval of CMD of the Subsidiary Company then Chairman, CIL shall be the Appellate authority.

9. Any change on the above may be done with approval of FDs of CIL.

10. All the orders of debarment or orders passed in appeal shall be marked to GM(CMC) / Civil / concerned HODs of CIL/Subsidiary Company. Further, all such orders will be uploaded in Coal India site as well website of the Subsidiary Company.

11. Efforts shall be made by the concerned Department so that such order is linked to e-tender portal of Coal India Limited.

Annexure-XVII(a): Details of Applicant's experience for Route-I

(On Applicant's letterhead)

Details of the Solar Photo Voltaic-based grid connected power project(s) executed by the Applicant as EPC:

Sl. No.	Project name	Capacity (MWp)	Location of installation	Client / Customer Name, Full Address, Tel No., Fax No., Client contact person (name, designation, mob no, email ID)	Date of award	Date of commissioning	Number of months of successful operation from the last date of bid submission	Current status of project (e.g. under construction, successful operation)	Applicant's Scope of work in the project (e.g. EPC, O&M)	Whether documentary evidence have been furnished in this Application as per clause 14.5 of NIT (Yes / No)
1										
2										
3										
	Add rows for more no. of projects									
Total Capacity										

(Sign. & Seal of Authorized Signatory)

Place:

Date:

Note: The details provided here shall be used for assessing eligibility against criterion mentioned in clause 14.5 of NIT provided copy of supporting documents are submitted as mentioned in the same.

Annexure-XVII(b): Details of Applicant's experience for Route-II

(On Applicant's letterhead)

Details of the Solar Photo Voltaic-based grid connected power project(s) executed by the Applicant as a Developer:

Sl. No.	Project name	Capacity (KWp)	Location of installation	EPC/ Contractor Name, Full Address, Tel No., Fax No., EPC/ Contractor contact person (name, designation, mob no, email ID)	Date of award of LOA/ Work Order/ Contract Document by the Project Developer	Date of commissioning	Number of months of successful operation from the last date of bid submission	Current status of project (e.g. under construction, successful operation)	Applicant's Scope of work in the project (e.g. Developer, EPC, O&M)	Whether documentary evidence have been furnished in this Application as per clause 14.5 of NIT (Yes / No)
1										
2										
3										
	Add rows for more no. of projects									
Total Capacity										

(Sign. & Seal of Authorized Signatory)

Place:

Date:

Note: The details provided here shall be used for assessing eligibility against criterion mentioned in clause 14.5 in NIT provided copy of supporting documents are submitted as mentioned in the same.

Annexure-XVIII

PROJECT MASTER PLAN

SECTION – VI: TECHNICAL SPECIFICATION

INDEX

TABLE OF CONTENTS

PART-A
SUBSECTION – 1

1-A PROJECT INFORMATION

1.0 INTRODUCTION

Coal India Limited (CIL) is the state-owned coal mining corporate came into being in November 1975 is at the forefront of the nation's coal production in the Indian energy sector, CIL. CIL alone produces around 83% of country's entire coal output. In a country where 69% of the total electricity generation is coal based, CIL virtually empowers the nation's power sector. Around 80% of CIL's total supplies are catered to power sector.

CIL is currently developing several Solar, Floating & Hybrid innovative Renewable Energy Projects. In the years to come CIL has a major role to play in the Renewable Energy sector's development. The company has an aim to develop a total cumulative capacity of 5 GW of Renewable Energy by the year 2028-29.

In this regard CIL participated in Gujarat Urja Vikash Nigam's (GUVNL) auction to supply power from 600 MW of grid-connected solar power project (Phase XXI) to be set up at Khavda Solar Park, Gujarat. CIL was awarded a capacity of 300 MW and the organization envisages the execution of green energy technologies by way of implementing ground based Solar PV Power Plant for setting up 300 MW grid connected Solar Photovoltaic (PV) Power Projects.

Accordingly, this specification is for the EPC package of Solar PV Project for the development of 300MW capacity.

This EPC package is proposed to be awarded to multiple bidders in single/multiple plots as defined with suitable award criteria to be intimated separately in the bidding documents.

2.0 ABOUT PROJECT

Name of the Project	Development of 300MW Khavda Solar Photovoltaic Project in Gujarat, India.
Solar Park Project	600MW Khavda Solar Park Project
Plant Capacity	300MW at Grid Connection Points.
Metering Point	400KV side of 400/765 KV Khavda PS-II Pooling Sub-Station of CTU. However, one more metering system is to be installed at 33 KV side of 400/33 KV Internal Pooling Sub-station where power from the Solar Power Project is injected for measuring export / import from each project.

3.0 LOCATION AND APPROACH

Location of Site	PLOT NO. 3,4,5 of Phase-I of GIPCL Solar Park
Nearest Town	Bhuj
Nearest Railways Station	Bhuj
Nearest Commercial Airport	Bhuj

GIPCL's Solar Park is sitiuated in Great Rann of KUTCH, Near Village Khavda, Tal. Bhuj, District Kutch, Gujarat, India.

4.0 AREA AVAILABILITY

Land availability: 03 Plots in GIPCL's Solar Park each of 450 Acres

Land will be provided by CIL on "as is where is basis" received from GoG.

5.0 TECHNOLOGY

In Solar Photo Voltaic Power Generation, the direct conversion of solar radiation into electricity is achieved by using semiconductor devices "Solar Cells", which work on the principles of photo electric effect.

6.0 SITE SPECIFIC TECHNICAL DATA

Refer APPENDIX – 1

7.0 EVALUATION CRITERIA

Refer NIT.

8.0 STATUTORY COMPLIANCE, GRID CONNECTIVITY AND POWER EVACUATION

The scope of power evacuation system in the scope of the bidder is upto the terminal point as indicated in the tender SLD. The Bidder shall be responsible for terminating their 33kV evacuation feeder at 33kV Main Pooling Switchgear built by GIPCL.

Bidder shall comply all provisions and amendments thereafter of

(i) Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022

(ii) CERC 'Detailed Procedure for Connectivity and GNA' under the Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022"
(iii) CEA (Technical Standards for Connectivity to Grid) Regulation,2007
(iv) CEA (Technical Standards for construction of Electrical Plants and Electrical Lines) Regulation,2010
(v) CEA (Grid Standard) Regulation,2010
(vi) CEA (safety requirements for construction, operation and maintenance of Electrical Plants and Electrical Lines) Regulations,2011
(vii) CEA (Measures relating to Safety and Electrical Supply) Regulations,2010
(viii) CEA (Installation and Operation of Meters) Regulations 2006
(ix) Indian Electricity Grid code Regulation,2010
(x) CEA (Technical standards for communication system in Power system operations) Regulation 2020
(xi) CERC (Communication System for Inter State Transmission of Electricity) Regulations 2017
(xii) MNRE guidelines/OM/Advisory/Clarifications
(xiii) And any other applicable standard/regulations

a) CIL shall conduct detailed Grid compliance study with Power Plant Controller for solar project as per CEA technical standard for grid connectivity and latest guideline of RLDC first charging clearance. In this regard, bidder shall provide all technical details including Inverter bench marking report, Generic model data of Inverters, suitable for use in PSS/E and PSCAD software available at RLDC and Encrypted user-defined model (UDM)/generic model of Inverter in PSS/E software (*.dll files) as applicable. Provision of PSCAD model of inverter shall also be in bidder's scope. In case any site testing required for grid compliance as per RLDC, it shall also be conducted.

b) Bidder shall provide all required data to enable CIL to complete detailed consolidated Grid compliance study at least 6 months before the scheduled First Charging date of the plant and availability of PSSE and PSCAD model of Inverter and PPC shall be ensured by Bidder during selection of respective Manufacturer.

c) Bidder shall provide all data for performing applicable study/simulation reports as per 'Procedure for Integration of solar plant those are regional entities" for submission to RLDC for first time charging clearances (as required by regulatory/statutory body). Bidder may refer latest FTC (First Time Charging) clearance documents with regards to same.

e) Bidder shall update themselves latest requirement for technical data requirement/PSSE/PSCAD Model as per WRLDC/CTU. The minimum data required is attached in Appendix-5 for IBR (Inverter Based Resources) to be submitted to CIL for Grid study. Bidder shall submit above documents within 3 months from LoA. However, the final requirement or any other requirement shall be intimated during detail engineering in due course of interaction with WRLDC.

f) EPC supplier has to apply on behalf of Solar Project Developer (SPD) has to apply for First Time Charging (FTC) approval for its installed capacity as per prescribed procedure by Western Region Load Dispatch Centre (WRLDC)/CEA/CERC. All the necessary compliance at 33 kV level, i.e. Study Reports/Models, additional equipment for reactive power support etc as required by the WRLDC shall be in the scope of Selected Bidder. First Time Charging obligation is to be solely fulfilled by Selected Bidder's and for any noncompliance of Selected Bidder and delay in FTC, SPPD will not be responsible. (As per CEA guidelines for RE generators considering 0.95 PF, the Reactive power Requirement for 100 MW plant would be 33 MVAr.). SPD, CIL shall facilitate the EPC supplier.

Bidder shall facilitate CIL in addressing all the queries of CTU/RLDC with respect to reports and models are answered to their satisfaction.

All equipment, materials and services whether explicitly stated in Technical Specifications or otherwise and that are necessary for the successful commissioning of Solar Plant as per latest statutory regulations/procedures issued by bodies like CERC/SERC, CEA, RLDC/NLDC/SLDC,CTU/STU,MNRE, other Ministry etc. shall be deemed to be included in the scope of work of the Contractor

9.0 GENERATION GUARANTEE

a) The Bidder shall give NEEGG per annum after considering proposed configuration and all local conditions, solar insolation, wind speed and direction, air temperature & relative humidity, barometric pressure, rainfall, sunshine duration, grid availability and grid related all other factors and losses due to near shading, incidence angle modifier, irradiance level, temperature loss, array loss, module quality loss, module array mismatch loss, soiling loss and various inverter losses etc.

b) Bidders are expected to undertake their own study of solar profile and other related parameters of the area and make sound commercial judgment about power output i.e. Net Electrical Energy Guaranteed Generation.

c) The Bids should have the NEEGG equivalent to minimum 28% CUF at the Delivery Point for the first year. The degradation in NEEGG quoted for any year shall not be more than 0.5% of that quoted for the previous year. If the Bidder anticipates any degradation of the modules during the first year, it shall be taken care of by the Bidder to provide additional capacity of solar PV modules to meet guaranteed generation at the end of first year to avoid liquidated damages/compensation on account of guaranteed generation.

10.0 **Liquidated Damages** for shortfall in performance during O&M period are elaborated in Section -III: Special Conditions of Contract - Liquidated Damages for Delay and Underperformance

OTHER DETAILS

The following clearances shall be arranged by bidder. However, necessary documentations/applications shall be in the name of CIL.

SL	ITEM	DETAILS
1	Water Requirement during construction	To be arranged by bidder
2	Power Requirement during construction	To be arranged by bidder
3	MOEF Clearance	Shall be arranged by CIL, wherever applicable
4	SPCB Clearance	Application by CIL. Inputs for application & processing to be facilitated by bidder
5	MNRE Clearance	To be facilitated by bidder
6	Chief Electrical Inspector Clearance	To be facilitated by bidder
7	Tree Cutting Permission	NA

Water and Power arrangement are also being done by SPPD in parallel and shall be made available as and when ready. However, during construction, onus of any such arrangement would remain with Bidder only.

APPENDIX – 1
SITE SPECIFIC TECHNICAL DATA

A. **Solar Insolation Data for Proposed Site**

Month	Solar Insolation (kWhr/m^2)	Albedo
January	142.8	0.27
February	153.6	0.26
March	200.2	0.26
April	216.5	0.26
May	226.8	0.26
June	191.2	0.25
July	146.3	0.25
August	142.0	0.26
September	167.0	0.27
October	174.7	0.28
November	139.8	0.28
December	132.7	0.27
Year	2033.6	0.27

B. **MODULE MOUNTING** – Single Axis E-W Tracker

C. **CABLE LAYING METHODOLOGY**

Bidder can propose suitable alternate cable laying methodology except directly buried philosophy for Khavda location, keeping in view of the site specific issues related to water submergence, soil condition etc, which shall be reviewed during the detail design engineering. Directly buried philosophy is not acceptable in the project and must be ignored if mentioned elsewhere in the specifications.

D. **PROJECT LOCATION CLASSIFICATION (CORROSION PROTECTION)**

Parameter	Coastal / Non-Coastal	Corrosive Category (as per ISO12944-2)
For below Ground Structures (including up to 300mm above ground)	**Coastal**	**C5-M**
For Above Ground Structures (Beyond 300mm)	**Non-Coastal**	**C4**

Corrosive category (for Paints)

Classification of environments for Corrosive category shall be in accordance with ISO12944-2, the applicable atmospheric corrosivity categories C4 (high); C5-M (very high- marine).

ISO12944-5 shall be used related to paint systems in combination with guidance for the selection of different types of protective paint system. Wherever specification allows LT electrical panels, UPS, SCADA panel, Fire protection panel etc. associated with Inverter station to be placed outdoor, the enclosure of the same should be well engineered product having proper ventilation system and must be protected from harsh environment & direct sunlight/rainfall. Radiation and absorption effects of outdoor environment must be considered for temperature rise calculations. The temperature rise should not be more than working temperature of components. Requirement of suitable shed/canopy shall be reviewed based on the offered solution during detailed engineering stage.

For metal enclosed outdoor HT switchgear/RMU, pooling switchgear on the LT side (if applicable) from string inverter to inverter transformer, suitable shed shall be provided considering the O&M space.

Painting of outdoor metallic enclosed electrical panels including HT switchgear/RMU shall be as per ISO 12944-5, corresponding to corrosive category mentioned in the above table.

For outdoor inverter including containerized solution, painting corresponding to site condition shall be provided.

Unless noted otherwise, all steel structures exposed to environment would be painted to meet the requirements of C4 corrosion category or would be galvanized to minimum 90microns.

RAINFALL – Heaviest rainfall in one hour (in mm): 48.8mm Or As per Nearest city / town (as mentioned in Appendix-A of IRC:SP:13-2004.)

E. **SEISMIC DATA & DESIGN CRITERIA** – **Seismic Zone 5**, Provisions of IS 1893 (Part 1) shall be followed**.**

F. **WIND DATA & DESIGN CRITERIA**

Basic wind speed shall be as per IS 875 (Part-3) (Based on survey of India Political map printed in 2002).

The minimum design wind pressure (Pd) to be considered for design of MMS, Equipment Fixing, Buildings, Rooms, etc. as below:

BASIC WIND SPEED, m/s	Design Wind Pressure, min, Pd (N/m^2)

47	890

For Khavda park, the minimum design wind pressure (Pd) = 890 N/m2

Area Drainage Study report carried out by GIPCL is attached for reference purpose only.

APPENDIX – 2

Deleted

APPENDIX – 3A
LIQUDATED DAMAGES

1.

LD FOR SHORTFALL IN GENERATION DURING O&M PERIOD

Refer NIT

APPENDIX – 3B
LIABILITY DURING AMC

1.0 CONTRACTORS LIABILITY DURING AMC PERIOD.

Contractor shall carry out regular predictive maintenance during entire AMC period through OEM or *OEM authorized service provider.*

BG for O&M, AMC and Extended warranty contract as per Section – III – Special conditions for Contract – Contract Performance Security

The requirement of Comprehensive AMC of Critical Equipment is revised as follows:

Equipment/System	Comprehensive AMC*
Inverter	10 Years
SCADA	10 Years
Tracker	10 Years

** Starts from date of commissioning of full capacity*

Further details and conditions regarding this BG shall be as mentioned in SCC.

APPENDIX – 4
FACILITIES FROM CIL FOR KHAVDA SOLAR PROJECT

a) Allocation of land of total area of 1350 Acres.
b) Availability of connectivity at 33 / 400kV pooling station of GIPCL. Power from GIPCL pooling station will be transmitted to 400/765 KV Khavda PS-II pooling station of CTUIL.
c) Right of Way for installation of underground cable from project to Pooling Station.
d) Water Supply during operation period.
e) Storm Water Drainage System / Bunding as decided by GIPCL
f) Outer fencing of Solar Park as decided by GIPCL
g) SRRA and Weather Station
h) Fire Safety
i) Support in Power Supply during construction

Note - All <u>temporary arrangements</u> w.r.t approach roads, drainage, office set up etc. as necessary to take up the project construction work, would be in bidder's scope.

*** Supply of 33kV Cable interconnecting Inverter Duty Transformer and ICOG, inter-pooling cable between 2 plots (if proposed), cable joining and termination kits including laying of 33kV Cable shall be in the scope of bidder.**

APPENDIX – 5

Requirement of Single IBR unit Simulation model & Benchmarking report

Requirement of Single IBR unit Simulation model & Benchmarking report-

- Single SoC (Statement of Conformity) and Evaluation Report for Type test report as per CEA Connectivity standard mentioning all Hardware/software/Firmware version
- Fault current characteristics (voltage -current) of Inverter during fault condition.
- Current and voltage Waveform capture facility during LVRT/HVRT at Inverter output terminal during event and accessible to CIL in PPC.
- Inverter controller Setting facility from local as per CEA Regulation.
- Time synchronization facility of Inverter with PPC/SCADA
- Single IBR Controller Setting in compliance with CEA grid connectivity regulation.
- Single IBR model shall be prepared or get from OEM (for PSS/E and PSCAD) and benchmark it with the lab/factory/field test measurements taken during certification process. Benchmarking report shall include model validation against all the clauses mentioned in B1 & B2 of CEA Technical Standards for Connectivity to the Grid (Amendment) Regulation, 2019.
- A separate benchmarking report /simulation comparison is required for SCR=5 and 3 for PSS/E and PSCAD software and furnishing the Parameters for the same. Provision to change setting in inverter according to various operating condition at site is to be provided.

Following shall be part of submission-

1. Comparison of field test measurement with simulation results numerical values & as well as graphical values for following points.
    a. Power Quality (only in EMT).
    b. Active power set change (RMS & EMT)
    c. Reactive power control- V control, pf & Q control (RMS & EMT)
    d. IBR capability demonstration (RMS & EMT)
    e. LVRT (RMS & EMT)
    f. HVRT (RMS & EMT)
    g. Frequency response (RMS & EMT)

2. Final simulation model parameters like Generator model, Electrical control model, drive train model etc. shall be included in benchmarking report. (RMS & EMT)
3. Firmware version of IBR unit controller for which IBR unit got certified shall also be included in this report.
4. Field test report documents shall be referenced in the benchmarking report.
5. Ensure the setting kept in IBR while field testing & actual IBR installed at site are same, if any alteration kindly include justification for the same.
6. IBR simulation model flat run results for 100 seconds with simulation time step of 1ms shall be included for electrical parameters (P, Q, V, f) and speed to be included (RMS)
7. EMT model of IBR unit- flat run results for 100 seconds with simulation time step of 10us or greater shall be included for electrical parameters (P, Q, V, f) and speed. Further, model shall get initialised within 3 seconds & shall have snapshot capability.
8. Model compatibility: EMT models provided to shall be compatible with PSCAD version 4.6 and above and Intel Visual FORTRAN version 15 or higher and RMS model for PSS/E version 34.4 and above. Same shall be included in the report. The models which is compatible with PSCAD V5 (latest version) with GNU Fortran compiler and with intel Fortran compiler need to be provided. If the model compiled in one compiler is not compatible with other compiler, it is requested to provide both models
9. Include a table having IBR controller setting, RMS & EMT model parameter for different control parameters as specified. (RMS & EMT)
10. IBR unit model for PSS/E shall include .sav, .dyr, .py, .idv, .sld, .out files and PSCAD .pscx and other supporting files.
11. Conclusion part include table for which models are benchmarked & whether the model replicates the actual. Error in simulation vs. actual shall be minimum to the extent possible, however it shall not be more than 5%.

1-B INTENT OF SPECIFICATION

1.0 INTENT OF SPECIFICATION

The scope of the proposal shall be Design, Engineering, Supply, Construction, Erection, Testing, and Commissioning of Khavda Solar PV plant along with power evacuation system Including supply of PV modules. The scope also includes Five (05) years Operation and Maintenance (O&M) of the solar PV plant as well as Annual Maintenance Contract (AMC) of critical equipment for a period of ten (10) years as mentioned in Appendix 3B Part A. The scope of work covers the following activities and services in respect of all the equipment & works specified and covered under the specifications and read in conjunction with "Scope of Supply & services" elaborated elsewhere.

All equipment, materials and services whether explicitly stated or otherwise and that are necessary for the satisfactory operation of the Solar PV system and its integration with the existing AC Systems as described in the specification shall be deemed to be included in the scope of work of the Contractor and shall not be limited to the following:

1) Basic Engineering of the plant and systems.

2) Detailed design of all the equipment and equipment system(s) including civil works.

3) Providing, Review and approval of engineering drawings, data, process

4) Calculations, test procedures, Structural Design Calculations, Equipment Layout, Drawings / Data sheets of bought out items, Civil Structural / Architectural Drawings, etc.

5) Providing Operation & Maintenance/ instruction manuals, as built drawings and other information

6) Providing training of Employer's personnel

7) Finalization of sub-vendors, manufacturing quality plans and Field quality plans.

8) Complete manufacturing including conducting all type, routine and acceptance tests; Civil, Structural and Architectural works to the extent applicable, including construction facilities and construction power distribution.

9) Packing and transportation from the manufacturer's works to the site including customs clearance & port clearance, port charges, (if any).

10) Receipt, storage, preservation and conservation of equipment at the site; Fabrication, pre-assembly, (if any), erection, testing, pre-commissioning and commissioning and putting into satisfactory operation all the equipment including successful completion of initial operation

11) Reliability and Functional guarantee tests after successful commissioning of full capacity

12) Supply of Spares.

13) Satisfactory completion of the contract.

14) Special tools and tackles if any required for maintenance of the plant.

15) Installation and commissioning of SCADA, OWS at Solar plant CMCS with supply and laying of OFC and associated hardware and software.

1.1 The work to be carried out as per the above scope shall be all in accordance with the requirements, conditions, appendices etc. given in Technical Specifications (Section-VI) together with those stated in other Sections / Sub-sections of Bid Documents which shall be considered as a part of this volumes completely as if bound herewith. It is not the intent to specify herein all aspects of design and construction nevertheless, the equipment and civil works shall conforming all aspects to high standard of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the Employer, who will interpret the meaning of the specification and drawings and shall have a right to reject or accept any work or material which in his assessment is not complete to meet the requirements of this specification and/or applicable Indian / International standards mentioned elsewhere in this specification.

1.2 Bidders are requested to carefully examine and understand the specifications and seek clarifications, if required, to ensure that they have understood the specifications. Such clarifications should be sought within the time period as stipulated in section NIT. Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. However, if the bidder feels that, in his opinion, certain features brought out in his offer are superior to what has been specified, these may be highlighted separately.

1.3 The Bidder shall be responsible for providing all material, equipment and services, specified or otherwise which are required to fulfill the intent of specification and ensuring operability, maintainability and the reliability of the complete work covered under this specification.

1.4 Failure of any equipment to meet the specified requirements of tests carried out at works or at site shall be sufficient cause for rejection of the equipment. Rejection of any equipment will not be held as a valid reason for delay in completion of the works as per schedule. Contractor shall be responsible for removing all deficiencies and supplying the equipment that meet the requirement.

1.5 Before submitting his bid, the bidder should inspect and examine the site and its surroundings and should satisfy himself as to the nature of the ground and subsoil, the quantities and nature of work, materials necessary for completion of the work and their

availability, means of access to site and in general shall himself obtain all necessary information as to risks, contingencies and other circumstances which may influence or affect his offer. No consequent extra claims on any misunderstanding or otherwise shall be allowed by the Employer.

2.0 SCOPE OF WORK (full scope of work or reference to NIT)

2.1 Detailed design of Grid Interactive Solar PV Plant, civil, electrical & mechanical auxiliary systems including preparation of foundation drawings, single line diagrams, installation drawings, electrical layouts, design calculations etc. Design memorandum and other relevant drawings and documents required for engineering of all facilities within the scope to be provided under this contract, are covered under contractor's scope of work.

2.2 Bidder shall monitor the PV module performance data before the PV Module becomes operational using PV Analyzer of reputed make. This data has to be stored at site and shared with **CIL during commissioning period**. Bidder shall also carry out PV Module performance data review and storage using PV analyzer during O&M period.

2.3 Works related to site clearance including removal of bushes, trees, levelling, grading, finishing and other additional works in the scope of bidders. Mandatory permission/ licenses/ statutory clearances from Competent Authorities for undertaking blasting related works, disposal of cutting material, etc. shall be carried out by the Bidder.

2.4 **Detailed system wise scope is elaborated in 2-A (Electrical Scope of supply & Works), 2-B (Civil scope of supply Works) & 2-C (Miscellaneous Works) of Part-A, Section-VI.**

2.5 **Detailed system wise Technical Specification is elaborated in Part-B, Section-VI.**

2.6 **PLOT ALLOCATIONS FOR 300 MW KHAVDA SOLAR PARK:**

The evaluation criteria along with methodology & the requirements shall be as per NIT

1-C PROVENESS

PROVENESS CRITERIA

The bidder/his sub-vendor(s) is required to meet the Proveness criteria and/or qualification requirement for critical component and bought out item as per the criteria stipulated below:

1.0 **Solar Engineering Firm**

If the bidder himself does not fulfill the Technical Eligibility Criteria as per Section I Notice Inviting Tender, the bidder shall employ an Engineering Firm who has engineered and fulfills the criteria prior to the following reference date.

Date of submission of proveness documents to CIL or (LOA date + 1 month), whichever is earlier.

The scope of work of engineering for the above project by the Firm shall necessarily include the following:

i. Selection and Sizing of:
   a. Inverter
   b. PV Modules
   c. DC Cables
   d. AC Cables
ii. Finalization of Plant Layout with shadow analysis
iii. Energy Estimation

The Firm shall undertake at least the above scope of engineering for the proposed Solar PV Power Plant.

2.0 **Tracker System:**

The Bidder/its Sub-vendor should have designed, manufactured, supplied, erected/supervised erection, and commissioned/supervised commissioning Solar Tracker System of the proposed design/type for cumulative capacity of 100MW -with minimum project capacity of 30 MW in last seven financial year as on ending last day of month previous to the one in which bid applications are invited. The bidder/its Sub-Vendor may use the credentials of its Parent/Group/Holding company for meeting the requirement. The reference plants as per above mentioned capacity where Solar Tracker System was supplied, must have been in successful operation for at least one (1) year prior to the following reference date:

CLAUSE NO.	TECHNICAL SPECIFICATIONS
	Date of submission of proveness documents to CIL or (LOA date + 1 month), whichever is earlier And The proposed Tracker design/type shall be of proven technology with Independent Engineers Bankability review report from reputable agencies like Black and Veatch, DNV, IITs or other premier institutions/agencies
3.0	**Solar Inverter Transformers** a) The Bidder/its Sub-vendor should have designed, manufactured and supplied transformers of 33kV or higher voltage class of cumulative capacity of 40 MVA or above, out of which at least one such supply order for a single plant should be of 10 MVA or above capacity. The reference plant in which transformers of 10 MVA or above capacity (consisting of one or more) were supplied, must have been in successful operation for at least six (6) months prior to the following reference date: **Date of submission of proveness documents to CIL or (LOA date + 6 months), whichever is earlier.** And a) Bidder/its sub-vendor should have its own facilities for conducting all routine tests for transformers as per IS: 2026/IEC 60076. And b) 2.5 MVA, 33kV or higher rated inverter transformer manufactured by Bidder/ its sub-vendor should have been successfully short circuit tested.
4.0	**Solar Inverter** a) The Bidder/its Sub-vendor should have designed, manufactured and supplied grid connected solar Inverters of cumulative capacity of 40 MW or above, out of which at least one such supply order for a single plant should be of 10 MW or above capacity. The reference plant in which 10 MW or above capacity solar Inverters (consisting of one or more) were supplied, must have been in successful operation for atleast six (6) months prior to the following reference date: ***Date of submission of proveness documents to CIL or (LOA date + 6 months), whichever is earlier.*** And b) The Bidder/sub-vendor should have in-house solar Inverters routine testing facility as per relevant standard of solar Inverter.

And

c) The offered solar Inverter model or any of its product family Inverter model or similar Inverter topology model must have been in successful operation for atleast six (6) months the reference date mentioned above. The Inverter product family model or similar Inverter topology model power rating should not be less than 50% of the offered Inverter model rating. The similar Inverter topology model must have identical power circuit configuration and same maximum DC input voltage rating as compared with the offered Inverter model. The Inverter product family model or similar Inverter topology model shall be further technically assessed to establish the similarity with the offered Inverter model and same shall be subjected to CIL acceptance.

Note: - (i) The individual Inverter capacity of one (1) MW or above (for central Inverter) and 40kW or above (for string Inverter) shall only be considered for capacity determination.
(ii) In case the inverter manufacturer is not meeting the requirement as mentioned in Clause 5.0 (a) & (c) above, they can utilize the credentials of its principal/ holding or subsidiary company/ associate/ collaborator (a solar inverter manufacturer) through technology tie-up for meeting the criteria as stipulated in clauses 5.0(a) & (c).

5.0 HT Power cables (3.3kV or above but below 33kV)

The Bidder/ Sub Vendor should have manufactured and supplied following cables, prior to the following reference date:

Date of submission of proveness documents to CIL or (LOA date + 6 months), whichever is earlier.

a) At least 100kms of XLPE insulated power cables of 1.9/3.3 kV or higher voltage grade, executed in one or more limited to maximum of three orders.

b) At least one (1) km of flame retardant low smoke cables of any voltage level.

c) The plant for which cable have been supplied should have completed at least six months of successful operation prior to the date the reference date mentioned above.

6.0 HT Power cables (33kV)

The Bidder/ Sub Vendor should have manufactured and supplied following cables, prior to the following reference date:

Date of submission of proveness documents to CIL or (LOA date + 6 months), whichever is earlier.

(a) At least 20kms of XLPE insulated power cables of 19/33 kV or higher voltage grade, executed in one or more limited to maximum of three orders.
(b) At least one (1) km of flame retardant low smoke cables of any voltage level.
(c) The plant for which cable have been supplied should have completed at least six months of successful operation prior to the reference date mentioned above.

7.0 DC Solar cables

The Bidder/ Sub Vendor should have manufactured and supplied following cables, prior to the following reference date:

Date of submission of proveness documents to CIL or (LOA date + 6 months), whichever is earlier.

(a) At least 150 kms of XLPO insulated DC Solar cables of 0.63/1.1 kV or higher voltage grade of minimum 4 sq mm size executed in one or more limited to maximum of three orders.
(b) The plant for which cable have been supplied should have completed at least six months of successful operation prior to the reference date mentioned above.
Note: In case the DC solar cable manufacturer is not meeting the requirement as mentioned in Clause 7.0 (a) and/or 7.0(b) above, they can utilize the credentials of its principal/ holding or subsidiary company/ associate/ collaborator (a solar DC cable manufacturer) through technology tie-up for meeting these criteria as stipulated in clauses 8.0(a) and (b) below.

8.0 Cable Laying Agency

The bidder/ Subcontractor should have executed cabling works in which it has installed Power cables of 1.1 kV or higher-grade cables along with associated accessories for an industrial installation which should have been in successful operation for a period of at least two (2) years prior to the following reference date.The total quantity of Power cables (HT cables, LT cables, DC cables etc.) laid should be 100 kms or more in maximum two contracts/works

Date of submission of proveness documents to CIL or (LOA date + 6 months), whichever is earlier.

PART-A
SUBSECTION – 2

2-A ELECTRICAL SCOPE OF SUPPLY & SERVICES

1.0 BASIC ENGINEERING DESIGN PARAMETER OF SOLAR PV PLANT

a) Plant Capacity:

AC Capacity – 300MW

b) DC Capacity

DC Capacity – 405MWp (MINIMUM)

(Supply, Packing, Forwarding, Transportation, Unloading and Storge at Site is in the EPC Bidder Scope)

c) Designed System Voltage: 1500 V DC

d) **Design Philosophy:** Bidder is free to propose his design of the solar plant including solar plant layout, solar block sizing, inverter sizing, inverter-transformer sizing etc. subject to meeting the boundary conditions/design parameters as specified in the table below. Bidder would be required to submit design details for actual Module Rating (in Wp) that would be supplied by the Bidder (minimum 540Wp), during detailed engineering.

The Bidder need to supply additional 0.5% of the installed DC Capacity Section 2A – 1.b) as mandatory spares.

Sl. No.	Description	Details
1.	Annual Radiation (Global Horizontal)	2033.6 kWh/m2
2.	Type of SPV Module	Mono Crystalline Silicon - Bifacial
3.	Peak Power rating of Module	**540 Wp (Min)**
4.	PV Module Dimensions	2272 (±10) mm x 1133 (±3) mm
5.	PV Module Mounting Hole – Longer edge	400 ± 1mm 960 to 1000 ± 1mm 1400 ± 1mm
6.	PV Module Mounting Hole –Shorter edge	1091 ± 3mm
7.	Module Efficiency	Minimum 20% at Standard Test Conditions (STC)
8.	Fill Factor	0.75 (Minimum)
9.	Bi-faciality	Minimum 70%
10.	Module back	Glass or Transparent Back sheet
11.	Design Mechanical load	Minimum 1600Pa Downward and Upward when fixed at 400mm Hole Distance
12.	Min Pitch*	5.5m for 540 Wp
13.	Tracker	Single Axis E-W Tracker
14.	Thermal Loss Factor (Uc, Uv)	Uc-29 Watts/m2-K Uv-0.0 Watts/m2-K
15.	DC Cabling loss at STC + AC Cabling loss at STC	2.5 % (Individual DC and AC Cabling loss shall be as per system design chosen by bidder)
16.	Transformer Loss (for MV transformer, i.e. for IDT)	As per Transformer data sheet (Maximum 1.5%)
17.	Module Quality Loss	0.0%
18.	Modules Mismatch Loss	1.2%
19.	LID Loss	2.0%
20.	Soiling Loss	1.5%
21.	IAM Losses	As per PV Module Characteristic
22.	Auxiliary Energy Loss	5 Watts/kW
23.	Unavailability of the system	

24.	Unavailability time fraction	1.0%
25.	Number of periods	3
26.	Auxiliary Power Loss at per Pooling Substation	As per Actual outside PVSYST
27.	Power Transformer Loss	As per Actual data sheet, input by CIL during detailed Engg. stage

Qualification of Sub-Vendor of Solar PV -Modules

- The Sub-vendor should be listed in the Approved List of Module Manufactures as per MNRE.
- The Sub-vendor should have supplied a PV Module of cumulative capacity of More than 500MW in last 5 years from the date of publication of the tender.
- The Sub-vendor should have an annual manufacturing capacity of more than 500 MW per annum.

* Based on the actual Module panel size, the parameters may be modified suitably as per site conditions.

Bidder to mandatorily LIMIT the output of the Solar PV Plant at the Injection Point in PV Syst so that the Power injected into the grid NEVER exceeds the threshold of plot capacity.

Bidder shall submit PV Syst report complying with the design parameters specified above and the actual Module PAN file supplied by CIL to arrive at the Target Generation for first year O&M at 400kV Metering Point.

e) **Inverter Capacity**: The continuous combined rating of all PCUs shall not be less than Plant capacity at unity power factor at ambient temperature of 50 deg C and 0.95 p.f. at 45 deg. C. **Provided further that each Inverter shall be able to maintain its performance specified above even with voltage variation of up to ± 5% at Inverter terminal.**

Same size of Inverter is recommended for the whole plant and same size of Inverter Transformer is also preferred considering Mandatory spare management. Foundation design of Inverter and Inverter transformer shall be of one type as per highest size.

f) **33 kV Local Pooling Switchgear**

1) Bus Bar rating of HT Switchgear: As per Single Line Diagram.
2) System Fault Current Rating: As per Single Line Diagram.
3) Dynamic withstand Current rating: **2.5 times of system fault current.**
4) DC Supply shall be used for control and protection system of switchgear. In case UPS AC supply is considered for auxiliary control and protection supply for switchgear (except CMCS), then suitably rated AC/DC converter/power pack shall be used to meet the DC control supply requirement of switchgear panels.
5) The 33kV switchgears (both indoor and outdoor type where allowed as per TS) shall have an internal Arc Classification corresponding to system fault current
6) The switchgear shall be cooled by natural air flow. Forced cooling shall be considered in case current rating is 2000 A or above

g) Construction of Store Room – 01 No. per block/plot **–**

h) **Outdoor containerized solution/compact** substation with inverter, inverter transformer & HT switchgear as inverter station are acceptable. However, technical specification of inverter, HT switchgear and inverter transformer as pof technical specification shall be applicable.

i) **Earth Pit for DC System**:1 Nos. per 1.50 MWp.

Nos. of earth pit indicated is valid if all the earth pits are interconnected in single mesh of earth pits

j) **Metering:** As per SLD

k) **Module Cleaning System:** Provision for module cleaning shall be as mentioned in chapter D-3 of the Technical specification.

l) **Cable sizing criteria:**

The minimum size of cable based on 33kV voltage level power application shall be as per protection time grading requirement subject to min. of 0.3 sec. For any cable feeder the minimum time for cable size calculation shall be the immediate one

upstream breaker (towards grid) relay time setting plus 100 msec. For final power evacuation to Power Transformer the time for cable size calculation shall be minimum 1.0 sec.

m) **SCADA:** Licenses for Remote Monitoring of SCADA - 2 Nos with provision of Concurrent viewing for all users. Solar Plant SCADA shall also communicate with the Owner's SCADA, placed in Swichyard Control Room, in a server client methodology on Modbus TCP/IP or any industry standard communication protocol for full monitoring and control of entire plant from CCR (Central control room) SCADA situated at substation.

n) **DC and LT Power cable voltage drop criteria**: From Module to Inverter Transformer shall be limited to 3% of rated voltage. For all other LT cables, Maximum Voltage drop shall be limited to 3% of rated voltage. 1.9/3.3kV grade LT cable shall be used for connection between Inverter and Inverter Transformer.

o) DC system voltage of 125V/250V shall be considered for design of equipment rating, which has auxiliary voltage fed from 110V/220V battery.

The detailed scope of work in accordance with this specification is elaborated below. The scope of the contractor shall be deemed to include all such items which although are not specifically mentioned in the bid documents and/or in contractor's proposal but are needed to make the system complete in all respects for its safe, reliable, efficient and trouble-free operation and the same shall be furnished and erected unless otherwise specifically excluded as per Section Terminal Points & Exclusions.

2.0 SUPPLIES & ASSOCIATED WORKS

DC SIDE	
•	Unloading, receipt, storage, erection and installation of Solar PV Modules (Supply of Modules is not in EPCbidder scope – Refer Detailed Specs)
•	HT Cables
•	DC Cables including field connectors and DWC pipes
•	Single Axis E-W Tracker along with foundation
•	String Combiner Box (if applicable)
•	Power Conditioning unit
AC SIDE	
•	LT Switchgeartrack
•	HT Switchgear
•	Inverter Transformer& Auxiliary Transformer
•	LT Cables
•	HT Cables – 1.9/3.3 kV and 19/33kV Cable between Inverter Duty Transformer and ICOG & inter-pooling 33kV cable (if applicable)
•	Cable Laying – DC,LT & HT cables
•	SCADA & Time Synchronization Equipment
•	Instrumentation and Communication cable

•	Lightning Protection System
•	Plant Illumination system
•	Auxiliary Power Supply System
•	Battery and Battery Charger
•	UPS
•	Grid interfacing so as to meet statutory requirements and comply with CERC code.
GENERAL SYSTEMS	
•	Weather Monitoring Station
•	Fire Detection and protection system
•	Module Cleaning system (Wet)

3.0 POWER EVACUATION SYSTEM, TELEMETRY & SCADA.

3.1 **Power Evacuation System:** The Bidder shall terminate each 33kV export feeder at 33/400kV internal pooling substation of GIPCL as per Plot Single Line Diagram (SLD). All hardware required for 33kV cable termination at 33/400kV switchyard, including supply of outgoing 33 kV AC cables, support structure and civil works required for the same, shall be under scope of bidder.

Also, supply of 33kV Cable interconnecting Inverter Duty Transformer and ICOG, inter-pooling cable between 2 blocks (if proposed), cable joining and termination kits including laying of 33kV Cable shall be in the scope of bidder.

3.2 **Telemetry System:** The arrangement to transmit data required by the Load Dispatch Centre (LDC) from Solar plant to NLDC/RLDC/SLDC as per extant regulations and procedures for grid management upto 400/765kV PGCIL KPS# at Khavda Solar Park is in contractor's scope.

The required hardware and software, including laying of Communication/Fibre Optic cable to Owners' FOTE panel at 33/400kV GIS Substation required for communication of Solar plant data is included in the contractor's scope. Communication link and communication controller/Gateway used for data communication to FOTE panel/LDC shall be redundant (one for normal operation and other as hot standby). If any upgradation/ modification required at FOTE, it shall be done by the bidder.

Bidders are advised to update themselves with LDC requirement for compliance related to Automatic Meter Reading (AMR), telemetry data, channel and procedures for engineering of telemetry solution accordingly.

The above real time data communication facility with REMC/RLDC shall comply CERC (Communication System for Interstate Transmission of electricity) Regulation 2017, Procedure for Implementation of the Framework on Forecasting and Scheduling for Renewable Energy (RE) Generating Stations, CEA (Technical Standards for Communication System in Power Systems Operations) Regulations,2020 and amendments thereof.

3.3 **Provision of SCADA HMIS/SERVER Operator Work-Station (OWS) at Owners' Control Room at 33/400kV GIS Switchyard**

SCADA, & other associated electrical system shall be placed at the identified location inside Control Room of Owners' 33/400kV GIS Switchyard.

Sl No	Description	Quantity
1	Engineering cum Operator work station (EWS+OWS) (Desktop & Monitor)	01 Set
2	Operator work station (OWS) (Desktop & Monitor)	01 Set
3	Portable (laptop based) EWS	01 No
4	Historian (Desktop)	01 No
5	50 Inch LED display	01 No
6	Control Desk	01 Set
7	Chairs for Control Desk	02 No
8	Laser Printer	01 No

***The SCADA/ all other related system supplied for EPC shall have facility to synchronize time on Network Time Protocol with Main SCADA Time Synchronization Equipment (supplied by Owner) at Switchyard Control Room.**

4.0 **OPERATION AND MAINTENANCE (O&M) Target Generation test:**

The supply of PV modules is in the scope of EPC vendor, therefore the bidder should conduct **Performance Guarantee (PG) Tes**t before the dispatch of the module to the project location. Also, to ensure proper O&M during O&M Period, there shall be **an O&M Target Generation Test for THREE months** . During O&M Target Generation Test, bidder shall be responsible for operation and maintenance of the plant so that the plant is running in the most optimum operation and generating in line with the designed parameters. Details of this test are mentioned elsewhere in the Specification.

The supplier should furnish Test Certificates (in six copies), if applicable along with original documents to GM (Solar) Corporate Office CIL. Otherwise, the supplier's bill remain unpaid and the consequent demurrage/losses etc., will be to the supplier's account.

5.0 **SOLAR PV MODULE – Performance Determination Methodology**

I. The procurement of Solar PV modules is in the Scope of the EPC Bidder. Any shortfall in generation during O&M Period resulting from the non-performance of the PV Modules (Defective Modules*) is the Liability of the Bidder and shall be intimated by the EPC Bidder to the Owner at the earliest.

II. The determination of Defective Modules, for initial troubleshooting and preliminary assessment at site, shall be done jointly by the Engineer in-charge and the bidder. In such a scenario, the Defective Modules shall be replaced with the healthy ones from Mandatory Spares by the contractor to reduce the downtime of the Solar PV Plant.

* Defective Module is one whose either Isc (Short Circuit Current) or Voc (Open Circuit Voltage) or their combination thereof is less than 10% of average of 5-7 healthy modules of identical rating. The selection of healthy modules shall be done by Engineer Incharge (in consultation with the Module Manufacturer and as per the Approved Technical Documents) and bidder. Module shall also be declared as defective, if its output power is derated more than it's deemed Wp capacity taking consideration of yearly degradation. However, the responsibility for measuring the PV module performance output through the use of reputed make PV Analyzer etc, shall lie with the bidder.

2-B CIVIL SCOPE OF SUPPLY & SERVICES

1.0 SCOPE

The broad scope of work under this package shall include Civil, Structural and Architectural Works related to but not limited to the following areas, System, Structures / Substructures, Buildings and Facilities:

A. Design & Construction of Permanent Facilities

S.No.	Facility / Building	Quantity
1.	Site investigation-Topography survey & Geotechnical investigation	As required.
2.	Mounting structure (E-W Single axis tracker).	As required
3.	Central Monitoring and Control Station (CMCS) building with parking shed.	**NIL**
4.	Inverter Room(s) - Pre-Engineered Building (PEB) / Containerized System	As required.
5.	Permanent Store-Room / Ware House	**NIL**
6.	Cable Trenches / Trestle including any Cable Tray supporting facility	As required.
7.	Security Room & Toilet	As required (Min. 1 in each Block)
8.	All Equipment Supporting Foundation and Structures	As per Detailed Engineering & Geotech Investigation including Reference to Flood Levels.
9.	Sewage disposal system such as Septic Tank & Soak pit for all toilets.	As per actual.
10.	Internal Roads	As per bidder's proposal and Tender Drawing (Refer Vicinity Map / Layout and Road Section Drawings)
11.	Drainage system including Recharge Pits	As per bidder's proposal, Tender Drawing and GIPCL Recommendations / Report
12.	Permanent Project Boundary Fencing with Gate(s)	**Nil**

13.	Any internal Fencing and Gates, e.g. for Yards (Transformer, inverter, etc.)	As per Tender Drawing / System Requirement
14.	**CIL Site Office**:	**NIL**

Any other misc. requirement necessary for completion of commissioning & operation in line with Bidder's technical proposal / detailed Engineering.

B. Site Preparation (as required for installation of panels / equipment etc. during construction, erection and commissioning activities).

1. Cutting, Clearing, transporting and disposal of plants, bushes, other vegetation, roots, stubs etc.
2. Site grading including slope protection, ground preparation/ filling/ levelling (if required) of the identified area for solar plant.
3. Any temporary drainage including any dewatering, site approach & service roads.
4. All temporary work in bidder scope i.e. Fencing, Parking Shed, Road, Porta cabin and other infrastructures etc.
5. Flood level calculation with 25 Years Return Period – For maintaining Plinth level of the building and equipment foundation level.
6. Swatch Bharat Yojana policy for cleaning and deposal of sewage.

Note – Bidders are also advised to visit site location to appraise themselves with local conditions.

C. O&M Related Facilities to be developed by EPC Contractor

1. Rainwater Harvesting for RCC Buildings - If RCC Buildings are provided.
2. Design, Supply & Installation of a Module cleaning system including any requisite Construction works.
3. Design & Construction of Permanent water Supply / Network system for cleaning / washing.
4. **Additional scope as per facilities for Khavda Solar Park Project:**

    a. CIL intends to provide water supply during plant operation for module cleaning through Khavda RE Park. Accordingly, the bidder shall connect the pipeline from the nearest source / tapping point (Likely to be near PSS location - Tentative) to the solar plant washing system and other O&M Facilities.

    b. Water may or may not be continuously available from CIL water pipeline due to limited supply, infrastructure maintenance etc. at a given point in time. Thus, water storage tanks shall be designed and installed / constructed by the bidder for their respective projects for water storage purpose to ensure continuous water supply for plant facilities during O&M.

    c. The bidder has to provide **Wet Cleaning System** for Solar PV Project.

d. During O&M period, ***Optimum utilization of wet (by water) cleaning system shall be used as per requirement of cleaning cycle for Solar PV Modules*** and water may be used as less as possible for cleaning of solar panels as per the direction of owners Engineer In-charge. CIL shall provide water for minimum 10 cleaning cycle/year.

e. Any fencing (if required) shall be in bidder scope for protection of their offices, labour camps (as per LMA permission), equipment etc. against theft or otherwise.

D. Other Site-Specific Activities

1. **Array Layout for Robotic cleaning system:** Array layout shall be designed considering future provision for operating Robotic cleaning system from reputed manufacturers/suppliers. The continuous length of solar array table (or MMS) for using Robotic cleaning system, the distance between two modules of two different Array tables, required levelling and grading shall be done by the bidder. The bidder shall provide the details of compatible models of Robotic cleaning system from a different manufacturers/supplier and same shall be used in detail engineering of array layout design.

2. Supply of Robotic Cleaning system is **not in the bidder scope**.

E. Site Investigations ###

1. Topographical survey
2. Geo-Technical investigation

- Bidder to refer List of Annexures

NOTES

A. In case, any study / investigation report / design carried out by CIL, has been shared with bidder, then it is solely for the purpose of guidance of the bidder. Bidder may cross verify the data / design system on its own without any financial / time implications to CIL.

ANNEXURE – 1B
Survey, Investigation report & Recommendations (if any)

A. **SURVEY & INVESTIGATION REPORTS:**

1. Topography survey of the sites is enclosed with this document for reference only. However, bidder would carry out topographical survey on his own. No time extension would be admissible on account of this.
2. Geotechnical studies** of the sites is enclosed with this document for reference only. However, bidder shall carryout detailed Geotechnical Investigation, as per the requirements of Technical Specification provided at Cl. 2.0, Chapter C-1/ Section-VI. No time extension would be admissible on account of this.

** CIL to provide geotechnical investigation report in the proposed area. The geotechnical investigation report comprising of Boreholes, Laboratory tests, Chemical analysis, etc. in respect of the sub-strata prevailing at site is available for the Bidder's study. The representative are enclosed at Appendix-I for Bidder's reference. These are solely for the purpose of guidance of the Bidder.

The onus of correct assessment/interpretation and understanding of the existing sub soil conditions/data, including ground water table, permeability, expansiveness of soil etc. is on the Bidder.

Reports on Area Drainage Study and Foundation System prepared by GIPCL, are available for the Bidder's study at Owner's office. These are solely for the purpose of guidance of the Bidder. The onus of correct assessment/ interpretation and understanding, is on the Bidder.

B. **Geotechnical investigation work** shall preferably be got executed by the Contractor through any reputed government of private organization having valid ISO/IEC 17025:2017 accreditation from NABL.

**Refer detailed technical specification in Part-B* (*Civil Work) of Part B – Subpart C*

2-C MISCELLANEOUS

1.0 CODES AND STANDARDS

All works shall be carried out as per the standards/codes (IEC, IS etc.) referred in the specification. All standards, specifications and codes of practice referred to shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those codes/standards referred the former shall prevail.

Equipment complying with other internationally accepted standards such as BS, UL, DIN, VDE etc. will also be considered, if they ensure performance and constructional features equivalent or superior to standards listed in the specification. In such case the Bidder shall clearly indicate the standards adopted, furnish a copy in the English of the latest revisions in force as on date of opening of bid and shall clearly bring out salient features for comparison.

2.0 APPROVALS

The scope of the bidder includes complete design and engineering, technical coordination (including participation and arranging technical co-ordination meetings), finalization of drawings/ documents, submission of engineering drawing / documents and processing of their approvals by the Employer as per relevant clauses of Section VI (Technical Specifications) and other relevant clauses given elsewhere in the Technical Specifications. Further, the scope shall also include submission, in proper shape & format, of all types of manuals, handbooks & documents in requisite numbers to the Employer at different phases of the project as per the requirement of Employer. The contractor shall have to arrange technical coordination meetings and ensure participation.

3.0 PAINTING

The bidder's scope of work includes painting of all equipment and structures as per the Employer's standard color-coding scheme. The painting shall include required application of finish paint indicated elsewhere in the Technical Specification. The quality and finish of paints shall be as per standards of BIS or approved equivalent, suitable for coastal (corrosive) conditions of site. Employer’s Color-Coding scheme shall be furnished during detailed engineering stage.

4.0 TESTING

During detailed engineering, the contractor shall submit for Owner’s approval the reports of all the type tests as listed in this specification. Unless specified, the type test should have conducted within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under

this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However, if the contractor is not able to submit report of the type test(s) conducted within applicable period or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client /owners representative and submit the reports for approval.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

5.0 SPARES

The Bidder shall include in his scope of supply all the necessary Mandatory spares as described elsewhere in the Bid documents.

6.0 TRAINING OF EMPLOYERS PERSONNEL

The bidder shall provide training (free of cost) to the personnel of CIL for 15 man**-** days at his works and at site for erection, testing, commissioning and O&M. Expenses towards travel, lodging, and boarding and other expenses for the personnel shall be borne by CIL.

PART-A
SUBSECTION – 3

3-A TERMINAL POINT AND EXCLUSIONS

1.0 ELECTRICAL INTERFACES

1.01 TERMINAL POINT

The Bidder shall terminate each export feeder of 33 KV side of 400/33 KV Internal Pooling Sub-station where power from the Solar Power Project is injected for measuring export / import from each project. All hardware required for 33kV cable termination at 33kV Main Pooling Switchgear shall be under scope of bidder.

1.02 EXCLUSION

The following are excluded from the scope of Contractor under this contract:

a. Main Pooling 33kV Switchgear and associated equipment.
b. 400/33 KV Internal Pooling Switch yard for 300MW including Power Transformers for each block and Substation Automation System.
c. Grid Compliance Study, PPC & Substation SCADA at Switchyard Control Room.
d. Space for accommodating Solar SCADA and other equipment at GIS Switchyard Control Room.
e. DC & AC source of supply required for above equipment at GIS Switchyard Control Room.
f. Grid Compliance Study, PPC & Substation SCADA at Switchyard Control Room.
g. 400kV Transmission line from 33/400kV GIS Switchyard to 400/735kV PGCIL KPS#

2.0 CIVIL INTERFACES

2.01 TERMINAL POINT

All Internal Project Roads and all Drainage are in Bidder Scope and shall be constructed and connected suitably the with Main Road at Park periphery / PSS location etc. by the Bidder.

Permanent fencing of the project is in bidder scope. Also, any temporary arrangement for safety and security of project, Manpower as well as any storage arrangement (Equipment or otherwise) etc. during construction would be in Bidder Scope. All temporary arrangements w.r.t approach roads, drainage, office set up, labour management etc. as necessary to take up the project construction work, would be in bidder's scope.

2.02 EXCLUSION

The following Civil works are excluded from the scope of Contractor under this contract:

a. Peripheral Road joining PSS with Main Approach Road (Refer Vicinity Map / Layout)

PART-B
A – DC SYSTEMS

A-1 SOLAR PHOTOVOLTAIC (SPV) MODULES

GENERAL

Under 'Make in India' policy of Government of India, Purchase Preference will be given to eligible bidders as per Public Procurement (Preference to Make in India), Order 2017 issued vide order No. P-45021/2/2017-B.E.-II dated 15th June 2017 (subsequently revised vide orders dated 28.05.2018, 29.05.2019, 04.06.2020, 16.09.2020 and 04.03.2021) of Department for Promotion of Industry and Trade, Ministry of Commerce and Industry.

The Module specifications should be as per parameters mentioned in SECTION 2A Clause 1.

A-2 TRACKER SYSTEM

1.0 GENERAL

The PV modules shall be mounted on metallic structures called Module Mounting Structures (MMS) having adequate strength and appropriate design, to withstand various loads on the MMS including design wind pressures. Modules shall be mounted on non- corrosive support structures with Automatic motor powered **Realtime East-West tracking**.

2.0 TRACKER SYSTEM

The Tracker System shall be of proven design capable of tracking Sun's path actively, intended to maximize the energy output from PV Module. Design shall be based in accordance with the site climatic conditions and seismic loads, soil characteristics, thermal loads caused by expected fluctuations of materials and ambient temperatures and the minimum required design wind speed.

2.1 STANDARDS

a) UL 2703: Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels or equivalent

b) UL 3703: Standard for Solar Trackers or equivalent

c) IEC TS 62727: Photovoltaic systems - Specification for solar trackers

d) IEC 62817:2014+AMD1:2017 CSV: Photovoltaic systems – Design qualification of solar trackers

2.2 DESIGN

a) Only single axis East-West real time tracking

b) Configuration - Both, single and multi-rows options are accepted.

c) Tracker Range of Movement (ROM): +/- 60 degrees or better

d) DC/AC Self-powered drive system with battery backup of 3 days autonomy.

e) Individual row-level bi-directional control

f) Redundant communication (wireless) for individual Trackers

g) Stow configuration: optimal Angle, as per aero elastic instability analysis.

h) Design wind speed as per site condition, basic wind speed as per wind map of India from IS 875 Part 3: 2015.

i) Suitable material for corrosion category compliance as per Corrosion map of India, EN ISO 14713, EN ISO 1461, EN ISO 12944-5 or ASTM 123.

Operational temp: -10 to 50 degree Celsius.

k) Integration to Plant SCADA

l) Cleaning - Compliant with robotic module cleaning

m) Minimum 400mm clearance to be maintain at module edge with maximum angle.

2.3 REQUIREMENTS

a) Tracking system shall be followed by either means of sun's positioning algorithm or optimization algorithm with a minimum tracking accuracy of ± 2° between the pointing vector of the sun and the pointing vector of the modules.

b) The tracking system shall have back tracking algorithm to avoid inter-row shading and optimizing irradiance collection for both row avoidance shading and diffuse light optimization.

c) All local tracking controls shall be mounted on the tracking structure. A suitable arrangement/bellows shall be provisioned to protect actuator assembly from extreme outdoor harsh condition, dust and UV rays.

d) In case of failure of supply, the arrays should return to the stow position. Bidder shall supply a tracking mechanism with an inbuilt feature for meeting the requirement.

e) All modules associated with a specific tracking system should be connected to a common inverter.

f) Suitable redundancy in sensing and auxiliary power supply shall be provided for fail-safe stowing of trackers. Redundancy in control is also desirable for the safe operation of trackers. Detail of the scheme for various redundancy shall be finalized at the time of detailed engineering.

g) Safety measures such as stop devices shall be applied to ensure personal safety.

h) Tracker shall be equipped with safety features like, auto high wind stow to the designed angular position and shall have uninterrupted communication with monitoring console/station. It should be capable of sending alarms to the monitoring station in case of failure or abnormal operations of the tracking systems.

i) For each row an earthing cable shall be installed to interconnect all metallic parts of foundation, tracker structure and PV modules of each table.

j) Tracker design shall also include a provision for fastening DC cables to the structure each 500mm without causing tearing or fluttering of cables.

k) Tracker shall able to track as per proposed stow strategy supported by Wind Tunnel test.

l) Tracker Torque Tubes should be galvanized in accordance with, ISO 1461, ISO 14713, ISO 9223, or relevant standard as per Corrosive Category of proposed Solar PV Site.

2.4 MODULE MOUNTING ARRANGEMENT

a) Module mounting structures shall be designed to withstand the extreme weather conditions in the area. The site design wind speed factors k1, k2, k3 and k4 and pressure coefficient shall conform to IS 875 (Part-3): 2015 or as per a Wind Tunnel Study from a reputed national/international facility, for the design of MMS. However, design wind pressure to be considered for design, shall not be taken less than the minimum wind pressure "pd" as mentioned in the Technical Specification.

If the Bidder is going for wind tunnel test for the analysis & design of complete MMS and solar tracking system following shall be ensured.

i. It must be done from an institute of repute (IITs / CSIR-SERC / CPP Wind Engineering / RWDI or equivalent) in Indian / international facility.

ii. Bidders must ensure that offered tracker has proven design with wind tunnel test simulating relevant site conditions. The analysis and design shall be completed within two months from the actual date of issue of LOA.

iii. Tests and design must comply with relevant Indian/ International codes.

iv. The design shall be shown in STAAD pro or similar commercially available software for further checking by CIL as and when required.

v. Refer **Appendix-1** for site-specific design parameters.

b) The structural material and design shall be as per Design Criteria for Module Mounting Structures (MMS). The structural Material Yield Strength and Minimum Design Thickness can be as per "Proprietary Design" of Tracker supplier, and It shall conform to relevant Indian / international codal design provisions. The Proposed Solar PV tracker system should be certified for successful performance of MMS and tracker system by designer for its design life of 25 Years after COD. The Solar PV tracker system shall also fulfil the requirements of proveness criteria as per Chapter 1-C.

c) The design and the calculations for the MMS and the foundation system shall be submitted for prior approval of CIL before the commencement of construction and shall be based on the soil Geotechnical Investigation report.

d) Further details related to structures and foundations have been mentioned in the chapter on civil works of these specifications.

e) The Structure shall be analyzed and designed in accordance with finite element method and the fundamental principles of Engineering using commercially available software (such as STAAD pro or similar), with dead loads and imposed loads considered as per IS 875 (Part 1 & 2) respectively, and with wind loads considered as per IS 875 (Part 3) or as per Wind Tunnel study done from a reputed national/international facility (IITs / CSIR-SERC / CPP Wind Engineering / RWDI or equivalent). Analysis shall be done as per appropriate load combinations preferably as per IS codes.

f) The Structure must be provided with limit switches to control the rotation of the frame.

g) All nuts & bolts or clamps shall be of Stainless steel, Aluminium or Metal Alloy type for a module to structure connection, and other structural bolts shall be of grade HDG 5.6 or 8.8 or exclusively designed for solar tracker systems by manufacturers. Which should suffice the design life for 25 years and more for Corrosive Category proposed for Solar Park and confirm to Indian / international codal provision.

h) Tracker Based MMS would be provided with Module Supporting Member(s) including the provision for fixing of modules, such that the maximum pressure in module frame is limited to +/-1600Pa (Design) / +/-2400Pa (Test) under Wind Load or any Combination. Higher permissible stress would be permitted based on actual inputs and module fixing location during post award Engg. subject to approval of EIC.

2.5 PROTECTION AGAINST CORROSION & UV

Appropriate measures shall be considered, as required, to protect the structure, foundation, and all components against corrosion during the expected lifetime of the Plant. Structural steel shall be hot dip galvanized as per ISO 1461 (or BS 729), EN 10346, ISO 14713, IS 4759, ISO 9223 and as per Corrosive Category of proposed Solar PV Site. However minimum galvanization to be provided would be as per details mentioned for conventional MMS structure.

Non-metallic materials placed outdoors shall be UV and sand resistant and withstand high ambient temperature operation regimes as per the climatic conditions over the whole Plant design lifetime, and where materials are specified in any part of this RFP, those characteristics are to be considered as a minimum requirement. Metallic materials are not explicitly required to be UV resistant but in case protective coating is required, this shall be UV and sand resistant.

All materials used for concrete, reinforced concrete structures, steel structures, aluminum structures or structural elements or any other building material shall be of high quality, free from defects likely to undermine the strength and duration of service of the Plant.

2.6 BEARING

a) The bearing should be type tested for operation cycles which solar plant will go through in its life of 25 years.

b) Preferably there should not be any lubrication in the bearing, but if there is any, then it should be maintenance free. No cleaning should be needed.

c) The bearing should also be resistant to dust, water and any other external parameters. Test report to be submitted.

2.7 MOTOR AND ACTUATOR

a) The motor should be IP 65 or better and it should be powered by reliable supply to drive the link through gear or hydraulic/electric actuator.

b) The temperature rises in the motor during operation specified in IS12802: 1989 should not be more than approximately 10°C.

c) The location and moisture or fumes shall not seriously interfere with the operation of the motor.

d) The severity of vibration for the motors shall be within the limits specified in IS 12075: 1987.

2.8 CONTROLLERS

a) Trackers should have an industrial grade system for its automatic control and operations. For all outdoor controllers, it should be housed in IP-65 enclosure.

b) Battery back-up should be provided for Controller and motor for at least 15 minutes with power pack cum UPS. Alternatively, the bidder can provide backup power from the UPS of inverter room or CMCS room.

c) The controller must be enabled with a feature of stowing during high-speed winds.

d) The Real Time Clock (RTC) of the trackers shall have a facility to be time synchronized with SCADA on Network Time Protocol (NTP).

e) A suitable communication link between the master controller of tracker and tracker SCADA system shall be arranged. The software for communication and analysis shall be provided by the tracker supplier. Tracker SCADA shall be interfaced with solar SCADA on an open protocol such as MODBUS.

f) Battery back-up should be provided for Controller and motor as per design specified in Cl 2.2. Alternatively, the bidder can provide backup power from the UPS of inverter room or CMCS room.

2.9 STUDIES/REPORTS

The following studies, and reports shall be submitted by the Bidder for the offered solution. The studies and reports shall provide a positive outcome of the respective tests, designs, and concepts for the utilization of the proposed single axis tracking system in the Project:

a) Stow strategy control system: The Tracker supplier is solely responsible for the definition and implementation of a proper stow strategy, which clearly demonstrates and guarantees the safe operation of the tracker during all wind events with speed up to and including the maximum one defined as per local structural code. The following points, including but not limited to, should be made available as part of the safety stow strategy:

- Tracker inclination and orientation at safety stow position
- Maximum wind speed in [m/s] as [3-sec gust / 10min average] defined at 10m height which the tracker can withstand in working position
- Stow alarm function and wind speed at which it is triggered
- Safety strategy during installation / commissioning
- In case that batteries are used, which is the minimum charge level required in

order to reach safety stow position

- Security of communication protocols required for the active stow
- Time requirement to move the tracker from working position into stow position considering also safety factors
- System redundancies that help to minimize risk of failure. Emergency system in case of tracking or measurement defects
- Dynamic analysis and tests along with static coefficients based on the actual tracker configuration, stiffnesses and geometry
- Aeroelastic instability analysis for the proposed tracker structure to show that the stow angle will not result in aeroelastic instability
- Definition of tolerances, maximum terrain inclinations North-South, East-West

b) Wind tunnel tests from a recognized wind expert institute (IITs / CSIR-SERC / CPP Wind Engineering / RWDI or equivalent).

c) Independent Engineers Bankability review report from reputable agencies like Black and Veatch, DNV, IITs or other premier institutions/agencies.

d) Structure design review document from any IIT Civil/Structural certifying department, if required.

2.10 WARRANTY

- 25-year lifetime design (at least) considering local ambient conditions and in respect of all standards for the PV modules support structures and foundations
- 5-year warranty starting with the Project Commercial Operation Date (COD) for the complete mounting structure including but not limited to the design, material, and installation of the tracker, substructure, power unit, piles, and foundations
- 25 years for corrosion protection.

3.0 CODES AND STANDARDS

The applicable codes and standards $A = \pi r^2$ as mentioned below.

1	IS 875: Part 1 & 2	Code of practice for the design loads for buildings and structures
2	IS 875: Part 3	Code of practice for the design loads for buildings and structures-Wind Loads
3	IS 800: 2007	Code of practice for use of structural steel in general building construction
4	IS 4759	Hot-dip zinc coatings on structural steel and other allied products
5	IS 1868	Anodic Coatings on Aluminium and its Alloys

Equivalent National and International standard/code would also be acceptable Module Mounting structures (MMS) with trackers.

A -3 DC CABLES

The DC Cables in a solar PV plant are used in the following areas

i. Interconnecting SPV modules

ii. From SPV Modules upto SCB

iii. From SCB upto the Inverter.

1.0 DC CABLES (Interconnecting SPV MODULES and from SPV Modules TO SCB)

Each module, provided by Employer, shall have two 4 sq.mm stranded UV resistant cables and terminated with DC plug-in connector directly. The positive (+) terminal shall have a male connector while the negative (-) terminal a female connector. All the modules in the PV plant shall be arranged in a way so as to minimize the mismatch losses.

It is to be ensured by the contractor that the Modules installed on a MMS Table, in two rows, should be connected to each other so as to minimize the shading effect. The same is to be achieved by connecting the modules in the upper row of consecutive tables in series. Similarly, the modules in the lower row are to be connected in series and to be kept separate from the modules in the upper row. Bidder can also propose a different scheme during detailed engineering subject to engineering review and acceptance.

Cables used for inter-connecting SPV modules as well as Modules to SCB's shall conform to the requirements of **EN 50619:2014/IS17293:2020** applicable for DC cable for photovoltaic system. The connectors used for interconnecting the modules and connectors used for connecting the strings and/or to the String combiner Box, i.e. field connectors to be mated shall be of same make and model otherwise they shall be tested for Inter-compatibility as per detailed Specification of Field Connectors given elsewhere in this specification).

These cables shall also meet the fire resistance requirement as per the above standard and shall be electron beam cured.

All cables except module cable used for (+) ve and (–)ve shall have distinct color identification.

In addition to manufacturer's identification on cables as per **EN50618/IS 17293**, following marking shall also be provided over outer sheath.

(a.) Cable size, voltage grade and code designation “PV”

(b.) Word 'HALOGAN FREE LOW SMOKE’

(c.) Sequential marking of length of the cable

The distance between two consecutive printing, identification or embossing shall not be more than 550 mm. The Printing shall be progressive, automatic, in line and marking shall be legible and indelible.

Type test, routine, acceptance tests requirements for these cables shall be as per **EN50618:2014/IS 17293:2020**. **All test charges** shall be deemed to be included in the cable price. Sampling for acceptance tests will be as per IS 7098.

A maximum of 8 Cables (4 Circuits) shall be laid in one HDPE Pipe for DC Cable from Module to string monitoring box (if applicable). The fill factor of the pipe should not be more than 40%.

However, in case of necessity to lay more than 8 cables (4 circuits) in one pipe, the same shall be allowed during detailed engineering and as per the derating factors recommended by the cable manufacturer. Fill factor criterion is still to be maintained.

Bidder to ensure that there is no gap and proper packing at the junction of two pipes, in which DC cable is laid, using proper method and accessories, like bell mouth.

1.1 Bidder can propose DC Cables (Interconnecting SPV Modules and from SPV Modules to SCB) with Nylon 12 sheath/other suitable material between Insulation and outer sheath of the DC Cable. Such cables can be laid without DWC/HDPE pipes. Such cable should be type tested. The proposal to accept such cable and such laying methodology shall be reviewed during detailed engineering.

2.0 DC CABLES (STRING COMBINER BOX TO INVERTER)

Cables used between SCBs and Inverters shall be of 3.3kV (E) grade. These Power cables shall have compacted Aluminium / Copper conductor, XLPE insulated, PVC inner- sheathed (as applicable), Armoured / Unarmoured, FRLS PVC outer sheathed conforming to IS: 7098 (Part-II). These cables shall confirm to the requirements of the standards & codes specified in the relevant chapter.

For other details refer chapter –LT Cables

2.1 Bidder can propose DC Power Cables (SCB to Inverter) with armour of HDPE/other suitable material instead of Steel or Aluminium Armour. Such cable should be type tested. The proposal to accept such cable shall be reviewed during detailed engineering.

3.0 DC CABLES SIZING CRITERIA

As per relevant clause in Chapter 2-A

4.0 CABLE DRUM

For details refer clause 8.0 of Chapter - AC Cables

A-4 STRING COMBINER BOX

1.0 GENERAL

String Combiner Box (SCB) is used in multi-string photovoltaic systems to combine the individual strings electrically and connect them to the Inverters. It shall have protection devices to protect the PV modules from current/voltage surges. Nos. of input to each SCB shall be decided during detail engineering based on approved SLD and the temperature rise calculations.

Vendor to note that DC system 1500-Volt rating only is acceptable. Accordingly, component/assembly shall comply with 1500 V rating as applicable.

Voltage rating of the selected component shall be 1500V (Min.) as per system requirement during detail engineering. SCB offered for 1500V Application shall have already been type tested and in satisfactory operation in Solar plant with 1500 V DC system.

2.0 CODES AND STANDARDS

S NO.	CODES	DESCRIPTION
1	UL 94V	Fire Resistant/ flammability for Enclosure
2	UL 746C	UV Resistant for Enclosure
3	IEC 62262/EN 50102	Mechanical Impact Resistance for Enclosure
4	IS 2147/IEC 60529	Degrees of protection provided by enclosures (IP Code)
5	IEC 61643-12	Surge Protection
6	IEC 62208	Enclosure for low voltage Switchgear and control gear assemblies

Vendor shall submit the suitable Test Certificate/Report from accredited lab(s) indicating compliance of mentioned codes and standard if asked for the offered component or assembly.

3.0 GENERAL REQUIREMENT

SCB shall be equipped (but not limited to) with the following.

i. DC Disconnector /Breaker to disconnect the PV strings from the Inverter for maintenance purpose as per specification mentioned in this chapter.

ii. All component in the SCB shall be suitable for operation within temperature range of 0-65 Deg C.

iii. Fuse in each SCB input (both positive and negative) shall be provided to prevent the reverse short circuit current flow. However, in case of negative string fuse is not required as per recommendation of inverter manufacturer, string cable shall preferably be terminated with field connector with SCB.

iv. Surge Protection Devices for protection against surge currents and voltages as per specification given in separate clause. Other associated items like cable glands, lugs, vents and items required for the protection and completeness of the system shall be provided

v. The common collection bus bars should be made up of zinc/tin coated copper and shall be suitably sized to limit temperature rise within safe operating limits.

vi. Vendor shall ensure adequate clearance with suitable insulated separator between positive bus and negative bus if it is in same enclosure. Positive and Negative section shall be orientated horizontally (Landscape orientation) on the either side of separator. Separate compartment for negative section and positive section for termination of positive and negative string input shall be preferred.

4.0 DC SURGE PROTECTION DEVICES (SPD) for PV Solar Application:

DC output SPD shall consist of three Metal Oxide Varistors (MOV) type surge arrestors which shall be connected from positive and negative bus to earth. The discharge capability of the SPD shall be at least 12.5kA at 8/20 microsecond wave as per IEC 61643-12 and shall be rated for MCOV 1500 Volt DC. During fault and failure of MOV, the SPD shall safely disconnect the healthy system. SPD shall have thermal disconnector to interrupt the surge current arising from internal and external faults. In order to avoid the fire hazard due to possible DC arcing in the SPD due to operation of thermal disconnector, the SPD shall be able to extinguish the arc. SPD shall have local visual indication and potential free contact for remote indication.

5.0 STRING FUSES

In order to provide protection to all cables and modules, string fuses shall be provided with strings. String fuses shall be of gPV category and dedicated to solar applications and conform to IEC 60269-6 or UL-2579 standards and fuse base shall comply with IEC 60269-1. String fuses should be so designed that it should protect the modules from reverse current overload. Fuses or Isolation Link shall be mounted in pull out type fuse holders. Fuse holders shall be suitable for DIN rail mounting. PCB mounted fuses are not acceptable. Fuse rating for single and combined input (limited to two) shall be calculated and finalized as per the current rating (Isc) of the PV module installed and the same be finalized during detailed engineering which shall be suitable for 1500 Volt for crystalline module. For Thin film modules, fuse rating shall be decided during detail engineering. In case of negative grounded system, requirement of string fuses as well as inverter input fuses on negative side shall be decided based on the recommendation of Inverter (PCU) manufacturer. There should be minimum 10 mm gap between two fuses (fuse holders).

6.0 SCB ENCLOSURE AND ASSEMBLY

SCB shall satisfy the following requirement.

i. The enclosure shall be made of UV Protected, Halogen Free, and Fire-retardant GRP/FRP/Polycarbonate material with self-extinguishing property.

ii. Degree of protection for enclosure shall be at least IP 65. All the part shall be corrosion resistant and enclosure surface shall be free from crazing, blistering, wrinkling, color blots/striations. There should not be any mending or repair of surface.

iii. The mechanical impact resistance of enclosure shall be IK 07 or better.

iv. The size of the enclosure and general arrangement of the component shall be designed in such a way that the average temperature of enclosure shall not exceed 62 degree C and operating temperature of the components used in the enclosure shall not exceed 72 deg C or OEM recommended temperature limit at ambient temperature of 50 deg C for rated load conditions along with spare. The components mounted inside the SCB shall have higher temperature withstand capability and operation/performance of should not be affected due to derating by temperature.

v. Complete assembled SCB shall be subject to heat run type test to be witnessed by owner after manufacturing. The heat run test to be carried out at 1.25 times the rated current i.e. 1.25 x (Imp of PV Modules) x (no. of string inputs + spare). In case it is found that the temperature rise is beyond the acceptable limits, bidder shall redesign the assembly and perform the test free of cost to verify that temperature rise is within acceptable limit.

vi. In each SCB 5 % spare terminals along with cable glands and fuse rounded off to next higher integer shall be provided to connect the PV strings.

vii. All terminals blocks shall be rated for min 1000V/1500 V and rated continuously to carry maximum expected current.

viii. SCB shall be mounted under the PV module or under proper shed with minimum 150mm extension at all sides of SCB for protection from direct radiation. Design and dimensions of SCB structure must be such that minimum **400 mm (bending of DC cable also to be considered)** of ground clearance is available below SCB at site for repair and maintenance. All the erection hardware and mounting accessories shall be galvanized steel.

ix. All internal wiring shall be carried out with stranded copper wires with voltage rating mentioned elsewhere in the specification. All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to component terminals and terminal blocks. Wire terminations shall be made with solder less crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations.

Engraved core identification plastic ferrules marked to correspond with the wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on wires and shall not fall off when the wire is disconnected from terminal blocks.

x. If metallic hinge is being used with enclosure cover, it shall be made of SS 304 and shall be rust proof. Enclosure shall be provided with captive screws so that it screw don't fall off when cover is opened. Screw shall be made of corrosion free material. Suitable non-conducting protection cover shall be provided for any metallic hinge/screw/fastener to avoid contact with live part of the assembly.

xi. Mounting plate inside the SCB for mounting/fixing of devices shall be made of FRP/GRP or equivalent non-conducting material.

xii. Offered enclosure shall have adequate space to fix one String Monitoring card, One Modbus SPD and One DC-DC converter for internal power supply with suitable terminal block for retrofitting of enclosure to convert the offered combiner box as String Monitoring Box in future by CIL. Vendor shall submit a sample Internal GA drawing with aforementioned components for future use of CIL in addition to the drawing/document(s) for inspection and dispatch of offered assembly for CIL approval.

7.0 DC On-load Isolator

Solar PV On-load Isolator shall be suitable for 1500Vdc operational voltage having minimum Insulation voltage of 1500 V dc, in true 2 pole or 3 pole construction with 500Vdc per pole breaking. Any multipolar device achieving this configuration with shorting link (with less than 500Vdc per pole), will not be acceptable. The Isolators shall be type tested to carry the nominal current at rated Voltage till ambient Temperature of 60 Deg C without any de-ration, inside the String Junction box. The Switching part shall necessarily contain reinforced break with an integrated magnetic arc-extinguishing system for the PV arc. The PV isolator need to positive break indication given through a position indication window. The PV Isolator terminals need to be silver plated, and shall comply with IEC 60947-3 and tested for PV application. These shall withstand any PV current and should have no critical current.

8.0 A- TYPE TEST

Vendor shall submit the following Type Test/ Product Certification from any National/International accredited lab for approval.

a. Temperature rise test on complete assembled Box as per acceptable limit mentioned in relevant clause.
b. Type test for enclosure as per code and standard mentioned in relevant clause.
c. Thermal ageing at 70 Deg C for 96 hours as per IEC 60068-2
d. HV Test.

B- Routine test:

All acceptance and routine tests as per the specification and relevant standards.
An indicative list of tests / checks is mentioned in QA chapter on String combiner box. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

9.0 DC PLUG-IN CONNECTORS FOR FIELD CABLING

9.1 GENERAL REQUIREMENT

Field connectors are electrical connectors/coupler used for connecting solar panels and also strings of panels to String combiners box. Cable connector to be used for connecting SPV modules and String combiner boxes shall be in accordance with IEC 62852: 2014.

Connector shall be of plug and socket design to be plugged together by hand but can be separated again using a tool only. Contractor shall ensure that field connectors to be mated shall always be of same make and model or shall be tested Inter-compatible as per IEC 62852: 2014 for offered make(s).

Mating of connectors of different makes/model shall not be acceptable if not tested for inter-compatibility by any accredited lab.

Bidder can propose Y-connector type DC Field Connector for paralleling two DC strings from PV Module to SCB. However, bidder to provide fuse in positive side of Y-connecter. Fuse shall be sized as suitably.

9.2 TECHNICAL REQUIREMENTS

Rated Current, IEC (85°C)	30 A (4 mm^2, 6 mm^2), 40 A (10 mm^2)
Rated Voltage	Min 1500 Volts
Connector Design	Snap-In locking Type
Protection Degree	IP68 (Mated)
Ambient Temperature	(-) 40^0 C to (+) 85^0 C
Protection/Safety Class	Class II
Contact material	Cu
Contact surface material	Silver/Tin
Contact resistance for plug connecter	≤ 0.5 milli-ohms
Stripping length	10 mm
Inflammability class	UL 94-V0
Insulating Material	PPE / PPO/Polyamide
Pollution degree	3
Certification	UL/TUV/CSA/EAC or Equivalent

9.3 TYPE TEST FOR DC PLUG-IN CONNECTORS

a. Protection Degree (IP)
b. Operating Temperature
c. Inflammability
d. Pollution Degree
e. Voltage Withstand (Rated Voltage/Test Voltage)

f. Salt mist, cyclic (sodium chloride solution) as per IEC 60068-2-52

g. Product Certification

A-5 POWER CONDITIONING UNIT

1.00 The Power Conditioning Unit (PCU) is Solar Inverter designed to convert solar PV DC power to 3-phase AC power and fed into utility grid. The PCU shall consist of solid-state electronic switch along with all associated control & protection, filtering, measuring instruments and data logging devices. The PCU shall have suitable maximum power point tracker (MPPT) for operating the input PV Array at its maximum power point. The PCU output shall always follow the grid voltage & frequency by sensing the grid voltage and phase and the PCU shall always remain synchronized with the grid. The PCU shall use only self-commutated device which shall be adequately rated. The continuous combined rating of all PCUs shall be as per Chapter 2-A.

2.00 **CODES AND STANDARDS**

The PCU shall conform to all applicable IEC standard. Where an applicable IEC standard is not available, IS/ any applicable international standard shall be referred to as best practice.

IEC-61683	Energy efficiency requirements
IEC 61000	Emission/ Immunity requirement
IEEE 519	Recommended practices and requirements for harmonic control in electrical power systems.
IEC 60068	Environmental testing
IEC 62116	Testing procedure—Islanding prevention measures for power conditioners used in grid-connected photovoltaic (PV) power generation systems
IEC 62109-1 & 2	Safety of power converters for use in photovoltaic power systems.
EN 50530	Overall efficiency of grid connected photovoltaic inverters.
IEEE 1547/IEC 61727/ BDEW	Standard for interfacing solar PV plant with utility grid.
IEC 60529	Ingress protection test
Grid Connectivity	Relevant CEA regulations and Indian grid code as amended and revised from time to time.

3.00 **GENERAL REQUIREMENTS**

3.01 **Applicable both for Central and String Inverter**

PCU shall meet the following technical parameter

1.	Maximum Input voltage DC	1500V
2.	Nominal output voltage frequency	50Hz

3.	Continuous operating frequency range	47.5 Hz to 52 Hz
4.	AC Voltage Range	± 10% of rated AC voltage
5.	Euro efficiency	Minimum 97% (as per IEC 61683)
6.	Number of MPPT	Single MPPT or Multi-MPPT
7.	Surge Protection Device (SPD)	Type-I & II DC side
		Type-II AC side
8.	Euro efficiency	Minimum 97% (as per IEC 61683)
9.	Operating power factor range	0.8 Lead to 0.8 Lag (adjustable)
10.	Night SVG (Q at Night)	Required.
11.	Current harmonics	As per CEA regulation requirement
12.	Current THD value	< 3% at nominal power
13.	DC Injection	<0.5 % at rated current
14.	Operating ambient temperature	0 to 60 ° C
15.	Humidity	95 % non-condensing
16.	Maximum Noise level	75 dBA (for indoor application)
17.	Flicker	As per CEA regulation requirement
18.	Remote start and stop facility from SCADA	Required.
19.	Active power limit control, reactive power, and power factor control features.	Required. Possible both from PPC and SCADA.
20.	PCU designed DC fault current level	Maximum short circuit current of PV array connected to PCU and duration continuous.
21.	PCU designed AC fault current level	Maximum short circuit current of LV side of Inverter Duty transformer and duration one sec.

22.	(i) AC & DC overcurrent protection. (ii) Synchronization loss protection. (iii) Over temperature protection. (iv) DC & AC under and over voltage protection. (v) Under & over frequency protection. (vi) Cooling system failure protection (vii) PV array ground fault monitoring & detection (viii) PV array insulation monitoring (ix) LVRT protection (x) Anti-islanding protection (xi) Grid monitoring	Required.

3.02 The PCU shall comply with the Central Electricity Authority Technical (standards for connectivity to the grid) regulation 2007 with all latest amendments.

3.03 The PCU shall be capable of supplying reactive power as per grid requirement during solar and non-solar hours. PCU shall have Static Var Generation (SVG) function.

3.04 The PCU shall have protection against any sustained fault in the feeder line and against lightning discharge in the feeder line.

3.05 The Contractor shall ensure by carrying out all necessary studies that the PCU will not excite any resonant conditions in the system that may result in the islanded operation of PV plant and loss of generation. In case there is excitation of any resonant condition in the system during PV plant operation that may result in the islanding/tripping of the PV plant and affect the power transfer, it shall be the responsibility of contractor to rectify the design and carryout required modification in the equipment of his supply.

3.10 The PCU must be self-managing and stable in operation.

3.11 In case of grid failure, the PCU shall be re-synchronized with grid after revival of power supply. Bidder to furnish the time taken by PCU to be re-synchronized after restoration of grid supply during detailed engineering.

3.12 The PCU shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of PCU component failure or from parameters beyond the PCU's safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU front panel to cause the PCU to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCU protective devices.

3.13 PCU shall have necessary limiters in build in the controller so as to ensure safe operation of the PCU within the designed operational parameters.

3.14 PCU shall have thermal overloading protection to prevent failure of switching devices (i.e. IGBT) and other components of Inverter. PCU controller shall automatically regulate/limit the power output to reduce the PCU cabinet and switching devices temperature. Bidder to

	submit the PCU power vs ambient temperature curve during details engineering stage. PCU shall be able to provide inverter inside cabinet (in soft analog value) to SCADA system for remote monitoring, storing and report generation purpose.
3.15	PCU shall be provided with Mobile user interface facility for monitoring of inverter by plant O&M personal for better O&M and highest yield from the PV plant. In case PCU does not have this facility, then Bidder can provide the same facility through plant SCADA system.
3.16	PCU shall have AC and DC side monitoring capability and reporting to SCADA system (measured analog and digital value measured within PCU). Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.
3.17	All-important alarm and trip signals shall be configured in the PCU and their corresponding modbus address shall be provided for SCADA configuration. Signal shall necessarily be included such as LVRT in action and trip operated, HVRT trip, islanding protection operated, over current operated, Inverter cabinet temperature high alarm and all other important signals. Details shall be finalized during details engineering stage.
3.18	DC Overloading: - Maximum PCU DC overload loading shall be limited to its design PV Array Power to PCU nominal AC power ratio. Bidder needs to submit all the relevant technical document/test report from PCU manufacturer (OEM) during details engineering stage in support of declared PCU design DC overloading capacity.
3.19	EARTHING OF INVERTERS: - The PCU shall be earthed as per manufacturer recommendation. During detail engineering the Bidder needs to submit the details earthing arrangement of PCU and system earth pit requirement during detail engineering stage. The detail specification for panel earthing for safety has been mentioned elsewhere in this specification.
3.20	**OPERATING MODES OF PCU** a) **Low Power Mode: -** The PCU shall be able to wake-up automatically when PV array open circuit voltage value is equal/more than preset value in the PCU program. Once its start generation the PCU shall automatically enter maximum power mode. b) **Maximum Power Point Tracking (MPPT): -** In order to maximize the energy collection from solar PV array, the PCU shall have inbuilt MPPT controller and same shall be able operate the PV array at its maximum power point by adjusting output voltage of PV array system according to atmospheric condition. PCU MPPT controller shall ensure that it operate the PV array system at its global maximum power point under all operating conditions of PV array including cloudy atmospheric condition. c) **Sleep Mode**: - PCU shall automatically go into sleep mode when the output voltage of PV array and/or output power of the inverter falls below a specified limit. During sleep mode the inverter shall disconnect from grid. Inverter shall continuously monitor the output of the PV array and automatically start when the DC voltage rises above a pre-defined level.

The above clause is applicable for unity power factor operation/no reactive power support to grid. In case reactive power is required to be supplied to grid, in that case the PCU shall remain connected to grid and supply reactive power as per grid requirement. Inverter shall continuously monitor the output of the PV array and automatically start active power generation when the DC voltage rises above a pre- defined level.

d) **Standby Mode: -** In standby mode the PCU DC & AC contactor are open, inverter is powered on condition and waiting for start command.

3.21 In case auxiliary supply of PCU is met internally, then it should have sufficient power backup to meet the LVRT requirement.

3.22 Bidder to submit third-party verified OND files of the inverter during detail engineering.

4.00 CENTRAL INVERTER

4.01 PCS must have provision to be isolated from grid through Air Circuit Breaker/MCCB. The ACB/MCCB as required can be provided as a part of PCS/its Modules or separately based on standard design and configuration of PCS manufacturer. The ACB and MCCB shall be able to withstand the maximum fault current for minimum one sec duration. ACB/MCCB shall be able to isolate PCU from AC grid under all fault current condition. Any alternate provision other than ACB/MCCB which is recommended by OEM and meeting the requirement, shall be considered on case-to-case basis during detailed engineering stage.

4.02 Suitable rated fuse shall be provided (at inverter end) in incoming DC cable from each string combiner box (SCB). One set spare terminal with fuse (as applicable) and holder shall be provided for the future use. In addition, the PCU shall have suitable rated DC motorized isolator/MCCB or contactor for isolation of PV array from inverter.

4.03 String Monitoring facility:- PCU shall be provided with current monitoring transducer at incoming DC cables from each string combiner box (SCB) for PV array zone monitoring purpose. The current transducers used for this purpose shall have accuracy of 1.0 class or better.

4.04 The PCU should be designed for parallel operation through galvanic isolation. Solid state electronic devices shall be protected to ensure smooth functioning as well as ensure long life of the inverter. Parallel operated PCU system are also accepted subjected to recommendation of PCU manufacturer. In such case, PCU design shall also ensure that no abnormal interaction shall take place among the PCU unit during any grid operating condition which may result in outages.

4.05 PCU shall have suitable communication card (Modbus TCP/IP) for networking and SCADA integration and same shall support dual master communication. PCU shall include all important measured & internal calculated analog values and alarm & trip signals for remote monitoring, storing and report generation purpose in SCADA system.

Details list of above such parameters shall be provided along with their Modbus address during detail engineering stage.

4.06 In case of modular design of PCU is offered, the Contractor shall ensure that no abnormal interaction shall take place among the various PCU modules during any grid operating condition which may result in outages. The PCU controller offered by the Contactor shall be such as to ensure stability, reliability, and a good dynamic performance. The Bidder shall indicate the control scheme adopted for modular PCU and its merits and the test which will check its performance.

4.07 Bidder may offer liquid cooling system subject to CIL approval. In case Liquid cooled inverters are offered, Bidder to ensure that coolant is used in closed cycle. Complete inverter along with cooling system shall be of proven design.

4.08 The Inverter shall have suitable arrangement for negative grounding of solar PV array system and the ground current shall be limited to safe limit. Ground current shall be measured continuously, and alarm shall be generated in case ground current reaches to predefined set value. Inverter shall trip in case ground current more than safe operating limit.

4.11 Inverter shall have emergency stop push button for tripping of inverter with complete DC & AC electric isolation.

4.12 **INDOOR CENTRL INVERTER**

a) The PCU enclosure protection class shall be IP 20 or better protection.

b) COOLING AND VENTILATION: -
To prevent the maximum permissible temperature in the inverter room from being exceeded because of internal heat emission of inverters and other auxiliaries in the inverter room, the inverter room in the PV plant shall be adequately ventilated. The Ventilation plant capacity and air quality of inverter room shall be as per inverter and other auxiliary's system manufacturer's recommendations. Filter banks at the air inlet of the inverter room shall be provided to prevent dust ingress. Bidder shall furnish peak power consumption of cooling system (cooling fans, pumps etc.) of the PCU along with the data sheet.

Ventilation shall be designed in such a way that the temperature rise of the inverter rooms does not exceed the maximum designed temperature of Inverters and other auxiliary equipment's placed inside the inverter room. Accordingly, the air velocity through the filter shall be suitably chosen to remove the heat from the inverter room. All exhaust and fresh air fans shall be provided with thermostat control.

4.13 **OUTDOOR CENTRL INVERTER**

a) Outdoor PCU enclosure must be suitable to withstand the harsh environmental conditions for complete life of plant.

b) The PCU enclosure protection class shall be IP 54 or better protection. For outdoor solution (Other than containerized), the electronic card compartment shall have IP 65 or better protection.

c) Bidder to submit temperature endurance test report of complete assembly during detail engineering stage.

d) For Outdoor PCU (without containerized solution) the complete assembly should be placed inside a shed made of structural steel section preferably tubular/hollow section and color coated metal sheets for roof with BMT 0.5 mm and at least 60cm projection in all side. For containerized solution separate shed is not required, however, the container shall have projection of at least 60cm wherever an opening in the inverter door exposes the inverter component to outside environment. Structural steel and paints for shed shall be as per ISO 12944-5.

e) Outdoor inverter (including containerized solution) platform shall be raised Min 1250 mm from NGL. Cable bending radius and other relevant factors to be considered during platform design. This shall be reviewed during detailed engineering.

5.00 STRING INVERTER

5.01 The string inverter enclosure protection class shall be IP 65 or better protection.

5.02 The string inverter should be placed inside a canopy shed with atleast 15 cm in all direction, if installed in open. Alternatively, the Bidder can also install the inverter on the column post of the module mounting structure, below the modules. In such case, the canopy is not required, and the column and foundation shall be designed accordingly.

5.03 String inverter shall have suitable communication port (TCP-IP/PLC) for SCADA integration. All necessary hardware, software and accessories used for communication with SCADA (including smart logger Data logger) at both the ends shall be provided by the bidder. String Inverters system shall support dual master communication.

5.04 String inverter shall have string monitoring (MPPT level) capability and reporting to SCADA system. Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.

5.05 Anti-PID device along with all hardware and communication cable/device shall be provided in case negative grounding of PV string provision is not available in string inverter.

5.06 DC fuse requirement for PV string at string inverter end shall be as per string manufacturer/system requirement and same shall be finalized during detail engineering stage.

5.07 Provision for AC and DC electrical isolation device (such as MCB/MCCB/Isolator) inside string shall be as per string inverter manufacturer practice.

5.08 Local Display unit for viewing important parameters, configuration and troubleshooting purpose shall be provided as per string inverter manufacture practice. In case standard design of string inverter does not include display, then string inverter shall be provided with required software along with accessories (2 sets for complete plant) for interface with inverter or facility for mobile viewing and configuration with laptop.

5.09 LT Junction box, switchboard, and switchgear requirement for string inverter system as per chapter B-1 (LT Switchgear).

6.00 TYPE TESTING

Applicable both for Central and String Inverter

During detailed engineering, the contractor shall submit all the type test reports including temperature rise test and surge withstand test carried out within last ten years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

ROUTINE TESTING:

All acceptance and routine tests as per the specification and relevant standards. Charges for these shall be deemed to be included in the equipment price

An indicative list of tests / checks is mentioned in QA chapter on PCU (Inverter). However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

PART-B
B – AC SYSTEMS

B-1 LT SWITCHGEAR

1.0 CODES AND STANDARDS

The design, materials, and method of LT switchgear shall conform to the applicable IEC standard. All equipment shall be installed, and all work shall be carried out in accordance with relevant IEC standards. Where an applicable IEC standard is not available, IS/ any applicable international standard shall be referred to as best practice. All standards, specifications and codes of practice shall be the latest editions including all applicable official amendments and revisions.

As a minimum requirement, the following standards shall be complied with:

IS	Details
IEC 60947/ IS13947	Low-voltage switchgear and control gear
IS 2705	Current Transformers
IS 3043	Code of practice for earthing.
IS 3072	Code of practice for installation and maintenance of Switchgear
IS 3156	Voltage Transformers
IS 3202	Code of practice for climate proofing of electrical equipment.
IS 3231	Electrical relays for power system protection.
IS 13703/ IEC 60269	HRC Cartridge fuses
IS 10118 (4 parts)	Code of practice for selection, installation and maintenance of switchgear and control gear.
IEC 60255	Electrical Relays

2.0 TECHNICAL PARAMETERS

A. POWER SUPPLY (AC SYSTEM)		
(i)	Voltage	415V $\pm$ 10%, 3 Phase, 4 wire, Neutral Solidly Earthed
(ii)	Frequency	50 Hz +/- 5%
(iii)	Minimum system fault level	As per system fault current (for 1 sec)
(iv)	Short time rating for bus bars, ckt. breakers, current transformers and swgr. Assembly.	As per system fault current (for 1 sec)
(v)	Maximum ambient air Temperature	50 deg. C

BUS BARS		
(vi)	Continuous current rating at 50ºC ambient:	As Per Requirement
(vii)	Temperature Rise allowed above ambient	40^0C for plain joints 55^0C for Silver plated joints
B. MCCB		
(i)	Rated voltage	415V
(ii)	Rated Insulation Level	690V
(iii)	Rated ultimate and service SC breaking capacity (As per system requirement)	As per system fault current (for 1 sec)
(iv)	Rated making capacity	2.1 times of System fault current
(v)	Utilization category	A
C. DIGITAL MFM		
(i)	Accuracy class	0.5
(ii)	MFM shall be provided at LT incomer feeder. MFM shall have suitable communication port for integration with SCADA system.	
D. CURRENT TRANSFORMERS		
(i)	Type	Cast Resin Bar Primary
(ii)	Voltage class and frequency	650V, 50HZ
(iii)	CT Secondary Current	1 A
(iv)	Class of insulation	E or better
(v)	Accuracy class & burden	
	a) For Protection	5P20, 5VA
	b) For Metering	Class 1.0, 5VA (min)
(vi)	Instrument Security Factor for metering CT	5
E. VOLTAGE TRANSFORMERS		
(i)	Type	Cast Resin
(ii)	Voltage Ratio	415 / 110V for line PT 415/√3 / 110/√3V for Bus PT
(iii)	Method of Construction	Vee Vee
(iv)	Accuracy Class	0.5
(v)	Rated Voltage factor	1.1 continuous, 1.5 for 30 sec.
(vi)	Class of insulation	E or better
(vii)	One minute power frequency withstand voltage	2.5 KV

F. HRC FUSES		
(i)	Voltage Class	650 Volts
(ii)	Rupturing capacity	80kA (RMS) for AC circuits
G. CONTACTORS		
(i)	Type	Air break electro magnetic
(ii)	Utilising Category	AC3 of IS/IEC 60947 for non-reversible AC4 of IS/IEC 60947 for reversible drives
H. SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS		
(i)	Colour finish	
	Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers) The paint thickness shall not be less than 50 microns
	Cable entry	
(ii)	Power Cables	Bottom
	Control Cables	Bottom

The quantities/Nos. of the Feeders /MCCB shall be so as to meet the system requirements. 5% spare with minimum 01 No. to be provided on each board/switchgear having more than 5 MCCB. However, no spare Air circuit breaker panels are required.

3.0 DETAILS OF INDOOR DISTRIBUTION BOARDS

Applicable for Auxiliary Power Supply system and String Inverter distribution board of rating upto & including 400A.

3.1 Switchboards shall be of metal enclosed, indoor, floor-mounted, free-standing type.

3.2 All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold- rolled sheet steel and 4.0 mm for non-magnetic material.

3.3 All panel edges and cover / door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge/ bend by the weight of maintenance personnel working on it.

3.4 The switchboards shall be of bolted design. The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cut outs shall be true in shape and devoid of sharp edges.

CLAUSE NO.	TECHNICAL SPECIFICATIONS
3.5	All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 4X as per IS/IEC 60947. All cutouts shall be provided with EPDM / Neoprene gaskets. However, the control / relay compartments shall have degree of protection not less than IP 5X.
3.6	All switchboards shall be of uniform height not exceeding 2450 mm.
3.7	Switchboards shall be supplied with base frames made of structural steel sections, along with all necessary mounting hardware required for welding down the base frame to the foundation / steel insert plates.
3.8	All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. Replacement /Maintenance of individual equipment/ component shall be possible without switching off or isolating the other equipments/components.
3.9	Each switchboard shall be provided with undrilled, removable type gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall be provided with gasket to ensure enclosure protection.
3.10	The minimum clearance in air between phases and between phases and earth for the entire busbars shall be 25mm. For all other components, the clearance between "two live parts", "a live part and an earthed part", shall be at least ten (10) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for busbars the clearances specified above should be maintained even when the busbars are sleeved or insulated. All connections from the busbars up to switch / fuses/MCCB shall be fully insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits. All busbars and jumper connections shall be of high conductivity aluminum alloy / copper of adequate size.
3.11	All switchboards shall be provided with three phase and neutral busbars. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.
3.12	The cross-section of the busbars shall be uniform throughout the length of switchboard section and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents. Neutral busbar short circuit strength shall be same as main busbars.
3.13	All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet molded compound or equivalent type polyester fiber glass molded insulator. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided, anti-tracking barriers shall be provided between the supports. Insulator and barriers of inflammable material such as Hylam shall not be accepted. The busbar insulators shall be supported on the main structure.
3.14	All busbar joints shall be provided with high tensile steel bolts, belleville / spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated busbar joints shall

	be thoroughly cleaned at the jointed locations and suitable contact grease shall be applied just before making a joint. All bolts shall be tightened by torque spanner to the recommended value. The overlap of the busbars at each joint surface shall be such that the length of overlap shall be equal to or greater than the width of the busbar. All copper to aluminum joints shall be provided with suitable bimetallic washers.
3.15	All busbars shall be colour coded as per IS: 375.
3.16	Wherever the busbars are painted with black Matt paint, the same should be suitable for temperature encountered in the switchboard under normal operating conditions.
3.17	The Bidder shall furnish calculations establishing the adequacy of bus bar sizes for specified current ratings.
3.18	Panel space heaters shall be provided and the supply for this shall be tapped from incomer, before the isolating switch/circuit breaker. Incoming circuit to space-heater shall have an isolating switch, HRC fuse and neutral link of suitable rating. Panel illumination and plug-socket shall also be tapped from the space heater supply.
3.19	A galvanized steel / Copper / Aluminum earth bus shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded / bolted to the framework of each panel and breaker earthing contact bar. Vertical earth bus shall be provided in each vertical section which shall in turn be bolted / welded to main horizontal earth bus.
3.20	The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current to earth without exceeding the allowable temperature rise.
3.21	All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosure framework and truck shall be maintained even after painting.
3.22	All metallic cases of relays, instruments and other panel-mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. All the equipment mounted on the door shall be earthed through flexible wire/braids. Insulation color code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors, soldering is not acceptable. Looping of earth connections, which would result in loss of earth connections to other devices, when a device is removed, is not acceptable. However, looping of earth connections between equipment to provide alternative paths to earth bus is acceptable.
3.23	VT and CT secondary neutral point earthing shall be at one place only, i.e. on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.
3.24	All hinged doors having potential carrying equipment mounted on it shall be earthed by flexible wire/ braid. For doors not having potential carrying equipment mounted on it, earth continuity through scraping hinges/ hinge pins of proven design may also acceptable. The Contractor shall establish earth continuity at site also.

3.25	All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables.
3.26	All auxiliary wiring shall be carried out with 650V grade, single core stranded copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5 mm2 (min.) for control circuit wiring and 2.5 mm2 (min) for CT and space heater circuits.
3.27	Extra flexible wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the doors shall be properly sleeved or taped.
3.28	All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminal blocks.
3.29	All internal wiring terminations shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor or an equally secure method. Similar lugs shall also be provided at both ends of component-to-component wiring. Insulating sleeves shall be provided over the exposed parts of lugs to the extent possible. Screw-less (spring loaded) / cage clamp type terminal shall also be provided with lugs.
3.30	Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS: 375. Red Ferrules should be provided on trip circuit wiring.
3.31	Cable termination arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminum conductor, PVC/ XLPE insulated, armored / unarmored and PVC sheathed cables. All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc., shall be provided by the contractor, to suit the final cable sizes.
3.32	All power cable terminals shall be of stud type and the power cable lugs shall be solderless crimping ring type conforming to IS: 8309. All lugs shall be insulated/ sleeved.
3.33	All Switchgears, MCCs, Distribution Boards, Fuse boards, all feeders, local push-button stations etc. shall be provided with prominent, engraved identification plates.
3.34	All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Inscription & lettering sizes shall be subject to Employer's approval.
3.35	Caution name plate "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.
3.36	The gaskets, wherever specified, shall be of good quality EPDM / neoprene with good ageing, compression and oil resistance characteristics suitable for panel applications.
3.37	The bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature as per Indian standards / specification. Continuous current rating

at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.

3.38 ON/OFF status and protection trip status of incomers and bus coupler (if applicable as per SLD) be provided for SCADA system.

3.39 Suitable changeover and interlocking arrangement shall be provided for incomers and bus coupler (if applicable as per SLD).

3.40 It shall be the responsibility of the contractor to fully coordinate the overload and short circuit breakers/fuses with the upstream and downstream circuit breakers / fuses, to provide satisfactory discrimination. Further the various equipment supplied shall meet the requirements of type ii class of co-ordination as per IS: 8544.

3.41 All sheet steel work shall be pretreated, in tanks, in accordance with is: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "class-c" as specified in is: 6005. The phosphate surfaces shall be rinsed and passivated. After passivation, electrostatic powder coating shall be used. Powder should meet requirements of is 13871 (powder costing specification). Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless required otherwise by the employer. The paint thickness shall not be less than 50 microns.

4.0 MCCB

1. MCCB shall be fixed type module, air break type, having trip free mechanism with quick make and quick break type contacts. MCCB shall have current limiting feature. MCCB of identical ratings shall be physically and electrically interchangeable. MCCB shall be provided with 1 NO and 1NC auxiliary contacts.
2. MCCB shall have inbuilt front adjustable releases (overload & short circuit) and shall have adjustable earth fault protection unit also. The protection settings shall have suitable range to achieve the required time & current settings. LED indications shall also be provided for faults, MCCB status (on/off etc).
3. MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit rating. Extended cable terminal arrangement for higher size cable may also be offered. ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door cannot be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked. The MCCBs being offered shall have common/interchangeable accessories for all ratings like aux. switch, shunt trip, alarm switch etc. The MCCBs shall have the current discrimination up to full short circuit capacity and shall be selected as per manufacturer's discrimination table.

5.0 FUSES

5.1 All fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC circuits shall be rated for 80kA rms (prospective) breaking capacity at 415V AC and for DC circuits, 20kA rms breaking capacity at 240V DC.

5.2 Fuse shall have visible operation indicators. Insulating barriers shall be provided between individual power fuses.

5.3 Fuse shall be mounted on insulated fuse carriers, which are mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type of bases. In such cases one set of insulated fuse pulling handles shall be supplied with each switchboard.

5.4 The Neutral links shall be mounted on fuse carriers which shall be mounted on fuse bases.

6.0 INDOOR LT SWITCHGEAR FOR STRING INVERTER

In addition to the above clauses (relevant), the following shall also be applicable for switchgear ratings more than 400A.

6.1 All switchboards shall be divided into distinct vertical sections (panels), each comprising of the following compartments.

(a) BUSBAR COMPARTMENT: - A completely enclosed bus bar compartment shall be provided for the horizontal and vertical busbars. Bolted covers shall be provided for access to horizontal and vertical busbars and all joints for repair and maintenance, which shall be feasible without disturbing any feeder compartment. Auxiliary and power busbars shall be in separate compartments.

(b) SWITCHGEAR / FEEDER COMPARTMENT: - All equipment associated with an feeder of rating above 400A shall be housed in a separate compartment of the vertical section. ACB shall be provided for feeders of rating 1000A and above. The design of the vertical section for such an arrangement shall ensure ease of termination of power cables of size & quantity as per system requirement. The compartment shall be sheet steel enclosed on all sides with the withdrawable units in position or removed. Insulating sheet at rear of the compartment is also acceptable. The front of the compartment shall be provided with the hinged single leaf door with captive screws for positive closure.

(c) CABLE COMPARTMENT/CABLE ALLEY: - A full-height vertical cable alley of minimum 250mm width shall be provided for power and control cables. Cable alley shall have no exposed live parts and shall have no communication with busbar compartment. Cable terminations located in cable alley of capacity more than 400 A shall be designed to meet the Form IVb and for less than 400A A shall be designed to meet the Form 3b (as per IEC 61439) for safety purpose. Wherever cable alleys are not provided for distribution boards, segregated cable boxes for individual feeders shall be provided at the rear for direct termination of cables.

For circuit breaker external cable connections, a separately enclosed cable compartment shall also be acceptable. The contractor shall furnish suitable plugs to cover the cable openings in the partition between feeder compartment and cable alley. Cable alley door shall be hinged.

(d) CONTROL COMPARTMENT: - A separate compartment shall be provided for relays and other control devices associated with a circuit breaker.

6.2 All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 4X as per IS/IEC 60947 (for indoor panels). All cutouts shall be provided with EPDM / Neoprene gaskets. However, the control / relay compartments shall have degree of protection not less than IP 5X.

6.3 Provision of louvers on switchboards would not be preferred. However, louvers backed with metal screen are acceptable on the busbar chambers where continuous busbar rating is 1600 A and above.

6.4 Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboard, except for the horizontal busbar compartment. EPDM / Neoprene gasket shall be provided between the panel sections to avoid ingress of dust into panels.

6.5 The minimum clearance in air between phases and between phases and earth for the entire busbars. and bus-link connections at circuit-breaker shall be 25mm. All busbars and jumper connections shall be of high conductivity aluminum alloy / copper of adequate size.

6.6 After isolation of power and control circuit connections it shall be possible to safely carryout maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose. Wherever two breaker compartments are provided in the same vertical section insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.

6.7 All switchgear (circuit-breaker) panels shall be of single-front type. The covers shall be provided with "DANGER" labels. All panel doors shall open by 90 deg or more.

6.8 All circuit-breaker modules shall be of fully draw out type having distinct 'Service' and 'Test' positions. Suitable arrangement with cradle / rollers, guides along with tool / lever operated racking in / out mechanism shall be provided for smooth and effortless movement of the chassis.

6.9 All switchboards shall be provided with three phase and neutral busbars. Two separate sets of vertical busbars shall be provided in each panel of double front DBs. Interleaving arrangement for busbars shall be adopted for switchboards with a rating of more than 1600A. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.

6.10 ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door

	cannot be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked.
6.11	The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear switchgear also.
6.12	Temperature raise test of LT switchgear of rating more than 400A: - The temperature rise of the horizontal and vertical busbars and main bus links including all power draw out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55 deg C with silver plated joints and 40 deg C with all other types of joints over an outside ambient temperature of 50 deg C. The temperature rise of the accessible parts/external enclosures expected to be touched in normal operation shall not exceed 20deg. C. The temperature rise of manual operating means shall not exceed 10deg. C for metallic & 15 deg. C for insulating material. Temperature rise for the busbars shall be carried out at 90% of the rated current.
6.13	The carriage and breaker frame shall get earthed while being inserted in the panel and positive earthing of the breaker frame shall be maintained in all positions, i.e. SERVICE & ISOLATED, as well as throughout the intermediate travel.
6.14	Electrically controlled circuit breaker boards shall be provided with DC control supply.
7.0	**CIRCUIT BREAKERS**
7.1	Circuit breakers shall be three pole, air break, horizontal draw out type, and shall have fault making and breaking capacities as specified in "Technical Parameters". The circuit breakers which meet specified parameters of continuous current rating and fault making / breaking capacity only after provision of cooling fans or special device shall not be acceptable.
7.2	Circuit breakers along with its operating mechanism shall be provided with suitable arrangement for easy withdrawal. Suitable guides shall be provided to minimize misalignment of the breaker.
7.3	There shall be "SERVICE", "TEST" and "FULLY WITHDRAWN" positions for the breakers. In "Test" position the circuit breaker shall be capable of being tested for operation without energizing the power circuits i.e. the power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the "SERVICE", "TEST" or "FULLLY WITHDRAWN" position. Circuit Breaker rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition.
7.4	Separate limit switches, each having required numbers of contacts shall be provided in both "SERVICE" and "TEST" position of the breaker. All contacts shall be rated for making, continuously carrying and breaking 10 Amp at 240 V AC and 1 Amp (Inductive) at 240 V DC respectively.

CLAUSE NO.	TECHNICAL SPECIFICATIONS
7.5	Suitable mechanical indications shall be provided on all circuit breakers to show "OPEN", "CLOSE", "SERVICE ", "TEST" AND "SPRING CHARGED" positions.
7.6	Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half a cycle of rated frequency.
7.7	Movement of a circuit breaker between "SERVICE" and "TEST" position shall not be possible unless it is in open position. Attempted withdrawal of a closed-circuit breaker shall preferably not trip the circuit breaker. In case the offered circuit breaker trips on attempted withdrawal as a standard interlock, it shall be ensured that sufficient contact exists between the fixed and draw out contact at the time of breaker trip so that no arcing takes place even with the breaker carrying its full rated current.
7.8	Closing of a circuit breaker shall not be possible unless it is in "SERVICE" position, "TEST" position or in "FULLY WITHDRAWN" position.
7.9	Circuit-breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the stationary isolated contacts when the breaker is withdrawn. It shall however be possible to open the shutters intentionally against pressure for testing purposes.
7.10	Breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.
7.11	Circuit breakers shall be provided with coded key / electrical interlocking devices, as per requirements.
7.12	Circuit breaker shall be provided with anti-pumping feature and trip free feature, even if mechanical anti-pumping feature is provided.
7.13	Mechanical tripping shall be possible by means of front mounted Red "trip" push-button. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.
7.14	Complete shrouding / segregation shall be provided between incoming and outgoing bus links of breakers. In case of bus coupler breaker panels the busbar connection to and from the breaker terminals shall be segregated such that each connection can be approached and maintained independently with the other bus section live. Dummy panels if required to achieve the above feature shall be included in the Bidder's scope of supply.
7.15	Circuit breaker open/close shall be possible from SCADA and open/close status and all other important signal status shall be provided for SCADA monitoring.
7.16	Power operated mechanism shall be provided with a Universal motor suitable for operation on DC Control supply. In case of DC supply motor should satisfactorily operate with voltage variation between 85% to 110% nominal control supply voltage. Motor insulation shall be class "E" or better.

7.17 The motor shall be such that it requires not more than 30 Seconds for fully charging the closing spring at minimum available control voltage.

7.18 Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.

7.19 The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.

7.20 Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.

7.21 All circuit breakers shall be provided with closing and trip coils. The closing coil shall operate correctly at all values of voltage between 85% to 110% nominal control supply voltage. The trip coil shall operate satisfactorily at all values of voltage between 70% to 110% nominal control supply voltage.

7.22 Provision for mechanical closing of the breaker only in "Test" and "WITHDRAWN" positions shall be made. Alternately, the mechanical closing facility shall be normally made inaccessible; accessibility being rendered only after deliberate removal of shrouds.

7.23 The ACB Panel door shall not be possible to open in breaker closed condition. Further, the racking mechanism shall be accessible only after opening the breaker panel door.

7.24 Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit-breaker module in a cubicle at each location. The trolley shall be such that the top most breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic trolley shall be such that all type, size and rating of breaker can be withdrawn /inserted of particular switchgear.

7.25 Electrical Parameter of Circuit Breaker

1)	Type	Air break spring charged stored energy type
2)	Operating duty	O-3 MIN-CO-3 MIN-OC
3)	Symmetrical interrupting	As per system fault current (for one sec)
4)	Short circuit rating	2.1 times of System fault current (peak)
5)	Short Circuit Breaking current	
	a) AC Component	As per system fault current (for one sec)
	b) DC Component	As per IS:13947
6)	Short time withstand	As per system fault current

8.0 AC JUNCTION BOXES (for use with string inverters)

8.1 Separate AC Junction box shall be used for string inverters AC output connection. Protection class for AC junction box shall be IP 54 or better protection. All components of junction box shall be suitable for rated output voltage (with + 10% variation) of string inverter, grid frequency of 50 Hz +/- 5%, ambient temperature 50 deg. C and system fault current for 1 sec.

8.2 AC junction box shall be of metal enclosed type. All frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold-rolled sheet steel and 4.0 mm for non-magnetic material. The minimum clearance in air between phases and between phases and earth shall be at least twenty five (25) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers.

8.3 All power cable terminals shall be of stud type and the power cable lugs shall be of tinned copper solderless crimping ring type conforming to IS: 8309. All lugs shall be insulated/ sleeved.

8.4 EPDM / Neoprene gasket shall be used to prevent ingress of dust into panels.

8.5 All non-current carrying metal work of the junction box shall be effectively connected to the system earth bus.

8.6 Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless required otherwise by the Employer. The paint thickness shall not be less than 50 microns.

9.0 TEMPERATURE-RISE (For LT Switchgear having capacity more than 400A)

The temperature rise of the horizontal and vertical busbars and main bus links including all power draw out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55 deg C with silver plated joints and 40 deg C with all other types of joints over an outside ambient temperature of 50 deg C. The temperature rise of the accessible parts/external enclosures expected to be touched in normal operation shall not exceed 20deg. C. The temperature rise of manual operating means shall not exceed 10deg. C for metallic & 15 deg. C for insulating material. Temperature rise for the busbars shall be carried out at 90% of the rated current.

10.0 DERATING OF COMPONENTS

The Bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature as per Indian Standards / Specification. Continuous current rating at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.

The Bidder shall indicate clearly the derating factors if any employed for each component and furnish the basis for arriving at these derating factors duly considering the specified current ratings and amb. temperature of 50 deg C.

11.0 ROUTINE TESTS: -

All acceptance and routine tests as per the specification and relevant standards to be carried out. Charges for these shall be deemed to be included in the equipment price. An indicative list of tests / checks is mentioned in QA chapter as LT switchgear. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

B-2 HT SWITCHGEAR

1.0 CODES AND STANDARDS

All standards, specification and codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of Techno commercial bid. In case of conflict between this specification and those (IS Codes, Standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards and codes.

Sl No	IS Code	Name Of Equipment
a)	IS: 722	AC electricity meters.
b)	IS: 996	Single phase small AC and universal electrical motors.
c)	IS: 1248	Direct Acting indicating analogue electrical measuring instruments and Accessories.
d)	IS/IEC: 60947	Degree of protection provided by enclosures for low voltage switchgear and control gear.
e)	IS: 2544	Porcelain post insulators for systems with nominal voltages greater than 1000 Volts.
f)	IS: 2705	Current transformers.
g)	IS: 3156	Voltage Transformers
h)	IS: 6005	Code of practice for phosphating of iron and steel.
i)	IS: 5082	Specification for wrought aluminum and aluminum alloy bars, rods, tubes and selections for electrical purposes.
j)	IEC: 61850	Communication Standard for Numerical relays
k)	IEC: 61131-3	Automation Standard for Numerical relays
l)	IS: 9046	AC contactors for voltages above 1000 volts and upto and including 11000 Volts.
m)	IS: 13703	Low voltage fuses
n)	IS: 9385	HV fuses
o)	IS: 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV
p)	IS: 9921	A.C. disconnectors (isolators) and Earthing switches for voltages

		above 1000 V
q)	IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
r)	IS: 13118	Specification for high voltage AC circuit breakers.
s)	IEC: 60099-4	Metal oxide surge arrestor without gap for AC system
t)	IS/IEC: 62271-100	High voltage alternating current circuit breakers.
u)	IS/IEC: 62271-200	High voltage metal enclosed switchgear and control gear.
v)	IEC: 60947-7-1	Terminal blocks for copper conductors
w)	IS :513 (2008)	Cold Rolled Low Carbon Steel Sheets and Strips

2.0 TECHNICAL PARAMETERS

A. SYSTEM PARAMETERS		
a)	Nominal System voltage	33kV
b)	Highest System voltage	36kV
c)	Rated Frequency	50Hz
d)	Number of phases/ poles	Three
e)	System neutral earthing	Solidly Earthed
f)	One minute power frequency withstand voltage	
	- for Type tests	70kV
	- for Routine tests	70kV
g)	1.2/50 microsecond Impulse withstand voltage	170kV (peak)
h)	Minimum system fault level	As per System Fault current (Refer Cl. 1 of Chapter 2-A)
i)	Short time rating for bus bars, circuit breakers, current transformers and switchgear assembly.	
j)	Dynamic withstand rating	2.5 times of system

		fault current
k)	- Space heaters	240 V AC single phase with neutral solidly earthed
l)	Maximum ambient air temperature	50 deg. C
m)	Internal Arc testing	As per system fault current (for Min 1 sec)

B. BUS BARS		
a)	Continuous current rating at 50^0C ambient:	As Per Requirement
b)	Temper Rise allowed above ambient	As per IEC 62271-1, 2017

C. SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS		
a)	Colour finish	
	Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers)
b)	Cable entry	
	Power Cables	Bottom
	Control Cables	Bottom
c)	Earthing conductor	Galvanized steel strip
d)	Service Continuity of swgrs (LSC2B-PM)	as per IS/IEC 62271-200

D. CIRCUIT BREAKERS		
a)	The circuit breakers current rating shall be selected from the load current at an ambient of 50 deg. C.	
b)	Short circuit breaker Current	
	a) A.C. component	As per Clause 1.0 of Chapter 2-A (Part A)
	b) D.C. component	As per IS: 13118 or IEC-62271
c)	Short Circuit making current	2.5 times of system fault current (peak)
d)	Operating Duty	O-3 min-CO-3 min-CO

e)	Total break time	Not more than 4 cycles
f)	Total make time	Not more than 5 cycles
g)	Operating Mechanism	Motor wound spring charged stored energy type as per IEC-62271

E.	**CURRENT TRANSFORMER**	
a)	Secondary Current	1A
b)	Class of Insulation	Class E or better
c)	Rated output of each	Adequate for the relays and devices connected, but not less than five (5) VA.
d)	Accuracy class	
	Protection	5P20/PS as per requirement
	Measurement	0.5 class or better as per requirement
e)	Instrument Security Factor for Measurement CTs	5
f)	CT Ratio	CT ratio shall be finalized during details engineering stage. Minimum CT primary side current shall be 110% of rated current.

F.	**VOLTAGE TRANSFORMERS**	
a)	Rated Voltage Factor	1.2 continuous for all VTs, and 1.9 for 8 Hours for star connected VTs.
b)	Class of insulation	Class E or better
c)	Other parameters	0.5 Class or better as per requirement. VA requirement shall be based on application/ requirement. Additional open delta core with damping resistor shall be provided in all VT's to prevent damage on account of Ferro-Resonance conditions
d)	At pooling switchgear, Bus VTs panels and line VTs in outgoing feeders shall be provided. All other switchgear location, at outgoing feeder cable charge indication shall be provided based on voltage sensing or use of voltage transformer.	

G. DIGITAL MFM		
a)	Accuracy Class	0.5 or better
b)	Digital MFM shall be provided for VCB panels as per requirement/SLD.	

3.0	**SWITCHGEAR PANEL**
3.1	The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying with clause No. 3.102 of IEC 62271-200, comprising of a row of free standing floor mounted panels. Each circuit shall have a separate vertical panel with distinct compartments for circuit breaker truck, cable termination, main busbars and auxiliary control devices. The adjacent panels shall be completely separated by steel / Aluzinc sheets except in bus bar compartments where insulated barriers shall be provided to segregate adjacent panels. The Service Class Continuity of Switchgears shall be LSC 2B-PM (as per IS/ IEC 622771-200). However, manufacturer's standard switchgear designs without inter panel barriers in busbar compartment may also be considered.
3.2	The circuit breakers and bus VTs shall be mounted on withdrawable trucks which shall roll out horizontally from service position to isolated position. For complete withdrawal from the panel, the truck shall rollout on the floor or shall roll out on telescopic rails. In case the later arrangement is offered, suitable trolley shall be provided by the Bidder for withdrawal and insertion of the truck from and into the panel. Testing of the breaker shall be possible in isolated position by keeping the control plug connected.
3.3	The trucks shall have distinct SERVICE and ISOLATED positions. It shall be possible to close the breaker compartment door in isolated position also, so that the switchgear retains its specified degree of protection. Circuit Breaker rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition. While switchboard designs with doors for breaker compartments would be preferred, standard designs of reputed switchgear manufacturers where the truck front serves as the compartment cover may also be considered provided the breaker compartment is completely sealed from all other compartments and retains the IP-4X degree of protection in the Isolated position. In case the latter arrangement is offered, the Bidder shall explain how this sealing is achieved and shall include blanking covers one for each size of panel per switchboard in his total Techno commercial bid price.
3.4	The switchgear assembly shall be dust, moisture, rodent and vermin proof, with the truck in any position SERVICE, ISOLATED or removed, and all doors and covers closed. All doors, removable covers and glass windows shall have gaskets all round with synthetic rubber or neoprene gaskets.
3.5	The control / relay compartments shall have degree of protection not less then IP 5X in accordance with IS/IEC 60947. However, remaining compartments can have a degree of protection of IP 4X. All louvers, if provided, shall have very fine brass or GI mesh screen. Tight fitting gourmet / gaskets are to be provided at all openings in relay compartment. Numerical Relays shall be fully Flush mounted on the switchgear panels at a suitable height.
3.6	The Switchgear shall have an internal Arc Classification of IAC FLR corresponding to system fault current. The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Pressure relief device shall be provided in each high voltage compartment of a panel, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of its spreading to other compartments and panels. The pressure relief device shall not however reduce the degree of protection of panels under normal working conditions. To

	demonstrate that the pressure relief device operates satisfactorily the Contractor shall submit a type test report in line with IEC 62271-200 Annex – A for each high voltage chamber. Wherever louvers are provided, the construction of louvers should be such that the IAC requirements are satisfied. Further, viewing glass windows shall have the same strength as the enclosure against Internal Arc.
3.7	Enclosure shall be constructed with rolled steel / Aluzinc sections. The doors and covers shall be constructed from cold rolled steel sheets of 2.0 mm or higher thickness. Gland plates shall be 2.5 mm thick made out of hot rolled or cold rolled steel sheets and for non-magnetic material it shall be 3.0 mm.
3.8	The switchgear shall be cooled by natural air flow. Forced cooling shall be considered in case current rating is above 2000 A or above.
3.9	The height of switches, pushbuttons and other hand operated devices shall not exceed 1800mm and shall not be less than 700mm.
3.10	Necessary guide channels shall be provided in the breaker compartments for proper alignment of plug and socket contacts when truck is being moved to SERVICE position. A crank or lever arrangement shall preferably be provided for smooth and positive movement of truck between Service and Isolated positions.
3.11	Safety shutters complying with IEC 62271-200 shall be provided to cover up the fixed high voltage contacts on busbar and cable sides when the truck is moved to ISOLATED position. The shutters shall move automatically, through a linkage with the movement of the truck. Preferably it shall however, be possible to open the shutters of busbar side and cable side individually against spring pressure for testing purpose after defeating the interlock with truck movement deliberately. In case, insulating shutters are provided, these shall meet the requirements of IEC 62271-200 and necessary tests as per IEC 62271-200 Clause 5.103.3.3 shall be carried out. A clearly visible warning label "Isolate elsewhere before earthing" shall be provided on the shutters of incoming and tie connections which could be energized from other end.
3.12	Switchgear construction shall have a bushing or other sealing arrangement between the circuit breaker compartment and the busbar / cable compartments, so that there is no air communication around the isolating contacts in the shutter area with the truck in service position.
3.13	The breaker and the auxiliary compartments provided on the front side shall have strong hinged doors. Standard and proven designs of switchgear manufacturers (other than above) shall be reviewed during detailed engineering stage. Busbar and cabling compartments provided on the rear side shall have separate bolted covers with self-retaining bolts for easy maintenance and safety. Breaker compartment doors shall be provided with single-shot latch type handle and shall have locking facility. Suitable interlock shall be provided, which will ensure that breaker is OFF before opening the back doors. Suitable interlock shall be provided to prevent opening of any compartment doors which has any of the MV equipment, in case the supply is ON.
3.14	In the Service position, the truck shall be so secured that it is not displaced by short circuit forces. Busbars, jumpers and other components of the switchgear shall also be properly supported to withstand all possible short circuit forces corresponding to the short circuit rating specified.

3.15	Suitable base frames made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and leveled when the flooring is being done, welding of base frame to the insert plates as per approved installation drawings shall be in Bidder's scope.
3.16	Alternatively, Outdoor HT switchgear can be offered for ICOG configuration. The outdoor switchgear shall have minimum IP 55 or better protection with painting and shed requirement as mentioned in Appendix-1 of Part-A, Sub section-1. The bidder shall submit the relevant details of the switchgear including the datasheets, drawings and applicable type test reports during the detailed engineering for Employers approval. Internal Arc requirement for metal enclosed outdoor HT switchgear shall be same as indoor type switchgear. The main pooling/final pooling switchgear shall be indoor only.
4.0	**CIRCUIT BREAKERS**
4.1	The circuit breakers shall be of Vacuum type.
4.2	They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating mechanism.
4.3	Circuit breaker shall be restrike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An anti-pumping relay shall be provided for each breaker, even if it has built-in mechanical anti-pumping features. An arrangement of two breakers in parallel to meet a specified current rating shall not be acceptable.
4.4	During closing, main poles shall not rebound objectionably and mechanism shall not require adjustments. Necessary dampers shall be provided to withstand the impact at the end of opening stroke.
4.5	Plug and socket isolating Contacts for main power circuit shall be silver plated, of self-aligning type, of robust design and capable of withstanding the specified short circuit currents. They shall preferably be shrouded with an insulating material. Plug and socket contacts for auxiliary circuits shall also be silver plated, sturdy and of self-aligning type having a high degree of reliability. Thickness of silver plating shall not be less than 10 microns.
4.6	All working part of the mechanism shall be of corrosion resisting material. Bearings which require greasing shall be equipped with pressure type grease fittings. Bearing pins, bolts, nuts and other parts shall be adequately secured and locked to prevent loosening or change in adjustment due to repeated operation of the breaker and the mechanism.
4.7	The operating mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and shall not lead to closing or tripping of circuit breaker. Failure of any auxiliary spring shall also not cause damage to the circuit breaker or endanger the operator.
4.8	Mechanical indicators shall be provided on the breaker trucks to indicate OPEN / CLOSED conditions of the circuit breaker, and CHARGED / DISCHARGED conditions of the closing spring. An operation counter shall also be provided. These shall be visible without opening the breaker compartment door.

4.9	The rated control supply voltage shall be as mentioned elsewhere under Technical parameters. The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 85% to 110% rated DC voltage. The shunt trip coil shall operate satisfactorily under all operating conditions of the circuit breaker upto its rated short circuit breaking current at all values of control supply voltage between 70% to 110% of rated DC voltage. The trip coil shall be so designed that it does not get energized when its healthiness is monitored by two indicating lamps (Red) and one trip coil supervision relay.
4.10	The time taken for charging of closing spring shall not exceed 30 seconds. The spring charging shall take place automatically preferably after a closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation. As long as power supply is available to the charging motor a continuous sequence of closing and opening operations shall be possible. One open-close- open operation of the circuit breaker shall be possible after failure of power supply to the motor. Spring charging motors shall be capable of starting and charging the closing spring twice in quick succession without exceeding acceptable winding temperature when the control supply voltage is anywhere between 85% to 110% rated DC voltage. The initial temperature shall be as prevalent in the switchgear panel during full load operation with 50 deg. C ambient air temperature. The motor shall be provided with short circuit protection.
4.11	Motor windings shall be provided with class E insulation or better. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in a hot, humid and tropical climate.
4.12	Circuit breaker shall be provided with inter pole barriers of insulating materials. The use of inflammable materials like Hylam shall not be acceptable.
5.0	**CONTROLS AND INTERLOCKS**
5.1	Rotary type Control switches shall be provided in each switchgear panel. The circuit breaker will normally be controlled from remote control panels through closing and shunt trip coils. The control switch and local control console of the relay flush mounted on the switchgear would normally be used only for testing of circuit breaker in isolated position, and for tripping it in an emergency. The closing and opening of the breaker shall also be possible from the Laptop through front serial port of the relay to facilitate commissioning activities.
5.2	The basic control scheme shall be developed in the numerical relay using programmable (soft) logics. Tripping of breaker shall be done either through numerical relay or Master Trip Relay.
5.3	Facilities shall be provided for mechanical tripping of the breaker and for manual charging of the stored energy mechanism for a complete duty cycle, in an emergency.
5.4	Each panel shall have two separate limit switches, one for the Service position and the other for isolated position.
5.5	Auxiliary Contacts of breaker may be mounted in the fixed portion or in the withdrawable truck as per the standard practice of the manufacturer, and shall be directly operated by the breaker operating mechanism.

5.6	Auxiliary contacts mounted in the fixed portion shall not be operable by the operating mechanism, once the truck is withdrawn from the service position, but remain in the position corresponding to breaker open position. Auxiliary contacts mounted on the truck portion, and dedicated for Employer's use shall be wired out in series with a contact denoting breaker service position. With truck withdrawn, the auxiliary contacts shall be operable by hand for testing. There shall be at least 2 NO and 2 NC breaker/contactor original Auxiliary contacts made available for the of the Employer's use.
5.7	The contacts of all limit switches and all breaker auxiliary contacts located on truck portion and fixed portion shall be silver plated, rated to make, carry and break 1.0A 240V DC (Inductive) / 10A 240V AC. Contacts of control plug and socket shall be capable of carrying the above current continuously.
5.8	Movement of truck between SERVICE and ISOLATED positions shall be mechanically prevented when the breaker is closed. An attempt to withdraw a closed breaker shall not trip it.
5.9	Closing of the breaker shall be possible only when truck is either in TEST/ISOLATED or in-service position and shall not be possible when truck is in between. Further, closing shall be possible only when the auxiliary circuits to breaker truck have been connected up, and closing spring is fully charged.
5.10	It shall be possible to easily insert breaker of one typical rating into any one of the panels meant for same rating but at the same time shall be prevented from inserting it into panels meant for a different type or rating.
5.11	Indications shall be provided in the relay console flush mounted on the panel front as brought out in the specification elsewhere. It shall be possible to easily make out whether the truck in SERVICE OR ISOLATED POSITION even when the compartment door is closed.
5.12	Reverse blocking and Inter tripping shall be implemented in switchgear boards level. Detailed scheme for the same shall be finalized during detailed engineering stage.
5.13	All required interlock shall be provided for safe operation of switchgears. Capacitive voltage detection or other alternative suitable arrangement (VT shall not be used) shall be used for outgoing feeder backdoor (cable chamber) open interlock.
6.0	**NUMERICAL RELAYS AND NETWORKING**
6.1	Circuit breaker feeders (with protection function as per requirement) shall be provided with communicable numerical relays (IED, i.e. Intelligent Electronic Device) complying with IEC-61850, having protection, control, and monitoring features. These relays shall be networked and suitably interfaced with the Solar SCADA system for dynamic SLD display, status monitoring, measurements, event / alarm displays, reports, etc. The relays shall be flush mounted on panel front with connections from the inside. These numerical relays shall be of types as proven for the application and shall be subject to Employer's approval. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio and other characteristics to provide required sensitivity. All equipments shall have necessary protections.
6.2	The numerical relay shall be capable of measuring and storing values of a wide range of quantities, events, faults and disturbance recordings. The alarm / status of each of

	protection function and trip operation shall be communicated to Solar SCADA. The numerical relays shall have built in feature / hardware interface to provide such inputs to Solar SCADA / for analog / digital values.
6.3	All relays shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Contacts for breaker close and trip commands shall be so rated as to be used directly used in the closing and tripping circuits of breaker without the need of any interposing / master trip relays. Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages and typically shall be more than 70% of the rated control supply voltage.
6.4	One minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).
6.5	Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.
6.6	Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.
6.7	All numerical relays shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts as per the requirement of control schematics. The quantities of such input / outputs shall be finalized during detailed engineering.
6.8	All the numerical relays shall have communications on two ports, local front port communication to laptop and rear port on IEC 61850 to communicate with the interface equipment for connectivity with the Solar SCADA. Laptop provided with PCU/SCADA shall be used to facilitate numerical relay configuration, DR and event/fault records downloading from relay locally. Latest version of hardware and Software for interfacing the numerical relays with laptop shall be provided. At least two sets of communication cable for Laptop to relay communication shall be provided.
6.9	All the numerical relays shall have adequate processor memory for implementing the programmable scheme logic required for the realization of the protection / control schemes, in addition to the built in protection algorithms. Numerical relays shall have inrush detection feature for blocking of user selectable protection functions.
6.10	Numerical relays shall have feature of current measurement. Relay shall be able to provide the same in soft to solar SCADA system.
6.11	Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.
6.12	Master trip (86) and non-86 trips shall be software configurable to output contacts.
6.13	Numerical relays used at main pooling switchgear shall have provision of both current and voltage inputs. Number of CT inputs for numerical relays at all switchgear panels shall be as per actual protections requirement but not less than 4 sets, 3 nos. for phase fault & 1 no. for earth fault. Relays shall be suitable for CT secondary current of 1A. All 33kV feeders shall be provided with non-directional EF and OC protection. Numerical relays used at main pooling switchgear shall have voltage protection and measurement feature.

6.14	Relay setting shall be based on time grading principle with minimum 100mSec shall be the grading margin. Least time setting at inverter transformer feeders and shall be increased towards the evacuation point (towards grid). Relay time setting shall be minimum 100 ms. However, relay current and time setting including time grading margin shall be as per Bidder offered system (with minimum as per above) considering smooth plant operation and proper protection integration/coordination with grid. Bidder can use same relay time setting for tie feeder panels between two switchgears. Relay setting of solar plant feeders shall be done in coordination with 33kV main pooling switch (grid side) relay setting. Any special/other protections, control interlocks etc as per requirement shall be provided by the Bidder. Details shall be finalized during detailed engineering stage.
6.15	For relay setting calculation grid side shall be taken upstream and inverter side shall be taken downstream. For any switchgear outgoing feeder shall be towards grid and incoming feeders shall be towards inverter to be considered.
6.16	All CT & VT terminals on the relays shall be of fixed type suitable for connection of ring-type lugs to avoid any hazard due to loose connection leading to CT open-circuit. In no circumstances Plug In type connectors shall be used for CT / VT connections.
6.17	All numerical relay shall have key pad / keys to allow relay settings from relay front. All hand reset relays shall have reset button on the relay front. Relay to be self or hand reset shall be software selectable. Manual resetting shall be possible from remote.
6.18	Relays shall have self-diagnostic feature with self-check for power failure, programmable routines, memory and main CPU failures and a separate output contact for indication of any failure.
6.19	Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC / ANSI programmable characteristics.
6.20	Design of the relay must be immune to any kind of electromagnetic interference. Vendor shall submit all related type test reports for the offered model along with the offer.
6.21	All cards / hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.
6.22	Relay shall be immune to capacitance effect due to long length of connected control cables. Any external hardware, if required for avoiding mal operation of the relay due to cable capacitance shall be included as a standard feature.
6.23	All I/Os shall have galvanic isolation. Analog inputs shall be protected against switching surges, harmonics etc.
6.24	Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.
6.25	Numerical relays shall have feature for Time synchronization through the SCADA System / networking. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system.
6.26	Ethernet switches shall be suitable to accept both AC & DC supplies with range of 70 % to 120 % of rated voltage.
6.27	Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.

6.28	Bidder to depute relay OEM protection engineer at CIL EOC office for finalization of relay setting and configuration during detail engineering stage. All numerical protection relay configuration and setting shall be done as per approved setting and configuration at switchgear manufacturer work by relay OEM or his authorized representative. All numerical relay testing and logic/interlock checking during commissioning stage at site shall be done under the supervision of Relay OEM or his authorized representative.
7.0	**OTHER PROTECTIONS AND CONTROL FUNCTIONS IN THE RELAYS**
7.1	Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker trip circuit both in pre trip and post trip conditions.
7.2	Schematics requiring auxiliary relays / timers for protection function shall be a part of numerical relay. The number of auxiliary relay and timer function for protection function shall be as required. Timer functions shall be programmable for on/off delays.
7.3	The numerical relay shall be able to provide supervisory functions such as trip circuit monitoring, circuit breaker state monitoring, PT and CT supervisions and recording facilities with Post fault analysis.
7.4	The numerical processor shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.
7.5	At least 200 time tagged events / records shall be stored with time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.
7.6	Diagnostics Automatic testing, power on diagnostics with continuous monitoring to ensure high degree of reliability shall be provided. The results of the self-reset functions shall be stored in battery back memory. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be available on the user interface.
7.7	The alarm/status of each individual protection function and trip operation shall be communicated to solar SCADA.
7.8	Sequence of events shall have 1 ms resolution at device level.
7.9	Measurement accuracy shall be 1 % for RMS Current and voltage.
8.0	**BUSBARS AND INSULATORS**
8.1	All Busbar and jumper connections shall be of high conductivity aluminum alloy. They shall be adequately supported on insulators as per manufacturer's standard proven design to withstand electrical and mechanical stresses due to specified short circuit currents.
8.2	Busbar cross-section shall be uniform throughout the length of switchgear. Busbars and other high voltage connection shall be sufficiently corona free at maximum working voltage.
8.3	Contact surfaces at all joints shall be silver plated or properly cleaned and non-oxide grease applied to ensure an efficient and trouble free connection. All bolted joints shall

	have necessary plain and spring washers. All connection hardware shall have high corrosion resistance. Bimetallic connectors or any other technically proven method shall be used for aluminum to copper connections.
8.4	Busbar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. Busbar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators. In case of organic insulator partial discharge shall be limited to 100pico coulomb at rated voltage x 1.1 / $\sqrt{3}$. Use of insulators and barriers of in-flammable material such as Hylam shall not be accepted.
8.5	Successful Bidder shall furnish calculation establishing adequacy of busbar sizes for the specified continuous and short time current ratings.
8.6	All busbars shall be color coded.
8.7	The temperature of the busbar and all other equipment, when carrying the rated current continuously shall be limited as per the stipulations of IEC 62271-1,2017, duly considering the specified ambient temperature (50 deg. C).
9.0	**EARTHING AND EARTHING DEVICES**
9.1	A copper / galvanized steel earthing bus shall be provided at the bottom and shall extend throughout the length of each switch board. It shall be bolted/ welded to the framework of each panel and each breaker earthing contact bar.
9.2	A copper / galvanized steel earthing bus shall be provided at the bottom and shall extend throughout the length of each switch board. It shall be bolted/ welded to the framework of each panel and each breaker earthing contact bar.
9.3	The earth bus shall have sufficient cross section to carry the momentary short-circuit and short time fault currents to earth as indicated under switchgear parameters without exceeding the allowable temperature rise.
9.4	Suitable arrangement shall be provided at each end of the earth bus for bolting to Employer's earthing conductors. All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.
9.5	All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical continuity of the whole switchgear enclosure framework and the truck shall be maintained even after painting.
9.6	The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions i.e. SERVICE and ISOLATED as well as throughout the intermediate travel. The truck shall also get and remain earthed when the control plug is connected irrespective of its position.
9.7	All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. Insulation colour code of earthing wires shall be green. Earthing wires shall be

connected to terminals with suitable clamp connectors and soldering shall not be acceptable. Looping of earth connections which would result in loss of earth connection to other devices, when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths of earth bus is acceptable.

9.8 VT and CT secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit may be removed without disturbing the earthing of other circuits.

9.9 Separate earthing trucks shall be provided by the Contractor for maintenance work. These trucks shall be suitable for earthing the switchgear busbars as well as outgoing / incoming cables or busducts. The trucks shall have a interlock to prevent earthing of any live connection.

9.10 As an alternative to separate earthing trucks the Bidder may also offer built-in earthing facilities for the busbars and outgoing / incoming connections, in case such facilities are available in their standard proven switchgear design. The inbuilt earthing switches shall have provision for short circuiting and earthing a circuit intended to be earthed. These switches shall be quick make type, independent of the action of the operator and shall be operable from the front of the switchgear panel. These switches shall have facility for padlocking in the earthed condition.

9.11 Interlocks shall be provided to prevent:

a) Closing of the earthing switch if the associated circuit breaker truck is in Service position.

b) Insertion of the breaker truck to Service position if earthing switch is in closed position.

c) Closing of the earth switch on a live connection.

d) Energizing an earthed Section: Complete details of arrangement offered shall be provided during detailed engineering, describing the safety features and interlocks.

9.12 The earthing device (truck / switch) shall have the short circuit withstand capability equal to that of associated switchgear panel.

All hinged doors shall be earthed through flexible earthing braid

10.0 PAINTING (INDOOR SWITCHGEAR)

All sheet steel work shall be pretreated, in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "Class-C" as specified in IS: 6005. The phosphated surfaces shall be rinsed and passivated. After passivation, Electrostatic Powder Coating shall be used. Powder should meet requirements of IS 13871 (Powder coating specification). Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless required otherwise by the Employer. The paint thickness shall be 50 microns or more as per the ambient conditions of installation area. Finished parts shall be suitably packed and wrapped with protective covering to protect the finished

surfaces from scratches, grease, dirt and oil spots during testing, transportation, handling and erection.

11.0 INSTRUMENT TRANSFORMERS

11.1 All current and voltage transformers shall be completely encapsulated cast resin insulated type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 50 deg. C. The class of insulation shall be E or better.

11.2 All instrument transformers shall withstand the power frequency and impulse test voltage specified for the switchgear assembly. The current transformer shall further have the dynamic and short time ratings at least equal to those specified for the associated switchgear and shall safely withstand the thermal and mechanical stress produced by maximum fault currents specified when mounted inside the switchgear for circuit breaker modules.

11.3 The parameters of instrument transformers specified in this specification are tentative and shall be finalized by the Employer in due course duly considering the actual burden of various relays and other devices finally selected. In case the Bidder finds that the specified ratings are not adequate for the relays and other devices offered by him, he shall offer instrument transformer of adequate ratings and shall bring out this fact clearly in his Techno commercial bid.

11.4 All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.

11.5 Current transformers may be multi or single core and shall be located in the cable termination compartment. All voltage transformers shall be single phase type. The bus VTs shall be housed in a separate panel on a truck so as to be fully withdrawable.

11.6 All voltage transformers shall have suitable current limiting fuses on both primary and secondary sides. Primary fuses shall be mounted on the withdrawable portion. Replacement of the primary fuses shall be possible with VT truck in isolated position. The secondary fuses shall be mounted on the fixed portion and the fuse replacement shall be possible without drawing out the VT truck from service position.

11.7 All voltage transformers shall be designed and manufactured for 0.8 Tesla operating point on B-H curve. VT shall be fully insulated type (i.e. double pole construction and neutral side fully insulated to rated BIL). VT shall be manufactured without any joint in secondary winding.

12.0 SURGE ARRESTOR

The surge arrestors shall be provided as per tender SLD/ as per system requirement and shall be of metal oxide, gapless type generally in accordance with IEC 60099-4 and suitable for indoor duty. These shall be mounted within the switchgear cubicle between line and earth, preferably in the cable compartment. Surge arrestor selected shall be suitable for un-earthed system and rating shall be in such a way that the value of steep fronted switching over voltage generated at the switchgear terminals shall be limited to the requirements of switchgear.

13.0	**CONTROL SUPPLY AND SPACE HEATER SUPPLY**
13.1	Each switchboard shall be provided at least two (02) Nos of DC feeders for the control supply.
13.2	In case two DC sources are provided, then suitable rated blocking diodes in both circuit has to be provided. Alternately Bidder can provide source selection switch.
13.3	One suitable rated 240V single phase AC supply feeder per switchboard / Switchboard section for space heater supply. Bidder shall provide necessary switch and fuse to receive, isolate and distribute to each panel.
13.4	Each sub circuit shall have separate fuses. Fuse size shall be determined so as to achieve selective clearance between main circuit and sub circuit in case of fault. Potential circuits for protection and metering shall also be protected by separate fuse.
13.5	All fuses shall be of link type conforming to IS: 13703 / 9385 mounted on suitable fuse bases. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage. All accessible live connection to fuse bases shall be adequately shrouded.
13.6	All DC circuits shall be fused on both poles. Single phase AC circuits shall have fuses on line and link on neutral.
13.7	DC and AC supply monitoring relay shall be provided and alarm shall be generated in SCADA system in case of failure of supply.
14.0	**SPACE HEATER**
14.1	Each switchgear panel shall be equipped with thermostatically controlled space heater(s), suitably located in breaker and cable compartments to prevent condensation within the enclosure. The space heater shall be connected to 240V single phase AC auxiliary supply available in the switchgear, through switches and fuses provided separately for each panel.
14.2	A 240V single phase 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF switch for connection of hand lamp.
15.0	**TERMINAL BLOCKS**
15.1	Terminal blocks shall be 650V grade, 10Amps rated, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals the screw shall be captive, preferably with screw locking design.
15.2	Terminal blocks for CT and VT secondary leads shall be of stud type, made up of unbreakable polyamide 6.6 grade. They shall be provided with links to facilitate testing, isolation star / delta formation and earthing. Terminal blocks for CT secondary shall have the short-circuiting facility. The terminals for remote ammeter connection etc. shall also be disconnecting type only. All metal parts shall be of non-ferrous material. Screws shall be captive.

15.3	At least 10% spare terminals for external connections shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks. Space for adding another 10% spare terminals shall also be available in each panel.
15.4	There shall be minimum clearances of 250 mm between the terminal blocks and the cable gland plate and 150 mm between two rows of terminal blocks.
15.5	All panel wring for external connections shall terminate on separate terminal blocks which shall be suitable for connecting two (2) stranded copper conductors of 2.5 sq. mm on each side, or alternatively, the terminal blocks shall have the possibility of double shorting space to facilitate looping.
16.0	**SWITCHGEAR WIRING**
16.1	All Switchgear panels shall be supplied completely wired internally upto the terminal block ready to receive Employer's external cabling. All inter cubicle wiring and connections between panels of same switchboard including all bus wiring for AC and DC supplies shall be provided / done by the Contractor.
16.2	All internal wiring shall be carried out with 650 V grade, single core, 1.5 sq. mm. stranded copper wires having minimum of seven strands per conductor and color coded, PVC insulation. CT circuits shall be wired with 2.5 sq. mm. wires which otherwise are similar to the above. Extra flexible wires shall be used for wiring between fixed and moving parts such as hinged doors.
16.3	All wiring shall be properly supported neatly arranged, readily accessible and securely connected to equipment, terminals and terminal blocks. Wiring troughs or gutters be used for this purpose.
16.4	Internal wire terminals shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor. Insulation sleeves shall be provided over the exposed parts of lugs.
16.5	Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS: 375. Red Ferrules should be provided on trip circuit wiring.
16.6	Interconnection to adjacent panels shall be brought out to a separate set of terminal blocks located near the slots or holes, meant for the interconnecting wires. Arrangement shall permit neat layout and easy interconnections to adjacent panels at site and wires for this purpose shall be provided by Contractor looped and bunched properly inside the panels.
16.7	Contractor shall be fully responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.
16.8	The Contractor shall provide the necessary clamps wiring troughs etc. for all wiring inside the switchgear enclosed including the Employer's power and control cables.

17.0 POWER CABLE TERMINATION

17.1 Cable termination compartment shall receive the stranded Aluminum conductor, XLPE insulated, shielded, armored / unarmored, PVC jacketed, single core / three core, unearthed / earthed grade power cable(s).

17.2 A minimum clearance of about 600 mm shall be kept between the cable lug bottom ends and gland plates for stress cone formation for XLPE cables. Interphase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnection of cables. Dimensional drawing of cable connection compartment showing the location of lug, glands, CTs, gland plates etc. and the electrical clearances available shall be submitted for Employer's approval during detail engineering.

17.3 Cable termination compartment shall have provision for termination of power cables of sizes as indicated during detailed engineering with removable undrilled gland plates. For all single core cables gland plates shall be of nonmagnetic material. Cable entry shall be from bottom. Any change will be intimated later.

18.0 NAME PLATES AND LABELS

18.1 Each switch board shall have a name plate for its identification. All enclosure mounted equipment shall be provided with individual engraved name plates for clear equipment identification. All panels shall be identified on front as well as backside by large engraved name plates giving the distinct feeder description along with panel numbers. Back side name plates shall be fixed in panel frame and not on the rear removable cover.

18.2 Name plate shall be of non-rusting metal or 3-ply lamicoid with white engraved letterings, on black background or as per manufacturer’s proven standards. Inscriptions and lettering shall be subjected to Employer's approval.

18.3 Suitable stenciled paint mark shall be provided for identification of all equipment, located inside the enclosure, as well as for door mounted equipment, from the back side in addition to plastic sticker labels, if provided. These labels shall be located directly by the side of the respective equipment, shall be clearly visible and shall not be hidden by equipment wiring. Type of labels and fixing of labels shall be such that they are not likely to peel off / fall off during prolonged use.

19.0 MODULE DESCRIPTION (Typical)

Sl No	Panel Type	Application	Applicability
1	DB	Transformer Feeder	Transformer Feeder
2	DC	Incomer Feeder	Incomer Feeder
3	DD	Bus Coupler Feeder	Bus Coupler Panel for MV Boards
4	DE-IC	Tie Feeder	Tie Incomer Panel
5	DE-OG	Tie Feeder	Tie Outgoing Panel

6	G	Bus PT	Bus PT Panel
7	ICOG	Standalone Transformer feeder	Standalone panel with both incoming & outgoing cables

20.0 TEST

20.1 **TYPE TESTS**

All equipment to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the following type tests carried out not earlier ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

A)	Reports of the following type tests carried out on circuit breaker / circuit breaker panels, of each voltage class and current rating shall be submitted.
i)	Short circuit duty test on circuit breaker, mounted inside the panel offered along with CTs , bushing and seperators
ii)	Short time withstand test on circuit breaker, mounted inside panel offered together with CTs, bushings and separators.
iii)	Power frequency withstand test on breaker mounted in side panel.
iv)	Lightning impulse withstand test on breaker mounted in side panel.
v)	Temperature rise test on breaker and panel together. For this test, the test set up shall include three panels with breakers, the test breaker and panel being placed in the centre.
	The adjacent panels shall also be loaded to their rated current capacity. Alternatively the test panel may be suitably insulated at the sides, which will be adjoining to other panels in actual site configuration
vi)	Internal Arc Test as per IEC 62271-200
vii)	Measurement of resistance of main circuit.
viii)	Mechanical operation test.
B)	Short circuit withstand test of earthing device (truck / switch).
C)	Testing to observe compliance to degree of protection, shall be checked for each switch board enclosure and busbar chambers during routine inspection shall be as under. IP -4X: It shall not be possible to insert a one (1) mm. dia steel wire into the enclosure from any direction, without using force. IP-5X: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.

- However if the contractor is not able to submit report of the type test(s) conducted not earlier than ten years prior to the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract free of at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.
- All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
- The type test reports once approved for any projects shall be treated as reference. For subsequent projects of CIL, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

D) Type test reports for the following tests on the model of the Numerical relays, Ethernet switches shall be submitted for employer's review

Sl. No.	TEST ITEMS	Standard
i)	Dimensions of structure and visual inspection	IEC 60297-3-101
ii)	Functional requirements:	Relevant IEC 60255-100 series
	– Steady-state simulation	
	– Dynamic simulation	
iii)	Product safety requirements	IEC 60255-27
	(Including the dielectric tests and thermal short time rating)	
iv)	EMC requirements:	IEC 60255-26
	– Emission	
	– Immunity	
v)	Energizing quantities:	
	– Burden	N/A
	– Change of auxiliary energizing quantity	IEC 60255-11
vi)	Contact performance	N/A
vii)	Communication requirements	IEC 61850
viii)	Climatic environmental requirements:	IEC 60068-2-14, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-78, IEC 60068-2-30, IEC 60255-27
	– Cold	
	– Dry heat	
	– Change of temperature	
	– Damp heat	
ix)	Mechanical requirements: – Shock	IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3
	– Vibration	
	– Bump	
	– Seismic	
x)	Enclosure protection	IEC 60529, IEC 60255-27

Two (2) protected soft copies on CD-ROM of the approved test results shall be furnished with the equipment. These shall include complete reports and results of the routine tests

and type tests (if the latter is carried out) on equipment. If the type tests are not conducted, the CDs shall contain copies of the results of type tests carried out on identical equipment earlier.

20.2 **ROUTINE TESTS**

All acceptance and routine tests as per the specification and relevant standards IEC 62271-200 & IEC 62271-100 shall be carried out. Charges for these shall be deemed to be included in the equipment price.

An indicative list of tests / checks is mentioned as QA chapter on HT switchgear. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

20.3 **COMMISSIONING CHECKS / TESTS**

After installation of panels, power and Control wiring and connections, Contractor shall perform commissioning checks as listed below to verify proper operation of switchgear / panels and correctness of all equipment in all respects. In addition, the Contractor shall carry out all other checks and tests recommended by the manufacturers.

General

(a) Check name plate details according to specification.

(b) Check for physical damage

(c) Check tightness of all bolts, clamps and connecting terminals

(d) Check earth connections.

(e) Check cleanliness of insulators and bushings

(f) Check heaters are provided

(g) H.V. test on complete switchboard with CT & breaker in position.

(h) Check all moving parts are properly lubricated.

(i) Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators.

(j) Check for interchange ability of breakers.

(k) Check continuity and IR value of space heater.

(l) Check earth continuity for the complete switchgear board

Circuit Breakers

(a) Check alignment of trucks for free movement.

(b) Check correct operation of shutters.

(c) Check slow closing operation (if provided)

(d) Check control wiring for correctness of connections, continuity and IR values.

(e) Manual operation of breakers completely assembled.

(f) Power closing / opening operation, manually and electrically at extreme condition of control supply voltage.

(g) Closing and tripping time.

(h) Trip free and anti-pumping operation.

(i) IR values, resistance and minimum pick up voltage of coils.

(j) Simultaneous closing of all the three phases.

(k) Check electrical and mechanical interlocks provided.

(l) Checks on spring charging motor, correct operation of limit switches and time of charging.

(m) All functional checks.

Current Transformers

(a) IR value between windings and winding terminals to body.

(b) Polarity tests.

(c) Ratio identification checking of all ratios on all cores by primary injection of current.

(d) Magnetization characteristics & secondary winding resistance.

(e) Spare CT cores, if any to be shorted and earthed.

Voltage Transformers

(a) Insulation resistance test.

(b) Ratio test on all cores.

(c) Polarity test.

(d) Line connections as per connection diagram.

Cubicle Wiring

(a) Check all switch developments.

(b) It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked.

(c) All the wires shall be checked for IR value.

(d) Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component / equipment.

(e) Check terminations and connections.

(f) Wire ducting

21.0 SPECIFICATION FOR 33KV RING MAIN UNIT (If applicable)

21.1 33kV RING MAIN UNIT

Each Ring Main Unit shall have all the following major components in addition to the other items required for satisfactory performance of equipment:

a. Painted MS enclosure with steel base frame for Ring Main Unit.

b. 33 KV Ring Main Units, Non-extensible type along with requisite number of electrically operated breakers and manually operated Load break switches and earth switches as per Single line Diagram

c. Control protection and metering requirements as per system requirement and single line Diagram

d. Internal cabling for connections between the equipments of Ring Main Unit, lighting & earthing system along with required hardware, gaskets, gland plates etc as required.

21.2 TECHNICAL REQUIREMENTS

CODES AND STANDARDS: IS: 13118, IEC: 62271-200

The equipment shall have the following features:

1. ELECTRICAL SYSTEM PARAMETERS		
i	Nominal system voltage	33 KV
ii	Highest system voltage	36 KV
iii	Rated insulation level i) Impulse with stand voltage with 1.2 / 50 Micro second wave ii) One minute power frequency with stand voltage	 170 KV(Peak) 70 KV (RMS)
iv	Rated short circuit breaking capacity at specified site conditions (Minimum)	As per system fault current (Refer Cl. 1.0 of Chapter 2-A, Part A**)** with %age of DC component as per IEC-62271-100 corresponding to minimum operating time with operating conditions specified.
v	Rated short circuit making current (Minimum)	2.5 Times of system fault current.
vi	Rated short time withstand capacity (Minimum)	As per system fault current

vii	Rated operating duty cycle	O-3 minute-CO-3 minute – CO
viii	Maximum temperature rise over and ambient temperature of 50 deg.C	As per IEC: 62271-100
2. RMU CONFIGURATION		
i	RMU Configuration	Two Nos. Load break switches (LBS) and transformer circuit breaker as per system requirement.
ii	Extensibility	Non extensible type
iii	Load break switch, Circuit breaker & earth switch in RMU panel	All shall be fixed (Non draw out) type
iv	Insulation medium for panel/ bus bar	SF6 gas or Dry air in sealed metallic tank
v	Breakers & load break switches	SF6 gas or Vacuum type (with disconnector & earth switch)
vi	Internal Arc classified FLR	As per system fault current (for Min 1 sec)
3. RMU CONSTRUCTIONAL FEATURES		
i	RMU Panel type	Metal enclosed panel construction
ii	Service Location	Indoor/Outdoor
iii	Mounting	Free Standing
iv	Overall enclosure protection	IP54 minimum for MV Switchgear Compartments, Vermin proof
v	Doors	Front access with anti-theft hinge
vi	Covers	Bolted for rear access, with handles. All the accessible bolts / screws shall be vandal proof. One set of required Special tools per RMU shall be in the scope of supply.
vii	Construction	Sheet metal 2 mm thick CRCA/Aluzinc/Stainless-Steel (minimum) suitable for outdoor application.
viii	Base frame made of steel for RMU	Raised frame of 300 mm height
ix	Lifting lugs	Four numbers
x	Cable entry	Bottom
xi	Bus bar continuous rated current at Designed 50 deg.C ambient temperature	As per system requirement.
xii	Bus bar short time withstand capacity	As per system fault current (Minimum)
xiii	Maximum temperature rise above reference ambient 50 deg C	As per IEC reference standard
xiv	Earth bus bar	Aluminum sized for rated fault duty for 1

		sec
xv	Cooling arrangement	By natural air (without fan)
xvi	Panel internal wiring	Stranded flexible color coded PVC insulated copper wire 1.5 sq mm.(min.), 1100 volt grade
xvii	Gasket	Neoprene rubber
xviii	Marshalling terminal blocks	1.5 Sq mm, Nylon 66 material, screw type + 20% spare in each row of TB.
xix	Padlock facility	Required for all earth switches & all handles
xx	Explosion vents	To ensure operator's safety, design should ensure that gases / flames generated during flash over / blast in any of the compartment, must not come out from the front of RMU. Cable compartment & other compartments of the RMU should withstand Internal arc test for the indicated system fault current.
4. Requirements of sealed housing live parts (RMU SF6 gas chamber)		
i	Enclosure	Stainless steel enclosure, IP67 class
ii	SF6 gas pressure low alarm	To be given
iii	Provision for SF6 gas filling	To be given (For 'sealed for life' design of RMU, this is not applicable)
iv	Provision for SF6 gas pressure measurement	Manometer with non-return valve indication
v	Arc interruption method for SF6 breaker / Load break switch	Puffer type / rotating arc type
vi	Potential free contacts for SF6 gas 1NO +1NC pressure low	1NO +1NC
vii	Electrical Bushing	Preferably, bushing should be suitable for replacement at site.
5. LOAD BREAK SWITCH (LOAD BREAK ISOLATOR)		
i	Type	Three poles operated simultaneously by a common shaft
ii	Arc interruption in dielectric medium	SF6 or vacuum
iii	Operating mechanism for close/ open	Electrically operated through SCADA.
iv	Continuous current rating of LBS at design ambient temperature of 50 deg C	100 Amps minimum or as per system requirement
6. CIRCUIT BREAKER		

i	Type	Three poles operated simultaneously by a common shaft
ii	Arc interruption in dielectric medium	SF6 or vacuum
iii	Operating mechanism	Electrically Operated
iv	Emergency trip / open push button	On panel Front
v	Continuous current rating of Breaker at design ambient temp of 50 deg.C	100 Amps minimum or as per system requirement
vi	Short time withstand capacity	As per system fault current
vii	Breaker status auxiliary contact	2NO + 2NC wired to terminal block
viii	Current transformer Ratio	Suggestive rating: 100/1 A or as per requirement Other ratings as per manufacturer's standard may also be adopted. Sufficient space must be provided both in horizontal & vertical directions for mounting of CT's. Additionally, some CAUTION marking (by sticker/ paint) should be there to avoid CT's installation above the screen of cable (i.e. earth potential point.)
ix	CT accuracy class	Protection : 5P20 Metering : 0.5
x	Potential Transformer (PT) ratio and Accuracy Class	33000/ √3 /110/ √3 Accuracy class : 0.5 suitable for converter duty application as mentioned elsewhere in the specification
xi	Protections	Numerical relay as per requirements mentioned elsewhere in the specification. In addition to above Transformer protections like OTI, WTI, Buchholz, and Pressure Relief Valve (PRV) operated shall be suitably integrated in the protection circuit. Any AC/DC auxiliary supply requirement for the RMU shall be arranged as per requirement mentioned elsewhere in the specification.
xii	Relay aux contacts for remote indication	1NO+1NC Potential free wired to TB
xiii	Shunt trip (for door limit switch of enclosure or transformer) as per the adopted voltage	To be wired to terminal blocks
7. EARTH SWITCH		
i	Type	Three poles operated simultaneously by a common shaft

ii	Switching in dielectric medium	Dry air in sealed medium or SF6
iii	Operating mechanism for Close/Open	Manual
iv	Short time withstand capacity	As per system fault current
v	Aux contacts	1NO+1NC free wired to TB
vi	LBS Earth Switch close / open	Potential free contacts wired to terminal block.
vii	CB Earth Switch close /open	Potential free contacts wired to terminal block.
8. INDICATION		
i	Cable charge status indication for all Load Break Switches & Circuit Breaker	Circuit breaker capacitor type voltage indicators with LED on all the phases (Shall be clearly visible in day light)
ii	Spring charge status indication	On front for breaker
iii	Earth switch closed indication (For Each LBS)	front
iv	Load break switch ON/OFF indication	Green for OFF / Red for ON
v	Circuit breaker ON/OFF indication	Green for OFF / Red for ON
vi	Cable Fault Direction	Cable fault passage indicator.
vii	CB close / open	Potential free contacts wired to terminal block.
viii	Protection relay operated	Potential free contacts wired to terminal block.
ix	SF6 gas pressure low	Potential free contacts wired to terminal block.
9. RMU OPERATIONAL INTERLOCK		
i	Interlock type	Mechanical
ii	Load break switch & respective earth switch	Only one in 'close' condition at a time
iii	Circuit breaker & respective earth switch	Only one in 'close' condition at a time
iv	Prevent the removal of respective cable covers if load break switch or circuit breaker is 'ON'	Electrical / Mechanical
v	Prevent the closure of load break switch or circuit breaker if respective cable cover is open	Electrical / Mechanical
vi	Cable test plug for LBS/CB accessible only if Earth switch connected to earth	Mechanical

10. MIMIC DIAGRAM, LABEL AND FINISH		
i	On panel front with description of function & direction of operation of handles/buttons	
ii	Mimic diagram (Shall not be preferred with Stickers)	
iii	Operating instruction chart and Do's & Don'ts to be displayed on left / front side of panel enclosure on Al Sheet, duly affixed on panel.	
iv	Name plate on panel front	Fixing by rivet only
v	Material	Anodized aluminum 16SWG / SS
vi	Background	Satin Silver
vii	Letters, diagram & border	Black
viii	Process	Etching
ix	Name plate details	Month & year of manufacture, equipment type, input & output rating, purchaser name & order Number, guarantee period.
x	Labels for meters & indications	Anodized aluminum with white character on black background OR 3 Ply lamicoid.
xi	Danger plate on front & rear side	Anodized aluminum with white letters on red background
xii	Painting surface preparation	As per Appendix-1 of Part-A (For outdoor)
xiii	Painting external finish	As per Appendix-1 of Part-A (For outdoor) Shade-RAL 7032
xiv	Painting internal finish	As per Appendix-1 of Part-A (For outdoor) Shade-White

21.3 **TESTS OF RMU**

33 kV Switchgear/Ring Mains Unit shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests carried out within last ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of CIL, an endorsement sheet will be furnished by the manufacturer confirming similarity and “No design Change”. Minor changes if any shall be highlighted on the endorsement sheet.

B-3(A) INVERTER TRANSFORMER

1.0 TECHNICAL REQUIRMENTS (OIL FILLED TRANSFORMER)

Sr. No.	TRANSFORMER	INVERTER TRANSFORMER
i)	VA Rating & Quantity	As per system requirement
ii)	Voltage Ratio (KV)	As per system requirement
iii)	Duty, Service & Application	Continuous Solar Inverter application and converter duty (Outdoor)
iv)	Winding	AS per system requirement
v)	Frequency	50 Hz
vi)	Nos. of Phase	THREE
vii)	Vector Group & Neutral earthing	As per system requirement
viii)	Cooling	ONAN
ix)	Tap Changer	As per system requirement OCTC +/- 5% (min.)
x)	Impedance at75^{0}C	
	a) Principal Tap	As per system requirement and SLD* & as per Inverter manufacturer recommendation.
	b) Other Taps	
xi)	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)	
	a) Top Oil	50 deg.C
	b) Each Individual Winding	55 deg.C
xii)	SC withstand time (thermal)	2 sec.
xiii)	Fault Level & Bushing CT	As per system requirement
xiv)	Termination	As per system requirement
xv)	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC (However Inverter Transformer LV side winding & bushing insulation class shall be of at least 3.6 kV) Creepage distance : 31 mm/kV
xvi)	Noise level	AS PER NEMA TR-1
xvii)	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS: 6600/ IEC60076-7. As minimum

		requirement, Transformers shall be designed with 110% continuous thermal overloading capability. The same shall be tested during Temp Rise Type test.
xviii)	Flux density	Not to exceed 1.7 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%
xix)	Air Clearance	As per CBIP
xx)	Foundation	All the foundation shall be designed as per highest rating Transformer in case different capacity transformer are offered.

Note (common for Oil filled and dry type transformer):

- Inverter Transformer shall have copper/Aluminum Shield winding between LV & HV windings. Each LV winding must be capable of handling **non-sinusoidal voltage with voltage gradient as per relevant applicable standards and Inverter manufacturer recommendation.** Also each shield winding shall be taken out to tank with two separate connection from shield to bushing with proper support with 2 nos. 3.6 kV shield bushings and same shall be brought down along with support insulator from tank & copper flat up to the bottom of the tank for independent grounding.

- If Inverter transformer is provided indoor, it shall be necessarily dry type.

- Harmonic Factor as per Inverter manufacturer recommendation must be taken into account while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the dc bias component of 0.5% of rated Inverter output current is to be accounted for its effect on the transformer design.

- The adverse effect on life of transformer due to cloud intermittency and solar generation loading cycle must be compensated through suitable design (as applicable).

- The thermal design of Inverter Transformer needs to consider the temperature dependent performance of the Inverter. It is to in accordance with Inverter output and under worst condition it should not limit Inverter output.

- The multi-winding transformer needs to be designed for long term operating conditions with asymmetrical load on LV side i.e., in case three winding design, the transformer needs to operate reliable with only one Inverter supplying power to only one LV winding.
- For multi winding transformer, it is recommended to have close coupling and equal impedances on each of LV winding to HV winding and to have high enough impedance (8% min. based on one LV winding rating) between two LV windings in order to decouple these windings.
- In case of inverter transformer, it shall be proven and of successfully type tested design
- Contacts from Inverter transformer fittings/protection devices shall be wired for tripping of Inverter transformer Circuit Breaker. Detailed scheme regarding same shall be finalized during detailed engineering.
- Single Line Diagram (SLD) will be finalized during detailed engineering however kVA rating of LV winding of inverter transformer shall not be less than kVA capacity of respective Inverters connected to it.

2.0 CODES AND STANDARDS

Transformers	IS:2026, IS:6600, IEC:60076
Bushings	IS:2099, IEC:60137,IS 3347 ,IS 12676
Insulating oil	IEC 60296 ,IEC 61099/IS16081
Bushing CTs	IS:2705, IEC 60185
Indian Electricity Act 2003, BEE Guideline & CEA notifications	

2.1 General Construction

Transformer shall be constructed in accordance to IS: 2026 and IS: 3639 or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier.
The other important construction particulars shall be as below.

a. The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction and there should be provision for lifting by crane.

b. A double float type Buchholz relay conforming to IS: 3637 shall be provided.

c. Suitable Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.

d. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site

e. The transformer shall be provided with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal.

f. Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.

g. Transformer shall have Oil Temperature Indicator and Winding temperature Indicator with accuracy class of +/-2 deg.

h. Radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/valve at the bottom and air release plug at the top.

i. M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level. Wiring scheme (TB details) shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

2.2 Windings

a) The Bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.

b) The conductors shall be of electrolytic grade copper/electrolytic grade Aluminum free from scales & burrs.

c) All windings of the transformers shall have uniform insulation.

d) Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratio.

2.3 Core

a) The core shall be constructed from non-ageing, cold rolled, super grain oriented silicon steel laminations equivalent to M4 grade steels or better.

b) Core isolation level shall be 2 kV (rms.) for 1 minute in air.

c) Adequate lifting lugs will be provided to enable the core & windings to be lifted.

2.4 Insulating Mineral oil

No inhibitors shall be used in the transformer oil. The oil supplied with transformers shall be new and previously unused and must conform to following while tested at supplier's premises and shall have following parameters.

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm^2/s	≤ 12 at 40 ° C ≤ 1800.0 at (-)30 ° C
2.	Flash Point, ° C	≥ 140° C
3.	Pour point, ° C	≤ (-)40 ° C
4.	Appearance	Clear , free from sediment and suspended matter
5.	Density kg/dm^3 at 20 ° C	≤ 0.895
6.	Interfacial Tension N/m at 25° C	≥ 0.04
7.	Neutralisation value, mgKOH/g	≤ 0.01
8.	Corrosive sulphur	Non Corrosive
9.	Water content mg/kg	≤ 30 in bulk supply ≤ 40 in drum supply
10.	Anti-oxidants additives	Not detectable
11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	 ≤ 1.2 ≤ 0.8
12.	Breakdown voltage As delivered, kV After treatment, kV	 ≥ 30 ≥ 70
13.	Dissipation factor, at 90° C And 40 Hz to 60 Hz	≤ 0.005
14.	PCA content	≤1%
15.	Impulse withstand Level, kVp	≥ 145
16.	Gassing tendency at 50 Hz after 120 min, mm^3/min	≤ 5

Subsequently oil samples shall be drawn at:

Sr. No.	Parameters	Before filling in main tank & tested for	Prior to energization for following properties & acceptance norms:	Applicability
i)	BDV	60 kV (min)	60 kV (min)	Applicable for all Transformers.
ii)	Moisture content	10 ppm (max.)	10 ppm (max.)	

2.5 Bushings

i. Bushing below 52 kV shall be oil communicating type with porcelain insulator.

ii. LV Bushing below 3.6 kV used within transformer cable box, epoxy type bushing confirming to IS 2099/IEC 60137 also allowed as alternate to porcelain type

iii. No arcing horns to be provided on the bushings.

iv. Inverter Transformer LV bushing palms shall be silver/tin plated.

2.6 Bushing CTs

Shall be of adequate rating for protection (differential and others if any) as required, WTI etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

2.7 Valves

All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies.

Sampling & drain valves should have zero leakage rate.

2.8 Gaskets

a) Gasket shall be fitted with weather proof, hot oil resistant, nitrile rubber based gasket.

b) If gasket is compressible, metallic stops shall be provided to prevent over compression.

c) The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

2.9 PAINTING

PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
Inside of tank and Accessories (Except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
External surface of transformer and accessories including M Box (Except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceious iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	One coat each	Atleast 100 micron
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	Two coats each	Atleast 100 micron
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
Internal surface of M	Chemical resistant epoxy zinc phosphate	Two coats	Not less than

PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
Box	primer followed by chemical and heat resistant epoxy enamel white paint	each	100 micron

2.10 Neutral Earthing Arrangement

Neutral earthing shall be done as per system requirement and SLD. In case of solidly earthed neutral of Transformers, it shall be brought through insulated support from tank to the ground level at a convenient point with 2 nos. copper flat, for connection to ground network (as applicable). Neutral of Transformer if not used should be taken out through bushing and covered by insulating cap.

2.11 Cable boxes & disconnecting chamber (Disconnecting chamber applicable 3.3 kV and above & for Inverter Transformer both side)

(a) HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Employer's cable & termination. Phase segregation shall be achieved by insulating barriers (for 3.3 kV and above side)

(b) Cable boxes shall have bus bars / suitable terminal connectors of adequate size & bolt holes to receive cable lugs. The degree of protection of cable boxes shall be IP 55.

(c) A suitable removable gland plate of non-magnetic material drilled as per the Employer's instruction shall also be provided in the cable box

(d) The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron

(e) The contractor shall provide earthing terminals on the cable box, to suit Employer's GI flat.

(f) The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided (shall be discussed during detail engineering). The final cable size, number & length of terminating XLPE cable shall be furnished during detailed engineering.

(g) Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).

(h) Cable boxes shall have removable top cover (for transformer above 100 KVA) & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

2.12 FITTINGS

Following fittings shall be provided with Transformers covered under this sub section.

a)	-Conservator for main tank shall be provided with MOG with low oil level alarm contact, drain valve & indicating type free Cobalt free breather with transparent enclosure

	(Maximum height 1400 mm above ground level) etc.
b)	- Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement.
c)	- It shall be provided with minimum two numbers of spring-operated PRD (with trip contacts) with suitable discharge arrangement for oil shall be provided.
d)	OTI & WTI shall be 150 mm dial type with alarm and trip contacts with max. reading pointer & resetting device (maximum height 1500 mm above ground level). For Inverter Transformers, WTI shall be provided at least for all LV windings.
e)	Top & bottom filter valves with threaded male adapters, bottom sampling valve, drain valve/sludge removal valve at the bottom most point of the tank.
f)	Air release plug, bushing with metal parts & gaskets, terminal connectors on bushings (as applicable).
g)	Prismatic/toughened glass oil gauge for transformers.
h)	Bi-directional wheel/skids, M.Box, OCTC, Bushing CTs (as applicable), Insulating Oil, Cooling equipment.
i)	Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs, inspection cover, Bilingual R&D Plate, Terminal marking plates, two nos. earthing terminals etc.
j)	Bolts & nuts (exposed to atmosphere) shall be galvanized steel/SS.
k)	Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.
The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformers are deemed to be included.	

3.0 DRY TYPE INVERTER TRANSFORMER

Sr. No.	PARAMETERS	INVERTER TRANSFORMER
i)	**Type**	Epoxy cast resin/resin encapsulated
ii)	**Duty, Service & Application**	Continuous Solar Inverter application and converter duty (Indoor)
iii)	**MVA & Voltage ratio**	As per system requirement and SLD.
iv)	**Vector group**	
v)	**Termination & Bushing CT**	

vi)	**Fault Level & Earthing**	
vii)	**Tap changer type & range**	As per system requirement and SLD. OCTC +/-5% (min.)
viii)	**Impedance**	As per system requirement and SLD & as per Inverter manufacturer recommendation.
ix)	**Number of phases**	Three (3)
x)	**Type of cooling**	**AN** Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance guarantee shall correspond to air natural (AN) cooling.
xi)	**Bushing rating, Insulation class (Winding & bushing)**	As per relevant IS/IEC (However Inverter Transformer LV side winding & bushing insulation class shall be of at least 3.6 kV)
xii)	**Maximum Temperature rise of winding over 50 deg. C ambient. (by resistance method) with Air Natural (AN) cooling.**	**90** deg.C. (Class F) **115** deg.C. (Class H)
xiii)	**SC withstand time (thermal)**	2 sec
xiv)	**Noise Level**	Not to exceed values specified in NEMA TR-1.
xv)	**PD Level (max. Allowable)**	10 pc
xvi)	**Loading Capability**	Continuous operation at rated KVA on any tap with voltage variation of +/-10% corresponding to the voltage of the tap as well as in accordance with IEC60076-12/IS: 6600.
xvii)	**Flux Density**	Not to exceed 1.9 Wb/sq.m. at any tap position with +/- 10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds.

3.1 CODES AND STANDARDS

Dry type transformers	IS: 11171, IEC 60076-11
Indian Electricity Act 2003 and Indian Electricity Rules, BEE notification & CEA guidelines	

3.2 DESIGN AND CONSTRUCTIONAL FEATURES

3.2.1 The core shall be constructed from high grade non-ageing cold rolled grain oriented silicon steel laminations of M4 grade or better quality. The insulation of core to clamp-plates shall be able to withstand a power frequency voltage of 2 kV (rms) for one (1) minute.

3.2.2 The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23. In case it is placed outdoor, IP for enclosure shall be minimum IP-42 or higher. Enclosure shall be of a tested quality sheet steel of minimum thickness 2mm & shall also accommodate cable terminations. The housing door shall be interlocked such that it should be possible to open the door only when transformer is off. The enclosure shall be provided with lifting lugs and other hardware for floor mounting. Suitable bi-directional skids with pre-drilled holes shall be provided integral with the enclosure or bi-directional rollers shall be provided with suitable locking arrangement.

3.2.3 Winding conductor shall be electrolytic grade Copper/ Aluminum. Windings shall be of class F insulation or better. All windings are to be uniformly insulated.

3.2.4 Transformer HV bushings and LV bushings can be either solid porcelain or epoxy type. Bushing shall be suitable for satisfactory operation in the high ambient temperature inside Bus Duct enclosure (if applicable). LV flange area shall be of non-magnetic material.

3.2.5 Bushing CTs shall be provided in the LV neutral side of adequate rating for REF protection, WTI, etc (as applicable).

3.2.6 For Marshalling Box, the sheet steel used shall be at least 1.6 mm thick cold rolled. The box shall be tank mounted type. The degree of protection shall be IP-54 in accordance with IS-13947. Wiring Scheme shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

3.2.7 Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance shall correspond to air natural cooling.

3.3 PAINTING

3.3.1 The inside of enclosure and accessories (except M. Box) shall be painted with two coats of fully glossy white colour with total DFT of 25 to 60 microns. The external paint colour of transformer & accessories shall be blue corresponding to RAL 5012. The external surface of transformer & accessories shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of polyurethane finish paint with total DFT of 80 to 150 microns. The internal surface of M.Box shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of chemical & thermal resistant epoxy enamel white paint with total DFT of 80 to 150 microns.

3.4 FITTING

Winding temperature	Shall be Platinum resistance type temperature detector in

indicator (WTI)	each limb. Single Indicating meter may be provided for display of temperature of all limbs. Accuracy class of Indicating meter shall be +/- 1% or better and it shall have least count of 0.1 ^{o}C or better. 1 no. 4-20 mA signal shall be provided for remote monitoring of winding Temperature.
RTD/Thermistors	1 No. PT-RTD shall be embedded in each limb with alarm and trip contacts for remote annunciation. Additional 1 No. thermistor/RTD shall be embedded in each limb.
Fittings which are generally required for satisfactory operation of the transformers are deemed to be included, in the scope of supply of the Contractor.	

4.0 TESTS AND INSPECTION

In case the bidder/contractor has conducted type test(s) within last ten years, he may submit the type test reports to the owner for waiver of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
In case the Bidder is not able to submit report of the type test(s) conducted within last ten years from the date LOA by CIL, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract at no additional cost to the Employer and submit the reports for approval.

Short Circuit Test: -
In case short circuit test has not been conducted or the test report not meeting the specification requirement for the offered transformer manufacturer, Bidder /Sub-vendor shall establish" Ability to withstand the dynamic effects of short circuit "for the offered transformer as per latest IEC 60076-5.The ability to withstand the dynamic effects of short circuit can be established either by performing actual short circuit test or by method of calculation with reference to short circuit tested reference transformer as per IEC-60076- 5/Annexure-A&B. Bidder shall choose any one the two options mentioned below;

Option-1: - Performing actual short circuit test as Type Test. In order to meet project schedule, Bidder/Sub vendor shall take suitable steps quite in advance to ensure successful conduction of short circuit test within three months time from date of LOA failing which the offered make of the transformer shall not be considered.

Option-2: By theoretical evaluation of the ability to withstand dynamic effect of short circuit based on 'Calculation and Design and Manufacture Consideration'. In this regard the guidelines given in Annexure-A with applicable tables of the IEC 60076-5 is to be followed. The reference transformer chosen shall be of same application, winding configuration, conductor current density and as per Annexure-B of latest IEC-60076-5. Necessary Design document and reference test reports related to theoretical comparative evaluation must be submitted by Manufacturer/Bidder as required by Employer in this case.

S.N.	ROUTINE TESTS	
1.	All routine test shall be carried out in accordance with IEC 60076.	√
2.	Measurement of Voltage Ratio & phase displacement (as per IEC 60076-1)	√
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	√
4.	Vector group and Polarity Check (as per IEC 60076-1)	√
5.	Magnetic Balance and Magnetising Current Test	√
6.	Measurement of no load current with 415 V, 50 Hz AC supply	√
7.	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage (as per IEC 60076-1)	√
8.	Load Loss & Short Circuit Impedance Measurement on principal & Extreme Taps	√
9.	IR measurement (As per IEC 60076-1)	√
10.	Measurement of capacitance & tan delta to determine capacitance between winding & earth.	√
11.	Separate Source Voltage Withstand Test /Applied voltage test (as per IEC 60076-3)	√
12.	Induced overvoltage test/Induced voltage withstand(IVW) test as per IEC60076 part 3	√
13.	Repeat no load current/loss & IR after completion of all electrical test	√
14.	Oil leakage test on completely assembled transformer along with radiators (as per relevant clause of this sub section)	√
15.	Jacking test followed by D.P. test	√
16.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	√
17.	IR measurement on wiring of Marshalling Box.	√

S. N.	TYPE TESTS # (To be carried out on one transformer of each rating)	
1.	Lightning impulse (Full and chopped wave) test on windings (as per IEC 60076-3) (Not applicable for LV)	√
2.	Short circuit test (special test) as per IEC 60076-5 (if applicable).	√
3.	Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076. Gas Chromatography shall be conducted on oil sample taken before & immediately after temp. rise test. Gas analysis shall be as per IS: 9434 (based on IEC: 60567), results will be interpreted as per IS: 10593 (based on IEC: 60599).	√
4.	Measurement of harmonics of no-load current (special test)	√

S. N.	TYPE TESTS # (To be carried out on one transformer of each rating)	
5.	Measurement of acoustic noise level as per NEMA TR-1 (special test)	√
6.	Tank Vacuum & Pressure Test (as per CBIP norms)	√

(#) **NOTE: -**

i) All the type and special tests shall be conducted after performing Short Circuit Test. If Tank Vacuum & Pressure Test is to be carried out then it shall be conducted before SC test.

ii) Inverter Transformer LV winding Di-electric tests (except for lightning impulse test for LV winding) shall be carried out corresponding to levels (as per IEC 60076) for 3.6 kV class.

iii) All Type tests should be done as per Employer's approved procedure.

4.1 LEAKAGE TEST ON ASSEMBLED OIL FILLED TRANSFORMER (ROUTINE TEST)

All tank & oil filled compartment shall be tested for oil tightness by being completely filled with oil of viscosity not greater than that of specified oil at the ambient temperature & applying pressure equal to the normal pressure plus 35 KN/sq. m measured at the base of the tank. The pressure shall be maintained for a period of not less than 6 hours during which time no sweating shall occur. Bidder can perform this test at site depending upon urgency subjected to CIL approval.

Suitable Fire Fighting arrangements for Oil filled Transformers shall be provided if applicable as per Tariff Advisory Committee (TAC)/statutory requirements. In case Nitrogen based fire protection system is used, CBIP manual shall be followed for compliance. Firewall & soak pit as applicable (as per statuary requirement/TAC/IS 10028 / IS 1646) shall be provided of minimum 230 mm thickness of RCC wall or 355 mm thick fire resisting brick wall subject to CIL approval. However for all oil filled outdoor a pit shall be provided all around at a distance of 1.0 meter (min.) from transformer outer edge, a sump pit shall be provided for each pit. Transformer efficiency shall be as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electrical Lines) regulation, 2010.

4.2 ROUTINE / TYPE TESTS (DRY TYPE TRANSFORMERS)

Transformer shall be short circuit tested after conducting the routine tests.

Rest of the type tests shall be conducted after successful short circuit testing.

All routine tests in accordance with IS: 11171 / IEC 60076-11 shall be carried out on each transformer.

And All Type tests should be done as per Employer's approved procedure.

Routine / Type Tests (Dry Type Transformers)			
a.)	Measurement of winding Resistance for each tap position.		Routine
b.)	Measurement of voltage ratio at each taps position.		Routine
c.)	Vector group and polarity check		Routine
d.)	Measurement of impedance voltage/short circuit impedance & load loss at principal tap and extreme taps		Routine
e.)	Measurement of no load losses and magnetizing current at rated frequency and 90%, 100% and 110% rated voltage.		Routine
f)	Measurement of insulation resistance		Routine
g)	Measurement of capacitance and tan delta		Routine
h)	Dielectric Tests		
	1)	PF/Separate source AC withstand voltage test.	Routine
	2)	Chopped wave lightning impulse voltage test on windings (as per IEC 60076-3) (Not applicable for LV)	Type
	3)	Induced over voltage withstand test	Routine
i)	Partial discharge measurement		Routine
j)	Measurement of iron loss & IR (repeat after induced voltage test)		Routine
k)	Short Circuit test as per IEC (if applicable)		Type
l)	Noise Level Measurement		Type
o)	Temperature rise test as per IEC (HV & LV winding)		Type

B-3(B) AUXILIARY TRANSFORMER

1.0 TECHNICAL REQUIRMENTS (OIL FILLED TRANSFORMER)

Sr. No.	DESCRIPTION	AUXILIARY TRANSFORMER (AT)
i)	VA Rating & Quantity	As per system requirement and /or SLD*
ii)	Voltage Ratio (KV)	As per system requirement and / or SLD*
iii)	Duty, Service & Application	Continuous application (Outdoor)
iv)	Winding	TWO
v)	Frequency	50 Hz
vi)	Nos. of Phase	THREE
vii)	Vector Group & Neutral earthing	As per system requirement and /or SLD*
viii)	Cooling	ONAN
ix)	Tap Changer	As per system requirement and /or SLD*
x)	Impedance at 75^0C	
	a) Principal Tap	As per system requirement and /or SLD*.
	b) Other Taps	
xi)	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)	
	a) Top Oil	35 deg.C
	b) Winding	40 deg.C
xii)	SC withstand time (thermal)	2 sec.
xiii)	Fault Level & Bushing CT	As per system requirement and SLD*
xiv)	Termination	As per system requirement /cable box
xv)	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC Creepage distance: 31 mm/kV
xvi)	Noise level	AS PER NEMA TR-1
xvii)	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS: 6600.
xviii)	Flux density	Not to exceed 1.7 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%
xix)	Air Clearance	As per CBIP

If Auxiliary Transformer is a part of Inverter Cubicle, then the requirement specified herein shall not apply for Auxiliary Transformer.

Note (common for Oil filled and dry type transformer):

- Auxiliary transformers shall be suitable for 3 phase, 4 wire system with additional LVN bushing for equipment earthing.
- **Auxiliary Transformer can be either Oil (Natural/Synthetic Ester oil) filled or Dry Type (refer relevant specification).**
- **In case Ester Oil filled Transformer are offered, then 50% quantity shall be Natural ester filled and balance 50% quantity shall be of Synthetic Ester oil filled.**

2.0 CODES AND STANDARDS

Transformers	IS:2026, IS:6600
Bushings	IS:2099,IS 3347
Insulating oil	IS 16659 / IS 16081
Bushing CTs	IS:2705
Indian Electricity Act 2003, BEE Guideline & CEA notifications	

2.1 General Construction

Transformer shall be constructed in accordance to IS: 2026 and IS: 3639 or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier.

The other important construction particulars shall be as below.

a. The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction and there should be provision for lifting by crane.

b. A double float type Buchholz relay conforming to IS: 3637 shall be provided.

c. Suitable Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.

d. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site.

e. The transformer shall be provided with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal.

f. Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.

g. Transformer shall have Oil Temperature Indicator and Winding temperature Indicator (WTI applicable for transformer above 50 KVA) with accuracy class of +/-2 deg.

h. For Transformers above 100KVA, radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/valve at the bottom and air release plug at the top.

i. M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level (for transformer above 100 KVA). For transformer above 100 KVA, wiring scheme (TB details) shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

j. In case Natural Ester oil (IS 16659) filled transformer, the Transformer should be hermetically sealed and corrugated tank design. It should fitted with monitoring equipment like DGPT etc. for accessing the healthiness of Natural ester oil. As transformer becomes hermetically sealed, fitting, valves and accessories shall be decided during detail engineering, but all other part of tender specification related to design of transformer active part and testing requirement shall remain same. HV/LV Bushing shall be fitted vertically on tank cover and all necessary measures to be taken to make the transformer leakage proof. Suitable nitrogen capping system shall be provided for preserving Natural ester oil for O&M.

2.2 Windings

a) The bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.

b) The conductors shall be of electrolytic grade copper free from scales & burrs.

c) All windings of the transformers shall have uniform insulation.

d) Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratios.

2.3 Core

a) The core shall be constructed from non-ageing, cold rolled, super grain-oriented silicon steel laminations equivalent to M4 grade steels or better.

b) Core isolation level shall be 2 kV (rms.) for 1 minute in air.

c) Adequate lifting lugs will be provided to enable the core & windings to be lifted.

2.4 Insulating Mineral oil

No inhibitors shall be used in the transformer oil. The oil supplied with transformers shall be new and previously unused and must conform to following while tested at supplier's premises and shall have following parameters.

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm^2/s	≤ 12 at 40 ° C ≤ 1800.0 at (-)30 ° C
2.	Flash Point, ° C	≥ 140° C
3.	Pour point, ° C	≤ (-)40 ° C
4.	Appearance	Clear, free from sediment and suspended matter
5.	Density kg/dm^3 at 20 ° C	≤ 0.895
6.	Interfacial Tension N/m at 25° C	≥ 0.04
7.	Neutralisation value, mgKOH/g	≤ 0.01
8.	Corrosive sulphur	Non-Corrosive
9.	Water content mg/kg	≤ 30 in bulk supply ≤ 40 in drum supply
10.	Antioxidants additives	Not detectable
11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	 ≤ 1.2 ≤ 0.8
12.	Breakdown voltage As delivered, kV After treatment, kV	 ≥ 30 ≥ 70
13.	Dissipation factor, at 90° C And 40 Hz to 60 Hz	≤ 0.005
14.	PCA content	≤1%
15.	Impulse withstand Level, kVp	≥ 145
16.	Gassing tendency at 50 Hz after 120 min, mm^3/min	≤ 5

Subsequently oil samples shall be drawn at:

Sr. No.	Parameters	Before filling in main tank & tested for	Prior to energization for following properties & acceptance norms:	Applicability
i)	BDV	60 kV (min)	60 kV (min)	Applicable for all Transformers.
ii)	Moisture content	10 ppm (max.)	10 ppm (max.)	

For ester filled oil, relevant IS/IEC shall be followed for relevant oil parameters for type/routine test.

2.5 Bushings

a) Bushing below 52 kV shall be oil communicating type with porcelain insulator.
b) No arcing horns to be provided on the bushings.

2.6 Bushing CTs

Shall be of adequate rating for protection as required, WTI (WTI CT applicable for transformer above 50 KVA) etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

2.7 Valves

All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies.
Sampling & drain valves should have zero leakage rate.

2.8 Gaskets

a) Gasket shall be fitted with weatherproof, hot oil resistant, rubberized cork gasket.

b) If gasket is compressible, metallic stops shall be provided to prevent over compression.

c) The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

2.9 PAINTING

PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceious iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	One coat each	Atleast 100 micron
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	Two coats each	Atleast 100 micron
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 micron

2.10 Neutral Earthing Arrangement

Neutral earthing shall be done as per system requirement and SLD. In case of solidly earthed neutral of Transformers, it shall be brought through insulated support from tank to the ground level at a convenient point with 2 nos. copper flat, for connection to ground network (as applicable). Neutral of Transformer if not used should be taken out through bushing and covered by insulating cap.

2.11 Cable boxes & disconnecting chamber (Disconnecting chamber applicable 3.3 kV and above)

(a) HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Employer's cable & termination. Phase segregation shall be achieved by insulating barriers (for 3.3 kV and above side)

(b) Cable boxes shall have bus bars / suitable terminal connectors of adequate size & bolt holes to receive cable lugs. The degree of protection of cable boxes shall be IP 55.

(c) A suitable removable gland plate of non-magnetic material drilled as per the Employer's instruction shall also be provided in the cable box

(d) The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron.

(e) The contractor shall provide earthing terminals on the cable box, to suit Employer's GI flat.

(f) The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided (shall be discussed during detail engineering). The final cable size, number & length of terminating XLPE cable shall be furnished during detailed engineering.

(g) Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).

(h) Cable boxes shall have removable top cover (for transformer above 100 KVA) & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

2.12 FITTINGS

Following fittings shall be provided with Transformers covered under this sub section.

a)	-Conservator for main tank (transformer above 100 KVA shall be provided with MOG with low oil level alarm contact), drain valve & indicating type free Cobalt free breather with transparent enclosure (maximum height 1400 mm above ground level) etc.
b)	- Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement (Gas collecting arrangement applicable for transformer above 100 KVA).
c)	- For Auxiliary transformers below 2 MVA, diaphragm type explosion vent shall be provided.

d)	OTI & WTI shall be 150 mm dial type with alarm (WTI only for transformer above 50 kVA) and trip contacts with max. reading pointer & resetting device (maximum height 1500 mm above ground level).
e)	For transformer above 100 KVA: Top & bottom filter valves with threaded male adapters, bottom sampling valve, and drain valve/sludge removal valve at the bottom most point of the tank. For Transformer upto 100 KVA: common drain cum sampling cum bottom filter cum sludge removal valve and top filter valve can be provided.
f)	Air release plug, bushing with metal parts & gaskets, terminal connectors on bushings (as applicable).
g)	Prismatic/toughened glass oil gauge for transformers.
h)	Bi-directional wheel/skids, M.Box, OCTC, Bushing CTs (as applicable), Insulating Oil, Cooling equipment.
i)	Cover lifting eyes, transformer lifting lugs, jacking pads (jacking pad applicable for transformer above 100 KVA), towing holes and core and winding lifting lugs, inspection cover, Bilingual R&D Plate, Terminal marking plates, two nos. earthing terminals etc.
j)	Bolts & nuts (exposed to atmosphere) shall be galvanized steel/SS.
k)	Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.

The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformers are deemed to be included.

2.13 Tests and Inspection

S.N.	ROUTINE TESTS	
1.	All routine test shall be carried out in accordance with IEC 60076.	√
2.	Measurement of Voltage Ratio & phase displacement	√
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	√
4.	Vector group and Polarity Check	√
5.	Magnetic Balance and Magnetizing Current Test	√
6.	Measurement of no load current with 415 V, 50 Hz AC supply	√
7.	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage	√
8.	Load Loss & Short Circuit Impedance Measurement on principal & Extreme Taps	√
9.	IR measurement (As per IEC 60076-1)	√
10.	Separate Source Voltage Withstand Test /Applied voltage test.	√
11.	Induced overvoltage test/Induced voltage withstand (IVW) test .	√
12.	Repeat no load current/loss & IR after completion of all electrical test	√
13.	Oil leakage test on completely assembled transformer along with radiators (as per relevant clause of this sub section)	√
14.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	√
15.	IR measurement on wiring of Marshalling Box.	√

S.N.	TYPE TESTS#	
1.	Temperature Rise test at a tap corresponding to maximum losses as per IS 2026.	√
2.	Tank Vacuum & Pressure Test (as per CBIP norms)	√

2.14 Leakage test on assembled Oil filled Transformer (ROUTINE TEST)

All tank & oil filled compartment shall be tested for oil tightness by being completely filled with oil of viscosity not greater than that of specified oil at the ambient temperature & applying pressure equal to the normal pressure plus 35 KN/sq. m measured at the base of the tank. The pressure shall be maintained for a period of not less than 6 hours during which time no sweating shall occur. Bidder can perform this test at site depending upon urgency subjected to CIL approval.

2.15 Fire Fighting

Fire Fighting arrangements for Transformers shall be provided if applicable as per Tariff Advisory Committee (TAC)/statutory requirements. Firewall & soak pit as applicable (as per statuary requirement/TAC/IS 10028 / IS 1646) shall be provided of minimum 230 mm thickness of RCC wall or 355 mm thick fire resisting brick wall subject to CIL approval. However, for all outdoor transformer at a distance of 1.0 m (min.) from transformer outer edge. A sump pit shall be provided for each pit. Transformer efficiency shall be as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electrical Lines) regulation, 2010.

3.0 DRY TYPE AUXILIARY TRANSFORMERS:

Dry Type Transformer shall be constructed in accordance to IS: 2026, IS: 11171 or equivalent to any other international standard, Indian Electricity Act 2003, BEE Guideline & CEA notifications. Transformer rating and all related technical parameters including tap changer (if applicable) shall be as per system requirement/SLD and relevant standards. Transformer shall be suitable for continuous **indoor** duty application. Transformer shall be complete & functional in all respect. The other important construction particulars shall be as below.

a) The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23. The enclosure shall be provided with suitable hardware (as required).

b) The conductors shall be of electrolytic grade copper free from scales & burrs.

c) Dry Type Transformer windings shall be of class F insulation or better. Cooling shall be AN.

d) The core shall be constructed from non-ageing, cold rolled, grain oriented silicon steel laminations (M4 or better).

The fittings/accessories including protection/monitoring device (temperature scanner) generally required for satisfactory operation of the transformer, are to be provided.

B-3(C) TIE TRANSFORMER

NA

B-4 AC CABLES

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.
IS:7098 (Part -II)	Cross linked polyethylene insulated PVC sheathed cable for (Part -II) working voltage from 3.3 KV upto & including 33 KV
IS:1554 - I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS: 3961	Recommended current ratings for cables
IS: 3975	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IS: 5831	PVC insulation and sheath of electrical cables.
IS: 8130	Conductors for insulated electrical cables and flexible cords.
IS: 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332 Part-3:	Tests on electric cables under fire conditions. Tests on bunched wires or cables (Category-B).
IEEE-383	Standard for type test of Class IE Electric Cables
IS: 4905	Methods for random sampling.
IS: 10418	Specification for drums for electric cables.

1.0 GENERAL REQUIREMENTS

The cables shall be suitable for laying on racks, in ducts, trenches, conduits, overground cabling and underground (buried) installation with chances of flooding by water.

All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.

1.1. Cables shall be armored type if laid in switchyard area or directly buried.

Cable lengths shall be considered in such ways that straight through cable joints are avoided.

If cables are to be laid underground, laying shall be as per latest relevant IS code.

1.4 If cables are to be laid overground (eg on RCC/concrete pedestals etc), the cables shall be UV-resistant supported by test reports.

1.2. **CONDUCTOR**

Copper/aluminum conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.

1.3. **INSULATION**

XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C. PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.

The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core cables, shall have distinct extruded PVC inner sheath of black colour as per IS: 5831.

1.4. **ARMOUR**

For single core armoured cables, armouring shall be of copper/aluminium wires/ formed wires. For multicore armoured cables, armouring shall be of galvanised steel as follows:

Calculated nominal dia.of cable under armour	Size and Type of armour
Upto 13 mm	1.4mm dia GS wire
Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire / 3.15mm dia GS wire
Above 70mm	1.4mm thick GS formed wire / 4.0 mm dia GS wire

The aluminum used for armoring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264ohm mm2 per meter at 20 deg C. The sizes of aluminum armoring shall be same as indicated above for galvanized steel.

The gap between armor wires / formed wires shall not exceed one armor wire / formed wire space and there shall be no cross over / over-riding of armor wire / formed wire. The minimum area of coverage of armoring shall be 90%. The breaking load of armor joint shall not be less than 95% of that of armor wire / formed wire. Zinc rich paint shall be applied on armor joint surface of GS wire / formed wire.

1.5. **OUTERSHEATH**

Outer sheath shall be of PVC as per IS: 5831 & black in colour for power cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.
Oxygen index of min. 29 (as per IS 10810 Part-58).
Acid gas emission of max. 20% (as per IEC-754-I).
Smoke density rating shall not be more than 60 % (as per ASTMD-2843).

In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath.

Cable size and voltage grade - To be embossed
Word 'FRLS' at every 5 metre - To be embossed
Screen Fault current _ _ _KA for _ _ _ Sec. (Value of current & time shall be indicated) (If applicable)
Sequential marking of length of the cable in metres at every one metre -To be embossed / printed
The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.
All cables shall meet the fire resistance requirement as per IEEE - 383 with cable installations made in accordance with 'Flammability Test' and as per Category-B of IEC 332 Part -3.
Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum, over the declared value in the technical data sheets.
Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

2.0 CABLE SELECTION & SIZING

Cables shall be sized based on the following considerations:
Rated current of the equipment.
The Maximum Overall Voltage Drop: As per relevant clause in chapter 2-A,Part-A,Subsection 2.
Short circuit withstand capability.
Fault current- As per system fault current.
Time-As per protection time grading requirement subject to the minimum value mentioned at Cl 1.0 (l) Cable sizing criteria of Chapter 2-A.

3.0 DERATING FACTORS

De rating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

a) Variation in ambient temperature for cables laid in air

b) Grouping of cables

c) Variation in ground temperature and soil thermal resistivity for buried cables.

4.0 HT POWER CABLES

For single-core armored cables, the armoring may constitute the metallic part of insulation screening.

In case of single core cables where there are both metallic screening and armoring, there shall be extruded inner sheath between them.

Distinct extruded PVC inner sheath of black colour as per IS:5831 shall be provided for the cables as follows:

a) For all multicore cables.

b) For single core armored cables, where armoring is not being used as metallic screen

Cores of the cables of upto 3 cores shall be identified by colouring of insulation or by providing coloured tapes helically over the cores with Red, Yellow & Blue colours.

The cross-sectional area of the metallic screen strip/tape shall be considered in design calculations.

The eccentricity shall be calculated as

Eccentricity	Ovality
$\frac{t_{max} - t_{min}}{t_{max}} \times 100$	$\frac{d_{max} - d_{min}}{d_{max}} \times 100$
Where t-max/t-min is the maximum/minimum thickness of insulation and d-max/d-min is the maximum / minimum diameter of the core	

The eccentricity of the core shall not exceed 10% and ovality not to exceed 2%

Cables shall conform to IS: 7098 Part - II. These cables shall have mutli-stranded, compacted circular, aluminum conductors, XLPE insulated, metallic screened suitable for carrying the system earth fault current, PVC outer sheathed. The conductor screen and insulation screen shall both be of extruded semiconducting compound and shall be

applied along with the XLPE insulation in a single operation of triple extrusion process so as to obtain continuously smooth interfaces. Method of curing for cables shall be "dry curing / gas curing".

The metallic screen of each core shall consist of copper tape with minimum overlap of 20%. However for single core armored cables, the armoring shall constitute the metallic part of the screening.

The standard length for HT power cables shall be 1000 meter for all single core cables and 750 meters for 3 core cables. The length per drum shall be subjected to a maximum tolerance of +/- 5% of the standard drum length. The Employer shall have the option of rejecting cable drum with shorter lengths. One drum length of each cable size can be of non standard length (not less than 250 meter) so as to match the ordered quantity. For each size, the variance of total quantity, adding all the supplied drum lengths, from the ordered quantity, shall not exceed +/-2% and the payment shall be made based on the actual cable length supplied within this limit.

5.0 LT POWER CABLES

LT Power & control cables shall be of minimum 1100 volts grade XLPE /PVC insulated conforming to IS 1554 / IS 7098 (Part-I) for utilization voltages less than equal to 415 V.

For cable connecting central inverter and inverter transformer, no. of runs and interconnecting trench, bus bar terminations, lugs shall be provided in such a manner so that no overheating of contacts & terminals encountered. Sufficient space for cabling & termination shall be kept.

The sizing of the cable will depend on the feeder type. For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse. For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.

Single core cables shall have no Inner sheath as per IS: 7098 Part-I

All LT power cables of sizes more than 120 sq.mm. shall be XLPE insulated.

1.1 KV grade XLPE power cables shall have compacted aluminum/ copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), armored/ unarmored, PVC outer- sheathed conforming to IS:7098. (Part-I). Cables which are directly buried shall be armored.

1.1KV grade PVC power cables shall have aluminum/copper conductor (compacted type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed (as applicable) armored/ unarmored, PVC outer-sheathed conforming to IS:1554 (Part-I).

6.0 LT CONTROL CABLES

Conductor of control cables shall be made of stranded, plain annealed copper.

Outer sheath shall be of PVC as per IS: 5831 & grey in colour for control cables.

Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

1 core - Red, Black, Yellow or Blue
2 core- Red & Black
3 core-Red, Yellow & Blue
4 core-Red, Yellow, Blue and Black

For control cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The number shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of insulation. The colour of insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.

CABLE SELECTION & SIZING:

Control cables shall be sized based on the following considerations:

(a) The minimum conductor cross-section shall be 1.5 sq.mm.

(b) The minimum number of spare cores in control cables shall be as follows:

No. of cores in cable	Min. No. of spare cores
2C, 3C	NIL
5C	1
7C-12C	2
14C & above	3

1.1 KV Grade Control Cables shall have stranded copper conductor and shall be multicore PVC or XLPE insulated, PVC inner sheathed, armoured / unarmoured, FRLS PVC outer sheathed conforming to IS: 1554. (Part-I).

7.0 TESTS

Indicative list of tests/checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of power and control cables enclosed at relevant section.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. All cables to be supplied shall be of type tested design.

During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests carried out within last ten years from the date of bid opening. These

reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client /owners representative and submit the reports for approval.

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of CIL, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

The reports for following type tests shall be furnished:

Sl	Type Test	Remarks
	Conductor	
1.	Resistance test	
	For Armor Wires / Formed Wires	
2.	Measurement of Dimensions	
3.	Tensile Test	
4.	Resistance test	
5.	Wrapping test	
6.	Torsion test	For GS round wires only
7.	Elongation test	For GS wire only
8(a)	Mass& uniformity of Zinc Coating tests	For GS wires/formed wires only.
8(b)	Adhesion test	For GS wires/formed wires only
	For XLPE insulation & PVC Sheath	
9.	Test for thickness	
10.	Tensile strength and elongation test before ageing and after ageing	
11.	Ageing in air oven	
12.	Shrinkage test	
13	Hot set test	For XLPE insulation only
14	Water absorption test	For XLPE insulation only
15.	Loss of mass test	For PVC outer sheath only.
16.	Hot deformation test	For PVC outer sheath only.
17.	Heat shock test	For PVC outer sheath only
18.	Thermal stability test	For PVC outer sheath only
19.	Oxygen index test	For PVC outer sheath only

Sl	Type Test	Remarks
20.	Smoke density test	For PVC outer sheath only
21.	Acid gas generation test	For PVC outer sheath only
22	Flammability test as per IEC-332 Part-3 (Category -B)	For completed cable only
23	Insulation resistance test (Volume Resistivity method)	
24	High voltage test	
25. *	Partial discharge test	For HT cables only
26. *	Bending test	
27. *	Dielectric power factor test	
	a) As a function of voltage	
	b) As a function of temperature	
28. *	Heating cycle test	
29. *	Impulse withstand test	

* Not applicable for 3.3/3.3kV grade cables.

8.0 CABLE DRUMS

(a) Cables shall be supplied in wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. However, For Single core cables upto 6 Sq. mm size, supplier can do alternative packaging of whole Drum/Spool to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.

Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

B-5 CABLE INSTALLATION METHODOLOGY

1.0 CODES AND STANDARDS

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards/ codes as applicable.

IS:513	Cold rolled low carbon steel sheets and strips.
IS:802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
IS:1079	Hot Rolled carbon steel sheet & strips
IS:1239	Mild steel tubes, tubulars and other wrought steel fIttings
IS:1255	Code of practice for installation and maintenance of power cables upto and including 33 KV rating
IS:1367 Part-13	Technical supply conditions for threaded Steel fasteners. (Hot dip galvanized coatings on threaded fasteners).
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanising of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:3063	Fasteners single coil rectangular section spring washers.
IS:6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.

	IS:8308	Compression type tubular in- line connectors for aluminium conductors of insulated cables
	IS:8309	Compression type tubular terminal ends for aluminium conductors of insulated cables.
	IS:9537	Conduits for electrical installation.
	IS:9595	Metal - arc welding of carbon and carbon manganese steels - recommendations.
	IS:13573	Joints and terminations for polymeric cables for working voltages from 6.6kv upto and including 33kv performance requirements and type tests.
	BS:476	Fire tests on building materials and structures
	IEEE:80	IEEE guide for safety in AC substation grounding
	IEEE:142	Grounding of Industrial & commercial power systems
	DIN 46267 (Part-II)	Non tension proof compression joints for Aluminium conductors.
	DIN 46329	Cable lugs for compression connections, ring type ,for Aluminium conductors
	VDE 0278	Tests on cable terminations and straight through joints
	BS:6121	Specification for mechanical Cable glands for elastomers and plastic insulated cables.
		Indian Electricity Act.
		Indian Electricity Rules.

Equipment complying with other internationally accepted standards such as IEC, BS, DIN, USA, VDE, NEMA etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.

2.0 DESIGN AND CONSTRUCTIONAL FEATURE

Bidder to refer Appendix -1 of Ch. 1-A for acceptable cable laying methodology.

Inter Plant Cabling

Interplant cabling for main routes shall be laid in Cable trenches/cable trays/buried/duct banks. In case of Duct banks, pull-pits shall be filled with sand and provided with a PCC covering. All buried cables shall be of armoured type.

Bidder can propose overground cabling methodology (eg on RCC/concrete pedestals etc). In such cases, the cables shall be UV-resistant supported by test reports.

Cable Sizing Conditions

All cables shall be suitably derated as per the laying conditions for carrying the required load current and fault current. For derating, the ambient temperature for directly buried cables shall be taken as 40° C and 50° C for cables laid in air.

All XLPE cables shall be rated at 90° C conductor temperature for AC Voltage drop calculation and 80° C for DC Voltage calculation. However, for Voltage drop calculation in DC Cable, actual conductor temperature as per loading can be used

Trenches

PCC flooring of built up trenches shall be sloped for effective drainage with sump pits and sump pumps.

General

The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling.

Sizing criteria, derating factors for the cables shall be met as per respective chapters. However, for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminium conductor and 2.5 sq.mm. for copper conductor cable.

Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to:

- Meet all safety requirements.
- Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/interferences, etc

3.0 EQUIPMENT DESCRIPTION

Cable trays, Fittings & Accessories

Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.

Cable trays which are exposed to atmosphere shall be FRP based or better material with equivalent properties. The specifications for FRP cable trays are iterated below:

a. The FRP cable tray shall be ultraviolet resistant. FRP cable trays shall be manufactured in accordance with latest version of NEMA FG-1-1984-1993 and IS-6746 or its equivalent.

b. All cable trays and accessories shall be corrosion / chemical resistant, weather resistant, easy to drill and cut, Lightweight, high strength and flame retardant in accordance with ASTM E – 84 - Class 1 Rating and as per IS -6746 – Very Low Flammability and resistant to ultraviolet light. The oxygen index shall be minimum 30 as per ASTM-D-2863.

c. The minimum glass content in the FR material shall be 55%.

d. The minimum thickness for any FRP Tray should be 3mm & there should be no negative tolerance in Thickness.

e. The tray construction shall be such as to facilitate easy handling and to ensure easy laying of cables without causing damage to cables. The inside surface shall be free from sharp edges, burrs or projections.

f. Each section of tray shall be complete with necessary connector plate and hardware. All Hardware (Nuts, bolts, washers etc.) shall be of Stainless-Steel Material Grade: 316 for FRP trays joining plates. The bends, tees, reducers, crosses and droppers shall have required bending radius but not less than 300mm.

g. Suitable cable support systems based on FRP shall be supplied confirming with IS 6746. The average thickness for any FRP support should be 4mm & there should be no negative tolerance in Thickness.

Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant IS.

Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm.

Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanised as per relevant IS. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm.

Support System for Cable Trays

Cable tray support system shall be prefabricated similar or equivalent to "Unistrut make".

Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types: (i) C1:- having provision of supporting cable trays on one side and (ii) C2:-having provision of supporting cable trays on both sides. The support system shall be the type described hereunder:

a. Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardwares such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.

b. The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardwares fittings and accessories shall be prefabricated factory galvanized.

c. The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvanized surface shall be brushed and red lead primer, oil primer & aluminium paint shall be applied

d. All steel components, accessories, fittings and hardware shall be hot dip galvanized after completing welding, cutting, drilling and other machining operation.

e. Support system shall be able to withstand -

- weight of the cable trays
- weight of the cables (75 Kg/Meter run of each cable tray)
- Concentrated load of 75 Kg between every support span.
- Factor of safety of minimum 1.5 shall be considered.

Pipes, Fittings & Accessories

Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria

GI Pipes shall be of medium duty as per IS:1239

Duct banks shall be High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes.

Hume pipes shall be NP3 type as per IS 458

. **Junction Boxes**

Junction Boxes with IP:55 degree of protection, shall comprise of a case with hinged door constructed from cold rolled sheet steel of thickness 2mm. Top of the boxes shall be arranged to slope towards rear of the box. Gland plate shall be 3mm thick sheet steel with neoprene/synthetic rubber gaskets. All junction boxes shall be of adequate strength and rigidity, hot dip galvanized as per relevant IS, and suitable for mounting on wall, columns, structures etc. The boxes shall include brackets, bolts, nuts, screws M8 earthing stud etc. required for installation.

Terminal blocks shall be 1100V grade, 10Amps rated, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals the screw shall be captive, preferably with screw locking design. All terminal blocks shall be suitable for terminating on each side two (2) nos. stranded copper conductors of size upto 2.5 sq mm each. All internal wiring shall be of minimum 1.5 sq. mm cu. Conductor PVC wire.

Terminations & Straight through Joints

Termination and jointing kits for 33kV, 11kV, 6.6 kV and 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be pre-moulded type, taped type or heat shrinkable type. 33kV, 11kV and 6.6 kV grade joints and terminations shall be type tested as per IS:13573. 3.3kV grade joints and terminations shall be type tested as per VDE0278. Critical components used in cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the aluminium solderless crimping type cable lugs & ferrule as per DIN standard.

Straight through joint and termination shall be capable of withstanding the fault level for the system.

1.1 KV grade Straight Through Joint shall be of proven design.

Cable glands

Cable shall be terminated using double compression type cable glands. Cable glands shall conform to BS:6121 and be of robust construction capable of clamping cable and cable armor (for armored cables) firmly without injury to insulation. Cable glands shall be made of heavy-duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 microns. All washers and hardware shall also be made of brass with nickel chrome plating Rubber components shall be of neoprene or better synthetic material and of tested quality. Cable glands shall be suitable for the sizes of cable supplied/erected.

Cable lugs/ferrules

Cable lugs/ferrules for power cables shall be tinned copper solderless crimping type suitable for aluminium compacted conductor cables. Cable lugs and ferrules for control cables shall be tinned copper type. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of terminals provided on the equipment. Cable lugs and ferrule shall conform to relevant standard.

Trefoil clamps

Trefoil clamps for single core cables shall be pressure die cast aluminum or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength to withstand the forces generated by the peak value of maximum system short circuit current.

Cable Clamps & Straps

The cable clamps required to clamp multicore cables on vertical run shall be made up of Aluminium strip of 25x3 mm size. For clamping the multicore cables, self-locking, de-interlocking type nylon clamps/straps shall be used. The clamps/straps shall have sufficient strength and shall not get affected by direct exposure to sun rays and outdoor environment

Receptacles

Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped galvanized or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/column/structure, gland plate etc. The ON- OFF switch shall be rotary type heavy duty, double break,AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polymide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with inbuilt ELCB rated for suitable mA sensitivity.

Galvanizing

Galvanizing of steel components and accessories shall conform to IS:2629 , IS4759 & IS:2633. Additionally galvanizing shall be uniform, clean smooth, continuous and free from acid spots.

The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per IS:1367. The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified.

Welding

The welding shall be carried out in accordance with IS:9595. All welding procedures and welders' qualification shall also be followed strictly in line with IS:9595

4.0 INSTALLATION

Cable tray and Support System Installation

Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures.

Horizontally running cable trays shall be clamped by bolting to cantilever arms and vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both top and bottom side rails at an interval of 2000 mm in general. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000mm in general. Fixing of cable trays to cantilever arms or main support channel by welding shall not be accepted. Cable tray installation shall generally be carried out as per the approved guidelines/ drawings. Vendor shall design the support system along with tray, spacing etc in line with relevant standard.

The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated.

The contractor shall fix the brackets/ clamps/ insert plates using anchor fasteners. Minimum size of anchor fasteners shall be M 8 X 50 and material shall be stainless steel grade 316 or better. Anchor fastener shall be fixed as recommended by manufacturer and as approved by site engineer. For brick wall suitable anchor fasteners shall be used as per the recommendations of manufacturer. Make of anchor fasteners subject to QA approval.

All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75 mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor.

In certain cases it may be necessary to site fabricate portions of trays, supports and other non standard bends where the normal prefabricated trays, supports and accessories may not be suitable. Fabricated sections of trays, supports and accessories to make the installation complete at site shall be neat in appearance and shall match with the prefabricated sections in the dimensions. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminum paint.

Conduits/Pipes/Ducts Installation

The Contractor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in the floor/ roof/ wall/ cable tunnel/ cable trenches made for conduit installation shall be sealed and made waterproof by the Contractor **either with any proven fire sealing system rated for one hour or** Modular multi-diameter cable sealing system consisting of frames, blocks, Compression wedge and its accessories. **The Cable sealing system should have been tested for fire**

insulation for min. 1 hr as per BS 476 and shall also provide water sealing. System shall be anti- rodent and anti- termite.

GI pull wire of adequate size shall be laid in all conduits before installation. Metallic conduit runs at termination shall have two lock nuts wherever required for junction boxes etc.

Conduit runs/sleeves shall be provided with PVC bushings having round edge at each end. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed with Glass wool/Cement Mortar/Putty to prevent entrance of moisture and foreign material.

Exposed conduit/pipe shall be adequately supported by racks, clamps, straps or by other approved means. Conduits /pipe support shall be installed square and true to line and grade with an average spacing between the supports as given below, unless specified otherwise

Conduit /pipe size (dia).	**Spacing**
Upto 40 mm	1 M
50 mm	2.0 M
65-85 mm	2.5 M
100 mm and above	3.0 M

For bending of conduits, bending machine shall be arranged at site by the contractor to facilitate cold bending. The bends formed shall be smooth.

Junction Boxes Installation

Junction boxes shall be mounted at a height of 1200mm above floor level or as specified in the drawings and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/ expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.

Cable Installation

Cable installation shall be carried out as per IS:1255 and other applicable standards.

For Cable unloading, pulling etc following guidelines shall be followed in general:

- Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be

rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.

- While laying cable, ground rollers shall be used at every 2 meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer. Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.

Cables shall be laid on cable trays strictly in line with cable schedule.

Power and control cables shall be laid on separate tiers in line with approved guidelines/drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, H.T. cables shall be laid on topmost tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil center lines and clamped at every two meter. All multi core cables shall be laid in touching formation. Power and control cables shall be secured fixed to trays/support with self-locking type nylon cable straps with de-interlocking facilities. For horizontal trays arrangements, multi core power cables and control cables shall be secured at every five meter interval. For vertical tray arrangement, individual multi core power cables and control cables shall be secured at every one meter by nylon cable strap. After completion of cable laying work in the particular vertical tray, all the control cables shall be binded to trays/supports by aluminium strips at every five meter interval and at every bend.

Bending radii for cables shall be as per manufacturer's recommendations and IS: 1255.

Where cables crossroads/rail tracks, the cables shall be laid in hume pipe/ HDPE pipe.

No joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment in main plant area shall not be permitted. Vendor shall identify and accordingly procure the cable drum length.

In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.

Wherever few cables are branching out from main trunk route troughs shall be used.

Wind loading shall be considered for designing support as well Cable trays wherever required.

Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures.

The installation work shall be carried out in a neat workman like manner & areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day. Contractor shall replace RCC/Steel trench covers after the Installation work in that particular area is completed or when further work is not likely to be taken up for some time.

Separation

At least 300mm clearance shall be provided between:

- HT power & LT power cables,

- LT power & LT control/instrumentation cables,

Minimum number of spare cores required to be left for interconnection in control cables shall be as follows:

No. of cores in cable	No. of spare cores
2C,3C	NIL
5C	1
7C-10C	2
14C and above	3

Directly Buried Cables

- Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting, supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IS:1255.

- RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.

Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 20 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminum with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Contractor may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags

While crossing the floors, unarmoured cables shall be protected in conduits upto a height of 500 mm from floor level if not laid in tray.

Cable Terminations & Connections

The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer" instructions, drawings and/or as directed by Project Manager. Cable jointer shall be qualified to carryout satisfactory cable jointing/termination. Contractor shall furnish for review documentary evidence/experience reports of the jointers to be deployed at site.

Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job to the satisfaction of the Project Manager.

The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for punching of gland plates, painting and touching up. Holes shall not be made by gas cutting. The holes shall be true in shape. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminum sheets.

Control cable cores entering control panel/switchgear/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with self-locking type nylon cable ties with de interlocking facility to keep them in position.

All the cores of the control cable to be terminated shall have identification by providing ferrules at either end of the core, each ferrule shall be indelible, printed single tube ferrule and shall include the complete wire number and TB number as per the drawings. The ferrule shall fit tightly on the core. Spare cores shall have similar ferrules with suffix sp1, sp2, ---etc along with cable numbers and coiled up after end sealing.

All cable terminations shall be appropriately tightened to ensure secure and reliable connections

B-6 SCADA

1.0 GENERAL

1.1 Contractor shall provide complete SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire solar plant and its auxiliary systems.

1.2 Bidder shall include in his proposal all the Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cable etc. needed for the completeness even if the same are not specifically appearing in this specifications.

1.3 SCADA System shall have the provision to perform the following functions:

i) Remote control of all the HT Breakers either in hard or soft signal.

ii) Remote control of Inverter active and reactive power as per requirement mentioned in respective chapter.

iii) SCADA shall also be able to acquire, display and store real time data, status and alarm signal from following equipment included but not limited to as required or offered under the scope of this specification:

a) All the HT Switchgear/RMU equipment
b) Incomer and bus coupler breaker of LT Panel.
c) Power conditioning unit (PCU)
d) UPS and Battery charger as per requirement mentioned in respective chapter
e) Weather Monitoring Equipment
f) TEM/ABT/MFM meter, numerical relay, fire alarm panel, GPS time synchronization unit and transformer.
g) SCADA Hardware, Accessories and Communication link
h) Any other equipment required as per specification

iv) Display of status of major equipment in Single Line/Mimic Diagram. Mimic Diagram colour shall comply to IS 11954: Guide for colour coding of electrical mimic diagrams

v) Display and storage of derived/calculated/integrated values

vi) Generate, store and retrieve user configurable periodic reports. SCADA shall have facility to generate report in MS Excel file type.

vii) Remote monitoring of essential parameters of plant on the web using popular web browser without requirement of additional software. Same shall be authorized with user id and password using standard modem. User ID and password for remote view can only be changed by SCADA Administrator. Internet connection for transferring data to web shall be taken by Contractor in the name of CIL Site for O & M period.

	Please refer Chapter-2-A for Nos. of Web Client Licenses for remote monitoring, Nos. of OWS/EWS/Historian with location.
	viii) Performing self-monitoring and diagnostic functions
1.4	The contractor shall provide at least one GPS clock, which shall be synchronized with the SCADA system. All devices having real-time clock (RTC) with time synchronization facility and are communicating with plant SCADA shall be synchronized with GPS Clock through SCADA or directly with GPS Clock. The technical details of GPS have been specified elsewhere in the specification
1.5	Type of signal from equipment (Hard wired or Soft) shall be as per specification of the equipment mentioned in the respective chapter and approved during detail engineering.
1.6	SCADA shall provide real time performance monitoring according to IEC 61724 standard. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail.
1.7	The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is affected. Control system shall be designed to prevent abnormal swings due to loss of Control System power supply, failure of any Control System component, open circuit/short circuit. On any of these failures the controlled equipment/parameter shall either remain in last position before failure or shall come to fully open/close or on/off state as required for the safety of plant/personnel/equipment and as finalized during detailed engineering. System shall be designed such that there will be no upset when power is restored. These operation shall be demonstrated by vendor during Factory Accepted Test (FAT) in the presence of CIL Representative.
1.8	Contractor shall provide a Package/Split AC of suitable capacity decided by load requirement in SCADA Main control/CMCS room. All the power supply module, Ethernet switches and network accessories for non-air conditioned area shall be suitable for operating in ambient temperature of 50 Deg C minimum.
1.9	Power plant controller (PPC) shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working PPC processor, there shall be an appropriate alarm and simultaneously the hot standby PPC processor shall take over the plant control function automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. It shall be possible to keep any of the PPC processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor. The solar plant SCADA and PPC networks shall be suitably designed, so that PPC shall directly and independently able to control the individual solar inverter. Detailed control logic in the PPC shall be finalized during detailed engineering stage.
2.0	**SCADA CONTROLLER SYSTEM:**
2.1	The SCADA at Main control /CMCS room shall be of PLC/RTU/DCS based as per specification given hereunder. For other locations such as Inverter Room, PLC/ IO modules/RTUs are acceptable.

Main control /CMCS room SCADA shall have the following feature:

i) Facility for implementation of all logic functions for control, protection and annunciation of the equipment and systems.

ii) Main control /CMCS room SCADA shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working processor, there shall be an appropriate alarm and simultaneously the hot standby processor shall take over the complete plant operation automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. In the event of both processors failing, the system shall revert to fail safe mode. It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.

iii) The memory shall be field expandable. The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future. Programmed operating sequences and criteria shall be stored in nonvolatile semiconductor memories like EPROM. All dynamic memories shall be provided with buffer battery backup for at least 360 hours. The batteries shall be lithium or Ni-Cd type.

iv) A forcing facility shall be provided for changing the states of inputs and outputs, timers and flags to facilitate fault finding and other testing requirements. It shall be possible to display the signal flow during operation of the program.

3.0 DATA COMMUNICATION SYSTEM (DCS)

The Data Communication System shall include a redundant Main System Bus with hot back-up. Other applicable bus systems like cubicle bus, local bus, I/O bus etc shall be redundant except for backplane buses which can be non-redundant.

The DCS shall have the following minimum features:

i) Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLCs and between PLCs and operator workstation.

ii) The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.

iii) If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility.

iv) Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility (ECC) shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus

shall be automatic and completely bump less and the same shall be suitably alarmed/logged.

v) The design and installation of the system bus shall take care of the environmental conditions as applicable.

vi) Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 25% spare capacity shall be available for future expansion.

vii) Cat 6 UTP or fiber optic cables shall be employed.

viii) The Contractor shall furnish details regarding the communication system like communication protocol, bus utilization calculations etc.

ix) Contractor shall setup Gigabit Ethernet based Plant Local Area Network (LAN) to connect to different communication nodes at Inverter /Switchgear location etc. with redundant backbone using ring or better topology. For plant capacity more than 100MW (AC), there shall be more than one ring for each 100MW or part connecting field node (controller/switches) and CMCS SCADA in manner that there are equal nodes in each ring as for as possible. Each Modbus cable shall be provided with Surge protection device at SCADA Panel End. Specification of OFC and Modbus cable has been given elsewhere in this specification.

4.0 HUMAN MACHINE INTERFACE SYSTEM (HMIS)

i) HMIS configured around latest state-of-the art servers/Workstations with open architecture supporting OPC /TCP/IP protocols, etc.

ii) The SCADA shall be OPC version 2.05a compliant and implement a OPC-DA 2.05a server as per the specification of OPC Foundation. All data should be accessible through this OPC server.

iii) For communicating the generation data of plant in CIL, the SCADA system shall be interfaced/ connected with **PI server of CIL on OPC Protocol.** The details of CIL PI server shall be furnished during the detailed engineering.

iv) Graphical Interface Unit (GIU) / Operator work station (OWS) shall perform control, monitoring and operation (as applicable) for plant equipment's connected with SCADA system.

v) Engineering workstation (EWS) shall work as a programming station both for controller and SCADA. It shall be possible to use same EWS as programming station and the Human Machine Interface System.

vi) SCADA System shall be provided with redundant OWS. Operator shall be able to access all control/information related data under all operating conditions including a single processor and computer failure/hardware failure at CMCS in the HMIS.

vii) In addition to a desktop based EWS, vendor shall also provide dedicated portable **(laptop)** based EWS.

viii) All frequently called important functions including major displays shall be assigned to dedicated function keys on a soft keyboard for the convenience of the operator for quick access to displays & other operator functions.

ix) The mimic shall be configured on the HMI and it shall be possible to control, monitor and operate the plant from the same.

x) The SCADA System shall have ability to perform operator functions for each OWS / GIU as a minimum, include Control System operation (A/M selection, raise/lower, set point/bias change, on/off, open/close operation, mode/device selection, bypassing criteria, sequence auto, start/stop selection, drive auto selection, local-remote/other multi-position selection etc.); alarm acknowledge; call all kind of displays, logs, summaries, calculation results, etc.; printing of logs & reports; retrieval of historical data; and any other functions required for smooth operation, control & management of information as finalized during detailed engineering.

xi) The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.

xii) The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.

xiii) The system shall have built-in safety features that will allow/disallow certain functions and entry fields within a function to be under password control to protect against inadvertent and unauthorized use of these functions. Assignment of allowable functions and entry fields shall be on the basis of user profile. The system security shall contain various user levels with specific rights as finalized by the Employer during detailed engineering. However, no. of user levels, no. of users in a level and rights for each level shall be changeable by the programmer (Administrator).

xiv) Wherever Graphical Interface Unit is envisaged, it shall meet the minimum functional requirements of monitoring, operating & controlling the process and displaying information related to process locally. GIU shall be provided with TFT active matrix or LED display and keypad for operation. GIU shall be ruggedly designed to withstand hard environments like high temperature, shock and vibration.

xv) In addition to GUI Display, **one 50 Inch LED display** shall be provided at SCADA Room.

xvi) Bidder has to provide suitable hardware DMZ network firewall to restrict unauthorized access to HMI/ SCADA system. Details specification of hardware firewall is provided elsewhere in the specification.

xvii) SCADA shall have facility to provide real time reporting of alarms and statistical data through SMS and e-mails.

xviii) Programming of the PLC Processor/controller as well as programming of HMIS shall be user friendly with graphical user interface and shall not require knowledge of any specialized language.

xix) The programming of HMIS (like development and modification of data base, mimics, logs / reports, HSR functionalities etc.) shall also be possible through user-friendly menus etc.

xx) All programming functionalities shall be password protected to avoid unauthorized modification.

5.0 PROGRAMMING FUNCTIONALITIES

Programming of the PLC Processor/controller as well as programming of HMIS shall be user friendly with graphical user interface and shall not require knowledge of any specialized language. For example, the programming of PLC shall use either of the following:

- Flow-chart or block logic representing the instructions graphically
- Ladder diagrams

The programming of HMIS (like development and modification of data base, mimics, logs / reports, HSR functionalities etc.) shall also be possible through user-friendly menus etc.

All programming functionalities shall be password protected to avoid unauthorized modification.

6.0 SOFTWARE REQUIREMENT

i) All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirement shall be provided. The programs shall include high level languages as far as possible. The contractor shall provide sufficient documentation and program listing so that it is possible for the Employer to carry out modification at a later date.

ii) The Contractor shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.

iii) Industry standard operating system like WINDOWS (latest version) etc. to ensure openness and connectivity with other system in industry.

iv) SCADA system shall include the following standard protocols as a minimum:

a) Modbus (TCP/IP, RTU, ASCII).
b) Sub Station Protocol (IEC-61850 and IEC 60870 -5-101/104).

Any other protocol on which the offered equipment (by Contractor) will communicate with SCADA

v) The system shall have user friendly programming language & graphic user interface.

vi) All system related software including Real Time Operating System, File management software, screen editor, database management software, On line diagnostics/debug software, peripheral drivers software and latest versions of standard PC-based software, Antivirus software and latest WINDOWS based packages (MS Word, Excel and PowerPoint) etc. and any other standard language offered shall be furnished as a minimum.

vii) All application software for SCADA system functioning like input scanning, acquisition, conditioning processing, control and communication and software for operator interface of monitors, displays, trends, curves, bar charts etc. Historical storage and retrieval utility, and alarm functions shall be provided.

viii) The Contractor shall provide software locks and passwords to Employer's engineers at site for all operating & application software so that Employer's engineers can take backup of these software and are able to do modifications at site.

ix) The Contractor shall provide software license for all software being used in Contractor's System. The software licenses shall be provided for the project (e.g. organization or site license) and shall not be hardware/machine-specific. That is, if any hardware/machine is upgraded or changed, the same license shall hold good and it shall not be necessary for Employer to seek a new license/renew license due to up gradation/change of hardware/machine in Contractor's System at site. All licenses shall be valid for the continuous service life of the plant.

x) All the SCADA Software with license Key shall be handed over to CIL on the DVD/CD media. All the hardware and software shall be licensed to CIL.

7.0 **PARAMETRIC REQUIREMENTS**

The control system shall be designed such that under worst case loading conditions the response time shall not be worse than the following:-

i) On/Off Command:- The response time for screen update after the execution of the control command from the time the command is issued shall be one second (excluding the drive actuation time).

ii) Adjustment Command:- 0.5 to 1 second.

iii) On screen Updating and All Control related displays:- 1 second.

iv) Bar Chart displays, Plant Mimic displays, Group review displays, X-T Plot Displays and Plant Summary Displays :- 1 to 2 seconds.

v) All the Analog data shall be scanned at the resolution of 1(one) second and refreshed on screen however, recording of data shall be as finalized during detail engineering.

8.0 INPUT/OUTPUT MODULES

i) The SCADA system should be designed according to the location of the input/output cabinets as specified.

ii) Input Output modules, as required in the Control System for all type of field input signals (4-20 mA, non-changeover/change over type of contact inputs etc.) and outputs from the control system (non changeover/change over type of contact, output signals for energizing interface relays at suitable DC voltage as decided during detail engineering, 4-20 mA output etc.) are to be provided by the Contractor.

iii) Electrical isolation of 1.5kV with optical couplers between the plant input/output and controller shall be provided on the I/O cards. The isolation shall ensure that any inadvertent voltage or voltage spikes (as may be encountered in a plant of this nature) shall not damage or mal-operate the internal processing equipment.

iv) The Input/output system shall facilitate modular expansion in fixed stages. The individual input/output cards shall incorporate indications on the module front panels for displaying individual signal status.

v) Individually fused output circuits with the blower fuse indicator shall be provided. All input/output points shall be provided with status indicator.

vi) The I/O Module shall have the following features:

a) Power supply monitoring.

b) Contact bounce filtering.

c) Optical isolation between input and output signals with the internal circuits

d) In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode. The fail-safe mode shall be finalized during detailed engineering.

vii) Binary Output modules shall be rated to switch ON/OFF coupling relays of approx. 3 VA. Analog output modules shall be able to drive a load impedance of 500 Ohms minimum.

viii) In case of loss of I/O communication link with the main processing unit, the I/O shall be able to go to predetermined fail safe mode (to be finalized during detailed engineering) with proper annunciation.

ix) Requirement of Nos. of channel in each type of Module (Analog Input, Analog Output, Binary Input, Binary Output, RTD) and Modbus link at Inverter and main control room shall be calculated based on the Input/output signal list to be submitted by the contractor for approval during detail engineering.

9.0 SYSTEM SPARE CAPACITY

Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, Control System shall have spare capacity and necessary hardware/ equipment/ accessories to meet following requirement for future expansion at site:

i) 10 % spare channels in input/output modules fully wired up to cabinets TB.

ii) Wired-in "usable" space for 10% modules in each of the system cabinets for mounting electronic modules wired up to corresponding spare terminals in system cabinets.

iii) Empty slots between individual modules/group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of Contractor shall not be considered as wired-in "usable" space for I/O modules.

iv) Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 10 % blank space.

v) Each processor / controller shall have 20% spare functional capacity to implement additional function blocks, over and above implemented logic/ loops. Further, each processor / controller shall have spare capacity to handle minimum 20% additional inputs/ outputs of each type including above specified spare requirements, over and above implemented capacity. Each of the corresponding communication controllers shall also have same spare capacity as that of processor/controller.

vi) The Data communication system shall have the capacity to handle the additions mentioned above.

vii) Ten (10) percent spare relays of each type and rating mounted and wired in cabinets TB. All contacts of relays shall be terminated in terminal blocks of cabinets.

viii) The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time / duty cycle, etc. from those stipulated under this specification.

10.0 OPERATOR INTERFACE DISPLAYS/LOGS/REPORTS

i) Suitable Operator Interface Displays/Logs/Reports for control operation & monitoring shall be provided. The details shall be finalized during detailed Engineering stage.

ii) Minimum quantities shall be as follows:-

Various displays on the OWS shall as a minimum include P&ID displays or mimic, bar chart displays, X-Y & X-T plot (trend) displays, operator guidance message displays, group displays, plant start-up/shutdown message displays, system status displays etc. Number of displays and the exact functionality shall be on as required basis and as finalized during detailed engineering subject to the minimum quantities as given in subsequent clauses. For X-T & X-Y plots, the facility of providing a background grid on operator request shall be variable with adequate no. of divisions in both co-ordinates.

The minimum quantity of major types of displays per unit shall be as follows:

Sl	Display	Minimum Qty for Plant capacity of 50 MW or Less	Additional Qty for each 10 MW or part above 50 MW
a)	Control displays (group/sub-group/ sequence/loop)	(On as reqd. basis subject to 100 minimum)	(On as reqd. basis subject to 100 minimum)
b)	P&ID/ mimic display	25	5
c)	X-Y Plot (with superimposed operating curves + using user selectable stored data)	25+25	5+5
d)	Group displays	30	5
e)	Operator guidance message	20	NIL
f)	System status & other diagnostic display	on as required basis	on as required basis

The assignment for the above will be done by the contractor as per the requirement of operation of contractor's system as well as for maintenance. The balance displays shall be left as spare for future modification/addition.

11.0 HISTORICAL STORAGE AND RETRIEVAL SYSTEM (HSRS)

i) The HSRS shall collect, store and process system data from MMIPIS data base. The data shall be saved online on hard disk and automatically transferred to non-erasable long term storage media once in every 30 Days periodically for long term storage. Provision shall be made to notify the operator when hard disk is certain percentage full.

ii) The data to be stored in the above system shall include alarm and event list, periodic plant data, selected logs/reports.

iii) The system shall provide user-friendly operator functions to retrieve the data from historical storage. It shall be possible to retrieve the selected data on OWS in form of trend/report by specifying date, time & period. Further, suitable index files/directories shall also be provided to facilitate the same.

iv) In addition to above, the system shall also have facility to store & retrieve important plant data for a very long duration on portable external long term storage media. Bidder shall provide two numbers of portable external hard drive of 2TB each.

v) For long term plant performance analysis, the following plant data as a minimum with time stamping and interval as indicated in below table but not limited to shall be stored daily on historian.

Important plant data for a very long duration (plant life) Storage on Historian

Sl.	Parameter	Time Interval
1	Weather Monitoring Stations data: Global Horizontal Irradiance, Global Inclined Irradiance and Diffuse Horizontal Irradiance, Ambient Temp, Wind Speed, Wind Direction, Rain Fall and Relative Humidity.	1 (One) Minute
2	Calculated Daily Global Horizontal Insolation, Global Inclined Insolation and Diffuse Horizontal Insolation.	24 (Twenty Four) Hours
3	Power Conditioning Unit (PCUs):- DC Voltage, DC Power, DC Current, SMB/SMU Current (PCU end), AC Active & Reactive Power, Power factor, AC Current & Voltage, Energy, Inverter room temp, Inverter Cabinet temp and Modules Temp	1 (One) Minute
6	MFM, Energy meter and Numerical Relay data:- Active & Reactive Power, Energy (day), Current and Voltage	1 (One) Minute
7	Export feeder/s Energy Meter Data:- Active & Reactive Power, Energy import and export, Current and Voltage and Grid Frequency.	1 (One) Minute
8	Daily energy export from each Inverter	24 (Twenty Four) Hours
9	Total sum of daily energy export from all Inverter	24 (Twenty Four) Hours

12.0 SCADA PANEL/CABINET/CONTROL DESK/FURNITURE

i) The SCADA cabinets shall be IP-22 protection class.

ii) The Contractor shall ensure that the packaging density of equipment in these cabinets is not excessive and abnormal temperature rise, above the cabinet temperature during normal operation or air-conditioning failure, is prevented by careful design. The Contractor shall ensure that the temperature rise is limited to 10 deg. C above ambient and is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets. Ventilation blowers shall be furnished as required by the equipment design and shall be sound proof to the maximum feasible extent. If blowers are required for satisfactory system operation, dual blowers with blower failure alarm shall be provided in each cabinet with proper. Suitable louvers with wire mesh shall be provided on the cabinet.

iii) The cabinets shall be designed for front access to system modules and rear access to wiring and shall be designed for bottom entry of the cables for Main control room.

iv) The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications, preferred height of the cabinet shall not higher than 2200 mm. The cabinets shall be equipped with full height front and rear doors. The floor mounting arrangement for other cabinets shall be as required by the Employer and shall be furnished by the Contractor during detailed engineering. Wall mounted cabinet is acceptable for Inverter room/sub-pooling switchgear.

v) Cabinet doors shall be hinged and shall have turned back edges and additional braking where required ensuring rigidity. Hinges shall be of concealed type. Door latches shall be of three-point type to assure tight closing. Detachable lifting eyes or angles shall be furnished at the top of each separately shipped section and all necessary provisions shall be made to facilitate handling without damage. Front and rear doors shall be provided with locking arrangements with a master key for all cabinets. If width of a cabinet is more than 800 mm, double doors shall be provided.

vi) Two spray coats of inhibitive epoxy primer-surface shall be applied to all exterior and interior surfaces. A minimum of 2 spray coats of final finish colour shall be applied to all surfaces. The final finished thickness of paint film on steel shall not be less than 65-75 micron for sheet thickness of 2 mm and 50 microns for sheet thickness of 1.6 mm. The Preferable finish colors for exterior and interior surfaces shall conform to following shades:

a) Exterior:- As per RAL 9002 (End panel sides RAL 5012),
b) Interior:- Same as above

Paint films which show sags, checks or other imperfections shall not be acceptable. As an alternative, single coat of anodic dipcoat primer along with single textured powder coating with epoxy polyester meeting the thickness requirement is also acceptable

vii) Control desk shall be free standing table top type with doors at the back and shall be constructed of 2 mm thick CRCA steel plates. A 19 mm thick wooden top shall be provided on the desk to keep the monitors at top and computers inside. Control desk shall consist of vertical, horizontal and base supports with their coverings for work surface, keyboard trays, mouse pads, monitor shelf and concealed cable and wire way management, perforated trays with covers in both horizontal and vertical directions. ASCII Keyboard shall be capable of being pulled out through a tray.

viii) Contractor shall provide the two power supply feeders (DC supply or UPS AC) and one raw supply feeder of suitable rating to cater all the load requirements of SCADA panel/cabinet/control desk. System remain in service in case of single power supply failure/power supply module failure. Suitable alarm shall be generated in case of any power supply failure.

ix) The cabling / wiring between OWS & CPU'S, power supply cables etc. shall be aesthetically routed and concealed from view.

x) Chairs – Industry standard revolving chairs with wheels and with provision for adjustment of height (hydraulically/gas lift) shall be provided for the operators and other personnel in control room area. These shall be designed for sitting for long duration such that these are comfortable for the back. Arm-rests in one piece shall be of poly-urethane and twin wheel castor of glass filled nylon.

xi) One Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer.

xii) All the furniture shall be of reputed make (Godrej or Equivalent).

13.0 HMIPIS HARDWARE

i) The HMIPIS as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.

ii) The Workstation/Servers employed for HMIPIS implementation shall be redundant based on industry standard hardware and software which will ensure easy connectivity with other systems and portability of Employer developed and third party software.

iii) Redundant sets of communication controllers shall be provided to handle all the communication between the HMIPIS and redundant system bus and to ensure specified system response time and parametric requirements. Each communication controller shall have message checking facility. Power Fail Auto Restart (PFAR) facility with automatic time update shall be provided.

iv) All the peripherals shall conform to the following minimum requirement but the exact make & model shall be as approved by Employer during detailed engineering. The LAN to be provided under HMIPIS shall support TCP/IP protocol (Ethernet connectivity) with OPC RDI for interface with PLCs/other systems and shall have data communication speed of min. 100 MBPS. All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.

Engineering Workstations/ Operator Workstations/ Historian/ Portable EWS

SI No.	Features	Industrial Grade Engineering Cum Operator Workstations/ Operator workstations/ Other workstations/ Documentation station (in case not part of prog. Stn.)
1.	Processor	**Engineering Cum Operator Workstations:** 64 bit Server Grade (Xeon or Equivalent), Octacore minimum **For other Workstation:** 64 bit (i5 or Equivalent)

2.	Memory	**Engineering Cum Operator Workstations:** 16 GB RAM upgradable to 24 GB minimum **For other Workstation:** 8 GB RAM upgradable to 16 GB
3.	Hard Disk	**Engineering Cum Operator Workstations:** 1 TB RAID1 **For Historian:** 1 TB ultra wide RAID1 **For other Workstation:** 500 GB ultra wide RAID1 for OWS/ 500 GB for Portable EWS
	Communication port	**Engineering Cum Operator Workstations:** 2 Serial bus. Expansion slot=2 **For other Workstation:** 4 Serial bus, Expansion slot=2 **Portable EWS:** 2 Serial bus.
4.	Monitor (color)	Min 22" TFT Flat Monitor with non-interfaced refresh rate min. 75 Hz, Graphic Memory = 16 MB
5.	Removable bulk storage drive	1 TB (minimum)
6	Network Connectivity	**Engineering Cum Operator Workstations:** 4 Nos. Built-in Ethernet Network Port **For other Workstation:** 2 Nos. Built-in Ethernet Network Port **Portable EWS:** 1 No. Built-in Ethernet Network Port and 1 No. Wifi
7.	DVD R/W	16x or higher for EWS and OWS
8.	Keyboard	ASCII
9.	Pointing Device	Mouse
10.	Additional general purpose software (for using over network by servers/work stations/PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc.

11.	Software	MS. Windows latest, MS Office Editor (EXCEL,WORD, POWER POINT), Adobe Acrobat, Anti Virus, Network Security, Etc.

LED Display

1	LED Display	50 Inch LED Display, Display Resolution : 1920 x 1080, Wall Mounted, Reputed make (Samsung/Sony/LG or Equivalent)

Printer

Sr	Features	Networked Color Laser Printer
1	Paper Size	A3
2	Printing Speed (min.)- in normal mode for A4 size paper	6 ppm (Color)
		24 ppm (B&W)
3	Type	Heavy duty, at least 50000 pages/month
4	Resolution (black) (min.)	600 dpi
5	First page out time (with full graphic display)	=<1 min for color,
		<45 sec for BW
6	Paper input capacity (min.)	500 sheets
7	Additional features	Automatic Duplex Printing
8	Paper sheets (1 ream = 500 sheets) with printer (To be supplied with printer)	10 reams (A3)
		20 reams (A4)

14.0 SUPPLY OF OUTDOOR WIRELESS ACCESS POINT

Bidder has to supply 2(two) nos. of Industrial outdoor IEEE 802.11 b/g/n wireless access point with 2x10/100Base-T(X) having Far Distance Air Connectivity up to 7 KM and protection class IP-67 .It shall be suitable for pole with minimum operating temperature of 55 Deg C.

Bidder to note that Wireless Access Point is for CIL's own use only. Bidder shall be responsible to provide Communication connectivity for OWS for location other than CMCS, if required under the scope using OFC/CAT/WiFi link as feasible and approved during detail engineering.

15.0 ADDITIONAL CLAUSE

Please refer to the Chapter 2-A, Part-A for additional clause, if any related to this section of specification.

16.0 FACTORY ACCEPTANCE TEST (FAT)

FAT procedure shall be submitted by bidder for CIL approval and after approval of FAT procedure, FAT will be witnessed by CIL Engineering or authorized representative of CIL. SCADA shall communicate with all third party devices which are part of Solar Plant and the same shall be demonstrated during the FAT.

ROUTINE TESTS: All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price
An indicative list of tests / checks is mentioned in QA chapter on SCADA. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

17.0 TIME SYNCHRONISATION EQUIPMENT

Time Synchronization equipment shall be provided and shall be located in the Control Room. It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of the SCADA.

17.1 It shall be complete in all respects including antenna, all cables, processing equipment, etc.

17.2 All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Contractor.

17.3 It shall work from DC supplies only and the Contractor to clarify if any built-in battery backup is provided, in which case, same shall be of long life lithium batteries.

17.4 It shall be immune to hostile electrical environment. Suitable protections are to be provided against lightning surges and over-voltages in power supply systems and antenna feeders.

17.5 The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255.

17.6 All components of the SWYD SAS, including Substation Controllers, Workstations, Bay Control Units (BCU) and Bay Protection units (BPU) and all numeric protection relays as per requirement under this scope of technical specification or offered by bidder shall be synchronized with an accuracy of 1ms.

17.7 The GPS shall be synchronized with the SCADA system to be supplied under this contract. Necessary software and Hardware (including laying of communication cable) required for time synchronization with SCADA and all other devises shall be in scope of contractor.

17.8 The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.

17.9 The system shall have provisions for combination of any of the following output signals:

- NTP (network time protocol) 100Mbits Ethernet port
- IRIG-B00x (TTL, pulse width modulated signal)
- 2 x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts
- Any other output port as may be required for the offered system.
- Alarm status contact indicating healthy status of system

17.10 These output ports shall be compatible with the requirement of the equipment to be synchronized i.e. BCUs/ BPUs/Numerical Relays/IEDs etc as per scope of the specification. The master clock in control room shall also be synchronized with the time synchronization system. The actual port requirements (no./type) in line with the system offered shall be finalized during detailed engineering.

17.11 The equipment should have a periodic time correction facility of one-sec. periodicity. The equipment shall also have real time display in hour, minute, second (24 hour mode) and have a separate time display, having display size of approx. 144mm height.

18.0 TECHNICAL SPECIFICATION FOR NETWORK FIREWALL

Offered firewall shall include but not limited to the following features-

Technical Requirements for Network Firewall		
S No	**Feature**	**Required parameter**
A	**General**	
A1	Common Criteria Certification.	The offered product series or its operating system series must have achieved EAL (Evaluation Assurance Level) Certification of EAL4 or higher in the Common Criteria for Information Technology Security Evaluation (ISO/IEC 15408) for computer security certification.
A2	Architecture	The firewall should be a purpose built hardware appliance based next generation firewall (NGFW) solution having application awareness & Intrusion prevention function.
A3	End of sale	OEM End-of-sale declaration shall not have been released for the offered model at the time of the bid submission.
B.	**Hardware Specifications & Performance Parameters**	

B1	Firewall Interfaces	Minimum **Four or AS REQUIRED** Nos of gigabit 10/100 base T Ethernet ports to be provided.
		Provision of addition of at least Two Nos of gigabit Fiber SFP ports shall be available.
		Each Port must be configurable flexibly in any security zone as per the requirement without any fixed zone assignments.
		All the above specified interfaces shall be firewall interfaces. Internal Switch interfaces shall not be considered.
		The Firewall shall NOT have any wireless interfaces.
B2	Security Zones	At least four Security zones must be supported.
C	**Firewall Inspection**	
C1	Application Support for Inspection	Should support standard protocols
		Internet based applications like Telnet, FTP, SMTP, http, DNS, ICMP etc. should be supported for filtering
		Internet web 2.0 applications & widgets.
C2	NAT & PAT	Dynamic NAT as well as one to one NAT
		Port / IP Address Forwarding
		PAT
C3	Resistance to Evasion	The firewall shall be able to detect and block evasion techniques including SYN flood, Address spoofing and TCP split handshake etc.
D	**Application awareness**	
D1	Application intelligence and control	Firewall should support detection of application regardless of port, protocol etc.
		firewall must identify and control applications sharing the same session
		The firewall should allow creation of securities policies to identify, allow, block or limit an application regardless of port, protocol etc.
E	**Intrusion Prevention System (Integrated with firewall)**	
E1	General	The IPS must provide intrusion prevention functionality out of the box.
		The IPS should be capable of accurately detecting intrusion attempts and discern between the various types and risk levels, including unauthorized access attempts, pre-attack probes, suspicious activity, vulnerability exploitation etc

		The IPS should provide protection from Advanced Botnets, inbound and outbound.
		The IPS should use stateful detection and prevention techniques and provide zero-day protection against worms, Trojans, spyware, keyloggers, and other malware from penetrating the network.
E2	Detection Methods	The offered solution should use the following methods for detection of malicious traffic:
		(a) Signature based detection
		(b) Statistical Anomaly based detection
E3	Threat Intelligence and signature Updates	The IPS OEM should have a 24x7 security service update and should support real time signature update of the system as soon as updates are released.
E4	Exception List	The IPS should support the creation of Access Control Lists to bypass the inspection of any specific flow.
E5	DoS/ DDoS protections	The offered solution should be capable of preventing Denial of Service and Distributed denial of service attacks.
E6	Threat control features	The offered solution should provide the following Security features:
		a) Detection and blocking malicious web traffic on any port.
		c) Capability of detecting attacks within protocols independent of port used
		d) IPS Sensor should allow the admin to create IPS policies on the basis of IP addresses and range.
E7	Signature Tuning	The offered solution should allow enabling/disabling of each individual signature. Each signature should allow granular tuning to suit user requirement.

B-7 INSTRUMENTATION AND COMMUNICATION CABLE

1.0 COMMUNICATION CABLE (Optic Fibre Cable)

Optic Fiber cable shall be **8/12** core, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor /indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multimode fibers on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturing, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.
The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. Steel central number, Loose buffer tube design, 4 fibers per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly etc. The cable shall be suitable for maximum tensile force of 2000 N during installation, and once installed, a tensile force of 1000 N minimum. The compressive strength of cable shall be 3000 N minimum & crush resistance 4000 N minimum. The operating temperature shall be -20 deg. C to 70 deg. C.

All testing of the optic fiber cable being supplied shall be as per the relevant IEC, EIA and other international standards.

Bidder to ensure that minimum 50% (but not less 4) cores are kept as spare in all types of optical fiber cables

Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground buried installation.

Spliced/ Repaired cables are not acceptable.

Penetration of water resistance and impact resistance shall be as per IEC standard.

1.1 **Communication Cable (Modbus)**

Data (Modbus) Cable to be used shall be shielded type with stranded copper conductor based on VDE 0881. Cable shall have minimum 2 pair each with conductor size of 0.5 SQMM and core identification shall comply with DIN 47100. Cable shall be flame retardant according to IEC 60332-1-2. or equivalent Standard Surge protection device to be provided shall be approved from UL/CSA or any national/international approved lab.

2.0 INSTRUMENTATION CABLES

2.1 **Common Requirement**

S No.	Property	Requirement
1.	Voltage grade	225 V (peak value)
2.	Codes and standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6, VDE

		0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification.
3.	Continuous operation suitability	At 70 deg. C for all types of cables
4.	Progressive automatic on-line sequential marking of length in meters	To be provided at every one meter on outer sheath.
5.	Marking to read 'FRLS	To be provided at every 5 meters on outer sheath
6.	Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the declared value in data sheet
7.	Variation in diameter	Not more than 1.0 mm throughout the length of cable.
8.	Ovality at any cross-section	Not more than 1.0 mm
9.	Others	a) Durable marking at intervals not exceeding 625 mm shall include manufacturer's name, insulation material, conductor's size, number of pairs, voltage rating, type of cable, year of manufacturer to be provided. b) Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground-buried installation c) Repaired cables shall not be acceptable.
10.	Color	The outer sheath shall be of blue Blue

2.2 **Specific Requirement**

S No.		Property	Requirement
		Type of Cable	F and G Type cables
	A. Conductors		
1.		Cross section area	0.5 sq. mm
2.		Conductor material	High conductivity Annealed bare copper
3.		Colour code	As per VDE-815
4.		Conductor Grade	Electrolytic
5.		No & dia of strands	7x0.3 mm (nom)
6.		No. of Pairs	4,8,12,16,24,48
7.		Max. conductor resistance per Km (in ohm) at 20 deg. C	73.4 (loop)
8.		Reference Standard	VDE 0815
	B. Insulation		
1.		Material	Extruded PVC type YI 3
2.		Thickness in mm (Min/Nom/Max)	0.25/0.3/0.35

3.		Volume Resistivity (Min) in ohm-cm	1 x 1014 at 20 deg. C & 1x1011 at 70 deg. C.
4.		Reference	VDE 0207 Part 4
5.		Core diameter above insulation	Suitable for cage clamp connector
	C. Pairing & Twisting		
1.		Single layer of binder tape on each pair provided	Yes
2.		Bunch (Unit formation) for more than 4P	To be provided
3.		Conductor /pair identification as per VDE081	To be provided
	D. Shielding		
1.		Type of shielding	Al-Mylar tape
2.		Individual pair shielding	To be provided for F-type cabl
3.		Minimum thickness of Individual pair shielding	28 micron
4.		Overall cable assembly shielding	To be provided
5.		Minimum thickness of Overall cable assembly shielding	55 micron
6.		Coverage Overlapping	100% coverage with 20% overlapping
7.		Drain wire provided for individual shield	Yes (for F-type) Size=0.5 mm2,No.ofstrands=7, Dia of strands =0.3 mm ,Annealed Tin coated copper
8.		Drain wire provided for overall shield	Yes. Size=0.5 mm2, No.of strands=7,Dia of strands=0.3mm Annealed Tin coated copper
	E. FILLERS		
1.		Non-hygroscopic, flame retardant	To be provided
	F. Outer Sheath		
1.		Material	Extruded PVC compound YM1 with FRLS properties
2.		Minimum Thickness at any point	1.8 mm
3.		Nominal Thick-ness at any point	>1.8 mm
4.		Resistant to water, fungus, termite & rodent attack	Required
5.		Minimum Oxygen index as per ASTMD-2863	29%
6.		Minimum Temperature index as per ASTMD-2863	250 deg.C

7.		Maximum acid gas generation by weight as per IEC-60754-1	20%
8.		Maximum Smoke Density Rating as per ASTMD-2843	Maximum 60% To be provided (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as per ASTMD-2843)
9.		Reference standard	VDE207 Part 5,VDE-0816
	G. Electrical Parameters		
1.		Mutual Capacitance Between Conductors At 0.8 Khz (Max.)	120 nF/km for F type 100 nF/km for G-type
2.		Insulation Resistance (Min.)	100 M Ohm/Km
3.		Cross Talk Figure (Min.) At 0.8 Khz	60 dB
4.		Characteristic Impedance (Max) At 1 Khz	320 OHM FOR F-TYPE 340 OHM FOR G-TYPE
5.		Attenuation Figure At 1 Khz (Max)	1.2 db/km
	H. Complete Cable		
1.		Complete Cable assembly	Shall pass Swedish Chimney test as per SEN-SS 4241475 class F3.
2.		Flammability	Shall pass flammability as per IEEE-383 read in conjunction to this specification
	I. Tests		
1.		Routine & Acceptance tests	Refer Type Test requirement of Specification for C & I System
2.		Type tests	
	J Cable Drum		
1.		Type	Wooden drum (wooden drum to be constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum.
2.		Outermost layer covered with waterproof paper	Yes
3.		Painting	Entire surface to be painted

4.		Length	1000 m + 5% for up to & including 12 pairs 500 m + 5% for above12 pairs

B-8 EARTHING SYSTEM

1.0 **GENERAL REQUIRMENTS**

This specification is intended to outline the requirement of earthing (grounding) for Solar array (DC) side and AC Power block side of Solar PV Project. It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of earthling system meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of earthling system for safe and satisfactory operation of the plant shall be included under scope of the bidder.

Earthing requirement for outdoor metering yard/Switchyard has been mentioned elsewhere in the specification and hence shall be excluded from scope of this chapter unless earthing requirement of metering yard/Switchyard is specifically mentioned in this chapter.

Electrical Resistivity Test (ERT) of the soil is included in the scope of bidder.

1.1 **EARTHING DESIGN REQUIRMENT**

The object of protective earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose of this is to ensure that, in general, all parts of apparatus other than live parts, shall be at earth potential, as well as to ensure that operators and attendants shall be at earth potential at all times. Also by providing such an earth surface of uniform potential under and surrounding the station, there can exist no difference of potential in a short distance big enough to shock or injure an attendant when short-circuits or other abnormal occurrences take place.

Care must be taken for equipment with functional earthing that its service is not disrupted due to undesired disturbances in protective earthing system.

1.2 **CODES AND STANDARD**

The equipment/product furnished for earthing system shall meet the requirements of all the applicable relevant National/International codes and standards or their latest amendment Codes and Standards. Product certification has to be CE/UL/BIS/TUV or equivalent. The relevant codes and standard for earthing system are tabulated below.

IS: 3043	Code of practice for Earthing.
IEEE: 80	IEEE guide for safety in AC substation grounding
IEEE: 837	Standard for qualifying permanent connections used in substation grounding
IS: 2309	Code of Practice for the protection of building and allied structures against lightning.
IS: 802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.

IS: 2629	Recommended practice for hot dip galvanizing of iron & steel
IS: 2633	Method for testing uniformity of coating on zinc coated articles
IS: 513	Cold rolled low carbon steel sheets and strips
IS: 6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS 2062	HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL — SPECIFICATION
IS: 4736	Hot-dip Zinc coating for MS Tubes.
IS: 458	Precast Concrete Pipes (With and Without Reinforcement)
UL-467	Grounding and Bonding Equipment
IEC 62561-7	Requirements for earthing enhancing compounds
	CEA regulations for electrical safety-2010
	Indian Electricity Rules/ Indian Electricity Act.

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (codes and standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the above standards/ codes as applicable.

The earthing system includes earth electrode, installation of earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with equipotential earth bus and connection of equipment to equipotential earth bus.

2.0 **Earth Electrode**

The earth electrode is in direct contact with the ground provides means for conducting earth current with ground. Earth Electrode material should have good electrical conductivity and mechanical strength and should not corrode in wide variety of soil conditions. For an effective earthing system, following type of vertical earth electrodes can be used.

I. MS Rods
Hot rolled, Medium or High Tensile Steel Rod as per IS 2062 of length not less than 3000 mm.

II. Copper Bonded Rods
High tensile-low carbon steel rod having diameter not less than 14/17 mm of Length 3000 mm to be selected based on earth fault current. The Rod shall comply with requirements of BS 4360 Grade 43A or EN10025:2-004 S275JR, molecularly bonded by 99.99% pure high conductivity copper on outer surface with copper coating thickness 250 micron or more in conformity to UL-467. Its

surface shall be clean, free from mechanical defect and any visible oxide layer or foreign material.

2.1 **Earthing Enhancement Compound**

A low resistance earth electrode system is important to provide a low impedance path for the better dissipation of lightning/fault currents, and to protect personnel and equipment by minimizing and equalizing voltage potential differences. Earthing (ground) enhancement materials shall be used to improve the ground electrode resistance. Earth enhancement material shall be a superior conductive material which improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It shall be tested and should conform to the requirements of IEC 62561-7.It shall have the following characteristics:-

a) High conductivity, improves earth's absorbing power and humidity retention capability, non-corrosive in nature having low water solubility but highly hygroscopic.
b) Carbon based with min 95% of fixed carbon content premixed with corrosion resistant cement to have set properties. Cement shall not mix separately & shall not have Bentonite.
c) Resistivity of less than 0.2 ohms -meter.
d) It shall not depend on the continuous presence of water to maintain its conductivity and shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time.
e) It shall not dissolve, decompose or leach out with time and shall be environmental friendly, suitable for soils of different resistivity and any kind of earth electrode.

The Earth enhancement material shall be supplied in sealed, moisture proof bags, marked with Manufacturer's name or trade name, quantity etc. The minimum quantity of earth enhancement compound to be used with each earth-pit shall be 25 Kg.

2.2 **Earthing conductor**

Earthing conductor is the conductor for buried below the ground at the depth of 600 mm connecting earth pits to make interconnection of earth pit. To interconnect earth pits, following type of conductor can be used. Application of specific conductor and its size has been mentioned in relevant clause:

I. Galvanised Steel Flat (GS) Flat
GS/GI Flat (Strip) conductor shall comply to IS 2026 with Galvanization of 85 Micron as per IS. Material shall be clean and free form mechanical defects.

II. Copper Clad Steel (CCS) Earthing Conductor
The Copper Bonded Steel Grounding Conductor shall be made of steel with the coating of 99.99% pure copper complying to ASTM B 869-96 and ASTM B 452-93 standards. Each strand of CCS shall have continuous, uniform coating and the conductor surface shall be smooth and free from mechanical defects.

III. MS Rod

Hot rolled, Medium or High Tensile Steel Rod as per IS 2062 of length not less than 3000 mm and diameter of 40 mm.

2.3 **Earthing Technical and Installation Requirement**

Careful consideration should be given to installing an earthing system that meet or exceed statutory requirements. Contractor shall select certified product and ensure good workmanship for installation for satisfactory performance to fulfill the designed parameters all the times. Following care shall be taken while installation of earthing.

I. Metallic frame/ structure of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity, Crane rails, tracks, metal pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs, and rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing ensured by bonding the different sections of hand rails and metallic stairs. Metallic sheaths/screens, and armor of multi-core cables shall be earthed at both ends. Metallic Sheaths and armor of single core cables shall be earthed as per requirement mentioned elsewhere in the specification. Every alternate post of the switchyard fence shall be connected to earthing grid by one GS flat and gates by flexible lead to the earthed post. Portable tools, appliances and welding equipment shall be earthed by flexible insulated cable. Metallic column for Inverter/Switchgear shelter/E-house shall be earthed with two distinct connections at minimum two column. All the wall cladding section shall be earthed at minimum two location with flexible copper cable of not less than 50 sq. mm.

II. Each continuous laid lengths of cable tray shall be earthed at minimum two places by G.S. flats to earthing system, the distance between earthing points shall not exceed 30 meter. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground.

III. Neutral connections and metallic conduits/pipes shall not be used for the equipment earthing. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level.

IV. The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.

V. Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti- corrosive paint/compound.

VI. Suitable earth risers as approved shall be provided above finished floor/ground level, if the equipment is not available at the time of laying of main earth conductor.

VII. Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding. Resistance of the joint shall not be more than the resistance of the equivalent length of conductors.

VIII. Earthing conductors buried in ground shall be laid minimum 600 mm below grade level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm.

IX. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.

X. A minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench/foundation/underground pipes at crossings. Earthing conductors crossings the road can be installed in pipes. Wherever earthing conductor crosses or runs at less than 300 mm distance along metallic structures such as gas, water, steam pipe lines, steel reinforcement in concrete, it shall be bonded to the same. Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding / cleating at interval of 1000mm and 750mm respectively.

XI. Earth pit shall be constructed as per IS:3043. Electrodes shall be embedded preferably below permanent moisture level. Minimum spacing between electrodes shall be 600mm.

XII. Earth pits shall be treated with earth enhancement compound if resistivity is more than 20 ohm meter.

XIII. On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded. All equipment required for testing shall be furnished by contractor.

XIV. Contractor shall obtain all necessary statutory approvals for the earthing system before charging of the plant and electrical equipment.

3.0 TECHNICAL DETAILS FOR AC EARTHING SYSTEM

This section outlines the requirements of protective and functional earthing system to discharge AC fault current to earth and provide equipotential bonding for Transformer, HT and LT Switchgear Panel and other similar electrical equipment, Transformer neutral and shield.

The Contractor shall furnish the detailed design and calculations as per IEEE 80/IS 3043 for Employer's approval for equipment earthing.

1. Conductors above ground level and in built up trenches -Galvanized steel

2. Conductors buried in earth -Mild steel rod of 40 mm dia
(Any alternate proposal by bidder shall be reviewed and decided during detailed engineering based on requirement)

3. Earth electrodes - Mild steel rod of diameter 40mm or Copper bonded steel rod of dia not less than 17 mm

4. Life Expectancy - 25 years
5. Fault Level - Mentioned Elsewhere
6. Min. Steel corrosion - As per IS 3043
7. Soil Resistivity -Actual as per site condition

The sizes of earthing conductors for various electrical equipment shall be as below:

S No.	Equipment	Earth Conductor buried in Earth	Earth conductor above ground level and in built up trenches
1	33kV/11kV/6.6kV/3.3 kV/ switchgear equipment and 415V switchgear	--	65 x 8mm GS flat
2	415 V MCC/ Distribution boards / Transformers	--	50 x 6mm GS flat
3	LT Motors above 125 KW	--	50 x 6mm GS flat
4	LT Motors 25 KW to 125 KW	--	25 x 6mm GS flat
5	LT Motors 1 KW to 25 KW	--	25 x 3mm GS flat
6	Fractional House power motor	--	8 SWG GS wire
7	Control panel & control desk	--	25 x 3 mm GS flat/25 sq mm Cu cable
8	Push button station/Junction Box	--	8 SWG GI wire
9	Columns, structures, cable trays and bus ducts enclosures	--	50 x 6mm GS flat
10	Crane, rails, rail tracks & Other non-current carrying metal parts	--	25 x 6mm GS flat

1.1 Contractor shall ensure there at least two earth pits each dedicated for earthing of each Transformer, HT/LT Switchgear panel, transformer neutral, Battery Charger/UPS/Control

Panel etc. shall be provided. Earth electrode shall be located near to the equipment and all earth electrodes shall be interconnected with parallel conductor buried in earth surrounding the equipment.

1.2 Earthing system of different locations such as Inverter room/Pooling Switchgear/Sub pooling switchgear/Inverter shelter etc. shall be interconnected in single network of earthing with buried conductor of the size 65X8 MS Flat laid at 600 mm depth (**if specifically required to achieve the earth resistance value within the acceptable limit based on the soil property of site**). Contractor shall submit the calculation based on the system of earth conductor and electrode connected in single network. Location and manner of interconnection shall be approved during detail engineering.

Bidder shall also interconnect the earthing system of Solar PV plant with CIL existing earthing system wherever available **(applicable for Solar Projects being setup inside existing CIL Projects).**

1.3 For functional earthing of electronic component such as SCADA, contractor shall provide 1 no. (Min) isolated earth electrode near to the equipment connected with 2 run of copper cable of size not less than 25 sqmm. Contractor shall comply to the recommendation of OEM (Original Equipment Manufacturer) for electronic earthing and electrode can be connected with other earth electrode as per recommendation of OEM.

1.4 Each inverter duty transformer having shield between HV and LV winding shall be provided with 2 nos. Isolated earth electrode connected with each other for functional earthing of transformer shield. Each electrode shall be connected with transformer shield with separate 25X6 Cu flat. .

4.0 TECHNICAL DETAIL SOLAR ARRAY (DC) EARTHING

This section outlines the earthing requirement for discharging DC fault current to earth of Solar PV plant and provide equipotential bonding for Module Mounting Structure (MMS), SMB Mounting structure, Module Frames etc.

System Requirement for the solar array DC earthing:

Conductors buried in earth	-GS Flat or CCS
Conductors above ground level	-GS Flat or CCS
Earth Electrode	-32 mm or higher dia MS Rod or Copper bonded Steel rod of dia. not less than 14 mm
Life Expectancy	-25 Years
System fault level	-**5 KA for 1 Sec.**
Soil resistivity	-Actual as per site conditions
Min. Steel corrosion	-As per IS 3043

4.1 Each Module mounting structure (MMS), SPV Module frames, mounting arrangement for String Monitoring Boxes, Metallic Junction Boxes, Metal frames/Panel, Metallic Pipes of the solar array shall be effectively earthed by two separate and distinct connections to earthing system. Earthing system for solar array shall consist interconnected earth pits

	electrodes connected by 25X6 GS flat (Min.) or Copper Clad Steel (CCS) earthing Conductor of size not less than 120 SQMM laid at the depth of 600 MM below the ground. Minimum size of riser conductor to connect the structures to buried earthing conductor and structure to structure in the solar farm shall be 25X3 GS Flat or CCS of Min. 70 SQ MM size.
4.2	Periphery fencing wherever provided shall be earthed at every 100 meter interval with 25X3 GS flat connected with DC or AC side nearest buried earthing conductor.
4.3	Earthing conductor for connection to structure and equipment may be kept on the ground below MMS. However, these conductor shall be laid 300 mm below the ground along the pathway and/or crossing the pathway.
4.4	Equipment and structure in the solar farm shall be earthed in compliance to the IS: 3043 (Code of Practice for Earthing) and Indian Electricity Rules/Acts.
4.5	The Contractor shall furnish the detailed design and calculations for Owner's approval as per IS 3043 to determine the number of earth pit and size of earth conductor. However the no. of earth pit electrodes for the DC earthing shall be as per Clause. 2.0 of Chapter A-2
4.6	Buried earth conductor shall be laid all around periphery of solar array farm. GS flat above the ground for structure earthing shall be connected to the nearest buried conductor or electrode. All the earth electrodes shall be interconnected in single network/mesh and no electrode or group of electrodes shall be isolated/islanded. These electrodes shall be uniformly distributed in the solar farm at maximum practical extent and location of earth electrode shall be approved during detail engineering. A continuous earth path is to be maintained throughout the PV array.
4.7	Connection of DC earthing system and AC earthing system with location and manner of connection shall be approved during detail engineering. Contractor shall submit the design calculation of earthing system of AC and DC side as standalone (no interconnection) system.
4.8	Connection of riser to the structures shall be bolted or welded type. Portion of galvanized structure which undergoes welding at site shall be coated with two coats of cold galvanizing and anti-corrosion paint afterwards.
4.9	Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection, welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding.
4.10	Each PV Module frame shall be earthed in accordance with module manufacturer guidelines. In case module frame earthing is to be separately provided, it shall be earthed with minimum 2.5 SQMM flexible copper cables with lug at suitable location of module frame. Nos. of PV modules in single loop of earthing connection to module frame shall be as per Module manufacturer recommendation. Both ends of the loop of copper cable for earthing shall be connected with nearest earthed structure or earth conductor.
4.11	Contractor shall seek owner's approval for connecting solar array earth mesh with any other earth mat/earth grid of the solar PV plant.

4.12	Size of earth conductor, nos. of earth pits given in this clause is applicable for solar array earthing only. Relevant method and practice of laying of earthing conductor, earth pits and riser not mentioned herewith but given elsewhere in this specification is applicable to solar array earthing also.
4.13	Inverter functional earthing (Negative earthing, Anti PID Earthing) shall be carried out as per guideline of OEM. Contractor shall submit complete detail of such earthing from OEM and implement the earthing accordingly

B-9 PLANT ILLUMINATION SYSTEM

This chapter covers supply and installation of suitable illumination system along the approach roads to inverter room and inverter room(s), transformer yard and other facilities inside the plant.

1.0 DESIGN PHILOSOPHY

A comprehensive illumination system shall be provided in the entire project. Each building shall be provided with adequate light fittings,6A/16A socket, fans, etc. Exhaust fans shall also be provided in toilets, battery room, etc

All outdoor lighting system shall be automatically controlled by synchronous timer or photocell. Provision to bypass the timer or photocell shall be provided in the panel.

2.0 LIGHTING SYSTEM DESCRIPTION for CMCS and inverter room

Normal AC Lighting System: AC lighting system 415V, 3Phase, 4wire, will be fed from lighting panels Control Board (LPs) which in turn will be fed from the lighting distribution boards (LDBs) of AC Switch board MCC.
Emergency AC Lightning System: The emergency lighting system consisting of 20% of the lights shall be fed from UPS DB or DCDB as per scheme adopted by the EPC bidder. Load of the same has to be considered for UPS/ Battery and charger sizing. Bidder shall provide indoor and outdoor emergency lighting at each inverter room, CMCS, security room and main gate.

3.0 Lighting Fixture, Lamps & Accessories

a. All lighting fixtures and accessories shall be designed for continuous operation for its life under atmospheric conditions existing at site.

b. AC lighting fixtures and accessories shall be suitable for operation on 240 V, AC, 50 Hz supply with supply voltage variation of +/-10%, frequency variation of +/- 5% and combined voltage and frequency variation (absolute sum) of 10% DC lighting fixtures and accessories shall be suitable for operation on 220 V, with variation between 190 V & 240 V.

c. All lighting fixtures shall be complete with lamp(s), lamp holder(s), LED chip assembly, terminal blocks, clamps, locking arrangements, fixing brackets etc. Driver circuit/Control gears shall be provided as applicable / specified. The fixtures shall be fully wired upto terminal block. The internal wiring of the fixtures shall be done with suitable low smoke halogen free thermo-plastic or silicon rubber insulated or fire retardant PTFE copper conductor wires of suitable size and type. Further fuse protection of suitable rating in input side shall also be provided specifically for LED luminaires. However, the normal cross section of conductor shall be not less than 0.5 Sq. mm and minimum thickness of insulation shall be 0.6 mm. The wiring shall be capable of withstanding the maximum temperature to which it will be subjected under specified service conditions without deterioration and affecting the safety of the

luminaire when installed and connected to the supply. All fixing /locking screws, washers, nuts, brackets, studs etc, shall be zinc plated and passivated.

d. All lighting fixtures shall be provided with an external, brass/GI earthing terminal suitable for connecting 14 SWG, GI earthing wire. All metal or metal enclosed parts of the housing and accessories shall be bonded and connected to the earthing terminal as so to ensure satisfactory earthing continuity through out the fixture
e. The lighting fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection
f. The reflectors shall be manufactured from CRCA sheet steel or aluminium as specified. The aluminium reflectors shall be made of high purity aluminium sheet, polished electrochemically brightened and anodized or proven alternate arrangement of anodizing
g. Starters shall have bi-metal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without use of any tool. Starter shall have brass contacts and radio interference suppressing capacitor.
h. LED luminaires body shall such designed that heat sink/heat dissipating housing shall be mounted outside the overall luminaires fixture housing, and shall be suitably clearing the driver circuit. Further for outdoor type LED luminaires, the exposed heat sink shall be suitably designed to avoid dust/foreign particles accumulation on the same.
i. LED luminaires housing/body shall be pressure die cast aluminium or extruded Aluminium or CRCA as specified alongwith finished powder coating. Care shall be taken in the design that there is no water stagnation anywhere.

4.0 LED Luminaires:

4.1 **CODES AND STANDARDS**

All standards and codes of practice referred to herein shall be the latest edition including all applicable official amendments & revisions as on date of techno-commercial bid opening. In case of conflict between this specification and those (IS codes, standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards & codes.

16101:2012	General Lighting. LEDs and LED modules Terms and definitions
16102(Part 1):2012	Self Ballasted LED Lamps for General Lighting Services. Part-1 Safety Requirements.
16102(Part 2):2012	Self Ballasted LED Lamps for General lighting Services. Part-2 Performance Requirements.
16103(Part I):2012	LED modules for General lighting Safety Requirements.

15885(Part 2/Sec. 13) :2012	Lamp control gear Part 2 particular Requirements Section 13 d.c. or a.c. Supplied Electronic control gear for LED modules
16104:2012	d.c. or a.c. Supplied Electronic control gear for LED modules - Performance Requirements.
16105:2012	Method of Measurement of Lumen maintenance of Solid-state Light (LED) Sources.
16106:2012	Method of Electrical and photometric Measurements of Solid State Lighting (LED) Products
16107:2012	Luminarie Performance
16108:2012	Photobiological safety of Lamps and Lamp Systems
IS 513	Cold rolled low carbon steel sheets and strips
IS 12063	Classification of degree of protection provided by enclosures.
IS 14700 (Part 3/Sec. 2)	Electro magnetic compatibility (EMC) – Limits for Harmonic emission – THD < 15% (equipment, input current < 16 Amps. per phase.
IS 9000 (Part 6)	Environment testing: Test Z – AD: composite temperature/humidity cyclic test.
IS 15885 (Part 2/Sec. 13) IS 16004 – 1 and 2)	Lamp control gear: particular requirements for DC or AC supplied electronic control gear for LED modules.
IS 4905	Method for random sampling
IEC 60598	Ingress protection, luminaire performance and safety
IEC 61000-3-2	Total Harmonic Distortion
IEC 61000-4-5	Surge Protection
IES-LM 80 along with TM 21/ IS 16105	Lumen Depreciation and Rated life of LED chip
IES-LM 79 / IS 16106	Luminaire optics and color parameter and electrical parameter

4.2 **LED LIGHTING SYSTEM**

LED Luminaires shall be used for the lighting of all the indoor & outdoor areas. However for DC lighting & hazardous areas conventional type luminaires shall be used. In false ceiling area LED luminaires shall be recessed mounting type & in non-false ceiling area the LED luminaires shall be surface mounting type.

The individual lamp wattage for LED shall be upto 3 watt for outdoor type luminaires. However for indoor type luminaires fractional wattage LEDs are also acceptable. The LED chip efficacy shall be min 120 Lm/W. The luminaire efficacy shall not be less than 80 Lm/W. Heat sink/heat dissipation arrangement shall be provided in the luminaires. The LED used in the luminaires shall have colour rendering index (CRI) of Min 70 and 80 for outdoor and indoor luminaires respectively.

Colour designation of LED shall be “cool day light” (min 5700K) type for indoor type LED luminaires. Further for outdoor type luminaires, the colour designation shall be 5000K, except for well glass type LED luminaires, where the colour designation shall be 4000K. The LED luminaires shall have minimum life of 25,000 burning hours with 80% of lumen maintenance at the end of the life.

The beam angle for LED chip for indoor type luminaires shall be 120 degrees. However for highbay & flood light type outdoor luminaires the LED chip with suitable beam angle shall be used to deliver better lumen-output. The maximum junction temperature of bare LED without heat sink shall be limited to 85 deg C, further the lumen maintenance at this temperature shall be min 90%. The THD of tube light based LED Luminaires shall be less than 20%. For other type of luminaries, it shall be minimum 10%.

Further the EMC shall be as per IS 14700. The power factor of the luminaire shall not be less than 0.9. The marking on luminaire & safety requirements of luminaire shall be as per IS standards. Suitable heat sink/ heat dissipation arrangement, with proper thermal management shall be designed for the luminaires.

Driver Circuit: LED modules and drivers shall be compatible to each other. The LED module driver’s ratings and makes shall be as recommended by corresponding LED manufacturer. LED Drivers may have following control & protections:-

- Suitable precision current control of LED.
- Open Circuit Protection
- Short Circuit Protection
- Over Temperature Protection
- Overload Protection
- Surge Protection

Lighting panels shall be powder coated with color shade RAL9002. Lighting panels shall have IP55 degree of protection (for outdoor panels) and IP-4X for indoor panels (inside buildings).

Wires of different phase shall normally run in separate conduit.

Power supply shall be fed from 415 / 240 V normal AC supply through suitable number of conveniently located lighting distribution boards (LDB) and at least one 6/16A, 240V AC universal socket outlet with switch shall be provided in offices, cabins, etc.

Suitable number of 63A, 3ph, 415V AC industrial receptacles shall be provided for welding purposes at one location.

Incandescent lamps may be used only with DC Lighting.
Electrification of all building shall be carried out as per IS 732-1989, IS 4648-1968 and other relevant standards.

Indoor Lighting fixtures shall generally be controlled from switch boxes of each area not directly from lighting panel. Each switch shall control a maximum of three fixtures.
All luminaries and their accessories and components shall be of type readily replaceable by available Indian makes.
Following test reports to be submitted for LED chip/LED luminaires:

a) LED parameters like Lumen per watt, CRI, Beam angle from manufacturer.

b) LM 80/IS: 16105 report.

c) LM 79/IS: 16106 report

5.0 JUNCTION BOXES, CONDUITS, FITTING & ACCESSORIES

Junction box for indoor lighting shall be made of fire retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type.

Junction boxes for street lighting poles and lighting mast if applicable , shall be deep drawn or fabricated type made of min. 1.6 mm thick CRCA Sheet. The box shall be hot dip galvanized. The degree of protection shall be IP55.

All switches and receptacles upto 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox & plate.

Conduits, Pipes and Accessories:

Heavy duty PVC conduits conforming to IS: 9537 Part-III along with various accessories shall be used for indoor wiring in the buildings. These conduits shall be concealed in the wall/floor/roof. However, in PEB's, conduits can be fixed on surface.

Pull out boxes shall be provided at suitable interval in a conduit run .Boxes shall be suitable for mounting on Walls, Columns, etc. Pull-out boxes shall have cover with screw. Pull out boxes used outdoor shall be weather proof type suitable for IP: 55 degree of protection and those used indoor shall be suitable for IP: 4X degree of protection.

6.0 LIGHTING WIRES

Lighting wires shall be 1100 V grade, light duty PVC insulated unsheathed, stranded copper/aluminium wire for fixed wiring installation. colour of the PVC insulation of wires shall be Red, Yellow, Blue and Black for R,Y,B phases & neutral, respectively and white & grey for DC positive & DC negative circuits, respectively. Minimum size of wire shall not be less than 1.5.sq.mm. for copper

7.0 LIGHTING POLES

The Street Light system and peripheral lighting shall be designed generally in line with design guidelines. Height of the poles should be chosen so as not to affect working of Solar panels. The poles shall be FRP based confirming to AASHTO LTS-4-12, 2013, IS 2713- 1980, ANSI C136.20 2012 and tested as per relevant ASTM standards. The

FRP poles shall be ultraviolet resistance, corrosion proof, electrically insulated and shall have no reaction to direct contact with water. They shall be fire retardant with low flammability when tested in accordance to IS 6746. The thickness for any FRP Poles shall be ≥ 6mm & there should be no negative tolerance in thickness. Poles shall be highly resistant to impact deflection and bending, and shall be electrically non-conductive. The System shall be capable of withstanding the appropriate wind load etc as per IS 875 considering prevailing soil/ site condition considering all accessories mounting on pole.

The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB. Lighting shall be provided along boundary/periphery and at roads connecting Boundary Gate to strategic locations like CMCS/Switchyard

For internal roads, lighting may be provided at intermediatory locations as per bidders O&M practices

8.0 EARTHING

Lighting panels, etc. shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, fans, single phase receptacles etc. shall be earthed by means of separate earth continuity conductor. The earth continuity conductor 14 SWG GI wire shall be run along with each conduit run. Cable armours shall be connected to earthing system at both the ends.
Alternately Vendor may offer technically superior and proven product subject to approval of employer.

9.0 AVERAGE ILLUMINATION LEVEL

Location	Average Illumination Level (Lux)	Type of Fixture
Control Room	300	LED Luminaries
Store Room	200	LED Luminaries
Switchgear Room, HT Breaker Room	150	LED Luminaries
Inverter Room	150	LED Luminaries
Street lighting-Roads mentioned in Cl 7.0 above	10	LED Luminaries
Yard/ Substation	20 (general) 50 (on strategic equipment)	LED Luminaries

B-10 AUXILIARY POWER SUPPLY SYSTEM

1.00 GENERAL

1.01 Auxiliary power supply arrangement shall be in line with tender SLD. Each Inverter Room/local pooling/sub-pooling/CMCS room shall have its own auxiliary power supply system comprising of AC distribution board (ACDB) which shall be fed from LV side of Inverter transformer through suitably rated auxiliary transformers. ACDB in CMCS room shall have two incomer (100% rated) fed from two different sources. At CMCS, auxiliary transformer directly feed from 33kV switchgear are also acceptable. Following consideration shall be taken while arriving kVA capacity of auxiliary transformer,

1. 20 % future load margin.
2. The minimum kVA capacity of auxiliary transformer for CMCS requirement shall be 50kVA.

1.02 All non-critical auxiliary loads shall be fed directly from ACDB. However, emergency, and important load shall be fed from suitable sized Uninterrupted Power Supply (UPS) or Battery system. Input AC supply for Uninterrupted Power Supply (UPS) and Battery Charger shall be fed from ACDB. Bidder shall consider the following one of the supply options for feeding different equipment loads:

Sl No	Equipment Name	Option-1 ACDB	Option-2 UPS AC	Option-3 Battery DC supply
1.	SCADA including remote RTU/IO panel		✓	✓
2.	SCADA HMI		✓	✓
3.	Data logger		✓	✓
4.	Fire Detection /Alarm Panel		✓	✓
5.	Emergency Lighting		✓	✓
6.	CCTV (if applicable)		✓	✓
7.	HMI of SCADA		✓	✓
8.	Inverter's Auxiliary supply (if applicable)		✓	✓
9.	Energy Meter/MFM		✓	✓
10.	Sub and Local Pooling Switchgear control & protection		✓	✓
11.	Main Pooling Switchgear (CMCS) control & protection			✓
12.	Switchgear spring charging motor		✓	✓
13.	switchgear space heater	✓		
14.	Illumination, Fan supply etc	✓		
15.	Module washing system	✓		
16.	Other non-critical auxiliary loads	✓		
17.	Switchyard control and protection			✓
18.	Switchyard PLCC			✓

1.03 For inverter stations and sub-pooling systems, UPS system shall comprise of 1 x 100% UPS with 30 minutes backup. For CMCS, UPS system shall comprise of 2 x 100% UPS

	with 30 minutes backup for each. Each UPS shall consist of 1x100% charger and inverter, 1 x 100% Battery bank for providing required backup as above. Bypass Line static switch, manual bypass switch, 1 x 100% UPSDB, and other necessary Protective devices and accessories. In place of UPS, bidder can provide DC supply system (1 x 100% Battery with Charger system for inverter stations/sub-pooling systems and 2x 100% system for CMCS) with backup as indicated as above, if the auxiliary power supply requirement of the loads is in DC.
1.04	Each Battery with charger system shall consist of 1 x 100% charger and 1 x 100% Battery bank for required back up and 1 x 100% DCDB, and other necessary protective devices and accessories. DC supply system voltage shall be 12V or above upto 220V DC.
1.05	The rated AC output capacity shall be taken for UPS battery size calculation. However, the minimum UPS rating shall be 2KVA and the battery sizing shall be calculated on a minimum load of 1 KW (DC) for required backup. All UPS having rating 5KVA or more shall have three phase input.
1.06	The Bidder can provide alternate arrangement with suitable redundancies such as power pack with required backup for switchgears/RMUs located at local pooling/inverter station.
1.07	Solar Plant Main Pooling Switchgear shall be powered from 2X100% DC supply system. Each DC supply system shall consist of 1x100% charger, 1 x 100% station Battery bank rated 110V/220VDC (+10%,-20%) for providing minimum 30 minutes backup and DC switchgear. In case UPS fed from above DC supply system, in that case separate DC system for UPS is not required.
1.08	Requirements of DC supply system for switchyard is mentioned in switchyard chapter. Bidder can offer common DC system for both switchyard and CMCS, but their individual requirements must be met.
1.09	For CMCS, each UPSDB shall have two incomers fed from two separate UPS and one bus coupler. Similarly, each DCDB/DC switchgear shall have two incomers fed from two separate Battery-Charger and one bus-coupler.
1.010	DC system shall be design in such way that it is possible isolate the battery and charger for boost charging of batteries, while corresponding DC switchgear section shall be capable of being in service and continue to supply the DC load by closing of buscoupler.
1.011	Bidder shall submit configuration diagram, power supply distribution scheme, single line diagram and data sheets, all calculations such as Rectifier Modules/UPS Charger/Inverter rating calculations, battery sizing calculation etc. for UPS, Battery Charger & Battery system during detailed engineering stage for employer's review and approval.
1.012	Size and rating of UPS, Battery Charger and Battery shall be finalized during details engineering stage. Following shall be considered for sizing calculation; i. UPS load power factor shall be taken as 0.8 lagging. ii. UPS efficiency shall be taken as 80%. iii. UPS and charger design margin shall be taken 10% at 50 deg C. iv. IEEE-485 standard shall be followed for sizing calculation of Lead Acid Batteries and IEEE-1115 standard shall be followed for sizing calculation of Nickel- Cadmium batteries.

	v. For Battery sizing calculation, lowest electrolyte temperature shall be taken as 5 deg C more than the minimum ambient temperature or 15 deg cel whichever is lower, with Temperature correction factors as per relevant standards. vi. Batteries aging factor shall be taken as 1.25 and design margin factor shall be taken as 1.10.
2.00	**UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM**
2.01	The UPS shall have an overload capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 seconds. The overall efficiency of UPS shall be at least 80% on full load.
2.02	The UPS system shall be capable of operating without D.C. battery in circuit under all conditions of load and the performance of various components of UPS like inverter, charger, static switch etc. shall be guaranteed without the battery in circuit.
2.03	For UPS capacity 5 kVA or more, in addition to indications/display on UPS panel, important alarms along with important analog signal shall also be provided for use in SCADA. For UPS capacity less than 5 kVA bidder shall provide status, common alarm, and trip DI (soft or hard) signal to SCADA
2.04	The UPS chargers shall be self-regulating, solid state silicon controlled, full-wave rectifier type designed for single and parallel operation with battery and shall have automatic voltage regulators for close voltage stability even when AC supply voltage fluctuates. The charger should be capable to fully charge the required batteries as well as supply the full rated load through inverter. The charger shall be able to re-charge the fully discharge battery within 8 hours. The charger shall be design for input supply variation of ± 10% and frequency variation of ± 5%. Charger design shall ensure that there is no component failure due to fluctuations of input supply or loss of supply and restoration. The detailed specification for the battery charger for UPS rating of 5kVA and above has been mentioned in the battery charger section below in this specification.
2.05	The UPS inverter shall be of continuous duty, solid state type using proven Pulse Width Modulation (PWM)/Quasi square wave/step wave technique. Ferro-resonant types Inverters are not acceptable. The nominal voltage output shall be 230 Volts single phase, 50 Hz. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, etc. The total harmonic content shall be 5% maximum and content of any single harmonic shall be 3% maximum.
2.06	The static switch shall be provided to perform the function of transferring UPS loads automatically without any break from faulty inverter to standby AC source. Manual bypass switch shall be employed for isolating the UPS during maintenance.
2.07	Contractor has the option of supplying either Nickel Cadmium type batteries or Lead Acid Plante type batteries. The detailed specification for the batteries has been mentioned in the battery and charger section below in this specification.
2.08	Equipment enclosures shall match and line up in assemblies of freestanding floor mounted cabinets designed for indoor service.
2.09	Individual enclosure shall be ventilated switchboard type fabricated from not less than 1.6-mm thick sheet steel. Enclosures shall be furnished with concealed hinges. Front and rear doors shall be designed to permit easy access to all components for maintenance or

	replacement. The enclosures shall be reinforced with formed steel members as required to form a rigid self-supporting structure. Doors shall have three point latches.
2.10	Adequate ventilating louvers and enclosure top panels shall be included. All vent openings shall be covered with corrosion resistant fine screen coverings.
2.11	The cabinets shall be IP-42 protection class for indoor application and IP55 or better for outdoor application.
2.12	The temperature rise inside all the cabinets/enclosures shall not exceed 10 deg.C above ambient temperature.
2.13	The Contractor shall also carry out the site tests on UPS as required to be conducted as a standard practice of the UPS manufacture or deemed necessary by the Employer and mutually agreed between the Contractor and the Employer.
2.14	One set of tools shall be provided for maintenance and testing purposes.
3.00	**BATTERY CHARGER**
3.01	The chargers shall be self-regulating, solid state silicon controlled, full-wave rectifier type designed for single and parallel operation with battery and shall have automatic voltage regulators for close voltage stability even when AC supply voltage fluctuates, effective current limiting features and filters to minimise harmonics. The charger should be capable to fully charge the required batteries as well as supply the full rated load. Furthermore, the charger should be able to re-charge the fully discharged battery within 8 hours. The charger shall be current limited for charger circuit protection and protection of battery from overcharge shall also be provided. The current limit shall be continuously adjustable. The chargers shall have a slow walk-in circuit. Charger design shall ensure that there is no component failure due to fluctuations of input supply or loss of supply and restoration. The charger shall be design for input supply voltage variation of ± 10% and frequency variation of ± 5%.
3.02	Battery Chargers shall have a selector switch for selecting the battery charging mode i.e. whether trickle or Boost charging.
3.03	All Battery Chargers shall be provided with facility for both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage/current control, whether automatic or manual. Means shall be provided to avoid current/ voltage surges of harmful magnitude/nature which may arise during changeover from Auto to Manual mode or vice-versa under normal operating condition.
3.04	Soft start feature shall be provided to build up the voltage to the set value slowly. The chargers shall have load limiters which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the load limiter setting of the Charger. The load limiter characteristic shall be such that any sustained overload or short circuit in DC system shall neither damage the Charger nor shall it cause blowing of any of the charger fuses. The Charger shall not trip on overload or external short circuit. After clearance of fault, the Charger voltage shall build up automatically when working in automatic mode.
3.05	When on automatic control mode during Trickle charging, the Charger output voltage shall remain within +/-1% of the set value for AC input voltage variation of +/-10%, frequency

	variation of +3/-5%, a combined voltage and frequency (absolute sum) variation of 10% and a continuous DC load variation from zero to full load. Uniform and step-less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the Charger panel covering the entire Trickle charging output range specified & shall be capable of matching the float voltage correction recommendations (w.r.t. temperature) as suggested by the respective battery manufacturer. Step-less adjustment of the load limiter setting shall also be possible from 80% to 100% of the rated output current for Trickle charging mode.
3.06	During Boost charging, the Battery Chargers shall operate on constant current mode (When automatic regulator is in service). It shall be possible to adjust the Boost charging current continuously over a range of 50 to 100% of the rated output current for Boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be Vernier type.
3.07	Energizing the Charger with fully charged battery connected plus 10% load shall not result in output voltage greater than 110% of the voltage setting. Time taken to stabilize, to within the specified limits as mentioned elsewhere, shall be less than fifteen seconds.
3.08	Momentary output voltage of the Charger, without the Battery connected shall be within 94% to 106% of the voltage setting during sudden load Change from 100% to 20% of full load or vice-versa. Output voltage shall return to, and remain, within the limits specified as mentioned elsewhere in less than 2 seconds after the above-mentioned change.
3.09	Suitable filter circuits shall be provided in all the Chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of the DC load, even when they are not connected to a battery.
3.10	The DC System shall be ungrounded and float with respect to the ground potential when healthy. An earth fault relay shall be provided by the bidder in the DC distribution board for remote annunciation.
3.11	Digital Outputs shall be configured for connection to the SCADA for real-time charger status updating. Outputs like charger output current, output voltage, float/boost mode, etc may be configured to provide the update to SCADA.
3.12	The Battery Chargers as well as their automatic regulators shall be of static type. The Chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50°C.
3.13	For Lead Acid plante battery:-Battery chargers shall be capable of continuous operation at the respective rated load in Trickle mode i.e. Trickle charging the associated DC lead-acid Batteries while supplying the D.C. loads. The Batteries shall be Trickle charged at 2.25 Volts per cell. All chargers shall also be capable of Boost charging the associated D.C. Battery at 2.3 to 2.7 Volts per cell at the desired rate.
3.14	For Nickel-Cadmium battery:-Battery chargers shall be capable of continuous operation at the respective rated load in Trickle mode i.e. Trickle charging the associated DC Nickel-Cadmium Batteries while supplying the D.C. loads. The Batteries shall be Trickle charged

at 1.4 to 1.42 Volts per cell. All chargers shall be capable of Boost Charging the associated D.C. Battery at 1.54 to 1.7 Volts per cell at the desired rate.

3.15 All Battery Chargers shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. A thermal overload relay incorporating a distinct single phasing protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

3.16 The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective Charger.

3.17 Digital or analog indicating instruments shall indicate DC current, DC voltage & AC voltage.

3.18 The Chargers shall be indoor, floor mounted, self-supporting sheet metal enclosed cubicle type. The Contractor shall supply all necessary base frames, anchor bolts and hardware. The Charger shall be fabricated using cold rolled sheet steel shall not be less than 1.6 mm and shall have folded type of construction. The panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. Removable undrilled gland plates of at least 3.0 mm sheet steel and lugs for all cables shall be supplied by the Contractor. The Charger shall be tropicalized and vermin proof. Ventilation louvers shall be backed with fine brass wire mesh. All doors and covers shall be fitted with synthetic rubber gaskets. The Chargers shall have hinged double leaf doors provided on front and/or backside for adequate access to the Charger internals. All the Charger cubicle doors shall be properly earthed.

3.19 Treatment as per IS: 6005. Two coats of lead oxide primer followed by powder painting with final shade of RAL9002 for complete panel except end covers & RAL 5012 for end covers.

3.20 All acceptance and routine tests as per the manufacture recommendations and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. An indicative lists of tests / checks is mentioned in QA chapter on Battery charger. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

3.21 The cabinets shall be IP-42 protection class for indoor application and IP55 or better for outdoor application.

3.22 The Contractor shall also carry out the site tests on battery charger systems required to be conducted as a standard practice of the UPS manufacture or deemed necessary by the Employer and mutually agreed between the Contractor and the Employer.

4.00 BATTERY : NICKEL-CADMIUM BATTERY

4.01 BATTERY PARAMETER

a)	Battery Voltage	To be decide during Detail Engineering
b)	No. of Cells	To be decide during Detail Engineering

c)	Battery type	Nickel-Cadmium
d)	Nominal discharge voltage per Cell	1.2
e)	Float voltage	1.42V/Cell

Batteries should be suitable for continuous operation for the maximum ambient temperature as defined in technical parameters.

4.02 CODES AND STANDARDS

All standards, specifications and codes of practice referred to herein, shall be the latest editions including all applicable official amendments and revisions as on date of opening of techno-commercial bid. In case of conflict between this specification and those (IS codes, Standards etc.) referred to herein, the former shall prevail. All works shall be carried out as per the following standards and codes:

IEC 60623/ IS 10918	Specification for vented type Nickel Cadmium Batteries.
IS 106	Quality tolerances for water for storage batteries
IEC 60993	Electrolyte for vented Nickel-Cadmium cells
Indian electricity rules	
Indian electricity acts	

Equipment complying with other internationally accepted standards such as IEC., BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.

4.03 DC Batteries shall be stationary Nickel Cadmium Pocket plate type conforming to IS:10918. The batteries shall be high/medium discharge performance type suitable for the backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

4.04 DC batteries shall be suitable for standby duty. The batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42 V/cell.

4.05 **Construction Features:-**

a) Containers

Containers shall be made of polypropylene plastic material. Containers shall be robust, heat resistance, leak proof, nonabsorbent, alkali resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of translucent containers.

b) Vent Plugs

Vent plugs shall be provided in each cells. They shall be antisplash type, having more than one exit hole shall allow the gases to escape freely but shall prevent alkali from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition, the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte samples.

c) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS:10918. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative terminal posts shall be clearly marked.

d) Sediment Space

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

e) Electrolyte

The electrolyte shall be prepared from battery grade potassium hydroxide conforming to IEC 60993. The cells can be shipped either in charged condition or in dry condition. Necessary electrolyte for make-up shall be supplied separately.

f) Connectors and Fasteners

Nickel plated copper connectors shall be used for connecting adjacent cells and PVC insulated flexible copper cables shall be used for inter-row / inter-tier / inter-bank connections. Bolts, nuts and washers shall be Stainless Steel / Nickel coated steel to prevent corrosion. The thickness of Nickel coating of connectors should be not less than 0.02 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds.

g) Battery racks

Mild steel racks for all the batteries shall be provided. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries racks and supports for cable termination shall be coated with three (3) coats of anti-alkali paint of approved shade. Name plates, resistant to alkali, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

h) Test

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146(for all applicable tests for containers) / IS-10918 (for NI-CD batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and

Acceptance tests shall be as per Quality Assurance & Inspection table of battery. Charges for these shall be deemed to be included in the equipment price. An indicative lists of tests / checks is mentioned in QA chapter on Battery. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

5.00 BATTERY: LEAD –ACID PLANTE BATTERY

5.01 BATTERY PARAMETER

a)	Battery Voltage	To be decide during Detail Engineering
b)	No. of Cells	To be decide during Detail Engineering
c)	Battery type	Stationary Lead Acid Plante
d)	Nominal discharge voltage per cell	2.0V
e)	Float Voltage	2.25V/Cell

5.02 CODES AND STANDARDS

IEC 60896	Stationary Lead-Acid Batteries
IS : 266	Specification for sulphuric acid
IS : 1069	Specification for water for storage batteries
IS : 1146	Specification for rubber & plastic containers for lead acid storage batteries.
IS : 1652	Specification for stationary cells and batteries, lead acid type (with plante positive plates).
IS : 3116	Specification for sealing compound for lead acid batteries.
IS : 8320	General requirements and methods of tests for lead acid storage batteries.
IS : 6071	Specification for synthetic separators for lead acid batteries.
	Indian Electricity Rules
	Indian Electricity Acts

Equipment complying with other internationally accepted standards such as IEC, BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards alongwith copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.

5.03 DC Batteries shall be stationary lead acid Plante positive plate type conforming to IS:1652. The batteries shall be high/medium discharge performance type suitable for the

backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

5.04 DC Batteries shall be suitable for standby duty. The Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.25 V/cell.

5.05 **Construction Features:-**

a) Containers

Containers shall be made of transparent glass, hard rubber, suitable robust, heat resistance, leak proof, non absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of transparent containers. Float type level indicator shall be provided in case of opaque containers. The stem portion of the float should be long enough to prevent falling of the float inside the container even if there is no electrolyte in the container. The marking for the electrolyte level should be for the upper and lower limits. The material of level indicator shall be acid proof and oxidation proof. Container shall be closed/sealed lid type. Lid and sealing compound shall be non-cracking type. The container made of hard rubber and plastics shall be type tested as per IS: 1146. All type tests shall be carried out for sealing compound as per IS: 3116.

The pole sealing arrangement should be such that no acid particle get entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

b) Vent Plugs

Vent plugs shall be provided in each cells. They shall be antisplash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte sample.

c) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS : 1652 as applicable.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative post shall be clearly marked.

d) Sediment Space

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

e) Cell Insulator

Each cell shall be separately supported on PVC/porcelain/hard rubber insulators fixed on the racks with adequate clearance between adjacent cells. Minimum distance between adjacent cells shall be more than the bulge allowed for two cells in accordance with IS: 1146.

f) Electrolyte

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS: 266 and distilled water conforming to IS: 1069. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately.

g) Connectors and Fasteners

Lead or Lead coated copper connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. The thickness of lead-coating of connectors should not be less than 0.025 mm. The lead coating thickness shall be measured in accordance with APPENDIX F of IS:6848 (latest edition). All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds. End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC insulation. Necessary supports and lugs for termination of these cables on batteries shall also be supplied by the contractor.

h) Battery racks

Wooden racks for all the batteries shall be provided. These racks shall be made of good quality first class seasoned teak wood in line with CPWD specification. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries rack and wooden support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor. Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

i) Test

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146 (for rubber & plastic containers for lead-acid storage batteries)/IS 1652 (for lead-acid plante batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery. Charges for these shall be deemed to be included in the equipment price. An indicative lists of tests / checks is mentioned in QA chapter on Battery. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents

6.00 AUXILIARY EQUIPMENT

Manual discharge resistance bank suitable for each type of battery bank of UPS/Battery Charger has to be provided by contractor.

Following shall be provided (as per applicability) for maintenance purpose		
a	Hydrometers	2 Nos.
b	Set of hydrometer syringes suitable for the vent holes in different cells	2 Nos.
c	Thermometer for measuring electrolyte temperature	2 Nos.
d	Specific gravity correction chart	2 Nos.
e	Wall mounting type holder made of teak wood for hydrometer & thermometer	2 Nos.
f	Cell testing voltmeter (3-0-3 V)	2 Nos.
g	Alkali mixing jar	2 Nos.
h	Rubber aprons	5 Nos.
i	Pair of rubber gloves	
j	Set of spanners	5 Nos.
k	No smoking notice for each battery room	2 Nos.
l	Goggles (industrial)	2 Nos.
m	Instruction card	2 Nos.
n	Temperature indicator	1 No. per room
o	Cell lifting facility	1 Set per room

7.00 Following shall be taken as minimum load value for sizing calculation of UPS/Battery Charger/Battery system. However, Bidder needs to provide the details auxiliary power rating of each individual equipment. & any other load apart from below required for completion of the system is also in the scope of the bidder.

Sl No	Description	Rated Power in Watt	Remarks
1	HT Switchgear VCB Panel		
(i)	Closing Coil	300	First minute load
(ii)	Tripping Coil	300	Last minute load
(iii)	Spring Charging Motor	400	First minute load
(iv)	Numerical Relay	20	Continuous load

(v)	Auxiliary Relays	20 (total)	Continuous load
(vi)	LED Indication Lamps	10 (total)	Continuous load
(vii)	Misc. load	20 (total)	Continuous load
2	Inverter (if applicable)	300	Continuous load
3	SCADA panel at CMCS	2000	Continuous load
4	SCADA HMI including LED Display and Printer	500	Continuous load
5	SCADA RTU panel at PEB	400	Continuous load
6	Transformer N2 Injection unit at PEB (if applicable)	100	Continuous load
7	Fire Alarm Panel at CMCS	300	Continuous load
8	Fire Alarm Panel at PEB	200	Continuous load
9	WMS	100	Continuous load
10	Emergency Load (light + Fan) at CMCS	300	Continuous load
11	Emergency Load at PEB	100	Continuous load

Following shall be considered for main pooling/final pooling HT switchgear as a minimum.
(i) Per switchboard only one panel spring charging motor load shall be considered.
(ii) All outgoing and tie feeder panel trip coil load (subject to Minimum 3 Nos) shall be considered.
(iii) All outgoing feeders+ Aux transformer feeders+ 50% of incomer panel closing coil load shall be considered.

Following shall be considered for inverter station HT switchgear/RMU.
i) Per switchboard only one panel spring charging motor load shall be considered.
(ii) All panel trip coil and close coil load shall be considered.

8.00 SITE TESTS

The contractor shall carry out the following site tests as applicable on UPS, Battery Charger and Battery system. However, any other site test is required to be conducted as a standard practice of the OEM or deemed necessary by the employer and mutually agreed between the contractor and the employer, the same shall also be carried out.

8.01 **Light Load Test**

This test is carried out to verify that the UPS/Battery Charger is correctly connected and all functions operate properly. The load applied is limited to some percent of rated value. The following points should be checked:

a) Output voltage, frequency and the correct operation of meters;
b) Operation of all control switches and other means to put units into operation.
c) Functioning of protective and warning devices.

8.02 **A. C. Input Failure Test**

The test is performed in UPS/Battery Charger with a fully charged battery and is carried out by tripping input supply feeder or may be simulated by switching off all rectifiers and bypass feeder as at the same time. Output voltage variations are to be checked for

specified limits with an oscilloscope/Recorder.

8.03 **A. C Input Return Test**

AC input return test is performed in UPS/Battery Charger by closing AC input supply feeder, or is simulated by energizing rectifiers. Proper operation of rectifier starting and voltage and frequency variations are to be observed. This test is normally performed with a fully or partially charged battery.

8.04 **Auto changeover Test**

This test shall be carried out in UPS ACDB fed from two separate UPS system. Auto changeover of one UPS source to standby UPS to be check by tripping the active UPS manually or by simulation condition. This test shall be check as per approved auto changeover logic.

8.05 **Transfer Test (for UPS)**

This test is applicable for UPS with bypass, particularly in the case of an electronic bypass switch. Transients shall be measured during load transfer to bypass caused by a simulated fault and load retransfer after clearing of the fault.

8.06 **Full load test**

Load tests are performed by connecting the actual load to the UPS/Charger output. Load tests are necessary for testing output voltage and frequency, rated stored energy, recharge time, ventilation, and temperature.

8.07 **Rated Stored Energy Time (Battery test)**

This test is a load test to prove the actual possible time of battery operation. If rated load is not available in the case of large UPS/Battery charger, it is possible to apply a partial load to check the actual battery discharge characteristics and compare these with characteristics specified by the battery manufacturer. Discharge time with rated load shall then be calculated. The test shall be performed with a fully charged battery and also may be done under other battery conditions to be specified, if so agreed. Active power output of the UPS/Battery Charger and the battery voltage shall be recorded during the test. Since new batteries often do not provide full capacity during a starting up period, the discharge test may be repeated after a reasonable recharge time if the original test has failed.

8.08 **Rated Restored Energy Time**

Restored energy depends on the charging capacity of the rectifiers and the battery characteristics. If a certain recharging rate is specified, it shall be provided by repeating the discharge test after the specified charging period.

8.09 **Battery Ripple Current**

If battery ripple currents are specified, then the ripple current which depends on UPS operation shall be checked under normal operating conditions. Rough measuring methods are sufficient.

B-11 LIGHTNING PROTECTION SYSTEM

1.0 GENERAL REQUIRMENTS

This specification is intended to outline the requirement of external lightning protection (ELP/Lightning protection) for Solar array (DC) side and AC Power block side of Solar PV Project. It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of external lightning protection system meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of earthling system for safe and satisfactory operation of the plant shall be included under scope of the bidder.

Lightning protection requirement for outdoor metering yard/Switchyard has been mentioned elsewhere in the specification and hence shall be excluded from scope of this chapter unless Lightning protection requirement of metering yard/Switchyard is specifically mentioned in this chapter.

1.1 LIGHTNING PROTECTION DESIGN REQUIRMENT

The object of a lightning protection system is to protect buildings/structure and equipment's from direct lightning strikes, potential fire as well as the effects of injected lightning currents (non-incentive flash). It consists of termination systems for direct lightning, down conductors and an earth-termination system.

Care must be taken for while designing the lightning protection that surges are prevented in the electrical system to reduce failure of electrical and electronic equipment's.

1.2 CODES AND STANDARD

The equipment/product furnished for earthing system shall meet the requirements of all the applicable relevant National/International codes and standards or their latest amendment Codes and Standards. Product certification has to be CE/UL/BIS/TUV or equivalent. The relevant codes and standard for earthing system are tabulated below.

IS/IEC 62305	PROTECTION AGAINST LIGHTNING
IEEE: 80	IEEE guide for safety in AC substation grounding
IEEE: 837	Standard for qualifying permanent connections used in substation grounding
IS: 2629	Recommended practice for hot dip galvanizing of iron & steel
IS: 2633	Method for testing uniformity of coating on zinc coated articles
IS: 513	Cold rolled low carbon steel sheets and strips
IS: 6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS 2062	HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL — SPECIFICATION
IS: 458	Precast Concrete Pipes (With and Without Reinforcement)

UL-467	Grounding and Bonding Equipment
IEC 62561-7	Requirements for earthing enhancing compounds
NFC 17 -102	Early streamer emission lightning protection systems
CEA regulations for electrical safety-2010 Indian Electricity Rules/ Indian Electricity Act.	

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (codes and standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the above standards/ codes as applicable.

The lightning protection system includes lightning terminal, Down conductor, test ink, earth electrode, installation of lightning terminal, down conductor and earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with lightning terminal.

Detail specification of earthing system has been mentioned elsewhere in the specification .

2.0 DOWN CONDUCTORS

Down conductors shall be as short and straight as practicable and shall follow a direct path to earth electrode.

Each down conductor shall be provided with a test link at 1000 mm above ground level for testing but it shall be in accessible to interference. No connections other than the one direct to an earth electrode shall be made below a test point.

All joints in the down conductors shall be welded type.

Down conductors shall be cleated on outer side of building wall, at 750 mm interval or welded to outside building columns at 1000 mm interval.

Lightning conductor on roof shall not be directly cleated on surface of roof. Supporting blocks of PCC/insulating compound shall be used for conductor fixing at an interval of 1500 mm.

All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.

Lightning conductors shall not pass through or run inside GI Conduits.

Testing link shall be made of galvanized steel of size 25x 6mm.

Hazardous areas handling inflammable/explosive materials and associated storage areas shall be protected by a system of aerial earths

oxide layer or foreign material.

3.0 LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY

3.1 **Codes and Standard**

IS/IEC 62305: PROTECTION AGAINST LIGHTNING

NF C 17-102 : LIGHTNING PROTECTION WITH EARLY STREAMER AIR TERMINATION ROD

3.2 Complete Solar Array with associated structure shall be protected from Direct Lightning Stroke. Lightning Protection for solar array shall be achieved with any or both of the following two systems as per specification provided in the following section.

Single Rod Air Terminal (Faraday Rods)

Early Streamer Emission (ESE) Air Terminal

Suitable earthling and equipotential bonding shall be ensured for the lightning protection Air Terminal as per applicable standard/Equipment manufacturer guidelines.

Current carrying parts and accessories such as clamps, fasteners, down conductor, Test links and earth termination etc. shall be preferably procured from OEM of Air Terminals if it is supplied by them as part of lighting protection system.

3.3 **LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY WITH E.S.E AIR TERMINAL**

Solar array shall be protected from direct lightning stroke with Early Streamer Emission air terminal in accordance to NF C 17-102 .

Number and location of ESE air terminal shall be decided during detail engineering. For this purpose, design calculation considering protection level IV (minimum) and Autocad drawing of the layout of ESE terminal shall be submitted to CIL for approval.

ESE air terminal shall be type tested as per Annexure- C of NF C 17-102 (Latest Revision) in the manner as mentioned in the standard.

ESE Air terminal shall be supplied with test link, counter, down-conductor, Two earth pits, support mast and accessories required for completeness for ESE Lightning protection system.

Owner shall test ESE terminal (Each terminal/Sample basis) before installation with suitable instrument for functionality of terminal. Vendor shall replace the terminal free of cost if found defective.

Support mast for ESE Air terminal shall be heavy duty hot dip galvanized material and shall be suitable to withstand dynamic and static forces acting on it without failure. Foundation for the mast shall be M20 Grade concrete or better with minimum depth of 1200 MM.

4.0 LIGHTNING PROTECTION SYSTEM FOR BUILDING AND ENCLOSURE

Contractor shall provide lightning protection for Inverter room/shed/shelter/enclosure, main control room, Switchgear Room/shed/shelter and similar housing per IS/IEC 62305.

ESE Air Terminal shall not used for lightning protection of Metering yard/Switchyard .

B-12 METERING SYSTEM

NA

B-13 METERING YARD & OVERHEAD LINE

NA

B-14 CONTROL AND PROTECTION

NA

B-15 EHV CABLE AND ITS ASSOCIATED ACCESSORIES

NA

PART-B
C – CIVIL WORKS

C-1 TOPOGRAPHY SURVEY AND SOIL INVESTIGATION

1.0 TOPOGRAPHICAL SURVEY

Bidder shall conduct the Topographical Survey for the allocated plot in the proposed solar project. Topography report shall be provided by CIL for references purpose. The scope of work and technical specification for the same is as below:

1.1 Scope of Work

The Bidder shall carry out the Topographical Survey and prepare of Plans (Survey Maps) and report of the entire area for locating the Solar PV Power plant and its other systems.

Carrying out the Benchmark (GTS) to site(s) under survey by parallel levelling, establishing and constructing benchmark, grid and reference pillars in the field and spot level survey of the entire area at specified intervals and development of the contours. Bidder can also use DGPS for establishing the coordinates.

Carrying out cross-section of river/canal taking spot levels at an average 20 meters intervals or less depending upon the site conditions.

Furnishing all field data & drawings with Longitude and Latitude of all corners and strategic points. Furnishing of the survey report as described in detail in the succeeding paragraphs is also included in the scope of this work.

The work shall include construction of two permanent Benchmarks and reference pillars which shall be shown on the survey drawings.

Latitude and Longitude: The work shall be carried out in **UTM grids system**.

At least 50-meter width of the adjoining solar plots and area shall also be covered in the survey for correlation with adjoining plots. Presence of any well and/or tube well in the site or adjoining areas and water level in them shall be marked in the documents / Drawings.

1.2 Topographical Survey and Mapping

Positions, both in plan and elevation, of all natural and artificial features of the area like waterways, railway tracks, trees, cultivation, houses, fences, pucca and kutcha roads including culverts and crossings, foot tracks, other permanent objects like telephone posts and transmission towers etc. are to be established and subsequently shown on survey maps by means of conventional symbols (preferably, symbols used in Survey of India Maps), all hills and valleys within the area/areas is to be surveyed and plotted on maps by contours.

Method of the survey, contour intervals etc. shall be decided by the bidder with prior approval of the Owner (CIL), in case of steep slopes and dense jungle etc. where grading is not possible. Any unusual condition or formations on the ground, locations of

rock outcrops (if visible on the surface) and spring/falls, possible aggregate deposits etc. shall also be noted and plotted on the maps.

The field work shall be done with Total Station Equipment in the following steps:

Establishing horizontal and vertical controls and locating reference grids and benchmark in the area. Surveying for establishing spot levels and plotting contours. Surveying for locating the natural and manmade details as described earlier.

The grids for the survey work shall be established in N-S & E-W direction (Corresponding to Magnetic North).

1.3 Contouring

Bidder shall carry out spot level surveying at an interval of average 50 meters for contouring the area. Levels shall also be taken on all traverse stations and on salient points located at random over the area (ground points). Contours are to be interpolated at 0.5 M intervals after the above points are plotted.

1.4 Preparation & Submission of Survey Maps and Documents

The Contractor shall submit survey maps of the site in 1:10,000 scale indicating grid lines and contour lines, demarcating all permanent features like roads, railways, waterways, buildings, power lines, natural streams, trees etc. All the maps should be prepared in digitized forms using computer software like AutoCAD – Release 2016 or latest.

Bidder shall submit all data pertaining to the Survey and Array layout in original (.dwg & .pdf format) including all levels & co-ordinates in X-Y-Z format for the entire area in scale in Soft format and in hard copy (3 no's in A0 size).

2.0 GEOTECHNICAL INVESTIGATION SCHEME

2.0.1 The scheme for geotechnical investigation shall be as given at Clause 2.1 and shall be approved by Owner before execution. The Bidder shall carry out geotechnical investigation for establishing the sub-surface conditions and to decide type of foundations for the structures envisaged, construction methods, any special requirements/treatment called for remedial measures for sub-soil/ foundations etc. in view of soft sub-soils, aggressive sub-soils and water, expansive/swelling soils etc. prior to commencement of detailed design/drawings.

The Bidder shall obtain the approval for the field and laboratory testing scheme before undertaking the geotechnical investigation work.

2.0.2 The detailed Geotechnical Investigation has to be carried out by the bidder in line with the Technical Specification. Bidder shall carry out the design of foundation etc. based on the approved geotechnical report**.**

2.0.3 Field test shall include but not be limited to the following:

Boreholes, Standard Penetration Test (SPT), collection of disturbed and undisturbed soil samples (UDS), Trial Pits (TP), collection of water samples, Electrical Resistivity Test (ERT) etc.

2.0.4 Owner has carried out geotechnical investigation in the proposed area. The geotechnical investigation report comprising of Boreholes, Laboratory tests, Chemical analysis, etc. in respect of the sub-strata prevailing at site is enclosed as Annexure of Technical Specification, for Bidder's reference. These are solely for the purpose of guidance of the Bidder.

Bidder shall carry out his own Geotechnical Investigation, as per the requirements of Technical Specification provided at Cl. 2.1 below. No time extension would be admissible on account of this.

Bidder shall carry out the design of foundation etc. based on the approved geotechnical investigation report.

2.1 Scheme of Geotechnical Investigation

2.1.1) Minimum 1 No. of borehole of 7 m depth shall be carried out in every 12.5 acres of land. Minimum 1 number of ERT & 1 no. TP shall be carried out for every 100 acres or less area, as per layout. Depth of bore hole at Control Room Building shall be 12 m and that at Switchyard location shall be 15m or depth of borehole at these locations shall be as per approved geotechnical investigation scheme.

2.1.2) SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery upto 20%, met within a borehole. This test shall be conducted at every 1.5 m interval or at change of strata. The starting depth of SPT shall be 0.5m from ground level. UDS shall be collected at every 1.5m interval or at change of strata. In case UDS is not possible to collect, then interval of SPT shall be reduced to 1m instead of 1.5m.

2.1.3) The laboratory tests shall be conducted on soil, rock & water samples collected during field investigations in sufficient numbers. Laboratory tests shall be carried out on disturbed and undisturbed soil samples for Grain Size Analysis, Hydrometer Analysis, Atterberg Limits, Triaxial Shear Tests (UU), Natural Moisture Content, Specific Gravity and Bulk Unit Weight, Consolidation Tests, Unconfined Compression Test, Free Swell Index, Shrinkage Limit, Swell Pressure Test, Chemical Analysis test on soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, organic matter and any other chemicals harmful to concrete and reinforcement/ steel. Laboratory tests on rock samples shall be carried out for Hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (in-situ & saturated), Slake Durability etc.

On completion of all field and laboratory work, the Bidder shall submit a Geotechnical investigation report for approval. The Geotechnical investigation report shall contain field and laboratory observations/ data/ records, analysis of results and recommendations on type of foundation for different type of structures envisaged for all the areas of work.

Recommendations on treatment for soil, foundation, based on subsoil characteristics, soft soils, aggressive chemicals, expansive soils, etc. shall also be covered in the report, as applicable.

2.1.4) Geotechnical investigation work shall preferably be got executed by the Contractor through the Enlisted agencies, refer Annexure-1B of Chapter 2-B, Sub-section -2.

2.2 Foundation System

Foundation system for various facilities shall be designed and adopted as per approved geotechnical investigation report and relevant IS standard. The general requirements for the foundation system to be adopted, are as given below.

1) All structures/ equipment shall be supported either on suitable open foundation (isolated, combined, raft) or pile foundation depending on type of structures/ facilities, sub-strata, topography, etc.
2) If the encountered sub-strata is black cotton soil, the same shall be either replaced up to the full depth of black cotton soil or expansive soil shall be stabilized by suitable treatment.
3) No foundation shall rest in black cotton soil.
4) All foundation system shall be designed in accordance with the latest revisions of relevant Indian Standards. For short pile foundation, method by B. B. Broms shall be followed for calculating lateral resistance and lateral deflection of a pile.
5) Contractor shall furnish design of piles for approval.
6) Level of Ground water table for design purpose shall be considered as per the recommendation of geotechnical investigation report.
7) Minimum depth of foundation shall be 1.0m below ground level.
8) Testing of piles and interpretation of pile load test results shall be carried out as per the stipulations of IS: 2911 (Part-4). Contractor shall obtain approval for the pile load test scheme before undertaking the pile load test.
9) As per recommendation of Geotechnical Investigation Report, even for smaller structures, shallow foundations may not be feasible. Shallow foundation may be adopted with ground improvement. Accordingly, SBC value of improved ground shall be estimated based on ground improvement scheme adopted.
10) **Further, for design purpose, the ground water table shall be considered at ground level.**

Foundation system for various facilities shall be as per the table below:

Type of Structure	Type of Foundation
MMS	Bored Cast In-situ Pile
	Precast Driven Pile/ Spun Pile
	Stiffened Deep Cement Mixing (SDCM)
Boundary Wall/Fencing	Short Pile Foundation
Switchyard	Pile Foundation
CMCS Building	Pile Foundation
Inverter Stations	Pile Foundation
Transformer	Pile/Raft Foundation

Note: Optimized foundation type and size shall be decided during detailed engineering, however following minimum requirement considering aggressive behavior of soil to be adopted.
Minimum Grade of concrete: M30
Minimum diameter and capping of pile: 300mm

Chemical composition of Subsoil and Ground Water:

Details of treatment for foundations/ below-ground/ buried structures required to counteract soil/ ground water chemical environment shall be as per findings of geotechnical investigation. This shall require use of dense and durable concrete, control of water cement ratio, increase in clear cover, use of special type of cement and reinforcement, coating of concrete surface, etc. as per relevant IS codes. Bidder shall furnish the details of corrosion protection measures.

However, based on the Geotechnical Investigation carried out by the Owner, it may be inferred that near soils are typically slightly alkaline and are extremely corrosive to uncoated steel and are very highly corrosive to rebar in concrete materials. Based on chemical test results of subsoil and ground water, project site can be classified in Class 3 as per Table - 4 of IS: 456: 2000. Accordingly, minimum cement content, maximum water- cement ratio, cover to reinforcement and type of cement shall be provided.

As chloride is encountered along with sulphates in both sub-soil and ground water, Ordinary Portland cement with C_3A content between 5 and 8 % or Portland slag cement conforming to IS: 455, may be used for all buried RCC structural members.

Environmental exposure condition for exposed concrete surfaces shall be considered as ‘severe’ and for buried concrete, it shall be adopted as ‘very severe’, as per IS: 456.

C-2 SITE LEVELLING AND GRADING

1.0 SITE LEVELLING AND GRADING:

1.1 **Site levelling works involves the following works:**

1) Site levelling works/scheme shall match with the specific functional requirement of Solar PV optimum generation considering the full utilization of the plot area for the desired capacity
2) Site grading level shall be fixed with due reference to site drainage of the whole area, existing drainage pattern and system requirements.
3) For Plant boundary wall and fencing.

1.2 Based on the spot level, contour survey done and meeting above requirements, bidder can propose different site grade levels. The site levelling may be carried in patches/blocks. Bidder may also propose the site leveling and grading matching with the **natural topography** of the land considering the optimized use of the land, however bidder shall ensure to meet the desired power generation capacity in the allotted plot area. Bidder shall also ensure that no water ponding and flooding occurs in the low lying areas & effective drainage is provided in the whole plot area, in all kind of site levelling and grading or plant at natural topography schemes, bidders has to provide proper and effective drainage system in line with "Drainage System" chapter. After performing the optimization of levels from the detailed site survey by the Bidder, the final formation level of the plot in various areas shall be finalized. The area shall be suitably cut and filled to suit the layout requirement. The site levelling and grading scheme incorporating the above aspects shall be submitted to CIL for prior approval.

1.3 Fill shall normally be made up of Cohesive Non swelling material capable of being compacted up to 95% Standard Proctor density. In case earth has to be borrowed from outside the plant boundary, the same shall be arranged by the Bidder. The slope at the edge of graded areas shall not be steeper than 1:1.5 (1 vertical to 1.5 horizontal) in cutting and 1:2 in filling.

1.4 All buildings & switchyard area/sub-station area shall be constructed in levelled area. No foundation shall be allowed on back filled soil and in that case the depth of foundations shall reach up to NGL. Final Level will be approved in detail engineering.

1.5 The slope protection measure shall be provided in case inter levelled patches level difference is more than 2.0m. Random rubble/boulder/stone pitching/concrete blocks etc. shall be provided for the slope protection for road side slope, storm water ditches/drainage, embankment slopes, inter levelled patches slopes etc. as per design requirements.

1.6 Suitable sand erosion control measure shall be provided in case any sand dune or very loose soil areas fall inside the plot area. The same may be made with Random rubble/boulder/stone pitching/concrete blocks etc. Bidder shall also provide sufficient grass/buses/trees covers on these dune / loose soil patches.

1.7 Bidder shall also provide suitable sand erosion protection measure around the foundation as mentioned at relevant places in the technical specification.

1.8 **Green Belt development:**

The selection of plant types should be adaptable for agro climatic zones. Planting arrangement to be considered such that very little or no shadow falls on solar modules. Final selection for plants and seeds can be done by advice from forest / agriculture department and / or local experts. However, owner recommends the following:

Canopy vegetation (trees): Neem OR Babool
Trees to be planted by root-ball method to fast track growth.
Crown: 20 meters

For ground cover vegetation: Cenchrus ciliaris OR Cenchrus setigerus
Ground cover vegetation to be done by seed germination on site.
Crown: 70-80 cm

Bidders are also encouraged to plan additional suitable green belt with local shrubs and grasses in and around the respective plot area to control the soil erosion and better temperature in the plot area.

C-3 BOUNDARY WALL, FENCING AND GATE

1.0 General

The scope of work includes providing either or combination of following as per scope defined in **Plot Map** (General design data for Solar PV Site) of the proposed Solar Plant for the peripheral and common boundary.

a) Pre-Stressed Precast Boundary Wall – Bidder's Choice
b) Chain Link Fencing (e.g. Any Statutory Requirements)
c) RCC Fencing Poles with Barbed Wire (e.g. Office Areas)

2.0 Pre-Stressed Precast Boundary Wall

a) Boundary wall shall be provided by bidder on the periphery of allotted plot/plots. Bidder scope of work includes casting of pre-stressed precast boundary wall panels, columns etc. at bidder's facility/facility established by bidder at site/manufacturing unit, transportation of precast units at site and storage at locations identified by CIL, excavation for casting of foundation and fixing of panels as per drawing, construction of foundation, erection of columns to plumb & wall panels with required T&Ps, fixing of concertina with all items, backfilling as per specification etc. complete in all respect.

b) Bidder construction drawing shall also incorporate suitable scheme to place precast boundary wherever there is changes in ground levels, corner, joint, water body crossings, etc. Opening for gates/drains and for other crossing has to be suitably provided as per the requirement/drawing/instructions of engineer in charge.

c) The size of the foundation shall be decided based on the site conditions however the minimum diameter of the foundation shall not be less than 300 mm and depth 1800 mm.

d) Bidder has to ensure that damages such as cracks and chipping off of corners do not happen during handling due to knocking etc. In case, such damages happen, the same has to be brought to the notice of engineer in charge.

e) In case the damage is minor, the same has to be made good using approved epoxy resin. Non shrink grout can be used for chipped off corners. No monetary claim shall however be admissible for such repairs. The engineer in charge reserves the right to accept or reject any damaged precast unit and the decision shall be binding on the bidder.

f) Suitable foundation and boundary wall arrangement with steel grating/grill shall be made in the boundary wall scheme to ensure intact wall/safety in the water body/ drains entry and exit points in the plot area. The boundary wall shall be at sufficient height from water level. The toe wall for fencing at water body area shall be made of RCC only. Alternatively, in place of Toe wall, Concertina Fencing at Ground can also be provided as per Tender Drawing.

g) Boundary wall if provided, shall be executed in line with tender drawing Title: Pre-Stressed Precast Boundary Wall.
h) Cutting of high strength cable, distressing and lifting shall be as per the standard IS: 1343. Pre-stressing tendons of high tensile steel / wire shall be as per IS: 6003-2010. For 4mm dia wires min Tensile strength shall be 1715 N/mm2. Pretension force should not exceed 80% of ultimate tensile strength of the tendon. The pre-stressing shall be released from the panels and poles only when 50% of the characteristic strength of concrete is achieved.
i) Prestressed precast boundary wall members shall be designed as per IS-1343

Tolerances:

SL no	Item	Tolerance		
1	Length	(+/-) 0.1%		
2	Straightness or bow	1/750 of length		
3	Cross section dimensions	(+/-)3 mm		
4	Squareness	When considering the squareness of the corner, length of the two adjacent sides being checked shall be taken as base line. The shorter side shall not vary in length from the perpendicular by more than 5 mm.		
5	Flatness	The maximum deviation from a 1.5m straight edge placed in any position on a nominal plant surface shall not exceed 5 mm.		

3.0 **Chain Link Fencing:**

"Chain link fencing The fencing shall be of Chain link (GI or poly coat GI as specified) mesh fabric with internal, corner and stay posts of RCC (min 200mm x 200mm size, M30 grade) or Hot dipped GI angle (min. ISA 75x75x6 mm), as applicable, along with 230 thick brick/ 300 thick RR masonry toe wall, with 100mm thick M15 PCC foundation (min. width 450mm and min. depth 450 mm below GL).

Intermediate, corner and stay posts shall be supported with min. 300 mm dia. and 850 mm deep (below GL) piles in cement concrete (nominal mix 1:1:2). The column posts shall be extended in to the pile up to 800mm with 50mm cover at the bottom. The pile shall project 150mm above GL. The toe wall shall project 150mm above GL. The intermediate, corner and stay posts shall be supported by angle struts that shall have the same foundation as that of the main posts.

The brick masonry toe wall shall be plastered with 15thick CM (1:4) plaster on both faces and shall have min. 50 thick PCC (1:2:4) coping finished smooth and projecting 35mm on either side of the wall with top sloping inwards.

Spacing of intermediate posts shall not be more than 2.5m. Every 10th intermediate post shall be provided with a stay post while every corner post shall be provided with two stay posts on either side.
Joints in RR masonry shall be properly raked and pointed with CM (1:3).
In case of pond/ drain crossing the fence, RCC beam of adequate size supported on RCC columns on either side and suitable grill of MS square rods (vertical spacing not more than 150mm) of min. Size 25x25 mm and min. 3 no. horizontal 20 SQ MS rods or 50 mm x 8 mm thick flats secured to RCC beam and columns; shall be provided in place of toe wall for smooth flow of water.
The GI chain link mesh fabric (40x40 mm with min. wire gauge 3.15mm, both ends twisted) and fencing shall conform to IS: 2721. Poly coat GI chain link mesh (50x50mm) shall conform to ASTM 668 and fencing shall conform to ASTM 668.
Each fence panel, in lieu of tie wire, shall be provided with 35x35x3mm GI edge angle at top and bottom with mesh fabric firmly secured to them and to intermediate support angles.
All MS sections shall be painted with 2 coats of epoxy paint of approved make and shade over 2 coats of suitable primer."

4.0

RCC Fencing Post with Barbed Wire:

RCC fencing post shall be a straight type of total length of 1.8 meters. The height of RCC post shall min 1.2 meters from finished ground level.

Hooks for fixing Barbed Wire

Hooks shall be made of 6 mm dia MS bar. 9 Nos. Hooks shall be provided for fixing 'Steel Barbed Wire, A-3 or B-3 IS 278' at 1.8 meters post. The top hook should be provided 60 mm below the top of post and bottom hook should be provided 140 mm above the bottom of the pole. The central distance between the top and bottom hooks shall be equally divided to fix remaining hooks. Diagonal steel barbed wire fixed with RCC fencing post shall also be provided.
Inclined strut or stay post on either side shall be provided at every 15 meters c/c, corner and end. The maximum distance between two RCC, fencing post shall be 2.5 meters c/c.

Reinforcement of RCC Post:

In Post	Vertical 6 Dia Bars 4 Nos.	In Strut	Vertical 6 Dia Bars 4 Nos.
	Stirrups 6 Dia Bars 9 Nos.		Stirrups 6 Dia Bars 10 Nos.

Dimensions RCC Post

1. Bottom: 165 mm x 165 mm square, and
2. Top: 100 mm x 100 mm square.

Cement Concrete Mix and Manufacturing

Cement concrete to be used having the nominal mix of ratio 1:2:4 with 12.5 mm nominal size coarse aggregate. RCC Post shall be embedded into PCC block made from Cement Concrete nominal mix 1:5:10 below ground level. Concrete Mix shall be conforming to Grade M-15 of IS 456 (2000). RCC Fencing post shall be manufacturer at the factory and In order to ensure desired compressive strength, RCC fencing poles should be compacted with the help of plate form vibrator. The surface shall be uniform and free from voids. The concrete cover over the reinforcement shall not be less than 15 mm.

Tolerances for RCC Fencing Poles

SL no	Item	Tolerance
1	Length	(+/-) 0.1%
2	Straightness or bow	1/750 of length
3	Cross section dimensions	(+/-)3 mm

5.0 Chain Link Fencing for Yard (Transformer Yard, Metering Yard, etc.)

As per Tender Drawing Title: CHAIN LINK FENCING FOR YARD AND COMMON FENCING (5779-004(B)-POC-A-003C)

6.0 Main Gate

Mild Steel frame gate woven with chain linking having minimum span 4 m conform to IS: 2062 shall be provided. The gate shall be complete with the guide track, castor wheel, all fitting and fixture like hinges, aldrops, locking arrangement, posts, etc. The width of approach road shall cover the gate width at the main entrance with a suitable transition. All members used in gates shall be finished by cleaning of steel surfaces as per IS: 1477 (Part-II) and applying zinc chrome or zinc phosphate primer, followed by two coats of synthetic enamel paint. For finishing coat suitable colour pigment shall be added. All paints including primer shall be of reputed brand/manufacturer and as approved by the Engineer-In-charge. The method of application shall be as per the recommendations of the manufacturer.

One man movement passage gate (minimum 1.2m width) shall also be provided at the main entry gate. 400 mm height concertina with all supporting members shall also be provided on a gate (gates other than main entry gate) for better security.

The minimum size & requirements of the Gate's including all items shall be as per the fencing tender drawing title: "**Details of Main Gate".**

The main gate shall be constructed inside the plant/plot boundary line to provide sufficient space for Heavy motor vehicle and light motor vehicle for inspection/check before entering the solar plant and vehicles shall not disturb the traffic in the main approach road.

7.0 **HT cable support**

As per detailed Engineering, if overground cabling is envisaged to avoid submergence during flooding, following would be followed for overground support.

T-TYPE RCC Pedestals or Galvanized Steel Structure over Concrete Pedestals shall be constructed for laying of the HT cable from Transformer to 33kV switchgear. Height of such structures would be as per Electrical Cabling – Technical Requirement (System Design), w,r,t Flood Level Report.

C-4 DESIGN OF MODULE MOUNTING STRUCTURE & CIVIL WORKS

1. Design criteria for module mounting structure (MMS)

The design calculations and drawings for MMS shall be submitted for prior approval of CIL before the commencement of construction. The construction methodology for MMS, seasonal tilt mechanism / Tracker system (if allowed as per Ch. A-2) and its foundations shall be submitted for CIL approval before the start of works.

2. Scope:

This section covers the loads and design requirement of the structures, racking, and all other items required to furnish and install a complete ground mounting structural system which constitutes a photovoltaic array(s).

3. Design Loads:

A. Dead Load: The load obtained by summing up the weight of modules and self-weight of Structure including Purlins, rafter/beams, Bracings, struts, columns, necessary fittings, etc. to be added as a Dead load.
B. Wind Load: The wind load (positive and negative) normal to surface on the modules and wind load on the structural members.
C. Refer Appendix-1 of Technical specification for site-specific design parameters.
D. The concept of wind tunnel studies may be considered in the design philosophy for fixed seasonal module mounting structure as well as tracker system.

If the Bidder is going for wind tunnel study for the design and analysis of complete MMS following has to be ensured.

i. It must be done from an institute of repute having suitable wind tunnel facility (IITs / SERC Chennai or equivalent level institute in India).
ii. If the study is done by any reputed international facility the study results must be vetted by the wind domain expert at any of the IITs / SERC like institutes in India.

Bidder may also refer to the detailed provisions in chapter A-2 for Tracker system.

4. Design Parameters:

A. MMS design & analysis to be done on computer software (preferably STAAD) and the Bidder shall submit a write-up on the computer program used and its input (soft format) and output data for review and approval.

B. An increase in allowable stresses of structural materials should not be considered during design and analysis.

C. Wind pressure for following loads shall be considered as follows:

(1) Dead Load of steel with all members, fittings & panels.
(2) Load due to fair wind direction on design tilt angles of solar mounting structural members.
(3) Load due to adverse wind direction on design tilt angles of solar mounting structural members.
(4) Load on the side face of mounting structural members.

D. Wind pressure coefficient, load and load combination shall be as per Indian standards (latest revision) such as IS: 875, IS: 800, IS 801.

E. Design analysis and the forces on MMS (Compressive force, uplift force, shear and moment) shall be used for the design of foundation system.

F. Seasonal Tilting MMS type (as applicable): Mechanized arrangement for lifting MMS during seasonal tilting shall be provided with MMS. The lifting forces shall be transferred only through rafter/beam for lifting the MMS during seasonal tilt with a suitable hook, clamp, etc. and fixed at rafter/beam.

G. **Technical requirements/ parameter of the Tracker System shall be as per Chapter A-2 of this specification**. The Tracker System shall be of proven design. Design shall be based in accordance with the site climatic conditions and seismic loads, soil characteristics, thermal loads caused by expected fluctuations of materials and ambient temperatures and the minimum required design wind speed.

5. Vertical Deflection and Horizontal Sway Limits:

Limiting Deflection: The limiting permissible vertical deflection for structural steel members shall be as per following:

a) Maximum vertical deflection in purlin = Span / 180,
b) Maximum vertical deflection in rafter (cantilever span) = Span / 180 and
c) Maximum lateral deflection in column/vertical post = Height / 240
d) All deflection limits can also be as per the serviceability limit defined by the module manufacturer & tracker manufacturer OR the proposed deflection limits duly approved by the module manufacturer during detailed engineering.

6. Materials Specification & Coating for Structural Steel Works:

A. Hot-rolled/Cold-formed steel sections:

Members	Reference code	Yield strength, min, MPa	Non-Coastal		Coastal Area	
			Coating, Reference code	Min Thickness (mm)	Coating Reference code	Min Thickness (mm)
Column/ Vertical Post	IS 2062 / IS 1079	250	**90 micron** (IS 4759) (minimum)	**2.0**	110 micron (IS 4759) (minimum)	3.0
Bracing/Rafter/ Beam/Purlin				2.0		
Steel Tubes in all sections	IS 1161	240		2.0		

Hollow Steel in all sections	IS 4923	240		2.0		
Coupler/Plate/Cleat Splice/Sag Angle	IS 2062	250		2.0		2.0
		Yield strength, MPa	**Coating Class Designation**			
Rafter/ Beam/ Purlin (Pre-Galvanized steel sections)	ASTM A653M/ IS 1079	255-550	Z600 (ASTM A653M/ IS 277)	1.6	Not recommended in coastal areas	
NOTE:	1. Minimum elongation % shall be as per relevant Standard and Code. 2. Materials shall be fabricated in the shop. 3. Minimum coating requirement mentioned above in the table. 4. All structural calculations of cold formed steel section for checking the adequacy for strength and deflection criteria is to be done taking into consideration the maximum permissible negative tolerance over specified BMT i.e, the lower limit of BMT is to be considered. 5. The tolerance on Base Metal Thickness (BMT) thickness of steel shall be as given in IS 1852.					

B. Hot-dip Aluminium-Zinc alloy metallic coated sheet steel strip and sheet sections:

Members	Reference code	Yield strength, MPa	Coating Class Designation	Min Thickness (mm)	Coastal Area
Rafter/ Beam	**ASTM A792M/ IS 15961**	250 - 550	**AZM 165** (ASTM A792M) / (IS 15961)	**1.2**	**Not recommended in coastal areas**
Purlin	ASTM A792M/ IS 15961	250 - 550	**AZM165** (ASTM A792M) / (IS 15961)	0.9	Not recommended in coastal areas
NOTE:	1. Minimum elongation % shall be as per relevant Standard and Code. 2. Materials shall be fabricated in the shop. 3. Minimum coating requirement mentioned above in the table. 4. All structural calculations of cold formed steel section for checking the adequacy for strength and deflection criteria is to be done taking into consideration the maximum permissible negative tolerance over specified BMT i.e, the lower limit of BMT is to be considered. 5. The tolerance on Base Metal Thickness (BMT) thickness of steel sheets and coils shall be as given in IS/ISO 16163				

Painting of Steel Surfaces embedded in Concrete : For the portion of Steel surfaces completely embedded in Concrete as reinforcement or otherwise for foundation systems, the surface shall be prepared by Manual Cleaning and provided with Primer Coat of **Inorganic Zinc Silicate** Primer of Minimum 50 Micron Dry Film Thickness (DFT).

C. Bidder shall also use principles governing design that shall prevent or reduce the risks of corrosion as per IS 9172 and other relevant IS codes.

7. Connections:

Sl No	Connection	Grade
1	Solar PV module to purlin/structure connection.	
2	Bolts required to loose and tighten seasonally for	SS304, A2-

	seasonal tilting in the module mounting structure.	70
3	Other structural fixed connections.	HDG 5.6 & 8.8
4	Foundation Anchoring.	HDG 4.6

Note: Fastener shall conform to IS 1367

A. SS304 Fasteners (nuts, bolts, washers and U-bolts) shall be of corrosion-resistant austenitic steel. SS 304 Fasteners shall have a good anti-seize finish with proper wax coating for better durability and firm resistance to all types of failure including seasonal removal and re-fixing of bolts.

B. All fasteners shall be provided according to the connection design requirement. All bolts shall be tightened with designed torque mechanically immediately after the erection of MMS to avoid any possible damage due to any incidental storm during the erection stage.

C. One set of fasteners shall consist of one hexagonal head nut, one hexagon shape bolt, and two washers. The bots and nuts with inbuilt washers may also be provided.

D. In the ground mounting structure system with seasonal tilt arrangement, the column post and rafter/beam at seasonal tilt point of rotation shall be preferably hinged plate and bolt system.

8. Foundation System

Top of concrete/ height of collar for MMS foundation shall be minimum 300mm above Finish ground level. The proposed foundation system for MMS shall be based on findings/results of the approved geo technical investigation report. Following kind of foundation may be provided:

1. Short pile foundation (Min. 300mm dia.)
2. Rock anchor with concrete collar (Min. 700 sq.cm.)
3. Isolated, strip or raft foundation
4. Concrete ballast foundation

9. List of applicable Indian standards

IS 2062 - Hot Rolled Medium and High Tensile Structural Steel.
IS 811 - Cold Formed Light Gauge Structural Steel Sections.
IS 1161- Steel Tubes for Structural Purposes.
IS 4923 - Hollow steel sections for structural use.
IS 4759 - Hot-dip zinc coatings on structural steel and other allied products
IS 4736 - Hot-dip zinc coatings on mild steel tubes
IS 1868 - Anodic coatings on aluminium and its alloys.
IS 2629 - Recommended practice for hot-dip galvanizing of iron and steel.
IS 15961 - Hot dip aluminium-zinc alloy metallic coated steel strip and sheet (plain)
IS 9172 -Recommended design practice for corrosion prevention of steel structures.

C-5 CIVIL & STRUCTURE WORKS - GENERAL DESIGN CRITERIA

1.0 GENERAL

The layout, design and drawings for Buildings, Structure and foundation system shall be approved from CIL before the start of works. Design of RCC and Steel structures shall be carried out as per IS 456 and IS 800 respectively. Refer appendix-D1 for site specific design parameters.

2.0 INVERTER ROOMS & SECURITY ROOM

The following structures shall be designed and provided by the bidder:

A. Inverter Rooms: Inverter rooms consist of PCU's, LT panels, batteries, etc. shall be provided based on manufacturer recommendation, easy passage of O&M persons and cable trench layout required.

The inverter rooms shall be made through any of the options as mentioned below:

a) RCC framed structure with bricks/concrete blocks masonry walls,
b) Pre-Engineered Building in line with PEB Tender drawing & technical specification (IR PEB shall be provided only in **non-coastal area**),
c) Steel Containerized solutions.
d) On elevated RCC Platform.

The battery and its associated equipment shall be suitably segregated inside the Inverter room with proper ventilation arrangement.

The equipment inside the inverter room shall be placed to provide sufficient space for their maintenance.

B. Security Room: Prefabricated security room or brick/stone masonry with RCC slab near the entry of the main gate. The toilet room shall be made of brick/stone masonry with water facility

The buildings and allied works shall be designed to meet **NATIONAL BUILDING CODE** (SP: 07 2016) requirements. Finish floor level of all building/rooms shall be minimum 450 mm above from Finish graded level.

2.1 SPECIFICATION FOR RCC BUILDINGS AND OTHER RCC/MASONRY STRUCTURE.

Any building if made of RCC framed structure with bricks/concrete blocks masonry walls will be made in line with provisions of IS 456. The thickness of outer masonry walls shall be minimum 230mm in case of bricks and minimum 200mm thick in case of concrete

blocks. The roof shall be designed for a minimum superimposed load to 150 kg/m2. The bidder shall also provide rainwater harvesting system at all RCC building roofs (if provided).

3.0 GENERAL CIVIL WORKS

3.1 REINFORCED CONCRETE STRUCTURE, ALLIED WORKS AND FOUNDATION

a) All RCC works shall be designed mix as per IS 456 (2000). For structural concrete items, Ordinary Portland cement (43 Grade) conforming to IS: 8112 and Fly ash- based Portland pozzolana cement conforming to IS: 1489 (Part-1) shall be used for superstructure. Type of cement for sub-structures shall be decided based on the approved geotechnical Investigation report and special protection measures against chemically aggressive environment, specified at Cl.2.2 of Chapter C-1 of this specification.

b) Coarse aggregate for concrete shall be crushed stones chemically inert, hard, strong, durable against weathering of limited porosity and free from deleterious materials. It shall be properly graded. It shall meet the requirements of IS: 383.

c) Sand shall be hard, durable, clean and free from adherent coatings of organic matter and clay balls or pellets. Sand, when used as fine aggregate in concrete shall conform to IS: 383. For plaster, it shall conform to IS: 1542 and for masonry work to IS: 2116.

d) **Reinforcement steel:**

Non-coastal area	Coastal area
Reinforcement steel shall be of high strength deformed TMT steel bars of grade minimum Fe-415 and shall conform to IS: 1786. Ductile detailing in accordance with IS: 13920 shall be adopted for superstructure and substructure of all RCC buildings/structures	Reinforcement steel shall be of high strength deformed TMT steel bars with corrosion inhibitors, Corrosion Resistant Steel (CRS) re-bars, Fusion Bonded Epoxy Coated (FBEC) re-bars or Zinc Coasted re-bars of grade minimum Fe-415 shall conform to IS: 1786. Ductile detailing in accordance with IS: 13920 shall be adopted for superstructure and substructure of all RCC buildings / structures. Dense concrete around reinforcement, provision of thick covers, and addition of corrosion protection with re-bars shall be provided to the RCC structures

e) The following minimum grades of concrete for design mix and nominal mix shall be adopted for the type of structures noted against each unless not specified elsewhere.

Grade as per IS 456	Non-coastal area	Coastal area
M30	-	All RCC structural elements above and below ground level, precast concrete, transformer foundation, Equipment foundation, cable trench, oil pit, Grade Slab, Paving, culverts, road and MMS Foundation.
M25 (in-situ concrete) M30 (Precast)	All RCC structural elements above and below ground level, precast concrete, MMS foundation, cable trench, oil pit, Grade Slab, Paving, culverts	-
M25	Fencing work.	Fencing work, Base slab of drains. Plain Concrete Cement.
M25	Base slab of drains.	
M15	Plain Concrete Cement.	

The bidder shall carry out the design mix of M-30 and M-25 grade concrete on priority. The design mix shall be approved from CIL before the start of work.

* The use of nominal mix for M-20 grade (If applicable) may be accepted only in exceptional cases subject to approval of CIL Engineer-In-Charge. The same shall be the adopted subject to approval from CIL for specific work.

f) In case Geotechnical investigations require any special kind of cement or higher grade of concrete, the same shall be provided. The foundation system shall be made which transfer loads safely to the soil for the module mounting structures, depending on soil conditions, geographical condition, regional wind speed, bearing capacity, slope stability etc. All foundation system and foundation depth shall be decided based on the approved geotechnical investigation report. No foundation allowed on back filled soil and the foundation depth to reach upto natural ground level (NGL).

g) All loads shall be considered in line with IS: 875. Seismic loads for design shall be in accordance with IS: 1893 and relevant Standards.

h) IS: 2502 Code of Practice for Bending and Fixing of Bars for concrete Reinforcement must complied for reinforcements. IS 5525 and SP 34 shall be followed for reinforcement detailing.

i) A minimum 75 mm thick PCC shall be provided below RCC wherever RCC structure is laid over the ground. Proper and sufficient formwork/shuttering shall be provided for the required period as per IS 456.

3.2 Masonry Work

a) Brickworks shall be using at least class designation 7.5 of approved quality as per IS: 1077, IS: 2212 and IS: 3495. Concrete blocks shall be of a minimum compressive strength of 7.5 N/mm2 and shall be of Grade-A as per IS: 2185. Stone masonry work with hard stone in building works, foundation, plinth and drains shall be Coursed Rubble or Random Rubble masonry work with the stone of good quality and durability. The masonry surface shall be plastered with minimum 18mm plaster in case of CMCS walls. The stone masonry work shall be in line with IS: 1597, IS: 1122 and IS: 1126.

b) The cement mortar for all kind of masonry work shall be in the ratio 1 cement and 6 sand by weight.

c) Bricks/blocks required for masonry work shall be thoroughly soaked in the clean water tank for approximately two hours. Brick shall be laid in English bond style. Green masonry work shall be protected from rain. All masonry work shall be kept moist on all the faces for a period of seven days.

d) Bricks of class designation 5.0 N/mm2 and 3.5 N/mm2 may be permitted to have slight distorted & rounded edges provided no difficulty shall arise on this account in laying of uniform courses in non-load bearing structures and shall be subject to the approval of CIL. Tolerances on dimensions up to +/- 8% shall be permitted. Dimension test to be carried out as per IS code.

e) The external wall for the building shall be 230 mm thick walls and internal wall 230/115 thick as per requirements. The external wall of CMCS facing the transformer area shall be as per IS: 1646 - Code of practice for fire safety of buildings (general): electrical installations.

f) Use of fly ash brick for masonry shall be subjected to approval of CIL.

g) The suitable damp proof course shall be provided the proportion of cement, sand & aggregate shall be 1:2:4 using 6 mm down stone chips with a waterproofing admixtures. The thickness of the damp-proof course shall be minimum 40 mm.

3.3 Plastering

All external surfaces shall have 18 mm cement plaster in two coats, under layer 12 mm thick cement plaster 1:5 and finished with a top layer 6 mm thick cement plaster 1:6 (DSR 2013-13.11). White cement primer shall be used as per the manufacturer's recommendation.

At least one coat of plaster shall be applied to interior walls by hand or mechanically, to a total thickness of 12 mm using 1:6, 1 cement and 6 sand. Plastering shall conform to IS 1542, IS 1661, IS 1630. Oil bound washable distemper on smooth surface applied with minimum 2 mm thick Plaster of Paris putty for the control room. Plaster of Paris (Gypsum Anhydrous) conforming to IS: 2547 shall be used for plaster of Paris punning.

3.4 Water Supply

GI pipes of Medium quality conforming to IS 1239 (Part I-1990) or CPVC pipes conforming to IS 15778 shall be used for all portable hot and cold-water distribution supply and plumbing works.

The Syntax or equivalent make PVC storage water storage tank conforming to IS: 12701 shall be provided over the roof of the CMCS with adequate capacity for 10 No person and 24-hour requirement, complete with all fittings including float valve, stopcock etc. The capacity of the tank shall be minimum 500 litres.

3.5 Grouting

Cement mortar (1:2) grout with non-shrink additives shall be used for grouting below base plate of a column. The grout shall be high strength grout having a minimum characteristic compressive strength of min 30 N/mm^2 at 28 days.

3.6 Structural Steel

Structural steel design shall be carried out as per IS 800 and IS 801. Structural steel shall conform IS 2062 / IS 1079 or equivalent, Pipe shall be as per medium/high grade of IS 1161, Chequered plates shall conform to IS 3502 and Hollow steel sections for structural use shall conform to IS 4923.

3.7 Structural Steel/Steel Sheet Painting

All non-hot dip galvanised structural steel (excluding Module Mounting & SCB structure)/ Outdoor metal containers/ Enclosure/ Rolling shutter items shall be provided with paint designed for a minimum maintenance-free life of fifteen (15) years (high durability) as per **ISO 12944 and IS 800 or equivalent for its corrosion category**. For finishing coat suitable colour pigment shall be added. All paints including primer shall be of the reputed brand/manufacturer and as approved by the Engineer-In-charge. The method of application shall be as per the recommendations of the manufacturer. For corrosive category of refer appendix of site-specific data.

4.0 Transformer Yard and Metering Yard Civil Works

a) Transformer and equipment's foundations shall be founded on piles/isolated spread footings depending on the final geotechnical investigation report. Metering yard equipment's structures shall be designed as per IS 801 and IS 800.

b) Transformer foundations shall have its own pit which would cover the area of the transformer and cooler banks, so as to collect any spillage of oil or oil drainage in case of emergency. The oil pit shall be filled with granite stones of 40 mm size uniformly graded.

c) The bidder can propose soak pit under Transformer or Burnt oil pit at a distance connected to transformer soak pit depending upon oil quantity in Transformers. It shall be sized to accommodate the oil volume of the transformer connected to it, without backflow. The Gravel-filled level under transformer shall be in accordance with FGL outside pit and transformer bottom level.

d) The area around the transformer and equipment's shall be covered with gravel and galvanized chain link fence of height min 1.8 m with fence posts and gates shall be provided. The portion of the fence covering towards rail track shall be made of a removable type for movement of the transformer during erection /removal. In addition, a small gate, 1.2 m wide shall be provided for an entry. The transformer yard fencing work shall conform to CEIG requirements.

e) Transformer track rails shall conform to IS 3443. The requirement of a fire barrier wall between transformers shall be as per Electricity Rules and IS 1646 recommendations.

5.0 PIPE /CABLE RACKS & TRENCHES

a) The conventional methods of cables laying and installation shall conform to IS 1255 for laying direct in ground, drawing in ducts, laying on racks in air, laying on racks inside a cable tunnel and Laying along buildings or structures, etc.

b) Outdoor RCC Cable Trenches: RCC outdoor cable trenches in switchyard area shall be provided with pre-cast RCC removable covers with lifting arrangement. The top of outdoor trenches shall be kept at least 100 mm above the gravel level so that rainwater does not enter the trench.

c) Indoor RCC Cable Trenches: RCC indoor cable trenches shall be provided with **50X50X4** mm angles grouted on the top edge of the trench wall for holding minimum 6 mm thick mild steel checkered plate covers conform to IS: 3502 with lifting arrangement.

d) RCC cable trenches shall be constructed with wall thickness minimum 100 mm.

e) Trench Drainage: The trench bed shall have a slope of approx. 1/500 along the run & 1/250 perpendicular to the run. Incase straight length exceeds 30 m, suitable expansion joint shall be provided at appropriate distances. The expansion joint shall run through vertical wall and base of the trench. All expansion joints shall be provided

with approved quality PVC water stops. Suitable drainage at the lowest point of the trench shall be provided.

6.0 PLANT DRAINAGE SYSTEM

a) All Drains within a plot are in Bidder's Scope. Drawing by GIPCL shared as part of Tender Drawings is for reference purpose only however overall design should be on similar lines as provided in the said drawing. Lining of drains shall be as per provisions of Bidding Documents and applicable IS/IRC Code provisions.

b) Internal drains in all plots would also be developed and connected to Main drains (Along the Main Roads on West and East Side of Main CIL Plot) in due course of time. Main drains need to be designed as per layout of Roads and shall be suitable to take care of entire North Block's catchment area such that Main drains to be constructed in Northern Side (upper region plots, at a later date) can be suitably connected to the Main Drains in due course of time.

c) Surface drainage system shall be designed considering 'Heaviest rainfall in one hour in mm'. The minimum value of surface run off coefficient shall be considered as 0.6 in the design of drainage system. The drainage system shall be designed as per the IRC specifications and prevailing industry practices.

d) The drainage scheme shall be designed considering the catchment areas contributing to the existing drains, solar plant gradients and solar PV array layout. As per plant drainage requirement, a network of open drains shall be designed & provided to carry surface runoff. The drains shall be trapezoidal, rectangle section made of earthen type lining (Compacted Earth Lining) and hard surface lining (stone masonry/pitched, Boulder, Precast cement concrete/stone slab, *in-situ* cement lime/concrete lining, soil cement lining, etc.)

e) Bidders can also propose suitable detention pond, recharge dugwells, recharge pits, recharge trenches, and recharge soakways for quick disposal of storm water in the vicinity of the solar block/plot.

f) Bidder shall also ensure that drainage from his plot does not encroach/flood into the adjacent property and adjacent solar plots (if any). Bidder shall try to maintain existing natural drain and shall remodel the natural drains in case of any disturbance made. The same shall be as per the technical/design requirements without affecting the drainage pattern. The bidder plot drainage scheme shall include to drain out the drainage of the allotted plot and shall include contributing catchment area consisting of adjoining plots and nearby catchment area.

g) Provision of culverts and their design to be submitted separately. The road on the culvert portions of the drains shall be concrete road.

h) All Buildings shall be provided with plinth protection all around, sloped towards side drains. Plinth Protection shall be 75mm mm thick PCC laid over well compacted 75mm well grades brick ballast base. Building peripheral drains shall be stone

masonry/brick masonry/concrete works. These side drains shall be connected to area drains by either open drains or combination of open drains and underground pipes.

i) Grade level shall be fixed with due reference to highest high flood level of the receiving body of water. Laying of Hume pipe shall be in line with IS: 783.

j) Recommended Side Slopes for lined and unlined drains, other than RCC drains and Brick wall drains

Sl	Type of Soil	Side Slopes (Horizontal: Vertical)
1.	Very light loose sand to average sandy soil	2: 1 to 3: 1
2.	Sandy loam, Ordinary soil	1.5 : 1 to 2 : I (in cutting) 2 : I (in embankment)
3.	Sandy gravel/murum	1.5 : 1 (in cutting) l.S : I to 2 : I (in embankment)
4.	Black cotton	1.5 : 1 to 2.5 : I (in cutting) 2 : I to 3.5 : I (in embankment)
5.	Clayey soils	1.5 : I to 2 : I (in cutting) 1.5 : 1 to 2.5 : I (in embankment)
6.	Rock	0.25 : 1 to 0.5 : 1

i) A. Limiting velocity in **unlined drains**:

Very light, loose and to average sandy soil	0.60 m/sec.
Ordinary soil, Sandy loam, black cotton soil & similar soil	0.90 m/sec.
Murrum, hard soil	1.1 m/sec.
Gravel and disintegrated rock	1.5 m/sec.

B. Limiting Velocities in Different Types of **Lining in drains**:

Stone-pitched lining	1.5 m/s
Burnt clay tile or brick lining	1.8 m/s
Cement concrete lining	2.7 m/s

All above parameters may be suitably adjusted based on inputs being made available by CIL (Owner) for reference purpose. Also, any specific reference mentioned for Drain design in any IS Code or IRC Code would also be acceptable subject to approval of overall design during detailed Engineering stage.

All project drains would connect to the main drains of Park as per detailed layout to be prepared during detailed Engg. stage.

7.0 ELECTRIFICATION OF BUILDING

Electrification of all building shall be carried out as per IS 732-1989, IS: 4648-1968 and other relevant standards.

8.0 APPROACH ROADS

The approach road to the Solar Power Plant shall originate from the main approach road and connect to CMCS building, Metering yard/ Switchyard and Gates (whether or not such buildings are in Bidder's scope, all internal roads and their connection to Park facilities within project would be in Bidder's Scope only).

Approach Road: The approach road to the Solar Power Plant shall originate from the main approach road and connect to all Inverter rooms, module cleaning station and gates. Approach road shall be minimum 3.0 meter wide with minimum 500 mm wide shoulder on both sides.

Main Roads between the plots have been marked in the Layout Drawings, internal roads within the plot would be finalized as per bidder's detailed array layout.

Road sections for Main Roads (as marked in Layout Drawing) and Internal roads (with in the plot) shall be constructed as per respective Plot Map attached in Annexure.

9.0 LIST OF APPLICABLE INDIAN STANDARDS

Indian codes, and/or standards shall govern, in all the cases wherever they are available. In case of a conflict between such codes and/or standards and the specifications, the stringent provisions shall govern. Such codes and/or standard referred to shall mean the latest revision, amendments/changes adopted and published by the relevant agencies. In case of any further conflict in this matter, the same shall be referred to the Engineer-in- charge, whose decision shall be final and binding.

Other internationally acceptable standards shall be accepted, only if, no Indian Standards are existing. However, other standards also will be accepted if the Bidder establishes that the works are meeting the requirements of Indian Standards also.

A brief list of Indian Standards applicable to these works is as below:

General

IS: 875-I	**Code of Practice for Design Dead Loads for Building and Structures**
IS: 875-II	**Code of Practice for Design Imposed Loads for Building and Structures**
IS: 875-III	Code of practice for design loads (other than earthquake) for buildings and structures.
IS: 1893	Criteria for earthquake resistant design of structures.

IS: 4326	Code of Practice for earthquake resistant design and construction of buildings

Foundations

IS: 1080	Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell)
IS: 1904	Code of practice for structural safety of building foundations
IS: 2950	Code of practice for design and construction of raft foundations.
IS: 4091	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles
IS: 6403	Code of Practice for determination of bearing capacity of shallow foundations
IS: 8009	Code of Practice for foundation settlement calculations
IS: 2911	Design & Construction of Pile Foundation – Code of Practice

Concrete Structures

IS: 456	Code of practice for plain and Reinforced concrete
IS: 3370	Code of practice for concrete structures for the storage of liquids.
IS: 3414	Code of Practice for design and installation of joints in buildings
IS: 5525	Recommendation for detailing of reinforced concrete works
IS: 6313	Code of practice for anti-termite measures in buildings
IS: 13920	Ductile detailing of Reinforced Concrete Structures subjected to Seismic forces
IS: 1904	Code of practice for design and construction of foundations in soils general requirements

Steel Structures

IS: 800	Code of practice for use of structural steel in general building construction
IS: 801	Code of practice for use of cold-formed light gauge steel structure members
IS: 802	Code of Practice for use of Structural Steel in over Head Transmission Line Towers.
IS: 806	Code of practice for use of steel tubes in general building construction.
IS: 808	Dimensions for hot rolled steel beam, column channel and angle section
IS: 811	Specification for Cold Formed Light Gauge Structural Steel Sections
IS: 813	Scheme of symbols for welding
IS: 1079	Hot Rolled carbon Steel Sheet and Strip – Specification
IS: 2062	Hot Rolled Medium and High Tensile Structural Steel – Specification
IS: 4923	Hollow steel sections for structural use.
IS 1161	Steel tubes for structural purpose
IS: 2721	Galvanized steel chain link fence fabric – Specification

Painting and Coating

IS: 4736	Hot-dip zinc coatings on mild steel tubes

IS: 4759	Hot-dip zinc coatings on structural steel and other allied products – Specification
IS:1868	Anodic coatings on aluminum and its alloys
IS 2395-I	Painting of Concrete, Masonry and Plaster Surfaces – Code of: Operations and Workmanship
IS 2395-II	Code of practice for painting concrete, masonry and plaster surfaces: Schedule
IS 1477-I	Code of Practice for Painting of Ferrous Metals in Buildings: Pre-treatment
IS:1477-II	Code of practice for painting of ferrous metals in buildings: Painting
ISO 12944-1	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments
ISO 12944-5	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 5: Protective paint systems

Water supply and sanitary

IS: 1239	Mild steel tubes and tubulars and other wrought steel fittings
IS: 1172	Code of basic requirements for water supply, drainage and sanitation
IS: 1742	Code of Practice for building drainage
IS: 2527	Code of practice for fixing rainwater gutters and down pipes for roof drainage.
IS: 15778	Chlorinated polyvinyl chloride pipes for potable hot and cold water distribution supplies
IS: 16088	Chlorinated polyvinyl chloride pipes for automatic sprinkler fire extinguishing system
IS: 10124	Fabricated PVC fittings for potable water supplies
IS: 4985	Un-plasticized PVC pipes for potable water supplies
IS: 13592	Un-plasticized Polyvinyl Chloride (PVC-U) Pipes for Soil and Waste Discharge System Inside and Outside Buildings Including Ventilation and Rainwater System
IS: 12818	Un-plasticized polyvinyl chloride (PVC-U) screen and casing pipes for bore/tubewell
IS: 2470	Code of Practice for installation of septic tanks

Lining

IS 3872	Lining of Canals with Burnt Clay Tiles - Code of Practice.
IS 3873	Laying cement concrete/stone slab lining on canals - Code of practice.
IS 4515	Stone Pitched Lining for Canals - Code of Practice.
IS 7113	Soil-Cement Lining for Canals - Code of Practice.
IS 7873	Code of practice for lime concrete lining for canals.
IS 9097	Guide for laying lining of canals with hot bitumen or bituminous felts.
IS 10430	Criteria for Design of Lined Canals and Guidance for Selection of Type of Lining.
IS 10646	Canal linings - Cement concrete tiles.

IS 11809	Lining for canals by stone masonry - Code of practice.
IRC:SP:50	Guidelines on urban drainage.

Miscellaneous

IS: 1905	Code of Practice for structural use of un-reinforced masonry
IS: 3067	Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
SP: 6	Handbook for structural engineers (all parts)
SP: 7	National Building Code of India
SP: 16	Design Aids for reinforced concrete to IS:456
SP: 20	Handbook on masonry design and construction
SP: 22	Explanatory handbook on codes for earthquake engineering
SP: 24	Explanatory handbook on Indian Standard Code of Practice for plain and reinforced concrete
SP: 25	Handbook on causes and prevention of cracks in buildings
SP: 32	Handbook on functional requirements of industrial buildings
SP: 34	Handbook of concrete reinforcement & detailing
IRC: 37	Guidelines for design of flexible pavements
IRC: 42	Guidelines on Road Drainage
IRC: 58	Guidelines for the design of rigid pavements for highways
IRC: 73	Geometric design of roads

C-6 SWITCHYRAD CIVIL WORKS

NA

PART-B
D – GENERAL SYSTEMS

D-1 WEATHER MONITORING STATION

As a part of weather monitoring station, Bidder shall provide following measuring instruments with all necessary software & hardware required to integrate with SCADA so as to enable availability of data from meteorological instrument in SCADA. Each instrument shall be supplied with necessary cables, transmitters and accessories (Trackers, Mounting and base stand etc.) provided by OEM of the sensors only.

Aux. power required by instruments and data logger (If supplied) shall be from UPS only. Data logger shall have provision to receive redundant power supply.

All the instruments to be supplied shall have valid calibration certificate.

Single sensor for measuring combination of Wind Speed, Wind Direction, Relative humidity and Rainfall is also acceptable however offered sensor shall meet the specification as mentioned in following sections.
Bidders are advised to ascertain themselves, the applicable regulation related to weather data which has to be transmitted to control centers like SLDC/RLDC (Telemetry). Any signal/parameter/equipment though not specifically mentioned but which are required as per statutory regulation are also included in the scope of bidder.

1.0 SOLAR RADIATION SENSORS

Contractor shall provide Solar Radiation Sensors as per specification given in following section. Contractor has the option to provide these sensors on separate base or on a single base (radiation monitoring station) with tracker, shadow ring and transmitter etc provided by the OEM. Calibration certificate with calibration traceability to World Radiation Reference (WRR) or World Radiation Centre (WRC) shall be furnished along with solar radiation sensors. Bidder shall provide Instrument manual in hard and soft form.

1.1 Pyranometer

Bidder shall provide minimum **02 (Two) numbers** of Secondary Standard Pyranometers as per ISO 9060 **for measuring incident solar radiation as per following**

- Global Horizontal Irradiance (GHI)- 1 Nos.
- Global Inclined Irradiance (GII)-1 Nos

Technical Requirement of Pyranometer (for GHI and GII)

Sl.No	Details	Values
1.	Principle	Thermopile
2.	Spectral Response.	310 to 2800 nm
3.	Sensitivity	Min 7 micro-volt/w/m^2
4.	Time response (95%):	Max 15 s
5.	Non linearity:	±0.5%
6.	Temperature Response:	±2%
7.	Tilt error:	< ±0.5%.

8.	Zero offset thermal radiation:	±7 w/m^2
9.	Zero offset temperature change	±2 w/m^2
10.	Operating temperature range:	0 deg to +80 deg.
11.	Uncertainty (95% confidence Level):	Hourly- Max-3%, Daily-Max-2%
12.	Non stability:	Max ±0.8%
13.	Response Time (95% of final value)	<5 sec

Additionally, 01 (one) number **second class pyranometer** as per ISO 9060 for measurement of **Diffuse Horizontal Irradiance (DHI)** shall also be supplied.

Shadow ring/ball for measuring DHI shall require no regular adjustment for of tracker and shadow ring/ball. Pyranometer shall be shaded throughout the day and shall be exposed to diffuse solar radiation only to provide DHI value without any calculation.

All the Pyranometer have to be mounted at single location at shadow free area. The GII Pyranometer has to be at the same inclination as the angular tilt of module mounting structure. The above quantity of pyranometers shall be installed at central weather monitoring system.

Bidder shall provide 1 (One) no. Battery powered portable handheld data logger supplied by the OEM of the offered Pyranometer.

In addition to the above, bidder shall provide extra pyranometers, each with same specification & SCADA integration, such that one pyranometer exists for every 100MW capacity and part thereof. i.e. additional 2 more pyranometers apart from the set installed at central weather monitoring system. The location of these pyranometers shall be finalized during detailed engineering stage. The mounting structure shall have provision to fix the pyranometer in horizontal and tilted position.
Bidder shall also refer the requirement of returnable pyranometers as mentioned in Cl. 3.0 of D-6.

2.0 TEMPERATURE SENSORS

2.1 Ambient Air Temperature Sensor (Qty -1 no.)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-50 ^{o}C
3.	Accuracy	+ 0.2 ^{o}C
4.	Operating Temperature	0 to 50 ^{o}C
5.	Radiation Shield	Non-aspirated Radiation Shield

2.2 **Indoor Air Temperature Sensor (Qty – 1 no. at each Inverter room)**

"In case outdoor inverter is offered and associated equipment like PLC/RTU panel etc. is offered inside a closed room then minimum 2 such rooms shall be provided with temperature monitoring to be hooked up with SCADA."

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-70 ^{o}C
3.	Accuracy	+ 0.2 ^{o}C
4.	Operating Temperature and calibration	0 to 70 ^{o}C

2.3 **Module Temperature Sensor (Qty – 1 no. per 05 MWp)**

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-100 ^{o}C
3.	Accuracy	+ 0.2 ^{o}C
4.	Operating Temperature	0 to 100 ^{o}C

Module temperature sensor shall be fixed on the back of module surface with adhesive or tape without using any mechanical fastener.

3.0 Wind Sensor (Qty- 1 no)

Sl.No	Details	Values
1.	Principle	Frequency proportional to wind speed/Ultrasonic Sensor
2.	Velocity range	0-60 m/ sec
3.	Threshold	0.3 m/s
4.	Operating Temperature	0 to 50 deg C
5.	Accuracy	3% (upto 35 m/s), 5% (Above 35 m/s) RMS

3.1 **Wind Direction Sensor (Qty- 1no)**

Sl.No	Details	Values
1.	Principle	Potentiometric type sensor (Resistance proportional to Wind direction) /Ultrasonic Sensor
2.	Range	0-360 deg
3.	Accuracy	±5 deg
4.	Operating Temperature	0 to 50 deg C

4.0 RELATIVE HUMIDITY (%) (Qty- 1no)

Sl.No	Details	Values

1.	Range	0-100 %
2.	Accuracy	±3%
3.	Resolution	1%
4.	Operating Temperature	0 to 50 deg C

5.0 Additional Measurement

As per regulatory requirement, following measurement for the Solar PV is also included in the scope of bidder.

i. Direct Normal Irradiance (DNI)
ii. Sunrise and Sunset time
iii. Rainfall (mm)
iv. Cloud Cover –(Okta)
v. Air Density

Instrument and accuracy for the above-mentioned measurement shall comply with applicable regulation ("Implementation of the framework on forecasting, scheduling and imbalance handling for Renewable Energy (RE) generating stations including Power Parks on Wind and Solar at Inter-State Level").

6.0 CALIBRATION

All the measuring instruments to be supplied shall have valid and traceable calibration certificate. Each Pyranometer shall be recalibrated at an interval not more than two years and all other instruments shall be recalibrated at an interval not more than four years.

7.0 DATA LOGGER

Weather Monitoring system shall be provided with standalone Data logger suitable for outdoor application with IP65 Protection and industrial grade hardware suitable for operating temperature up to 55 Deg. C. Data logger shall be calibrated and proven in field for at least one year in outdoor environment. Data logger shall have following minimum features:

Processor	32 bits
Time synchronization	With Built in GPS Clock or with Solar SCADA GPC Clock
Wireless communication	GSM/GPRS Modem
Data storage	SD card, Min 2GB for storage of raw and processed data locally at resolution of 1 Second for retrieval whenever required. Data to be stored shall be in unencrypted CSV or equivalent format.
Display	LCD display for easy maintenance and debugging for site engineer
Scan resolution	3 sec or better

Analog to Digital Converter (ADC)	16 Bit, Sampling -10 Hz (Min)
I/P Channel	As required with 20 % spare of each type of channel

It shall have facility for arithmetic processing (Time Integration, Simple Average, and Moving Average etc.) of incoming raw data. Data logger shall be interfaced with Solar SCADA on modbus preferably on TCP-IP. Vendor shall submit Factory Acceptance Test (FAT) report and procedure before dispatch of material to site.

Data logger shall be provided with key-locked door access and all the cables (Power and Signal) to the data logger shall be protected with heavy duty HDPE pipes.

Project file (software, settings and sample reports) shall be handed over to site on permanent storage media (CD/DVD) in two copies after data integrity is verified by site and weather monitoring is commissioned. Any configuration changes shall be possible only with authorized User ID and password.

8.0 METEOROLOGICAL STATION

Sensors shall be installed at suitable height for which Mast/Structure for the sensor shall be provided by the bidder. Proper fencing shall be provided around meteorological station where the Pyranometer, Wind, Ambient Temp. Sensor, Data logger etc. are installed.

9.0 SOILING STATION

The Soiling Measurement System shall measure the performance loss from a PV array due to accumulation of dust, dirt, and other site-specific contaminants, collectively known as “soiling”. Soiling Stations shall use two full-sized modules. One is allowed to soil naturally, while the other is cleaned with an automatic washing system. Power and energy are monitored for both modules.

Bidder scope cover supply of complete system and its installation that includes Data logger, Automatic Module Cleaning System, cabling, software setup and interface with solar SCADA as per the technical requirement mentioned herein. Bidder shall also provide Solar PV module and its support structure.

One soiling station for every 100MW capacity and part thereof shall be provided.

TECHNICAL REQUIRMENT

The system shall consist of an automatic cleaning system that prevents soiling accumulation on the PV reference module (clean one), another PV module (Soiled one) which is allowed to accumulate soiling at the site-specific rate, an electronic data acquisition and analysis unit.

All components are provided in outdoor rated NEMA 4/IP 65 enclosures for long-term outdoor use. All cables are rated for outdoor use.

Following requirements are to be taken care by bidder:-

i) Data logger shall be field tested and shall be in satisfactory operation for a period not less than 6 Months.

ii) Data logger shall be calibrated (Measurement uncertainty less than 2%) before dispatch and calibration shall be traceable to any National/International lab. Data logger shall have flash memory not less than 1GB for local storage of data.

iii) Bidder shall submit the write up detailing the philosophy of measurement of soiling loss in his proposal. Measurement shall be based on comparison of Isc & Power.

iv) Datalogger shall have feature that includes but not limited to Moving Average calibration, Time Integration etc.

v) Bidder to facilitate the interfacing of data of Soiling Station to Solar SCADA on Modbus TCP/IP for trending, storage, retrieval and display of data

Automatic Cleaning System

The automatic cell-washing system cleans the PV reference module for accurate measurements. The system uses a suitable liquid spray to clean the reference module at user-determined intervals. The liquid tank is minimum 100 Liter. Under typical soiling conditions the liquid reservoir must be refilled periodically using the suitable liquid specified by OEM of Soiling station/PV module supplier.

Bidder shall supply 2 Nos of spare spray nozzle along with supply.

Measurements

The following measurement readouts are available via the Modbus interface:
Direct Soiling loss readout shall be available in SCADA for display and recording.

Temperature Rating

The system shall be rated for operation in ambient air temperatures from -20 °C to 60 °C

Any alternate technology proposed by bidder shall be reviewed during detailed engineering stage.

10.0 PV Analyzer (complete KIT with softwares)

Bidder shall provide minimum 2 Numbers of PV Analyzer Kits of reputed make to measure the PV Module performance. Analyzer kit shall have all necessary hardware connectors and required software for data analysis.

SL No	Details	Values
1.	PV Voltage	0-1500 V DC
2.	PV Current	0-30 A DC
3.	Voltage Accuracy	+/- 0.25 V
4.	Current Accuracy	+/- 40 mA
5.	Operating Temperature	0-60 Deg C

D-2 FIRE FIGHTING AND ALARM SYSTEM

11.0 GENERAL

The SPV plant shall be equipped with suitable fire protection & firefighting systems for protection of entire equipment, switchyard & control room as per CEIG requirements.

Bidder shall comply with recommendation of Tariff Advisory Committee for incurring minimal premium for insurance. The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection.

12.0 The firefighting system for the proposed power plant for fire protection shall consist of:

a) Sand buckets
b) Portable fire extinguishers
c) Microprocessor based fire alarm panel.

12.1 **Portable Fire Extinguishers and Sand Buckets**

Bidder to provide following numbers of type tested portable fire extinguishers as per relevant code in the rooms mentioned below.

Rooms (if applicable)	**DCP Type (ABC type) (10 Kg. Capacity)**	**CO_2 Type 9 kg capacity**	**Foam Type Hand 9 kg**	**Hand Portable pressurized water $C0_2$ 9 Litre**	**Sand Buckets**
Control Room	2	2	1	1	1
Each Inverter Room	1	1			
ACDB Room(If applicable	1	1			
Each Transformer Yard	1	1	1		1
Switchyard/Metering Yard	2	2			1
Security Room		1		2	
Pantry				2	

12.2 **Microprocessor based fire alarm panel**

Bidder to provide intelligent microprocessor based main fire alarm panel of modular construction complete with central processing unit, input and output modules, power supply module, supervision control and isolator modules with 10% spare provisions in each loop. Fire detection alarm system shall include) but not limited to the following items

1. Fire Alarm control Panel

2. Multi Sensor smoke detector
3. Heat Detectors
4. Hooter cum strobe
5. Manual call Point
6. Hooter
7. Fault isolation modules
8. Control Modules
9. Cables from Sensors to Fire panels.
10. Digital output from the fire detection system shall be integrated with SCADA
11. Network Control Module
12. Interfacing of Fire Alarm System with SCADA for display and storage of status and alarm in SCADA

Multi sensor type smoke detectors and heat detectors shall be provided for below false ceiling areas of control room and ACDB and/or inverter rooms. One (01) sensor shall be provided for each 20 sqm of area. All the cable trench inside the control room and inverter room shall be provided with Multi Sensor smoke detector.

Fault Isolation module shall be provided in every room and for every 15 sensors at location proposed by Bidder to be approved by employer during detail engineering.

12.3 **Fire Alarm Control Panel Indication**

i. Alarm conditions shall be immediately displayed on the control panel and in SCADA. Alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged the LED shall remain lit. A subsequent alarm received from another zone after acknowledgement shall illuminate the alarm LED and the panel display shall show the new alarm information.
ii. During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged.
iii. If the audible alarm signals are silenced for any reason, they shall automatically resound if another zone is activated.
iv. All alarm signals shall be automatically “locked in” at the control panel until the operated device is returned to its normal condition and the control panel is manually reset

There shall be weather proof Hooter cum strobe outside and strobe inside each Inverter room and control room for indication fire alarm for respective zone/area at suitable location that is visible from all direction. All the hardware, relay and accessories required for completeness of fire alarm system is in Bidder scope. Fire alarm system shall have its own battery and charger and it shall be provided power from UPS DB. Each Inverter room and control room shall be also be provided with manual call point, Alarm acknowledge and reset facility for alarm for respective zone only.

Bidder shall submit document to employer for approval that will include fire alarm system configuration, layout, BoM, Datasheet and necessary test report.

Bidder shall consider 30 % design and aging margin for selection of nos. of sensors in each loop and length of each loop. Bidder shall submit the certificate from OEM indicating maximum nos. of sensors in single loop and maximum length of single loop allowed with offered panel and type of cable to be used. Each Fire Alarm Control panel shall have provision for minimum 10 (Ten) % rounded to next higher integer but not less than 2 (two) nos. spare loops for future use of employer.

Bidder shall submit Site Acceptance Test (SAT) for approval by employer. Complete fire alarm system shall be checked at site for verification of faithful performance and completeness of the system. Bidder shall carry out necessary modification and supply hardware/accessories if required free of cost at site.

D-3 MODULE CLEANING SYSTEM

1.0 Wet Cleaning system with Fresh Water:

1.1 Bidder shall provide permanent arrangement for module washing in the SPV Plant. This shall include installing storage tank/deep tube/bore wells with pump and motor, requisite storage arrangement and laying network of HDPE pipe conforming to IS 4984 and other relevant codes. The module washing shall be complete in all respect and the details shall conform to the relevant IS codes. The complete scheme shall be subject to approval of the owner including inputs points, design and drawings for the system. Opening from the HDPE pipe with manual isolating valves should be provided at regular intervals. The opening pipes for fixing the movable/Hose pipes for spraying water on module shall be made of GI pipe. Bidder shall install flow meter at pump discharge/ main header for measurement of water consumption.

1.2 Design of solar PV module cleaning system shall be designed such that complete solar plant can be cleaned with fresh water **twice in a month**. Module cleaning system piping network shall be **close looped pipe network configuration** consists of Main pipe, sub- main and branches in the main plot. In array layout, if solar blocks is separated from main plot due to natural water body, nallah, roads, etc; Module cleaning system piping network may be design for **dead end/tree pipe network configuration**. Cut-off valves shall be provided at suitable junction points so that the repair works may be conducted at a particular area without disturbing the whole area.

The water used for cleaning should be of appropriate quality fit for cleaning purpose as per the recommendations of module manufacturer.

1.3 Bidder shall provide the piping and the **instrumentation diagram** (P&ID) of water washing arrangement including the physical sequence of branches, reducers, valves, pressure gauge, cleaning points with location of pump(s) and water storage tanks and submit for approval during detailed engineering.

1.4 The HDPE pipe shall be suitably protected against any impact load. The HDPE pipes shall be covered higher diameter GI pipe / NP3 Hume pipe at roads crossing for protection against any heavy loads etc. at roads section. The same protection shall also be provided wherever higher loads are expected. The bidder may also propose some other protection system for HDPE pipes.

1.5 Maximum length of hose pipe shall be 50 meters from tapping point.

1.6 The entire water washing system shall be tested for minimum 0.5 N/mm2 or double the maximum working pressure, whichever is greater.

1.7 End of the branch pipes/tapping points to be bent horizontal/downward to avoid entry of foreign materials like, earth, sand leaf, gravels, etc.

1.8	Bidder to ensure interconnection between the sub-systems of module washing system through isolating valve, so as module cleaning may be continued in case of outage of any sub-system.
1.9	Bidder shall ensure that the complete module washing system is integrated suitably with bore wells, check dam, motor and water pipe-line coming at the periphery of the respective plant i.e. near central PSS.
2.0	**Robotic Cleaning System (As applicable)**
2.1	The Module mounting structure/ table shall be designed and modelled considering connection details for robotic cleaning for travelling from one table to another. Crossing of overhead lines, cables through trays & pedestals, connecting approach road between the rows of MMS/Table in layouts shall be avoided for optimum use of dry/robotic cleaning system. Model of working shall be automatic cleaning, IP65 protection level, self-powered system with battery backup (without external supply), it should be compatibility & integrated with SCADA.
2.2	Each plot Bidder shall supply the complete robotic cleaning system at site as per approved Array/Plant layout drawings, and supervision of installation & commissioning by supplier along with owner O&M team, all other activities related to dry/robotic cleaning including storage, loading, unloading, transportation within site, its supply including start end docking station, bridge material required complete in all aspect, nuts and bolts, fasteners, installation, coordination, commissioning and any other activity not specified herein but required for successful commissioning of dry/robotic cleaning system is included in the scope of Bidder.
3.0	**Water Supply and Purification**
1.1	Raw Ground Water would be extracted by Owner through one Borewell located in nearby vicinity of PSS. The raw ground water is expected to be highly saline in nature.
1.2	Raw water would be provided after desalination and suitable tapping point would be made available to all the bidders at a given location in the vicinity of PSS. Exact location would be intimated to the bidders during detailed Engg. stage.
1.3	Water after desalination shall be tapped and transported by the bidders through permanent pipe network as detailed above in preceding paras.
1.4	Desalinated water as would be provided by the Owner, would be tested for its final suitability, by the bidder before using the same for module cleaning. Any further treatment of water if required for module cleaning as per technical requirements of modules, would be in Bidder's Scope only.

3.5	Accordingly, if required, Suitable capacity water softening / purification or RO system, as decided by the Bidder, shall be installed by the bidder for their respective scope of project(s), to make the supplied water as well as any rainwater stored through pits or RWH system, suitable for module cleaning and O&M purposes.
3.6	Suitable Earthing shall be provided as per I.E Rule/Act. Mandatory permission for bore well drilling shall be arranged by contractor if required from local competent.
4.0	**Main Road Crossing**
4.1	Permanent Main Road along with ide drains passing horizontally through the park in East-West Direction is envisaged to be built by the Owner.
4.2	Few Culverts are being provided to interconnect the Drains / Plots on N-S side of the Roads (**Refer Roads, Drain and Tr. Line Layout Drawing**).
4.3	Pipe / Cabling etc. where-ever required to pass the main road, would be suitably routed preferably through such culvert. However, it may be noted that because such culverts would be subject to water ingress during monsoons, bidders would be required to plan their pipe /cable routing and overall system design in a manner that all pipes, cables, equipment, panels etc., are safe for operation, during design life of plant.

D-4 PROJECT COMMISSIONING AND OTHER GENERAL REQUIREMENTS

1.0 PART CAPACITY COMMISSIONING:

CIL shall accept part capacity commissioning of Solar plant subject to the following conditions:

1. If acceptable to the solar power buying entity as per power sale conditions.
2. Minimum capacity for acceptance of first and subsequent part(s) commissioning shall be subject to acceptance of RLDC/other statutory bodies in compliance with grid code and other regulations/power sale conditions as mentioned above.

General conditions for Part/Final commissioning

1. All strings as per approved design shall be connected to inverter DC side.
2. Corresponding AC side works shall be completed for arranging dispatchable power to Grid along with data communication till RLDC.
3. The commissioning clearances shall be obtained from statutory authorities.

Scheduled Commissioning date will not get altered due to part commissioning.

Part Capacity/Final Commissioning and Trial run shall be carried out in compliance with the all-applicable statutory regulations (Latest) like Indian Electricity Grid Code, SLDC/RLDC, MNRE, CEA, STU/CTU requirements.

SPV Plant shall be deemed to be successfully commissioned only after commissioning acceptance/approval by RLDC for such capacity.

2.0 INSURANCE

The bidder's insurance liabilities pertaining to the scope of works are detailed out in Clauses titled Insurance in NIT.

D-5 OPERATION AND MAINTENANCE

1.0 The successful bidder shall carryout Operation and maintenance of complete SPV Plant along with power evacuation system till point of grid interconnection (including grid substation bays) from date of commissioning of full project capacity. Additionally, bidder to refer commercial portion of bidding document for details regarding O&M of part capacity commissioned**.** During O&M period, CIL personnel shall have unrestricted entry to the solar plant and Control Room any time. CIL may suitably depute its personals to associate with O&M activities. Contractor shall assist them in developing expertise through their day to day O&M activities. All records of maintenance must be maintained by the contractor which can be accessed by CIL on demand. These records are to be handed over to CIL after the O&M period of contract.

2.0 The bidder shall be responsible for supply of all spare parts, repairs / replacement of any defective equipment at his own cost as required from time to time during the O&M period.

3.0 The contractor shall be responsible for the Operation and Maintenance of the entire Solar PV plant during the O&M period. The brief scope of works is listed below. The details shall be further elaborated by the bidder in the O&M manual to be submitted to CIL for approval.

(a) Ensuring successful operation of SPV Plant for optimum energy generation.
(b) Ensuring Breakdown maintenance, Preventive maintenance overhauls, Arranging visit of O&M experts (when required) to maximize the availability of the solar plant.
(c) Daily work of the operators involves logging the voltage, current, power factor, power and energy output of the SPV plant, temperature, logging down individual array output data once a day
(d) The operator shall record monthly energy output of each array and transformer and reports shall be prepared on performance of SPV plant
(e) Submission of periodical reports to the owner on the energy generation & operating conditions of the SPV plant.
(f) Ensuring Safety and protection of the plant by deputing sufficient security personals
(g) Monitoring, controlling, troubleshooting, maintaining of records, registers.
(h) Supply of all type of maintenance spares, consumables and fixing / application of the same. In order to meet the emergent requirements, contractor, with the permission of Employer can utilize the mandatory spares being supplied under the contract. However, the used spares shall be replenished by the contractor within reasonable time.
(i) Cleaning of the plant including array yard on regular basis and as and when required.
(j) Cleaning of drains, cable trenches, box culverts etc.
(k) Module washing as per as per approved schedule.
(l) Herbicide spray and grass cutting on a periodic basis
(m) The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.
(n) The Contractor shall ensure that all safety measures are taken at the site to avoid accidents to his employees or his Co-contractor's employees

(o) The Contractor shall immediately report the accidents, if any, to the Engineer In charge & to all the concerned authorities as per prevailing laws of the state.

(p) The Contractor shall comply with the provision of all relevant Acts of Central or State Governments including payment of Wages Act 1936, Minimum Wages Act 1948, Employer's Liability Act 1938, Workmen's Compensation Act 1923, Industrial Dispute Act 1947, Maturity Benefit Act 1961, Employees State Insurance Act 1948, Contract Labor (Regulations & Abolishment) Act 1970 or any modification thereof or any other law relating whereto and rules made there under from time to time.

(q) In order to ensure longevity, safety of the core equipment and optimum performance of the system the contractor should use only genuine spares of high quality standards.

(r) Deployment of Plant in Charge, adequate number of technical support staff and other supporting personnel during the O&M period

(s) Bidder is required to maintain adequate O&M spare during the O&M contract period of the Solar PV plant with the view to maximize availability and generation of the plant. In case, Contractor uses mandatory spares, provided by CIL, the contractor shall have to return/replenish the spare(s) of the matching quality, quantity and rating within shortest possible time.

(t) At the time handing over of the plant by the contractor to CIL, the contractor shall handover equipment and spares in healthy condition.

(u) Bidder has to take Comprehensive Annual Maintenance Contract (AMC) from Original Equipment Manufacturer (OEM) ***or OEM authorized service provider*** for a period of 10 years for the following components:

- PCU System
  Replacement of spares like inductors, capacitors, electronic cards as per OEM recommendations
- SCADA & PPC
- Tracker System
  Replacement of spares as per OEM recommendations

Comprehensive AMC shall include all preventive maintenance and breakdown maintenance including replacement of any component to ensure that equipment is working satisfactorily as per design/system requirement. During AMC period, the OEM or its representative are required to visit at least once a year or as per OEM recommendation cycle for periodic maintenance. During AMC period, the OEM is required to respond within one working day through telecom or any electronic mean. In case of breakdown of the system, OEM has to send their representative within 72 hours. For the minor faults not hampering the generation e.g. communication, display etc., the OEM has to get the fault rectified within 7 working days.
Failure from the OEM to adhere the activity and the time schedule may lead to BG encashment.

(v) Replacement of equipment/spare parts/ updating of softwares being phased out or not being supported by OEM's is also included in bidder's scope.

(w) Contractor shall be responsible to carry out all test and work as required by statutory regulation in effect as on date of Techno-commercial bid opening during O&M period.

4.0 Insurance

As Per NIT

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5.0 LD for shortfall in Generation during O&M

Refer special condition of contract section-III

5.1 **Calculation of LD and Proposal for 50 MW Sample Project**

As per clause 2.0 APPENDIX 3A of TECHNICAL SPECIFICATIONS

5.2 Contractors' liability during AMC period.

As per this chapter and Chapter 1-A (Appendix – 3B)

6.0 Handing over of the Plant

(a) At the end of the contract period, the contractor shall hand over the plant and equipment back to the owner in completely safe and healthy condition and without any pending defect.

(b) The items supplied by CIL on returnable basis, such as spares parts (from mandatory spares or through procurement)), consumables, tools and plants, documents etc. shall be returned back to CIL. Else suitable recoveries shall be made from the Contractor's bills.

7.0 After O&M period, CIL may at its discretion decide to extend the existing O&M contract on mutually acceptable terms & conditions or undertake the O&M of the SPV Plant on its own.

D-7 SAFETY MANAGEMENT

1.0 Bidder shall submit the Safety Plan and the Safety Coordination Procedure as per the requirement of relevant Attachments of the bidding documents.

2.0 During the execution of the contract, the bidder and it's sub-vendor(if any) shall follow safety procedures for the safety of the personnel and the equipment during erection, testing, commissioning, operation and the maintenance during the contract period as per the regulatory requirements and the as per the original equipment manufacturer's recommendations.

3.0 All the expenses, charges towards compliance of the safety norms by the bidder as per the Safety Plan, Safety Policy, and the Safety Coordination Procedures are deemed to be included in the bid price. No additional claims shall be entertained towards meeting the safety requirements. Minimum price to be quoted for 'Safety Aspects/ compliance to Safety Rules' shall be as per relevant clause of bidding document.

4.0 Safety sign board to be provided near outdoor transformer yard, HT switchgear and all such risk zone areas.

PART-B
E – QUALITY ASSURANCE

E-1 QUALITY ASSURANCE ELECTRICAL

COMPONENTS
1) Array Junction Box/ String Monitoring Box/ String Combiner Box
2) PCU
3) LT Switchgear & LT Busduct
4) Cabling, Earthing, Lightning Protection.
5) Control Cables
6) LT Power Cables
7) MV (3.3kV/ 6.6 kV/ 11kV/ 33kV) Cables
8) HT Switchgear
9) SCADA and Accessories
10) DC System
a) Battery
b) Battery Charger
c) DC Health Monitoring System
11) Station Lighting
12) Transformer
13) Switchyard/Substation
14) Energy Meter
15) Module cleaning System and Ventilation

Components wise QA Chapter has been furnished below.
Indicative list of Vendors Approved for Electrical Components & Civil works are enclosed below.

2. **PCU (Inverter)**

PCU quality plan should include the following

A) Incoming Quality Checks on bought out items as per relevant standard as mentioned in Technical Specifications (TS)

B) In-process quality checks

C) Routine tests as per following on the assembled PCU:

1) Check of Dimension, Paint shade, Paint Adhesion, Thickness, make, rating, degree of protection, doors.

2) Uploading of Software to control board and checking of general parameter setting including protection settings (Manufacturer to perform on 100% Panel)

3) Control Circuit functional check including operation of contactors, relay and Circuit breakers (Manufacturer to perform on 100% Panel)

4) Display Panel functionality including Digital Input/Output check, Direction of rotation and ON-OFF control of the fans, Protection function check (by simulation or direct method), Abnormal voltage and frequency, DC ground fault, DC reverse polarity, AC & DC Over voltage, Calibration test (DC Voltage, AC Voltage and Frequency), Testing of wake up / auto start and stop with grid connectivity, Manual ON/OFF from PCU MMI with grid connectivity, IR test on main and control circuit, HV test on main and control circuit. (Manufacturer to perform on 100% Panel)

D) Following sample tests on the assembled PCU: (1 Panel per offered lot)

1. Sample testing to include measurement of phase currents, efficiencies, harmonic content and power factor at four points preferably 25%, 50%, 75% and 100% of the rated nominal power.
2. Maximum power point tracking (MPPT) functional check

3) LT SWITCHGEAR & BUS DUCT

SQE _10

LT SWITCHGEAR

(MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)

ATTRIBUTES / CHARACTERIS-TICS **ITEMS/ COMPONENTS/ SUB SYSTEM ASSEMBLIY** ↓	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per CIL Spec.	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint Shade, Adhesion, Thickness & Finish	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per CIL spec	All Routine tests as per CIL spec.
Sheet Steel (IS :513)	Y	Y		Y	Y		Y							
Aluminum Bus bar Material (IS : 5082)	Y	Y	Y	Y	Y		Y							
Copper Bus bar Material (IS: 613)	Y	Y	Y	Y	Y		Y							
Support Insulator	Y	Y	Y	Y			Y							
Air Circuit Breaker (IS: 13947)	Y	Y				Y	Y			Y	Y			Y
Energy Meters (IS: 13010, 13779)	Y	Y				Y	Y			Y				Y
Power & Aux. Contactors (IS: 13947)	Y	Y				Y	Y			Y				
Protection & Aux. Relays (IS : 3231) (IEC 60255 / IEC 61850)	Y	Y				Y	Y			Y				Y
Control & Selector Switches (IS: 13947)	Y	Y				Y	Y			Y				
CT's & PT's (IS 2705 / 3156)	Y	Y					Y							Y
MCCB (IS: 13947)	Y	Y					Y			Y				
Indicating Meters (IS: 1248)	Y	Y				Y	Y			Y				Y
Indicating Lamps (IS: 13947)	Y	Y				Y	Y			Y				
Air Break Switches (IS: 13947)	Y	Y				Y	Y			Y				
Control Terminal Blocks	Y	Y				Y	Y							

LT SWITCHGEAR

(MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)

ATTRIBUTES / CHARACTERISTICS **EMS/ COMPONENTS/ SUB SYSTEM ASSEMBLIY** ↓	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per CIL Spec.	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint Shade, Adhesion, Thickness & Finish	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per CIL spec	All Routine tests as per CIL spec. & IS
Fuse (IS 13703)	Y	Y				Y	Y							
Control Transformer (IS: 12021)	Y	Y				Y	Y			Y				Y
Push Buttons (IS: 4794)	Y	Y				Y	Y			Y				
Transducer (IEC: 60688)	Y	Y				Y	Y			Y				Y
CB (IS: 8828)	Y	Y				Y	Y			Y				
Breaker Handling Trolley	Y	Y				Y			Y	Y				Y
Synthetic Rubber Gasket (IS: 11149)	Y	Y		Y	Y		Y							
LT SWITCHGEAR IS: 8623	Y	Y				Y	Y	Y	Y	Y		Y	Y	Y

Notes:

. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
. Makes of all major Bought Out Items will be subject to CIL approval.

ELECTRICAL ACTUATOR WITH INTEGRAL STARTER

Test/Attributes / Characteristics / ITEM/ COPONENT / SUB SYSTEM ASSEMBLY/ TESTING	RPM ®	No Load Current ®	IR & HV Test®	Mounting Dimension®	All routine Test as per Standard & Specification®	Correct Phase Sequence®	Operation & Setting of limit Switch/Torque Switch®	Stall Torque/Current (A)	Hand Wheel operation/ Auto de clutch function (A)	Function of Aux. like Potentiometer, space heater, position indicator ®	EPT output ®	Grease leakage ®	Local/ Remote (Open-Stop-Close) Operation® Safety check (Single phasing, Phase correction, Tripping etc.) (A)
ELECTRICAL ACTUATOR WITH INTEGRAL STARTER(IS_9334)													
Motor	Y	Y	Y	Y	Y								
Final Testing	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note: 1) This is an indicative list of tests/checks. The manufacturer is to furnish a detailed quality plan indicating the practices and procedure adopted along with relevant supporting documents.

® - Routine Test (A) - Acceptance Test Y - Test applicable

LT BUSDUCT

ATTRIBUTES , CHARACTERISTICS / ITEM, COMPONENTS, SUB SYSTEM ASSEMBLY	Dimension & Surface Finish	Make, Type, Rating & TC	Electrical Properties	Mechanical Properties	Chemical Properties	Item to conform to relevant IS	WPS Approval, Welder Qualification	Weld Quality Check (DP test & x-ray Test)	Paint Shade, Thickness, Adhesion & Finish	Tightness by Torque measurement	Electrical Clearances	Galvanizing Test as per IS 2629/ 2633/ 4759	IR – HV – IR Test	Phase Sequence Check	Degree of Protection routine test as per CIL spec.
Aluminum Sheets / Plates / Strips / Flexibles / tubes (IS : 5082 / 737)	Y	Y		Y	Y	Y	Y	Y							
CRCA Flats / ISMC (IS 2062)	Y	Y		Y	Y	Y									
Neoprene / Synthetic Rubber Gaskets (IS 11149 / 3400)	Y	Y		Y	Y										
Rubber Bellows (IS : 3400)	Y	Y		Y	Y										
Support Insulator (BS : 2782, IEC : 660, IS : 10912)	Y	Y	Y	Y											
Galvanized Structure & GI Earthing Flat (IS : 2629 / 2633 / 4749)	Y	Y				Y						Y			
Space Heater & Thermostat		Y	Y										Y		
LT Busduct (IS : 8623 PART 2)	Y	Y				Y	Y	Y	Y	Y	Y		Y	Y	Y

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Makes of all major Bought Out Items will be subject to CIL approval.

ATTRIBUTES/CHARACTERESTICS ITEMS/COMPONENTS / SUBSYSTEMS	Dimension	Panel shape, paint/thickness adhesion	Pre-treatment of sheet	IP protection	Proof Load	Surface finish	Detection test*	HV & IR	Galvanise Test (if Applicable)	Functional	Bought out items/Bill of material	Routine tests as per relevant standard &	Acceptance tests as per relevant standard &	Constructional feature as per CIL Specification
Wall Mounted-Lighting Panel (IS-513, IS:5, IS:2629, 2633, 6745)	Y	Y	Y	Y		Y		Y		Y	Y	Y	Y	Y
Switch box/junction box/ Receptacles Panel (IS-513, IS:5, IS:2629, 2633, 6745)	Y	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y
Cable glands (IS-8121)	Y													Y
Cable lug	Y													Y
Lighting wire (IS-694)	Y											Y		Y
Flexible conduits (Galvanise & Epoxy) (IS-9537 & IS:2629, 2633, 6745)	Y		Y						Y			Y		Y
RCC Hume Pipe (IS-458)												Y		Y
Cable termination & straight through joint (IS 13573)	Y											Y	Y	Y
Cable Trays, bends, tees, crosses, Flexible supports system & accessories IS-513, IS:2629, 2633, 6745	Y		Y		Y	Y	Y		Y			Y		Y
Trefoil clamp	Y													Y
GI flats for earthing & lighting protection (IS 2062, 2629, 2633, 6745, 2833)	Y		Y						Y			Y		Y
GI Wire	Y											Y		Y
Fire sealing system (BS-476)												Y	Y	Y

Note:1.This is an indicative list of tests /checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

2.* Deflection Test on cable trays and Proof Load test on cable trays support system will be as per details given in the CILtechnical specification & approved MQP. The above acceptance tests shall be done only on one sample from each size of offered lot. This test is not applicable on bends, tees & crosses.

3. Make of all items will be subject to CIL approval.

4) CONTROL CABLES

Item / Components / Sub System Assembly \ Attributes / Characteristics	Make, Type & T.C as per relevant standard	Dimension/surface finish	Mechanical properties	Chemical Composition	Spark Test(as applicable)	Electrical properties	Lay length & Sequence	Armour coverage, cross over, looseness, gap between two wires	Sequential marking/ Batch marking/ surface finish/ cable length	T.S & elongation before & after ageing on outer sheath & insulation	Thermal stability	Anti termite coating on wooden drums	Constructional requirements feature as per CIL specification	Routine & Acceptance Tests as per relevant standard & CIL specification	FRLS Tests
Copper (IS-8130)	Y	Y	Y	Y		Y									
PVC insulation Compound (IS: 5831)	Y		Y			Y				Y	Y				
FRLS PVC Compound (IS-5831, ASTM-D2843, IS10810(Part 58), IEC-60754 Part-1)	Y		Y							Y	Y				Y
Extrusion & curing /Manufacturing of Core		Y			Y						Y				
Core Laying							Y								
Armour wire/strip	Y	Y	Y												
Inner sheath	Y	Y													
Armouring		Y						Y							
Outer Sheathing		Y							Y						
Finished Cable (IS-5831, ASTM-D2843, IS10810 (Part 58), IEC-60754 Part-1, IEC 60332 part III cat B)							Y	Y	Y	Y	Y		Y	Y	Y
Wooden drum(IS-10418) /Steel Drum		Y										Y	Y		

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Make of all major Bought out items will be subject to CIL approval.

ROUTINE TESTS		**Following routine tests shall be carried out on each drum of finished cables for all sizes.**
1)		Conductor Resistance test
2)		High voltage test
ACCEPTANCE TESTS		**Following Acceptance tests shall be carried out on each size of cables, in the offered lot.**
A) For Conductor (as per sampling plan mentioned in IS: 1554)		
	1)	Annealing test (Copper)
	2)	Resistance test
B) For Armour Wires / Formed Wires (If applicable) (as per sampling plan mentioned in IS: 1554)		
	1.	Measurement of Dimensions
	2.	Tensile Tests
	3.	Elongation Test
	4.	Torsion Test For Round wires only
	5.	Wrapping Test
	6.	Resistance Test
	7.	Mass of Zinc coating test For G S wires / Formed wires only
	8.	Uniformity of Zinc coating For G S wires / Formed wires only
	9.	Adhesion test For G S wires / Formed wires only
	10.	Freedom from surface defects
C) For PVC insulation & PVC Sheath (as per sampling plan mentioned in IS: 1554)		
	1)	Test for thickness
	2)	Tensile strength & Elongation before ageing (for tests after ageing see "D")

D) Ageing test:
If the compound manufacturer is carrying out Ageing test, test report of compound manufacturer is to be reviewed. If the compound manufacturer is not carrying out ageing test, then cable manufacturer will carry out ageing test & the test report will be reviewed by owner (quantum of ageing test sample shall be one sample /batch)

E) Following tests will be carried out on completed cables as per IS on each size:		
	1)	Insulation resistance test (Volume resistivity method)
	2)	High voltage test
F) Following tests shall be carried out on only one size of offered lot (comprising of all sizes):		
	1)	Thermal stability test on PVC insulation and outer sheath
	2)	Oxygen index test on outer sheath
	3)	Smoke density rating test on outer sheath
	4)	Acid gas generation test on outer sheath
G) Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cable will be carried out as per following sampling plan:		
		This test will be carried out using composite sampling i.e. irrespective of size; cables of one particular type (i.e. armoured, unarmoured) will be bunched together, as per calculations in line with the IEC. All sizes of armoured & unarmoured cables shall be covered.
H) Following tests shall be carried on one length of each size (armoured & unarmoured) of offered lot:		
	1)	Constructional / dimensional check, surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires, Sequential marking, drum / outer sheath extrusion's batch number marking
	2)	Measurement of Eccentricity & Ovality
GENERAL NOTE:		

(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by owner and Main Contractor at the time of final inspection. Owner and Main Contractor will also witness routine tests on cables on 10% sample basis.
(b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Contractor will witness routine tests on cables for the first order on 100% basis.

1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.
2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.
3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection.
4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.

6) LT POWER CABLES

Item / Components / Sub System Assembly \ Attributes / Characteristics	Make, Type & T.C as er relevant standard	Dimension/surface finish	Mechanical properties	Chemical Composition	Spark Test(as applicable)	Electrical properties	Hot Set Test/ Eccentricity & Ovality	Lay length & Sequence	Armour coverage, cross over, looseness, gap between two wires	Sequential marking/ Batch marking/ surface finish/ cable length	T.S & elongation before & after ageing on outer sheath & insulation	Thermal stability	Anti termite coating on wooden drums	Constructional requirements feature as per CIL specification	Routine & Acceptance Tests as per relevant standard & CIL specification	FRLS Tests
Aluminum (IS-8130)	Y	Y	Y	Y		Y										
XLPE Compound (IS-7098)	Y		Y			Y	Y				Y					
PVC insulation Compound (IS: 5831)	Y		Y			Y					Y	Y				
FRLS PVC Compound (IS-5831, ASTM-D2843, IS10810(Part 58), IEC-60754 Part-1)	Y		Y								Y	Y				Y
Extrusion & curing /Manufacturing of Core (PVC / XLPE)		Y			Y		Y					Y				
Core Laying								Y								
Armour wire/strip	Y	Y	Y													
Inner sheath	Y	Y														
Armouring		Y							Y							
Outer Sheathing		Y								Y						
Power Cable (Finished) (IS-5831, ASTM-D2843, IS10810(Part 58), IEC-60754 Part-1, IEC 60332 part III cat B)								Y	Y	Y	Y	Y		Y	Y	Y
Wooden drum(IS-10418) /Steel Drum		Y											Y	Y		

Notes:
1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Make of all major Bought out items will be subject to CIL approval.

ROUTINE TESTS	**Following routine tests shall be carried out on each drum of finished cables for all types (PVC / XLPE insulated) & sizes.**	
3)	Conductor Resistance test	
4)	High voltage test	
ACCEPTANCE TESTS	**Following Acceptance tests shall be carried out on each size of each type (PVC / XLPE insulated) of cables, in the offered lot.**	
A) For Conductor (as per sampling plan mentioned in IS: 1554 / 7098)		
	1)	Annealing test (Copper)
	2)	Tensile Test (Aluminum)
	3)	Wrapping Test (Aluminum)
	4)	Resistance test
B) For Armour Wires / Formed Wires (If applicable) (as per sampling plan mentioned in IS: 1554 / 7098)		
	1.	Measurement of Dimensions
	2.	Tensile Tests
	3.	Elongation Test
	4.	Torsion Test For Round wires only
	5.	Wrapping Test
	6.	Resistance Test
	7.	Mass of Zinc coating test For G S wires / Formed wires only
	8.	Uniformity of Zinc coating For G S wires / Formed wires only
	9.	Adhesion test For G S wires / Formed wires only
	10.	Freedom from surface defects
C) For PVC / XLPE insulation & PVC Sheath (as per sampling plan mentioned in IS: 1554 / 7098)		
	1)	Test for thickness
	2)	Tensile strength & Elongation before ageing (for tests after ageing see “D”)
	3)	Hot set test (For XLPE insulation)
D) Ageing test:		
If the compound manufacturer is carrying out Ageing test, test report of compound manufacturer is to be reviewed. If the compound manufacturer is not carrying out ageing test, then cable manufacturer will carry out ageing test & the test report will be reviewed by owner (quantum of ageing test sample shall be one sample /batch		

E) Following tests will be carried out on completed cables as per IS on each size of each type (PVC / XLPE insulated)		
	1)	Insulation resistance test (Volume resistivity method)
	2)	High voltage test
F) Following tests shall be carried out on only one size of offered lot (comprising of all sizes & types)		
	1)	Thermal stability test on PVC insulation and outer sheath
	2)	Oxygen index test on outer sheath
	3)	Smoke density rating test on outer sheath
	4)	Acid gas generation test on outer sheath
G) Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cables as per following sampling plan:		
		This test will be carried out using composite sampling i.e. irrespective of size; cables of one particular type (i.e. armoured PVC insulated, unarmoured PVC insulated, armoured XLPE insulated, unarmoured XLPE insulated) will be bunched together, as per calculations in line with the IEC. All sizes of PVC & XLPE insulated, armoured & unarmoured cables shall be covered. For one particular type, cables with OD less than or equal to 30 mm shall be clubbed together in touching formation while cables with OD greater than 30 mm shall be clubbed together leaving a gap equal to OD of cable having least diameter. Cable OD shall be taken as nominal overall diameter as per CIL approved datasheet.
H) Following tests shall be carried on one length of each size of each type (PVC / XLPE insulated) of offered lot:		
	1)	Constructional / dimensional check, surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires, Sequential marking, drum / Batch (outer sheath extrusion batch)number marking on sheath
	2)	Measurement of Eccentricity & Ovality

GENERAL NOTE:		
(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by owner and Main Contractor at the time of final inspection. Owner and Main Contractor will also witness routine tests on cables on 10% sample basis. (b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Contractor will witness routine tests on cables for the first order on 100% basis.		
1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.		

7) MV (3.3 KV / 6.6. KV / 11 KV / 33 KV) CABLES

Attributes/ Characteristics / Item / Components / Sub System Assembly	Make, Type & T.C as per relevant standard	Dimension/surface finish	Mechanical properties	Chemical Composition	Spark Test(as applicable)	Electrical properties	Hot Set Test/ Eccentricity & Ovality	Lay length & Sequence	Armour coverage, cross over, looseness, gap between two wires	Sequential marking/ Batch marking/ surface finish/ cable length	T.S & elongation before & after geing on outer sheath & insulation	Thermal stability on outer sheath	Metallic (Cu) Screening If applicable)	Anti termite coating on wooden drums	Constructional requirements feature as per CIL specification	Routine & Acceptance Test as per relevant standard & CIL specification	FRLS Test
Aluminum (IS-8130)	Y	Y	Y	Y		Y											
Semiconducting Compound	Y		Y			Y											
XLPE Compound (IS-7098 Part-II)	Y		Y			Y					Y						
FRLS PVC Compound (IS-5831, ASTM-D2843, IS10810(Part 58) ,IEC-60754 Part-1)	Y		Y								Y	Y					Y
Triple Extrusion & curing /Manufacturing of Core		Y			Y		Y										
Copper Tape	Y	Y	Y			Y											
Polyster tape	Y	Y															
Core Laying								Y									
Armour wire/strip	Y	Y	Y														
Copper tapping	Y	Y											Y				
Inner sheath	Y	Y															
Armouring		Y							Y								
Outer Sheathing		Y								Y							
Power Cable (Finished)								Y	Y	Y	Y	Y			Y	Y	Y
Wooden drum(IS-10418) /Steel Drum		Y												Y	Y		

Notes:
1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

2. Make of all major Bought out items will be subject to CIL approval.

ROUTINE TESTS	**Following routine tests shall be carried out on each drum of finished cables for all types & sizes.**	
1)	Conductor Resistance test	
2)	High voltage test	
3)	Partial discharge test **(for Screened cables only)**	
ACCEPTANCE TESTS	**Following Acceptance tests shall be carried out on each size of each type (voltage rating) of cables, in the offered lot.**	
A) For Conductor (as per sampling plan mentioned in IS: 7098 Part II)		
	1)	Annealing test (Copper)
	2)	Tensile Test (Aluminum)
	3)	Wrapping Test (Aluminum)
	4)	Resistance test
B) For copper tape / Wires (as per sampling plan mentioned in IS: 7098 Part II)		
	1)	Measurement of Dimensions
	2)	Conductivity check
B) For Armour Wires / Formed Wires (If applicable) (as per sampling plan mentioned in IS: 7098 Part II)		
	1.	Measurement of Dimensions
	2.	Tensile Tests
	3.	Elongation Test
	4.	Torsion Test For Round wires only
	5.	Wrapping Test
	6.	Resistance Test
	7.	Mass of Zinc coating test For G S wires / Formed wires only
	8.	Uniformity of Zinc coating For G S wires / Formed wires only
	9.	Adhesion test For G S wires / Formed wires only
	10.	Freedom from surface defects
C) For XLPE insulation & PVC Sheath (as per sampling plan mentioned in IS: 7098 Part II)		
	1)	Test for thickness
	2)	Tensile strength & Elongation before ageing (for tests after ageing see “D”)
	3)	Hot set test (For XLPE insulation)

D) Ageing test:		
If the compound manufacturer is carrying out Ageing test , test report of compound manufacturer is to be reviewed. If the compound manufacturer is not carrying out ageing test, then cable manufacturer will carry out ageing test & the test report will be reviewed by owner (quantum of ageing test sample shall be one sample /batch)		
(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by owner and Main Contractor at the time of final inspection. Owner and Main Contractor will also witness routine tests on cables on 10% sample basis. (b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Contractor will witness routine tests on cables for the first order on 100% basis.		
1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.		
E) Following tests will be carried out on completed cables as per IS on each size of each type		
	1)	Insulation resistance test (Volume resistivity method)
	2)	High voltage test
	3)	Partial discharge test (for Screened cables only)
F) Following tests shall be carried out on only one size of offered lot (comprising of all sizes & types)		
	1)	Thermal stability test on outer sheath
	2)	Oxygen index test on outer sheath
	3)	Smoke density rating test on outer sheath
	4)	Acid gas generation test on outer sheath
	5)	Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cable
G) Following tests shall be carried on one length of each size of each type of offered lot:		
	1)	Constructional / dimensional check, surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires, Sequential marking, marking of drum no. / Batch number of outer sheath extrusion
	2)	Measurement of Eccentricity & Ovality
GENERAL NOTE:		
(a) In case of manufacturers / supplier who have supplied cables in the past through Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by owner and Main Contractor at the time of final inspection. Owner and Main Contractor will also witness routine tests on cables on 10% sample basis. (b) In case of manufacturers / supplier WHO HAVE NOT SUPPLIED cables in the past through		

Corporate Centre:- Routine Test of manufacturer internal test report are to be verified by Owner at the time of final inspection. Owner will witness routine tests on cables for the first order on 10% sample basis and Main Contractor will witness routine tests on cables for the first order on 100% basis.
1. For Smoke Density rating test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 2. For Acid Gas Generation test: if the test result without conditioning is within (-)10% of the maximum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 3. For Oxygen Index test: if the test result without conditioning is within (+)7% of the minimum specified value, then, retesting is to be carried out with conditioning of samples as per standard and the test results after conditioning shall be final for acceptance/rejection. 4. In case the test results without conditioning do not meet the maximum/minimum specified value, the manufacturer may exercise the option of retesting the samples after conditioning as per standard.

8) HT SWITCHGEAR

ATTRIBUTES / CHARACTERISTICS

ITEMS, COMPONENTS, SUB-SYSTEM ASSEMBLY	Make, Type, Model, Rating & TC	Electrical Properties	Mechanical properties	Chemical Properties	Dimensions & Finish	Constructional, Functional & Operational Features as per CIL Spec.	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint shade, thickness, adhesion & finish	Functional Checks	HV & IR Test	Degree of Protection Routine test as per CIL spec.	CB Operation timing check	All Routine Tests as per relevant standard
CRCA steel sheet/ Aluzinc*/ Zincalum*/ Galvalum*	Y		Y	Y	Y		Y							
Aluminum Bus bar material (IS : 5082)	Y	Y	Y	Y	Y		Y							
Copper Bus bar material (IS : 613)	Y	Y	Y				Y							
Bus bar Support Insulator	Y	Y	Y		Y		Y				Y			
HT Circuit Breaker (IEC-62271-100)	Y				Y	Y	Y			Y			Y	Y
HT Contactors (IS : 9046 / IEC 60470)	Y				Y	Y	Y			Y				Y
Protection & Auxilliary Relays	Y				Y	Y	Y			Y				Y
HT CT's & PT's (IS : 2705 / 3156)	Y				Y		Y							Y
HT Fuses (IS : 9385)	Y				Y	Y	Y							
Surge Arrester (IEC : 99 –4)	Y				Y		Y							Y
LT Contactors (IS : 13947)	Y				Y	Y	Y			Y				
Control & Selector Switches (IS : 6875)	Y				Y	Y	Y			Y				
Indicating Meters (IS : 1248)	Y				Y	Y	Y			Y				Y
Indicating Lamps (IS : 13947)	Y				Y	Y	Y			Y				
Push Buttons (IS : 4794)	Y				Y	Y	Y			Y				
Control Transformer (IS : 12021)	Y				Y	Y	Y			Y				Y
LT Fuses (IS : 13703)	Y				Y	Y	Y							
Energy Meters (IS : 722)	Y				Y	Y	Y			Y				Y
Transducers (IEC : 60688)	Y				Y	Y	Y			Y				Y
Diodes	Y	Y				Y	Y			Y				
Terminal Blocks	Y	Y				Y	Y							
Synthetic Rubber Gasket (IS : 11149 / 3400)	Y	Y			Y		Y							
Breaker Handling Trolley	Y				Y	Y			Y	Y				
HT Switchgear Panel IEC-62271-200)	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Make of all major Bought Out Items will be subject to CIL approval.
3. Temperature rise test reports for diode plates with actual heat sink will be verified.

*. CRCA Galvanized steel with metal coating composed of Al (55%), Zn (43.4%) & Si (1.6%),

9) SCADA & ACCESSORIES

PROGRAMMABLE LOGIC CONTROLLER

TESTS / ITEMS	Visual ®	GA, BOM ,Lay Out of components ®	Dimensions ®	Paint Shade/ Thickness/Adhesion ®	Alignment of Section ®	Component Rating/ Make / Type ®	Wiring ®	IR & HV ®	Review of TC for instruments/ Devices/ Recorders, Indicators/ Mosaic Items/ Transducers ®	Accessibility of TBS/ Devices ®	Illumination ®	Functional Check for Control Element , Annunciation ®	Mimic ®	Test as per IEC 1131 ® *	Test as per Std ® & (A)
1. PLC Panel	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y		Y	Y
2. Control Desk With PLC	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		

Note: 1. **This is an indicative list of test/ checks. The manufacturer is to furnish a detailed quality plan indicating the Practice and Procedure along with relevant supporting documents.**

***Applicable for PLC Test** **Y - Test Applicable , ® - Routine Test (A) - Acceptance**

CONTROL DESK, PLC PANEL, SMOKE DETECTOR, FIRE ALARM & CONTROL SYSTEM

TESTS / ITEMS	Visual ®	GA, BOM, Lay Out of components ®	Dimensions ®	Paint Shade/Thickness/Adhesion ®	Alignment of Section ®	Component Rating/ Make / Type ®	Wiring ®	IR & HV ®	Review of TC for instruments/ Devices/ Recorders, Indicators/ mosaic Items/ Transducers ®	Accessibility of TBS/ Devices ®	Illumination ®	Functional Check for Control Element , Annunciation	Mimic ®	Test as per IEC 1131 ® *	Test as per Std ® & (A)
1. Control Desk	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
2. Annunciation/ Control/ PLC Panel	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y			Y	Y
3.Smoke Detectors (UL-268, EN-54 PT-7), Heat Detectors (UL-521/EN 54 PT-5) Annunciation/ Control Panel (UL -864, EN-54, PT-2)															Y

Note: 1) Detailed procedure of Environmental Stress Screening test shall be as per Quality Assurance Programme in General Technical Conditions

2) This is an indicative list of test/ checks. The manufacturer is to furnish a detailed quality plan indicating the Practice and Procedure along with relevant supporting documents.

- *Applicable for PLC
- Y - Test Applicable, ® - Routine Test (A) - Acceptance Test

INSTRUMENTATION CABLE

TESTS / ITEMS	Conductor Resistance @ & (A)	High Voltage @ & (A)	Insulation Resistance @ & (A)	Constructional detail, dimensions (A)	Outer-Sheath/core marking, end sealing (A)	Thermal Stability (A) +	Visual, Surface finish (A) +	Electrical Parameters ** (A) +	Persulphate Test (A) +	Overall/Coverage/Continuity (A)	Swedish chimney Test (SS-4241475) (A)	FRLS Test (A) ++	Tensile & Elongation before & after aging (A)	Vol. Resistivity, at room & Elevated Temp. (A)	Spark test report review @	
Instrument cable twisted and shielded																
Conductor (IS-8130)	Y			Y			Y									
Insulation (VDE-207)				Y	Y	Y	Y						Y		Y	
Pairing/Twisting				Y	Y		Y									
Shielding				Y			Y			Y						
Drain wire	Y			Y			Y		Y	Y						
Inner Sheath				Y	Y	Y	Y					Y	Y			
Outer Sheath				Y	Y	Y	Y					Y	Y			
Over all cable	Y	Y	Y	Y	Y		Y	Y			Y			Y		
Cable Drums (IS-10418)				Y			Y									

Note: High Temp. cables shall be subjected to tests as per VDE-207(Part-6) Compensating cables shall be checked for Thermal EMF/Endurance test as per IS 8784.
Note: This is an indicative list of tests/checks. The manufacture is to furnish a detailed Quality Plan indicating his practice & Procedure along with relevant supporting documents during QP finalization for all items.
Note: ® - Routine Test A - Acceptance Test Y - Test Applicable
Note: Sampling Plan for Acceptance test shall be as per IS 8784 (As applicable)

- * FRLS Tests: Oxygen / Temp Index (ASTM D-2863), Smoke Density Rating (ASTM – D 2843), HCL Emission (IEC-754-1)
- ** Characteristic Impedance, Attenuation, Mutual Capacitance, Cross Talk (As applicable)

\+ Sample size will be One No. of each size/type per lot.
++ Sample size will be One No. sample for complete lot offered irrespective of size/type.

POWER SUPPLY FOR C&I SYSTEMS (UPS/BATTERY/BATTERY CHARGER/ACDB/DCDB)

TESTS ITEMS	Visual/ dimension/rating/Paint Adhesion/	General arrangement/BOM/make of components	Efficiency/ regulation (A)	Input voltage variation (A)	Output voltage and frequency adj. range (A)	Preliminary light load test (R)	Load transfer and return test (R)	AC input failure and return test (R)	Partial operation and current division (R)	Relative harmonic content (R)	Restart with PRI, AC and battery (separately)(R)	System transfer and retransfer (R)	Asynchronous transfer (R)	Ripple content (R)	Load limiter operation (R)	IR/HV (R)	Tests as per standard & specification (R & A)
UPS/CONVERTER (IEC-146 PT4)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
VOLTAGE STABILISER	Y	Y	Y	Y	Y					Y		Y				Y	
LEAD ACID BATTERY (TUBLAR) - IS-1651																	Y
LEAD ACID BATTERY (PLANTE) - IS-1652																	Y
NICKEL CADMIUM BATTERY (IS-10918)(IEC-623)																	Y
SMF BATTERY																	Y
ACDB/DCDB																Y	Y
BATTERY CHARGER	Y	Y	Y	Y	Y				Y					Y	Y	Y	Y

10) DC SYSTEM

LEAD ACID BATTERY

ATTRIBUTES / CHARACTERISTICS ITEMS, COMPONENTS, SUB SYSTEM ASSEMBLY ↓	Dimensions & Finish	Conformance to relevant part drg. & Manufacturer' s standards	Chemical composition	Lead Coating Thickness (min. 25 microns, IS: 6848 App.F) & Adhesion Check	Conformance to CPWD Spec. for Teak Wood	Paint Process checks, Paint Shade, Thickness, Adhesion & Finish	Constructional requirements as per CIL Spec.	Routine & acceptance tests as per relevant standard
Container & Lids (IS : 1146)	Y	Y						
Vent Plugs	Y	Y						
Sealing Compound (IS : 3116)		Y	Y					
Positive & Negative Plates		Y	Y					
Separators (IS : 6071)	Y	Y						
Electrolyte (Water / Sulphuric Acid) (IS : 1069 / 266)		Y	Y					
Inter-cell Connectors & Fasteners	Y	Y		Y				
Battery Stand	Y	Y			Y	Y		
Cell Insulators	Y	Y						
Stack Assembly	Y	Y						
Lead Acid Battery (IS : 1652)	Y						Y	Y

Note: This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

Ni- Cd BATTERY

ATTRIBUTES / CHARACTERISTICS ITEMS, COMPONENTS, SUB SYSTEM ASSEMBLY ↓	Dimensions & Finish	Impact Strength	Conformance to relevant part drg. & Manufacturer' s standards	Resistance to Alkali	Chemical composition	Nickel Plating thickness	Paint Shade, Thickness, Adhesion & Finish	Routine & acceptance tests as per relevant standard
Container & Lids	Y	Y	Y	Y				
Vent Plugs	Y		Y	Y				
Perforated Steel Strips	Y		Y	Y		Y		
Active Material for Positive & Negative Plates			Y		Y			
Separators	Y		Y	Y				
Electrolyte			Y		Y			
Inter-cell Connectors & Fasteners	Y		Y	Y		Y		
Battery Stand	Y			Y			Y	
Cell Insulators	Y		Y	Y				
Stack Assembly	Y		Y					
Ni-Cd Battery (IS : 10918)	Y							Y

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Makes of all major Bought Out Items will be subject to CIL approval.

BATTERY CHARGER

Attributes / Characteristics Items / Components / Sub- assembly ↓	Make, Model, Type, Rating & Finish	Verification of Routine test reports as per relevant IS	Sheet Steel Pretreatment & Painting process checks	Conform to relevant Standard & CIL spec	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per CIL approved drgs & specification	Temperature Rise Test	Ripple Content Test, Load Limiter & AVR Operation Test	Dynamic Response Test	Operational & Functional Checks	HV & IR Test	Burn-In Test at 50^C for 48 hrs in energised condition	Alternating current measurement test	Degree of Protection Test as per CIL Spec.
Rectifier Transformer and Reactors IS : 4540, 2026)	Y	Y		Y			Y				Y			
Electronic Components including Potentiometer (Vernier Type)	Y			Y		Y								
Electronic Cards	Y			Y								Y		
PCB & racks for electronic cards	Y					Y								
Control & Selector Switches (IS : 6875)	Y			Y						Y				
Indicating Meters (IS : 1248)	Y			Y						Y				
Indicating Lamps (IS: 13947)	Y			Y						Y				
Air Break Switches / Fuses (IS : 13947 / 13703)	Y			Y						Y				
Control Terminal Blocks (IS : 13947)	Y			Y										
Control Transformer (IS : 12021)	Y			Y						Y				
Push Buttons (IS : 4794)	Y			Y						Y				
MCB (IS : 8828)	Y			Y						Y				
PVC insulated Copper control wires (IS : 694)	Y			Y										
Sheet Steel (IS : 513)	Y		Y	Y										
Synthetic Rubber Gaskets	Y			Y										
Annunciator	Y									Y		Y		
Battery Charger	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Makes of all major Bought Out Items will be subject to CIL approval.

BATTERY CHARGER
(of capacity up to 24 V / 48 V, 150 A DC)

Attributes / Characteristics Items / Components / Sub- assembly ↓	Make, Model, Type, Rating	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per approved drgs	Ripple Content Test, Load Limiter operation & AVR Operation Test	Operational & Functional Checks of aux. Devices like annunciator, switches, indicators etc.	HV & IR Test	Burn-In Test	Dynamic response test	AC input current measurement test	Temperature rise test
Battery Charger	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

2. Makes of all major Bought Out Items will be subject to CIL approval.

DC HEALTH MONITORING SYSTEM

Attributes / Characteristics Items / Components / Sub- assembly ↓	Make, Model, Type, Rating & Finish	Verification of Routine test reports as per relevant IS	Sheet Steel Pretreatment & Painting process checks	Conform to relevant Standard & CIL spec	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per CIL approved drgs & specification	Operational & Functional Checks	HV & IR Test	Burn-In Test at 50^C for 48 hrs in 303energized condition	Degree of Protection Test as per CIL Spec.
Enclosure	Y		Y	Y	Y					Y
Synthetic Rubber Gaskets	Y			Y						
Control & Selector Switches ,Indicating Meters, Indicating Lamps	Y			Y			Y			
Control Terminal Blocks ,Push Buttons, MCB	Y			Y			Y			
MCB	Y			Y			Y			
PVC insulated Copper control / signal cables	Y	Y		Y						
Transducers / detectors	Y	Y		Y			Y			
PCB & racks for electronic cards	Y									
Electronic Cards	Y						Y		Y	
Microprocessor Based Controller	Y						Y		Y	
SCADA	Y						Y			
Software	Y						Y			
DC Health Monitoring System	Y			Y	Y	Y	Y	Y	Y	Y

Notes:
1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Makes of all major Bought Out Items will be subject to CIL approval.

11) STATION LIGHTING

Item Components Sub System Assembly / Attributes Characteristic	Make, Type , Rating/ TC	Dimension	Pre-Treatment of sheat	Paint Shade Thickness Adhesion & Finish	Galvanization Tests	IP Test	Bought Out Items/ Bill of Material	HV & IR	Functional Check as per spec.	Constructional Feature as per NTP spec	Routine Test as per relevant std and spec	Acceptance Test as per relevant std and spec	Item to conform to relevant standard
Luminaries (IS-10322 Part-5 Sec.1 (non –LED type)	Y					Y		Y			Y	Y	Y
Electronic Ballast	Y										Y	Y	Y
Lighting Wire (IS-694)	Y										Y		
Fans (IS-374)	Y										Y		
Pole (IS-2713)	Y			Y						Y	Y	Y	
Lamps (IS-9800, IS-9974)	Y										Y	Y	
Lighting Mast (with raise & lower lantern type)	Y	Y			Y					Y	Y	Y	
Wall Mounted Lighting Panel (IS-513, IS-5)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Switch Box/ Junction Box/Receptacles/ Local Push Button Station / Lighting Panel (IS-513, 2629, 2633, 4759, 6745)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Cable Gland (BS-6121)	Y	Y									Y		
Cable Lug (IS-8309)	Y	Y									Y		
Flexible Conduit	Y										Y		
Lighting Transformer (IS-11171)	Y									Y	Y		

Epoxy & Galvanised Conduit (IS-9537, 2629, 2633, 4759, 6745)	Y	Y									Y		Y

LED Luminaire Quality Requirements

1) LED modules to conform to IS: 16103 part 2. Manufacturer to issue a certificate of compliance for the same.
2) Control gear to conform to IS 15885 part 2 section 13. Manufacturer to issue a certificate of compliance for the same.
3) LED luminaire to conform to IS 16107 part 2 section 1. Manufacturer to issue a certificate of compliance for the same.
4) LED luminaire marking to be as per IS 16107 part 2 section 1. Manufacturer to issue a certificate of compliance for the same.
5) Acceptance tests as per IS 16107 part 2 section 1 to be carried out on LED luminaire except long duration tests i.e. a) Chromaticity coordinates & correlated color temperature (CCT); b) Color rendering index (CRI). Manufacturer will submit a COC for above tests i.e. CCT & CRI
6) LED driver make, model, type & rating may be as per recommendations of LED module manufacturer.

Notes:
1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Make of all major Bought Out Items will be subject to CIL approval

12) TRANSFORMER

Oil Filled Transformer

Items/Components Sub Systems / Attributes / Characteristics	Visual & Dimensional Checks	Mechanical properties	Electrical strength	Thermal properties	Chemical Composition	Compatibility with oil	NDT / DPT / MPI / UT	Ageing Test.	Voltage Ratio, Vector Group & Polarity, Magnetic Balance Test	Make / Type / Rating / Model / TC / General Physical Inspection.	Functional check	WPS & PQR	Routine Test as per relevant standard / CIL Specification
Tank, H.V. & L.V. Cable Box / Flange throat	Y	Y					Y					Y	
Conservator / Radiator / Cooler / Pipes	Y	Y					Y						
Copper Conductor (IS:191)	Y	Y	Y		Y								
Insulating Material	Y	Y	Y	Y	Y	Y							
CRGO Lamination & Built Core	Y	Y	Y		Y	Y				Y			
Bushing / Insulator (IS:2544 / 5621)	Y	Y								Y			Y
Gasket	Y	Y			Y	Y		Y		Y			Y
Transformer Oil (IEC296)			Y										Y
OLTC / Off-Circuit Tap Changer	Y									Y			Y
Core Coil Assembly & Pre-tanking	Y								Y	Y			
Marshalling Box	Y									Y	Y		Y
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Valves	Y									Y	Y		
Welding (ASME Sect-IX)	Y						Y					Y	
Complete Transformer (IS:2026/ IEC-60076)	Y												Y

Note: 1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2) All major Bought Out Items will be subject to CIL approval.

LT INDOOR TRANSFORMER (DRY TYPE TRANSFORMER)

Attributes / Characteristics / Items/ Components Sub Systems	Visual & Dimensional check	Mechanical properties	Electrical strength	Thermal Properties	Chemical Properties	NDT / DP / MPI	Voltage Ratio, Vector Group & Polarity	Make / Type / Rating / Model /TC / General Physical Inspection	Routine Test as per relevant standard / CIL Specification
Enclosure door, H.V. & L.V. Cable Box / Flange Throat	Y	Y						Y	
Copper Conductor	Y	Y	Y		Y				
Insulating Material	Y			Y	Y				
CRGO Lamination & Built Core	Y							Y	
Porcelain Bushing /Insulator (IS:2544 / 5621)	Y	Y	Y					Y	Y
Gasket (IS 2712)	Y	Y						Y	Y
Off-Circuit Tap Changer	Y							Y	Y
Core Coil Assembly	Y						Y		
Marshalling Box	Y								Y
WTI, Thermistor, Terminal Connector	Y							Y	
Complete Transformer (IS:11171 / IEC 60076)	Y								Y

Notes: 1) This is an indicative List of test/checks. The manufacturer is to furnish a detailed Quality Plan indicating his practice and procedure along with relevant supporting documents during QP finalization for all item.
2) All major Bought out Items will be subject to CIL approval.

AUXILIARY / LT TRANSFORMER

Items /Components Sub Systems / Attributes / Characteristics	Visual & Dimensional Checks	Mechanical properties	Electrical strength	Thermal properties	Chemical Composition	Compatibility with oil	NDT / DPT / MPI / UT	Ageing Test.	Voltage Ratio, Vector Group & Polarity, Magnetic Balance Test	Make / Type / Rating / Model / TC / General Physical Inspection.	Functional check	WPS & PQR	Routine Test as per relevant standard / CIL Specification
Tank, H.V. & L.V. Cable Box / Flange throat	Y	Y					Y					Y	
Conservator / Radiator / Cooler / Pipes	Y	Y					Y						
Copper Conductor (IS:191)	Y	Y	Y		Y								
Insulating Material	Y	Y	Y	Y	Y	Y							
CRGO Lamination & Built Core	Y	Y	Y		Y	Y				Y			
Bushing / Insulator (IS:2544 / 5621)	Y	Y								Y			Y
Gasket	Y	Y			Y	Y		Y		Y			Y
Transformer Oil (IEC296)			Y										Y
OLTC / Off-Circuit Tap Changer	Y									Y			Y
Core Coil Assembly & Pre-tanking	Y								Y	Y			
Marshalling Box	Y									Y	Y		Y
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Valves	Y									Y	Y		
Welding (ASME Sect-IX)	Y						Y					Y	
Complete Transformer (IS:2026/ IEC-60076)	Y												Y

Note: 1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2) All major Bought Out Items will be subject to CIL approval.

13) SWITCHYARD/SUBSTATION (If Applicable)

Attributes / Characteristics / Items/ Components Sub Systems	Make, model, Type & Rating, Test Certificate	Routine & Acceptance Test as per IS / IEC	Functional requirements as per CIL Specification
Energy meter	Y	Y	Y
Circuit Breaker (IEC:62271-100)	Y	Y	Y
Isolator (IEC:62271-102)	Y	Y	Y
Current Transformer (IEC:60044/BS:3938/IS2705/ IEC: 61869)	Y	Y	Y
Potential Transformer (IEC:186A / 358/IS3156/IEC60044/ IEC: 61869)	Y	Y	Y
Bus Post Insulator (IEC:168 / 815 / IS:2544)	Y	Y	Y
Disc, Pin & String Insulator (IEC:383 / IS:731)	Y	Y	Y
Surge Arrestor (IEC:99-4/IS:3070)	Y	Y	Y
Spacers, Clamps & Connector (IS:10162 / 5561/ 617)	Y	Y	Y
Galvanized Steel Structures (IS:2062/2629/4759/6745)	Y	Y	Y
Vibration Damper (IS:9708)	Y	Y	Y
Sag Compensating Spring DIN:2089/2096 IS:3195 / 7906	Y	Y	Y
SF6 Gas filling & evacuating plant	Y	Y	Y
SF6 Gas Leak Detector	Y	Y	Y
Leakage Current Analyser	Y	Y	Y
Protection Relays	Y	Y	Y
Relay Test Kit	Y	Y	Y
Surge Monitor	Y	Y	Y

Notes : 1) This is an indicative list of test/checks. The manufacture is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents during QP finalization for all items.
2) All major Bought Out Items will be subject to CIL approval.

Portable FIRE EXTINGUISHERS

a) All fire extinguishers shall be tested as per relevant standard.

b) Performance / function test shall be carried out on sampling basis as per relevant code / standard.

14) ENERGY METER

Attributes / Characteristics Items / Components / Sub- assembly ↓	Make, Model, Type, Rating & Finish	Conform to relevant Standard & CIL spec	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features as per CIL approved drgs & specification	Burn-In Test and Elevated Temperature Test as per specification	All routine & acceptance tests as per IS 13779
Electronic Components	Y	Y				
PCB for electronic cards	Y					
Electronic Cards	Y	Y		Y	Y	
Terminal Blocks as per IS 13779	Y	Y				
Instrument Transformer CTs & PTs (IS : 2705 & IS 3156)	Y	Y				
Sheet Steel (IS : 513)	Y	Y				
Synthetic Rubber Gaskets IS 11149	Y	Y				
Energy meter IS 13779	Y		Y	Y	Y	Y

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Makes of all major Bought Out Items will be subject to CIL approval.

15) MODULE CLEANING AND VENTILATION QUALITY REQUIREMENTS

A. Module Cleaning System:

- Pipes, Valves, Pumps etc shall be tested as per requirements of relevant standard.

	MODULE WASHING SYSTEM : PUMP													
	TEST / CHECKS / ITEM / COMPONENTS	Material Test	WPS/PQR/Welder Qualification	DPT/MPI	Assembly Fit Up	Visual & Dimensional Check	UT	RT	Hydraulic / Water Fill	Balancing	Type Test	Performance Test	Other Test
A	**PUMP**				Y	Y						Y[6]	
A.1	Casing	Y[1]		Y[2]		Y			Y[4]				
A.2	Impeller	Y[1]		Y[2]		Y				Y[5]			
A.3	Shaft	Y[1]		Y[2]		Y	Y[3]			Y[5]			

NOTES

1 One per heat / HT batch

2 100% DPT shall be carried out on machined surfaces.

3 UT shall be done on shaft / tie rod with diameter above 40 mm.

4 All pressure retaining parts shall be hydrostatically tested at 200% of pump rated head or 150% of shut – off head, whichever is higher, for at least 30 minutes. No leakage is allowed.

5 Static and Dynamic Balancing shall be carried out on complete rotor assembly.

6 All pumps shall be tested at rated speed, for head, flow capacity, efficiency and power consumption for the entire operating range i.e. from shut off head to maximum flow. A minimum of 7 readings shall be taken to urve, plot the with one reading at design flow. Testing standard shall be HIS (Hydraulic Institute Standard) of USA.
Performance test shall be carried out with contract motor, wherever Liquidated Damages are to be ed ascertain based on performance test at shop.

MODULE WASHING SYSTEM: PIPES, FITTINGS, VALVES,

Tests/Checks / Items/Components	Material Test	DPT/MPI/RT	Ultrasonic Test	WPS/WQS/PQR	Hydraulic/Water Fill Test	Pneumatic Test	Assembly Fit up	Dimensions	Functional/Operational Test	Other Tests	all Tests as per relevants Std	Remarks
Pipes & Pipe Fittings	Y[a]		Y[b]					Y			Y	
Gate/ Globe/ Check valve	Y[a]		Y[b]	Y[c]		Y	Y	Y	Y	Y[3]		
Nozzles	Y[a]							Y				
Strainers	Y[a]		Y[b]					Y		Y[5]		
HDPE Pipes	Y[a]							Y				
Site Welding		Y[4]		Y	Y[1]							

NOTES (MEANING OF SUPERSCRIPTS)

a One per heat/heat treatment batch/lot.

b On machined surfaces only for castings and on butt welds.

c For shaft/spindles > or = 40 mm

1 100% Hydraulic test shall be carried out at 1.5 time design pressure or 2 times of working pressure or as per Technical specification/Data sheet/ governing standard.

2 Seat Leakage Test for Actuator Operated Valves, shall be done with by closing the valves with actuator.

3 Blue matching, wear travel for gates, valves, pneumatic seat leakage, and reduced pressure test for check valves shall be done as per relevant standard. Maximum allowable vacuum loss is 0.5 mm of Hg abs. for valves to be tested for vacuum operation for internal pressure 25 mm of Hg abs. for a period of 15 minutes. Functional checks of the valves for smooth opening and closing shall also be done. Valves shall be offered for hydro test in unpainted condition. Anti-corrosive protection shall be tested as per applicable code.

4 10% of welds (Root and finished welds) shall be subjected to DPT.

5 Pressure drop across the strainer for each type and size as a special test shall be carried out. In case of already carried out, the test report shall be submitted for review as applicable.

B. VENTILATION SYSTEM

- Split/Window Cassette Air conditioner less than 10 TR will be accepted on the basis of Manufacturer Standard Guarantee and Warrantee certificate.
- Fans, Filters etc. shall be tested as per requirements of relevant standard.

E-2 QUALITY ASSURANCE CIVIL WORKS

1.0 SAMPLING AND TESTING OF CONSTRUCTION MATERIALS

a) Before execution of any civil work the contractor shall conduct full-scale suitability tests on various construction and building material such as soil, fine and coarse aggregates, cement, construction chemicals, supplementary cementitious materials and construction water to ascertain their suitability for use and the concrete mix designs conducted from reputed institutes such as NCCBM-Ballabgarh, CSMRS-Delhi, selected IIT's, etc. as agreed by the Employer. The test samples for such full-scale testing shall be jointly sampled and sealed by the Employer and contractor, thereafter these shall be sent to the concerned laboratory through the covering letter signed by field quality assurance department (FQA)/EIC representative of the Employer. Format for sampling and testing of cement, coarse aggregate, fine aggregate, chemical admixture, fly ash, water, concrete mix design is enclosed at Annexure-I.

b) The contractor shall timely initiate the action with regard to the evaluation of aggregates and other building material including concrete mix design, so as to ensure completion of these tests before start of civil works at site, thereby not affecting any project work. The test reports and recommendations for suitability of the materials including concrete mix design shall be promptly submitted by the contractor to the Engineer-in-charge (EIC)/Head of Field Quality Assurance (FQA) Department of Employer.

2.0 LABORATORY AND FIELD TESTING

a) The field laboratory for QA activities shall be established and installed with the adequate facilities to meet the requirement of envisaged day to day tests during execution of the work. Temperature and humidity controls shall be available wherever necessary during testing of samples. The contractor shall furnish a comprehensive list of testing equipment/ instrument required to meet the planned/scheduled tests for the execution of works for EIC acceptance/ approval. The contractor shall mobilize the requisite laboratory equipment and QA manpower in well advance prior to the planned test activity.
The tests which cannot be carried out/do not have facilities for testing in the field laboratory shall be done at Employer acceptable third-party testing laboratory.

b) All equipment and instruments in the field shall be calibrated before the commencement of tests and then at regular intervals, as per the manufacturer's recommendation and as directed by the EIC. The calibration certificates shall specify the fitness of the equipment and instruments within the limit of tolerance for use. Contractor shall arrange for calibration of equipment and instruments by NABL or such accrediting agency complying with ISO/IEC-17025 accreditation and the calibration reports shall be submitted to EIC for their review and acceptance.

c) The QA activities (include all works, activities, equipment, instrument, personnel, material etc. whatsoever associated to comply with sampling, testing and quality assurance requirements) in all respects as specified in the technical specifications/ drawings / data sheets / quality plans / relevant standard codes / contract documents shall be carried out at no extra cost to the Employer.

d) The contractor shall carry out testing in accordance with the relevant IS/standards /codes and in line with the requirements of the technical specifications / quality plans. Where no specific testing procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and to the directions of the EIC.

3.0 FIELD QUALITY PLAN

a) Well before the start of the work, the contractor shall prepare and submit the Field Quality Plans (FQP) and obtain approval of Employer. This document shall detail out for all the works, equipment, services, quality practices and procedures etc. in line with the requirement of the technical specifications to be followed by the contractor at site. This FQP shall cover for all the items / activities required as per the contract / schedule of items, right from material procurement to completion of the work at site. An Indicative Field Quality Plan for civil works is enclosed at Annexure II for reference purpose.

4.0 PURCHASE AND SERVICE

a) To facilitate advance planning of material testing/ approval of bought out items (BOI), well before the start of activity as per L-2 network, representative samples shall be procured by the contractor from approved sub-vendors and submitted to the EIC for his approval before bulk procurement. In case of manufacturers test certificate (MTC) is submitted for acceptance, it shall be clearly traceable and correlated with the consignment received at site. MTC of all bought out items (BOI) shall essentially contain all the test parameters / characteristics specified in the technical specifications / standards / codes. In case the manufacturer's test certificate does not mention these details, sample from each lot shall be tested at the Employer acceptable third-party lab. Approval of material / sample by the Employer shall not relieve the contractor of his responsibility, for their conformance to the specification, as well as the requisite performance and quality of material.

b) Structural steel (plates and rolled sections i.e. channels, beams & angles) conforming to IS 2062 and Reinforcement steel conforming to IS 1786 supply if in the scope of the contractor shall be procured directly from Primary Steel Producers (Refer NOTE below). Any procurement route, other than direct procurement from primary steel producer, shall require prior approval of CIL. Currently, Primary Steel Producers acceptable are as below:

- SAIL
- JSW Steel Ltd
- Jindal Steel & Power
- Tata steel Ltd. (for Reinforcement steel/TMT bars)
- RINL (for long products/Rolled sections and Reinforcement steel/TMT bars)
- Arcelormittal Nippon Steel India Ltd. (for Flat products/ Steel Plates)
- ESL Steel Ltd. (for Reinforcement steel/TMT bars)
- JSW Ispat Special Products Ltd. (for long products/Rolled sections and Reinforcement steel/TMT bars).

Subsequently, if any new Primary Steel Producer/s are proposed during execution of contract, the same may be considered for acceptance subject to meeting the following qualifying requirements:

i) The proposed supplier should be a Primary Steel Producer, having a minimum production capacity of one million tons per annum (MTPA).
ii) The proposed supplier should be a regular manufacturer of Steel Plates and / or Rolled Sections and / or Reinforcement Steel for the last two years as on date of submission of proposal.
iii) The proposed supplier should also be a registered licensee with Bureau of Indian Standards for BIS:1786/2062 at the time of submission of proposal.

NOTE: The "Primary Steel Producer" shall mean Steel Producer of any capacity, irrespective of process route, starting their operations from iron making using iron ore, virgin or processed, with necessary refining facilities and rolling/processing facilities, at a single location or else in multiple locations provided that the entire gamut of iron and steel production, from iron making to finished steel production, is owned by the same company or its subsidiary company(ies). Provided that the iron making capacity is sufficiently matching the steel making capacity. Further, downstream units should use material from the upstream units of the same company or its subsidiaries.

i. In case of non-availability of certain steel section/s i.e. Angles, MS flats, rounds, square bars and chequered plate from all of the above acceptable primary steel producers (non-availability to be established by supporting documents), the Main contractor may source these sections directly from SAIL approved Conversion/Wet Leasing agent subject to the conditions given below:

1. Main Contractor to ensure continuity of BIS license of the manufacturer for the sections being manufactured for Employer supply.
2. Billets shall be procured from Employer approved Main Steel Producers. Proper records for traceability from raw material to final product shall be maintained.
3. Testing of one sample per 40 MT for each type of section/size or part thereof shall be carried out as per IS:2062 on finished product for physical and chemical properties. The sampling and testing for physical and chemical tests on finished product at Conversion/Wet Leasing agent shall be mandatorily witnessed by main contractor and all reports shall be presented during final inspection by CIL.
4. Each lot of delivery of finished product shall be accompanied with co-relatable Manufacturer's Test Certificate (MTC). MTC of finished sections shall be correlated with original MTC for Billets received from Main Steel Producer. MTC of finished sections shall include the reference of MTC for Billets from Main Steel Producer.
5. Employer will have access to carry out the surveillance checks for in-process stage.
6. In case of any defects are seen in the material at any stage, Main Contractor will replace the material without any cost implication to Employer.

ii. In case of non-availability of certain size/s of steel tubes conforming to IS:1161 and Hollow (square and rectangular) steel sections conforming to IS: 4923 from above acceptable primary steel producers, the same may be sourced from BIS approved sources having valid BIS license subject to the conditions given below:

1. Main Contractor to ensure continuity of BIS license of the manufacturer for the sections being manufactured for Employer supply.
2. Raw materials shall be procured from Employer approved Main Steel Producers.
3. 100% chemical analysis of the raw material (steel) shall be carried out as per IS: 228. Testing of samples of steel tubes and hollow sections from each lot shall be carried out as per IS: 1161 & IS: 4923 respectively on finished product.
4. Each lot of delivery of finished product shall be accompanied with co-relatable Manufacturer's Test Certificate (MTC).
5. Employer will have access to carry out the surveillance checks for in-process stage.
6. In case of any defects are seen in the material, Main Contractor will replace the material without any cost implication to Employer.

c) **For Module Mounting Structure**, the structural steel (other than those specified at 'b' above) may be procured from main contractor approved sources, subject to condition that they otherwise meet the requirement of technical specification.

The specific methodology to be followed for above procurement through conversion route/ BIS approved sources route shall be subject to approval by Employer in advance.

PART-B
F – GENERAL TECHNICAL REQUIREMENTS

F-1 GENERAL TECHNICAL REQUIREMENTS

1.0 INTRODUCTION

This part covers technical requirements which will form an integral part of the Contract. The following provisions shall supplement all the detailed technical requirements brought out in the Technical Specifications and the Technical Data Sheets.

2.0 BRAND NAME

Whenever a material or article is specified or described by the name of a particular brand, manufacturer or vendor, the specific item mentioned shall be understood to be indicative of the function and quality desired, and not restrictive; other manufacturer's products may be considered provided sufficient information is furnished to enable the Employer to determine that the products proposed are equivalent to those named.

3.0 BASE OFFER & ALTERNATE PROPOSALS

The Bidder's proposal shall be based upon the use of equipment and material complying fully with the requirements specified herein. It is recognized that the Contractor may have standardized on the use of certain components, materials, processes or procedures different than those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice may also be considered, provided the base offer is in line with technical specifications and such proposals meet the specified design standards and performance requirement and are acceptable to the Employer. Sufficient amount of information for justifying such proposals shall be furnished to Employer along with the bid to enable the Employer to determine the acceptability of these proposals.

4.0 COMPLETENESS OF FACILITIES

a) Bidders may note that this is a contract inclusive of the scope as indicated elsewhere in the specification. Each of the plant shall be engineered and designed in accordance with the specification requirement. All engineering and associated services are required to ensure that a completely engineered plant is provided.

b) All equipment furnished by the Contractor shall be complete in every respect, with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or those needed for erection, completion and safe operation & maintenance of the equipment and for the safety of the operating personnel, as required by applicable codes, though they may not have been specifically detailed in the respective specifications, unless included in the list of exclusions.

All similar standard components/ parts of similar standard equipment provided, shall be interchangeable with one another.

5.0 CODES & STANDARDS

5.1 In addition to the codes and standards specifically mentioned in the relevant technical specifications for the equipment / plant / system, all equipment parts, systems and works covered under this specification shall comply with all currently applicable statutory regulations and safety codes of the Republic of India as well as of the locality where they will be installed, including the following:

a) Bureau of Indian Standards (BIS)
b) Indian electricity act
c) Indian electricity rules
d) Indian Explosives Act
e) Indian Factories Act and State Factories Act
f) Indian Boiler Regulations (IBR)
g) Regulations of the Central Pollution Control Board, India
h) Regulations of the Ministry of Environment & Forest (MoEF),Government of India
i) Pollution Control Regulations of Department of Environment, Government of India
j) State Pollution Control Board.
k) Rules for Electrical installation by Tariff Advisory Committee (TAC).
l) Any other statutory codes / standards / regulations, as may be applicable.

5.2 Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in the specifications, the latest editions (as applicable as on date of bid opening), of the codes and standards given below shall also apply:

a) Japanese Industrial Standards (JIS)
b) American National Standards Institute (ANSI)
c) American Society of Testing and Materials (ASTM)
d) American Society of Mechanical Engineers (ASME)
e) American Petroleum Institute (API)
f) Standards of the Hydraulic Institute, U.S.A.
g) International Organization for Standardization (ISO)
h) Tubular Exchanger Manufacturer's Association (TEMA)
i) American Welding Society (AWS)
j) National Electrical Manufacturers Association (NEMA)
k) National Fire Protection Association (NFPA)
l) International Electro-Technical Commission (IEC)

m) Expansion Joint Manufacturers Association (EJMA)

n) Heat Exchange Institute (HEI)

5.3 Other International/ National standards such as DIN, VDI, BS, GOST etc. shall also be accepted for only material codes and manufacturing standards, subject to the Employer's approval, for which the Bidder shall furnish, along with the offer, adequate information to justify that these standards are equivalent or superior to the standards mentioned above. In all such cases the Bidder shall furnish specifically the variations and deviations from the standards mentioned elsewhere in the specification together with the complete word to word translation of the standard that is normally not published in English.

5.4 As regards highly standardized equipment National /International standards such as JIS, DIN, VDI, ISO, SEL, SEW, VDE, IEC & VGB shall also be considered as far as applicable for Design, Manufacturing and Testing of the respective equipment. In addition, these standards shall be referred for the design of machine foundations, wherever specifically mentioned in the specifications. However, for those of the above equipment not covered by these National / International standards, established and proven standards of manufacturers shall also be considered.

5.5 In the event of any conflict between the codes and standards referred to in the above clauses and the requirement of this specification, the requirement of Technical Specification shall govern.

5.6 Two (2) English language copies of all-national and international codes and/or standards which are not available with CIL and same is used in the design of the plant, equipment, civil and structural works shall be provided by the Contractor to the Employer within two calendar months from the date of the Notification of Award.

5.7 In case of any change in codes, standards & regulations between the date of bid opening and the date when vendors proceed with fabrication, the Employer shall have the option to incorporate the changed requirements or to retain the original standard. It shall be the responsibility of the Contractor to bring to the notice of the Employer such changes and advise Employer of the resulting effect.

6.0 EQUIPMENT FUNCTIONAL GUARANTEE

a) The functional guarantees of the equipment under the scope of the Contract is given elsewhere in the technical specification. These guarantees shall supplement the general functional guarantee provisions covered under General Conditions of Contract.

b) Liquidated damages for shortfall in meeting functional guarantee(s) during the performance guarantee tests shall be assessed and recovered from the Contractor as specified elsewhere in this specification.

7.0 DESIGN OF FACILITIES/ MAINTENANCE & AVAILABILITY CONSIDERATIONS

a) Design of Facilities

All the design procedures, systems and components proposed shall have already been adequately developed and shall have demonstrated good reliability under similar conditions elsewhere.

The Contractor shall be responsible for the selection and design of appropriate equipment to provide the best co-ordinated performance of the entire system. The basic requirements are detailed out in various clauses of the Technical Specifications. The design of various components, assemblies and subassemblies shall be done so that it facilitates easy field assembly and dismantling. All the rotating components shall be so selected that the natural frequency of the complete unit is not critical or close to the operating range of the unit.

b) Maintenance and Availability Considerations

Equipment/facilities offered shall be designed for high availability, low maintenance and ease of maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability/ availability and ease of maintenance. The Bidder shall also furnish details of availability records in the reference plants stated in his experience list.

c) Bidder shall state in his offer the various maintenance intervals, spare parts and man-hour requirement during such operation. The intervals for each type of maintenance namely the minor and major overhauls shall be specified in terms of fired hours, clearly defining the spare parts and man-hour requirement for each stage.

Lifting devices i.e. hoists and chain pulley jacks, etc. shall be provided by the contractor for handling of any equipment or any of its part having weight in excess of 500 kgs during erection and maintenance activities.

Lifting devices like lifting tackles, slings, etc. to be connected to hook of the hoist / crane shall be provided by the contractor for lifting the equipment and accessories covered under the specification.

8.0 DOCUMENTS, DATA AND DRAWINGS TO BE FURNISHED BY CONTRACTOR

a) Bidders may note that this is a contract inclusive of the scope as indicated elsewhere in the specification. Each of the plant and equipment shall be fully integrated, engineered and designed to perform in accordance with the technical specification. All engineering and technical services required ensuring a completely engineered plant shall be provided in respect of mechanical, electrical, control & instrumentation, civil & structural works as per the scope.

b) The Contractor shall furnish engineering data/drgs. for entire equipment covered under this specification in accordance with the schedule of information as specified in Technical

Specification and Data sheets.. This documentation shall include but not be limited to the following :

a) **INSTRUCTION MANUALS**

The Contractor shall submit to the Employer, draft Instruction Manuals for all the equipment covered under the Contract by the end of one year from the date of his acceptance of the Letter of Award. The Instruction manuals shall contain full details required for erection, commissioning, operation and maintenance of each equipment. The manual shall be specifically compiled for this project. After finalization and approval of the Employer the Instruction Manuals shall be submitted. The Contract shall not be considered to be completed for purposes of taking over until the final Instructions manuals have been supplied to the Employer. The Instruction Manuals shall comprise of the following.

(a) Erection & Commissioning Manuals/Checklists

The erection & Commissioning Manuals/Checklists shall be submitted atleast three (3) months prior to the commencement of erection activities of particular equipment/system. The erection manual should contain the following as a minimum.

a) Erection strategy.

b) Sequence of erection.

c) Erection instructions.

d) Critical checks and permissible deviation/tolerances.

e) List of tool, tackles, heavy equipment like cranes, dozers, etc.

f) Bill of Materials

g) Procedure for erection.

h) General safety procedures to followed during erection/installation.

i) Procedure for initial checking after erection.

j) Procedure for testing and acceptance norms.

k) Procedure / Check list for pre-commissioning activities.

l) Procedure / Check list for commissioning of the system.

m) Safety precautions to be followed in electrical supply distribution during erection

(b) Operation & Maintenance Manuals

i. The operating and maintenance instructions together with drawings (other than shop drawings) of the equipment, as completed, shall be in sufficient detail to enable the Employer to operate, maintain, dismantle, reassemble and adjust all parts of the equipment. They shall give a step by step procedure for all operations likely to be carried out during the life of the plant / equipment including, operation, maintenance,

dismantling and repair including periodical activities such as chemical cleaning of the generator. Each manual shall also include a complete set of drawings together with performance/rating curves of the equipment and test certificates wherever applicable. The contract shall not be considered to be completed for purposes for taking over until these manuals have been supplied to the Employer.

ii. If after the commissioning and initial operation of the plant, the manuals require any modification / additions / changes, the same shall be incorporated and the updated final instruction manuals shall be submitted to the Employer for records.

iii. A separate section of the manual shall be for each size/ type of equipment and shall contain a detailed description of construction and operation, together with all relevant pamphlets and drawings.

iv. The manuals shall include the following :

a. List of spare parts along with their drawing and catalogues and procedure for ordering spares.

b. Lubrication Schedule including charts showing lubrication checking, testing and replacement procedure to be carried daily, weekly, monthly & at longer intervals to ensure trouble free operation.

c. Where applicable, fault location charts shall be included to facilitate finding the cause of mal-operation or break down.

v. Detailed specifications for all the consumables including lubricant oils, greases, chemicals etc. system/equipment/assembly/sub-assembly - wise required for the complete plant.

vi. On completion of erection, a complete list of bearings / equipment giving their location, and identification marks etc. shall also be furnished to the Employer indicating lubrication method for each type/category of bearing.

b) **Project Completion Report**

The Contractor shall submit a Project Completion Report at the time of handing over the plant. After final acceptance of individual equipment /system by the Employer, the Contractor will update all original drawings and documents for the equipment/ system to "as built" conditions and submit.

c) **ENGINEERING INFORMATION SUBMISSION SCHEDULE**

Prior to the award of Contract, a Detailed Engineering Information Submission Schedule shall be tied up with the Employer. For this, the bidder shall furnish a detailed list of engineering information alongwith the proposed submission schedule. This list would be a comprehensive one including all engineering data / drawings / information for all bought out items and manufactured items. The information shall be categorised into the following parts.

a) Information that shall be submitted for the approval of the Employer before proceeding further, and

b) Information that would be submitted for Employer's information only.

The Engineering Information Schedule shall be updated month-wise.

The schedule should allow adequate time for proper review and incorporation of changes/ modifications, if any, to meet the contract without affecting the equipment delivery schedule and overall project schedule. The early submission of drawings and data is as important as the manufacture and delivery of equipment and hardware and this shall be duly considered while determining the overall performance and progress.

d) ENGINEERING PROGRESS AND EXCEPTION REPORT

Report giving the status of each engineering information including

(a) A list of drawings/engineering information which remains unapproved for more than four (4) weeks after the date of first submission

(b) Drawings which were not submitted as per agreed schedule.

The draft format for this report shall be furnished to the Employer within four (4) weeks of the award of the contract, which shall then be discussed and finalised with the Employer.

e) TECHNICAL CO-ORDINATION MEETING

- The Contractor shall organize and attend at least one monthly progress Meetings with the Employer/Employer's representatives during the period of Contract at mutually agreed venues for review of progress & resolving technical clarifications, if any. The Contractor shall attend such meetings at his own cost and fully co- operate with such persons and agencies involved during the discussions.
- The Contractor shall ensure availability of the concerned experts / consultants/ personnel who are empowered to take necessary decisions during these meetings. The Contractor shall be equipped with necessary tools and facilities so that, if required, the drawings/documents can be resubmitted after incorporating necessary changes and approved during the meeting itself.
- The Contractor shall furnish monthly progress report to the Employer detailing out the progress achieved on all erection activities as compared to the schedules. This shall be supplemented by printed colour photographs and video in VCD/DVD indicating various stages of erection and the progress of the work done at Site. The report shall also indicate the reasons for the variance between the scheduled and actual progress and the action proposed for corrective measures, wherever necessary.

f) DESIGN IMPROVEMENTS

The Employer or the Contractor may propose changes in the specification of the equipment or quality thereof and if the parties agree upon any such changes the specification shall be modified accordingly.

If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any changing the price and/or schedule of completion before the Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

g) EQUIPMENT BASES

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base, unless otherwise specifically agreed to by the Employer. Each base plate which support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

h) PROTECTIVE GUARDS

Suitable guards shall be provided for protection of personnel on all exposed rotating and/or moving machine parts. All such guards shall be designed for easy installation and removal for maintenance purpose.

i) LUBRICANTS, SERVO FLUIDS AND CHEMICALS

The Bidder's scope includes all the first fill and one year's topping, requirements of consumables such as oils, lubricants including grease, servo fluids, gases and essential chemicals etc. Consumption of all these consumables during the initial operation and final filling after the initial operation shall also be included in the scope of the Bidder.

As far as possible lubricants marketed by reputed companies shall be used. The variety of lubricants shall be kept to a minimum possible.

Detailed specifications for the lubricating oil, grease, gases, servo fluids, control fluids, chemicals etc. required for the complete plant covered herein shall be furnished. On completion of erection, a complete list of bearings/ equipment giving their location and identification marks shall be furnished to the Employer alongwith lubrication requirements.

Lubrication

Equipment shall be lubricated by systems designed for continuous operation. Lubricant level indicators shall be furnished and marked to indicate proper levels under both standstill and operating conditions.

j) Material of Construction

All materials used for the construction of the equipment shall be new and shall be in accordance with the requirements of this specification. Materials utilized for various components shall be those which have established themselves for use in such applications.

k) RATING PLATES, NAME PLATES & LABELS

Each main and auxiliary item of plant including instruments shall have permanently attached to it in a conspicuous position, a rating plate of non-corrosive material upon

which shall be engraved manufacturer's name, equipment, type or serial number together with details of the ratings, service conditions under which the item of plant in question has been designed to operate, and such diagram plates as may be required by the Employer.

Such nameplates or labels shall be of white non-hygroscopic material with engraved black lettering or alternately, in the case of indoor circuit breakers, starters, etc. of transparent plastic material with suitably coloured lettering engraved on the back. The name plates shall be suitably fixed on both front and rear sides.

l) Hanger/ support numbers shall be marked on all pipe supports, anchors, hangers, snubbers and restraint assemblies. Each constant and variable spring support shall also have stamped upon it the designed hot and cold load which it is intended to support. Suitable scale shall also be provided to indicate load on support/hanger.

Nameplates shall be as per best practices of the industry

All such plates, instruction plates, etc. shall be bilingual with Hindi inscription first, followed by English. Alternatively, two separate plates one with Hindi and the other with English inscriptions may be provided.

All segregated phases of conductors or bus ducts, indoor or outdoor, shall be provided with coloured phase plates to clearly identify the phase of the system

m) TOOLS AND TACKLES

The Contractor shall supply with the equipment one complete set of all special tools and tackles and other instruments required for the erection, assembly, disassembly and proper maintenance of the plant and equipment and systems (including software). These special tools will also include special material handling equipment, jigs and fixtures for maintenance and calibration / readjustment, checking and measurement aids etc. A list of such tools and tackles shall be submitted by the Bidder along with the offer.

The price of each tool / tackle shall be deemed to have been included in the total bid price. These tools and tackles shall be separately packed and sent to site. The Contractor shall also ensure that these tools and tackles are not used by him during erection, commissioning and initial operation. For this period the Contractor should bring his own tools and tackles. All the tools and tackles shall be of reputed make acceptable to the Employer.

5.0 Welding

a) If the manufacturer has special requirements relating to the welding procedures for welds at the terminals of the equipment to be per formed by others the requirements shall be submitted to the Employer in advance of commencement of erection work.

QUALITY ASSURANCE PROGRAMME

The Contractor shall adopt suitable quality assurance programme to ensure that the

equipment and services under the scope of contract whether manufactured or performed within the Contractor's works or at his sub-contractor's premises or at the Employer's site

or at any other place of work are in accordance with the specifications. Such programmes shall be outlined by the Contractor and shall be finally accepted by the Employer/authorised representative after discussions before the award of the contract. The QA programme shall be generally in line with IS/ISO-9001.A quality assurance programme of the contractor shall generally cover the following:

b) (a) His organisation structure for the management and implementation of the proposed quality assurance programme

(b) Quality System Manual

(c) Design Control System

(d) Documentation and Data Control System

(e) Qualification data for bidder's key personnel.

(f) The procedure for purchase of materials, parts, components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.

(g) System for shop manufacturing and site erection controls including process, fabrication and assembly.

(h) Control of non-conforming items and system for corrective actions and resolution of deviations.

(i) Inspection and test procedure both for manufacture and field activities.

(j) Control of calibration and testing of measuring testing equipment.

(k) System for Quality Audits.

(l) System for identification and appraisal of inspection status.

(m) System for authorising release of manufactured product to the Employer.

(n) System for handling, storage and delivery.

(o) System for maintenance of records, and

(p) Quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

c) GENERAL REQUIREMENTS - QUALITY ASSURANCE

a) All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme. An indicative programme of inspection/tests to be carried out by the contractor for some of the major items is given in the respective technical specification. This is, however, not intended to form a comprehensive programme as it is the contractor's responsibility to draw up and implement such programme duly

approved by the Employer. The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Bidder and will be submitted to Employer for approval. Schedule of finalisation of such quality plans will be finalised before award on enclosed format No. QS- 01-QAI-P-01/F3. If bidder wishes to appoint a TPIA for inspection on his behalf, same shall be intimated during finalisation of Quality plans. Such agency and their representative's credential would be reviewed and approved by CIL as per applicable procedures.

b) Manufacturing Quality Plan will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Contractor's/ Sub-contractor's/ sub-supplier's Quality Control Organisation, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted on electronic media e.g. CD Rom or E-mail in addition to hard copy, for review and approval. After approval the same shall be submitted in compiled form on CD-ROM.

c) Field Quality Plans will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Contractor's "Site Quality Control Organisation", during various stages of site activities starting from receipt of materials/equipment at site.

d) The Bidder shall also furnish copies of the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., as referred in Quality Plans along with Quality Plans. These Quality Plans and reference documents/standards etc. will be subject to Employer's approval without which manufacturer shall not proceed. These approved documents shall form a part of the contract. In these approved Quality Plans, Employer shall identify customer hold points (CHP), i.e. test/checks which shall be carried out in presence of the Employer's Project Manager or his authorised representative along with Contractor's QA representative or an CIL approved TPIA on behalf of Contractor and beyond which the work will not proceed without consent of Employer in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to Employer along with technical justification for approval and dispositioning.

e) No material shall be dispatched from the manufacturer's works before the same is accepted, subsequent to predispatch final inspection in presence of Contractor's QA representative or an CIL approved TPIA on behalf of Contractor, including verification of records of all previous tests/inspections by Employer's Project Manager/Authorised representative and duly authorised for dispatch by issuance of Material Despatch Clearance Certificate (MDCC).

f) All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.

g) The contractor shall submit to the Employer Field Welding Schedule for field welding activities in the enclosed format No.: QS-01-CQA-W-11/F1. The field welding schedule shall be submitted to the Employer along with all supporting documents, like welding procedures, heat treatment procedures, NDT procedures etc. at least ninety days before schedule start of erection work at site.

h) All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Employer.

All welding/brazing procedures shall be submitted to the Employer or its authorised representative for approval prior to carrying out the welding/brazing.

a) All brazers, welders and welding operators employed on any part of the contract either in Contractor's/sub-contractor's works or at site or elsewhere shall be qualified as per ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Employer.

b) Welding procedure qualification & Welder qualification test results shall be furnished to the Employer for approval. However, where required by the Employer, tests shall be conducted in presence of Employer/authorised representative.

c) For all pressure parts and high pressure piping welding, the latest applicable requirements of the IBR (Indian Boiler Regulations) shall also be essentially complied with. Similarly, any other statutory requirements for the equipment/systems shall also be complied with. On all back-gauged welds MPI/LPI shall be carried before seal welding.

d) Unless otherwise proven and specifically agreed with the Employer, welding of dissimilar materials and high alloy materials shall be carried out at shop only.

e) No welding shall be carried out on cast iron components for repair.

f) All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

g) All non-destructive examination shall be performed in accordance with written procedures as per International Standards, The NDT operator shall be qualified as per SNT-TC-IA (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and

equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.

All plates of thickness above 40mm & all bar stock/Forging above 40mm dia shall be ultrasonically tested. For pressure parts, plate of thickness equal to or above 25mm shall be ultrasonically tested.

a) The Contractor shall list out all major items/ equipment/ components to be manufactured in house as well as procured from sub-contractors (BOI). All the sub-contractor proposed by the Contractor for procurement of major bought out items including castings, forging, semi-finished and finished components/equipment etc., list of which shall be drawn up by the Contractor and finalised with the Employer, shall be subject to Employer's approval on enclosed format No. QS-01-QAI-P-01/F3. The contractor's proposal shall include vendor's facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation for identified sub-contractors enclosed and shall be submitted to the Employer for approval within the period agreed at the time of pre-awards discussion and identified in "DR" category prior to any procurement. Such vendor approval shall not relieve the contractor from any obligation, duty or responsibility under the contract.

b) For components/equipment procured by the contractors for the purpose of the contract, after obtaining the written approval of the Employer, the contractor's purchase specifications and inquiries shall call for quality plans to be submitted by the suppliers. The quality plans called for from the sub-contractor shall set out, during the various stages of manufacture and installation, the quality practices and procedures followed by the vendor's quality control organisation, the relevant reference documents/standards used, acceptance level, inspection of documentation raised, etc. Such quality plans of the successful vendors shall be finalised with the Employer and such approved Quality Plans shall form a part of the purchase order/contract between the Contractor and sub-contractor. With in three weeks of the release of the purchase orders /contracts for such bought out items /components, a copy of the same without price details but together with the detailed purchase specifications, quality plans and delivery conditions shall be furnished to the Employer on the monthly basis by the Contractor along with a report of the Purchase Order placed so far for the contract. **

c) Employer reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the Contractor's or their sub-contractor's quality management and control activities. The contractor shall provide all necessary assistance to enable the Employer carry out such audit and surveillance.

d) The contractor shall carry out an inspection and testing programme during manufacture in his work and that of his sub-contractor's and at site to ensure the mechanical accuracy of components, compliance with drawings, conformance to

functional and performance requirements, identity and acceptability of all materials parts and equipment. Contractor shall carry out all tests/inspection required to establish that the items/equipment conform to requirements of the specification and the relevant codes/standards specified in the specification, in addition to carrying out tests as per the approved quality plan.

e) Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Employer to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the Contractor in ensuring complete conformance of the materials/equipment supplied to relevant specification, standard, data sheets, drawings, etc.

f) For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.

g) Repair/rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Employer/ authorised representative.

Environmental Stress Screening

a) Environmental stress screening test process / procedure for eliminating infant mortile components for DDCMIS / PLC based system & for other systems having substantial electronics components (as determined by employer) like Electronic transmitter, CCTV components, PA systems etc. shall be necessarily furnished for any sub vendors proposed for vendor assessment and approval for this contract. For other approved sub vendors of above mentioned systems, contractor shall furnish the test procedure for eliminating infant mortile components in case, if it is asked for by the employer before these items are offered for inspection / dispatched to site.

Software Reliability / Quality Certification

a) Certification from OEM's authorized signatory that software offered with DDCMIS, PLC, CCTV, PA, Pyrometer, CEMS, AAQMS, EQMS, BHMS etc. declaring that the all the offered software(s) had gone through the established software quality test and offered software is not of β-version and offered software is also free from all known bugs as on date of approval of systems documents by CIL as a part of quality documentation review and approval process during detail engineering.

CIL follows a well defined sub-contractor's/sub-vendor assessment and approval process, the broad contours of which are also defined at CIL website www.CILtender.com alongwith a FAQ which answers most of the queries on the subject.

An indicative list of sub-vendors which has been accepted by CIL in the past for Corporate Awarded similar packages based on the respective Technical Specifications are enclosed in the tender specification for reference purpose only. The purpose of this

list is to provide general guidance to the prospective Bidders / Main Contractors for this package only. Further, this list is indicative in nature and may undergo revision for future packages based on the performance feedback received from CIL sites / other agencies about the supplier / sub vendors / supplied material. However, it is not the intention to limit the sub-vendor to only such names appearing in the above list and Main contractor is free to propose additional sub-vendors in his bid offer which will be subject to CIL sub- vendor assessment system upon receipt of requisite details in a time bound mutually agreed schedule. . Moreover listed suppliers may or may not be able to supply the material as per current Tech Specifications for the present package. Bidder is required to enquire before finalizing the suppliers / sub vendors for the present contract to meet provisions of the current Tech Specs.

Standard Manufacturing Quality Plan (SQP)/Indicative Manufacturing Quality Plan(IQP)/ Standard Field Quality Plan (SFQP)/ Indicative Field Quality Plan(IFQP) are enclosed for the major items, which can be used as a reference purpose for item under consideration.

The contractor's proposal shall include vendor's facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation for identified subcontractors and shall be submitted to the Employer for approval within a time bound schedule drawn during detailed engineering process. Such sub-vendor proposed in his bid offer shall be deemed to be identified in DR category and upon final acceptance by CIL in writing, contractor can place order on such accepted sub-vendor only.

Monthly progress reports on sub-contractor detail submission / approval shall be furnished as per Engineering Co-ordination Procedure. Such vendor approval shall not relieve the contractor from any obligation, duty or responsibility under the contract. Sub-vendor whose details are not submitted within the agreed cut-off date, shall be deemed to be withdrawn by the contractor.

d) QA DOCUMENTATION PACKAGE

a) The Contractor shall be required to submit the QA Documentation in two hard copies and two CD ROMs, as identified in respective quality plan with tick mark.

b) Each QA Documentation shall have a project specific Cover Sheet bearing name & identification number of equipment and including an index of its contents with page control on each document.

The QA Documentation file shall be progressively completed by the Supplier's sub- supplier to allow regular reviews by all parties during the manufacturing.

The final quality document will be compiled and issued at the final assembly place of equipment before dispatch. However CD-Rom may be issued not later than three weeks.

- Typical contents of QA Documentation is as below:-

a) Quality Plan
b) Material mill test reports on components as specified by the specification and approved Quality Plans.

c) Manufacturer / works test reports/results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.
d) Non-destructive examination results /reports including radiography interpretation reports. Sketches/drawings used for indicating the method of traceability of the radiographs to the location on the equipment.
e) Heat Treatment Certificate/Record (Time- temperature Chart)
f) All the accepted Non-conformance Reports (Major/Minor) / deviation, including complete technical details / repair procedure).
g) CHP / Inspection reports duly signed by the Inspector of the Employer and Contractor for the agreed Customer Hold Points.
h) Certificate of Conformance (COC) wherever applicable.
i) MDCC

- Similarly, the contractor shall be required to submit two sets (two hard copies and two CD ROMs), containing QA Documentation pertaining to field activities as per Approved Field Quality Plans and other agreed manuals/ procedures, prior to commissioning of individual system.
- Before dispatch / commissioning of any equipment, the Supplier shall make sure that the corresponding quality document or in the case of protracted phased deliveries, the applicable section of the quality document file is completed. The supplier will then notify the Inspector regarding the readiness of the quality document (or applicable section) for review.

  (a) If the result of the review carried out by the Inspector is satisfactory, the Inspector shall stamp the quality document (or applicable section) for release.
  (b) If the quality document is unsatisfactory, the Supplier shall endeavor to correct the incompleteness, thus allowing to finalize the quality document (or applicable section) by time compatible with the requirements as per contract documents. When it is done, the quality document (or applicable section) is stamped by the Inspector.
  (c) If a decision is made dispatch, whereas all outstanding actions cannot be readily cleared for the release of the quality document by that time. The supplier shall immediately, upon shipment of the equipment, send a copy of the quality document Review Status signed by the Supplier Representative to the Inspector and notify of the committed date for the completion of all outstanding actions & submission. The Inspector shall stamp the quality document for applicable section when it is effectively completed. The submission of QA documentation package shall not be later than 3 weeks after the dispatch of equipment.

e) **Project Manager's Supervision**

To eliminate delays and avoid disputes and litigation, it is agreed between the parties to the Contract that all matters and questions shall be referred to the Project Manager and without prejudice to the provisions of 'Arbitration' clause in Section GCC of Vol.I, the Contractor shall proceed to comply with the Project Manager's decision.

- The work shall be performed under the supervision of the Project Manager. The scope of the duties of the Project Manager pursuant to the Contract, will include but not be limited to the following:

(a) Interpretation of all the terms and conditions of these documents and specifications:
(b) Review and interpretation of all the Contractor's drawing, engineering data, etc:
(c) Witness or his authorised representative to witness tests and trials either at the manufacturer's works or at site, or at any place where work is performed under the contract :
(d) Inspect, accept or reject any equipment, material and work under the contract :
(e) Issue certificate of acceptance and/or progressive payment and final payment certificates
(f) Review and suggest modifications and improvement in completion schedules from time to time, and
(g) Supervise Quality Assurance Programme implementation at all stages of the works.

f) INSPECTION, TESTING AND INSPECTION CERTIFICATES

- The word 'Inspector' shall mean the Project Manager and/or his authorised representative and/or an outside inspection agency acting on behalf of the Employer to inspect and examine the materials and workmanship of the works during its manufacture or erection.
- The Project Manager or his duly authorised representative and/or an outside inspection agency acting on behalf of the Employer shall have access at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and if part of the works is being manufactured or assembled on other premises or works, the Contractor shall obtain for the Project Manager and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works.
- The Contractor shall give the Project Manager/Inspector fifteen (15) days written notice of any material being ready for testing. Such tests shall be to the Contractor's account except for the expenses of the Inspector's. The Project Manager/Inspector, unless the witnessing of the tests is virtually waived and confirmed in writing, will attend such tests within fifteen (15) days of the date on which the equipment is noticed as being ready for test/inspection failing which the contractor may proceed with test which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the inspector duly certified copies of test reports in two (2) copies.
- The Project Manager or Inspector shall within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Contractor, or any objection to any drawings and all or any equipment and workmanship which is in his opinion not in accordance with the contract. The Contractor shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall inform in writing to the Project Manager/Inspector giving reasons therein, that no modifications are necessary to comply with the contract.
- When the factory tests have been completed at the Contractor's or sub-contractor's works, the Project Manager /Inspector shall issue a certificate to this effect fifteen (15)

days after completion of tests but if the tests are not witnessed by the Project Manager /Inspectors, the certificate shall be issued within fifteen (15) days of the receipt of the Contractor's test certificate by the Project Manager /Inspector. Project Manager /Inspector to issue such a certificate shall not prevent the Contractor from proceeding with the works. The completion of these tests or the issue of the certificates shall not bind the Employer to accept the equipment should it, on further tests after erection be found not to comply with the contract.

- In all cases where the contract provides for tests whether at the premises or works of the Contractor or any sub-contractor, the Contractor, except where otherwise specified shall provide free of charge such items as labour, material, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Project Manager /Inspector or his authorised representatives to carry out effectively such tests on the equipment in accordance with the Contractor and shall give facilities to the Project Manager/Inspector or to his authorised representative to accomplish testing.
- The inspection by Project Manager / Inspector and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Programme forming a part of the contract.
- To facilitate advance planning of inspection in addition to giving inspection notice as specified at clause no 9.05.03- of this chapter, the Contractor shall furnish quarterly inspection programme indicating schedule dates of inspection at Customer Hold Point and final inspection stages. Updated quarterly inspection plans will be made for each three consecutive months and shall be furnished before beginning of each calendar month.
- All inspection, measuring and test equipment used by contractor shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Contractor shall maintain all the relevant records of periodic calibration and instrument identification, and shall produce the same for inspection by CIL. Wherever asked specifically, the contractor shall re-calibrate the measuring/test equipment in the presence of Project Manager / Inspector.

g) **ASSOCIATED DOCUMENT FOR QUALITY ASSURANCE PROGRAMME:**

c) List of items requiring quality plan and sub supplier approval. Format No.:QS-01-QAI-P-01/F3-R0.

d) Manufacturing Quality Plan Format No.: QS-01-QAI-P-09/F1-R1

e) Field Quality Plan Format No.: QS-01-QAI-P-09/F2-R1.

10.0 **PRE-COMMISSIONING AND COMMISSIONING FACILITIES**

The Contractor upon completion of installation of equipments and systems, shall conduct pre-commissioning and commissioning activities, to make the equipment/systems ready

for safe, reliable and efficient operation on sustained basis. During commissioning the Contractor shall carry out system checking and reliability trials on various parts of the facilities. All pre-commissioning/commissioning activities considered essential for such readiness of the equipment/systems including those mutually agreed and included in the Contractor's quality assurance programme as well as those indicated in clauses elsewhere in the technical specifications shall be performed by the contractor.

The pre-commissioning and commissioning activities of the equipment/systems furnished and installed by the contractor shall be the responsibility of the Contractor. The Contractor shall provide, in addition, temporary instrumentation and other measuring devices, test instruments, calibrating devices etc. and labour required for successful performance of these operations. If it is anticipated that the above test may prolong for a long time, the Contractor's workmen required for the above test shall always be present at site during such operations.

h) **All erection & commissioning checks shall be as per manufacturer's manual on mutually agreed terms**

(a) As soon as the facilities or part thereof has been completed operationally and structurally and before start-up, each item of the equipment and systems forming part of facilities shall be thoroughly cleaned and then inspected jointly by the Employer and the Contractor for correctness of and completeness of facility or part thereof and acceptability for initial pre-commissioning tests, commissioning and start-up at Site. The list of pre-commissioning tests to be performed shall be as mutually agreed and included in the Contractor's quality assurance programme as well as those included elsewhere in the Technical Specifications.

(b) The Contractor's pre-commissioning/ commissioning/start-up engineers, specially identified as far as possible, shall be responsible for carrying out all the pre-commissioning tests at Site. On completion of inspection, checking and after the pre-commissioning tests are satisfactorily over, the commissioning of the complete facilities shall be commenced during which period the complete facilities, equipments shall be operated integral with sub-systems and supporting equipment as a complete plant.

(c) The time consumed in the inspection and checking of the units shall be considered as a part of the erection and installation period.

(d) The check outs during the pre - commissioning period should be programmed to follow the construction completion schedule. Each equipment/system, as it is completed in construction and turned over for commissioning (start-up), should be checked out and cleaned. The checking and inspection of individual systems should then follow a prescribed commissioning documentation [SCL (Standard Check List) / TS (Testing Schedule) / CS (Commissioning Schedule)] to be furnished by the manufacturer/supplier.

(e) The Contractor shall conduct vibration testing to determine the 'base line' of performance of all plant rotating equipment. These tests shall be conducted when

the equipment is running at the base load, peak load as well as lowest sustained operating condition as far as practicable.

11.0 SAFETY ASPECTS DURING CONSTRUCTION AND ERECTION

In addition to the requirements given in Erection Conditions of Contract (ECC) the following shall also cover:

(a) Working platforms should be fenced and shall have means of access.

(b) Ladders in accordance with Employer's safety rules for construction and erection shall be used. Rungs shall not be welded on columns. All the stairs shall be provided with handrails immediately after its erection.

12.0 PACKAGING AND TRANSPORTATION

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. The Employer's Inspector shall have right to insist for completion of works in shops before dispatch of materials for transportation.

13.0 ELECTRICAL ENCLOSURE

All electrical equipment and devices, including insulation, heating and ventilation devices shall be designed for ambient temperature and a maximum relative humidity as specified elsewhere in the specification.

14.0 INSTRUMENTATION AND CONTROL

All instrumentation and control systems/ equipment/ devices/ components, furnished under this contract shall be in accordance with the requirements stated herein, unless otherwise specified in the detailed specifications.

a) All instrument scales and charts shall be calibrated and printed in metric units and shall have linear graduation. The ranges shall be selected to have the normal reading at 75% of full scale.

All scales and charts shall be calibrated and printed in Metric Units

b) All instruments and control devices provided on panels shall be of miniaturized design, suitable for modular flush mounting on panels with front draw out facility and flexible plug-in connection at rear.

c) All electronic modules shall have gold plated connector fingers and further all input and output modules shall be short circuit proof. These shall also be tropicalised & components shall be of industrial grade or better.

15.0 ELECTRICAL NOISE CONTROL

The equipment furnished by the Contractor shall incorporate necessary techniques to eliminate measurement and control problems caused by electrical noise. Areas in Contractor's equipment which are vulnerable to electrical noise shall be hardened to eliminate possible problems. Any additional equipment, services required for effectively eliminating the noise problems shall be included in the proposal. The equipment shall be protected against ESD as per IEC-801- 2. Radio Frequency interference (RFI) and Electro Magnetic Interference (EMI) protection against hardware damage and control system mal-operations/errors shall be provided for all systems.

16.0 ELECTRONIC MODULE/COMPONENT DETAILS

The Bidder shall have to furnish all technical details including circuit diagrams, specifications of components, etc., in respect of each and every electronic card/module as employed on the various solid state as well as microprocessor based systems and equipment including conventional instruments, peripherals etc.

It is mandatory for the Bidder to identify clearly the custom built ICs used in the package. The Bidder shall also furnish the details of any equivalents of the same.

Annexure-1 of GTR

S. N.	Description Of Documents	No of Prints (Sets)	NO. OF CD-ROMs
1	Drawings for Initial Submission (Either "FOR APPROVAL" or "FOR INFORMATION Category) and re-submissions after review by CIL (including Data sheets/ Calculations, all Equipment/instrument schedule, BOM etc)	8	1 Soft Copy (through 1 no of CD-Rom or through E-Mail)
2	Final Approved Drawings (Cat-I & Cat – IV Approved) (As referred in Sl no: 1 above)	3	4 CD-Roms
3	Documents / Drawings "AS BUILT"	4	4 CD-Roms
4	Type test reports (Initial)	8	1 Soft Copy (through 1 no of CD-Rom or through E-Mail)
5	Type test reports (Final)	1	2 CD-Roms
6	Erection manual "Final"	4 sets	1 CD-ROM
7	Operation & Maintenance manual "FINAL"	4 sets	4 CD-ROMs
8	Commissioning Procedure (if applicable) (FINAL)	4 sets	1 CD-ROM

S. N.	Description Of Documents	No of Prints (Sets)	NO. OF CD-ROMs
9	Performance and Guarantee test Procedure (Final)	8	1 Soft Copy (2 Floppy or 1 no of CD-Rom or through E-Mail)
10	Progress Reports	1	Through Mail
11	Project completion report	3	3 CD-ROMs
12	QA programme including Organisation for implementation and QA system manual (with revision-servicing)	1	1 CD-ROM
13	Vendor details in respect of proposed vendors including contractor's evaluation report.	1	1 CD-ROM
14	Manufacturing QPs, Field QPs, Field welding schedules and their reference documents like test procedures, WPS, POR etc.		
	i) For review/comment	-	3 sets of soft copy
	ii) For final approval	1 set floppies	4
15	Monthly Vendor Approval /QP approval status	2 sets	1 FLOPPY
16	QA Documentation Package for field activities on equipment / systems at site	2 sets	2 CD-ROMs
17	QA Documentation Package for field activities on equipment / systems at site	2 sets	2 CD-ROMs

PART-B
G – ERECTION CONDITIONS OF CONTRACT

G-1 ERECTION CONDITIONS OF CONTRACT

1.0 GENERAL

The following provisions shall supplement the conditions already contained in the other parts of these specifications and documents and shall govern that portion of the work of this contract which is to be performed at site. The erection requirements and procedures not specified in these documents shall be in accordance with the recommendations of the equipment manufacturer, or as mutually agreed to between the Employer and the Contractor prior to commencement of erection work.

The Contractor upon signing of the Contract shall, in addition to a Project Coordinator, nominate another responsible officer as his representative at Site suitably designated for the purpose of overall responsibility and co-ordination of the Works to be performed at Site. Such a person shall function from the Site office of the Contractor during the pendency of Contract.

2.0 CODE REQUIREMENTS

The erection requirements and procedures to be followed during the installation of the equipment shall be in accordance with the relevant Government of India Rules & Codes, accepted good practices in the industry and shall fulfill all statutory requirements.

3.0 ELECTRICAL SAFETY REGULATIONS

The contractor shall ensure that entire electrical installation work is executed by adopting applicable statutory safety regulations and best practices in the industry. The Contractor shall employ the necessary number of qualified, full time electricians to maintain his temporary electrical installation.

4.0 INSPECTION AND TESTING INSPECTION CERTIFICATES

The provisions of the clause entitled Inspection and Testing in the Technical Specification, shall also be applicable to the erection portion of the Works. The Employer shall have the right to re-inspect any equipment though previously inspected and approved by him at the Contractor's works, before and after the same are erected at Site. If by the above inspection, the Employer rejects any equipment, the Contractor shall make good for such rejections either by replacement or modification/ repairs as may be necessary to the satisfaction of the Employer. Such replacements will also include the replacements or re- execution of such of those works of other Contractors and/or agencies, which might have got damaged or affected by the replacements or re-work done to the Contractor's work.

5.0 CONTRACTOR'S SITE OFFICE ESTABLISHMENT

The Contractor shall establish an Office at the Site and keep posted an authorized representative for the purpose of the Contract. Any written order or instruction of the Employer or his duly authorized representative shall be communicated to the said

authorized resident representative of the Contractor and the same shall be deemed to have been communicated to the Contractor at his legal address.

6.0 CONTRACTOR'S FIELD OPERATION

The Contractor shall keep the Employer informed in advance regarding his field activity plans and schedules for carrying out each part of the works. Any review of such plan or schedule or method of work by the Employer shall not relieve the Contractor of any of his responsibilities towards the field activities. Such reviews shall also not be considered as an assumption of any risk or liability by the Employer or any of his representatives and no claim of the Contractor will be entertained because of the failure or inefficiency of any such plan or schedule or method of work reviewed. The Contractor shall be solely re- sponsible for the safety, adequacy and efficiency of plant and equipment and his erection methods.

The Contractor shall have the complete responsibility for the conditions of the Work-Site including the safety of all persons employed by him or his Sub-Contractor and all the properties under his custody during the performance of the work. This requirement shall apply continuously till the completion of the Contract and shall not be limited to normal working hours. The construction review by the Employer is not intended to include review of Contractor's safety measures in, on or near the Work-Site, and their adequacy or otherwise.

7.0 PROTECTION OF WORK

The Contractor shall have total responsibility for protecting his works till it is finally taken over by the Employer. No claim will be entertained by the Employer or the representative of the Employer for any damage or loss to the Contractor's works and the Contractor shall be responsible for complete restoration of the damaged works to original conditions to comply with the specification and drawings. Should any such damage to the Contractor's Works occur because of any other agency/individual not being under his supervision or control, the Contractor shall make his claim directly with the party concerned. The Contractor shall not cause any delay in the repair of such damaged Works because of any delay in the resolution of such disputes. The Contractor shall proceed to repair the Work immediately and no cause thereof will be assigned pending resolution of such disputes.

8.0 FACILITIES TO BE PROVIDED BY THE CONTRACTOR

8.1 **Contractor's site office Establishment**

The Contractor shall establish a site office at the site and keep posted an authorized representative for the purpose of the contract, pursuant to GCC.

8.2 **Tools, tackles, and scaffoldings**

The Contractor shall provide all the construction equipment, tools, tackles, and scaffoldings required for pre-assembly, installation, testing, commissioning and conducting Guarantee tests of the equipment covered under the Contract. The Contractor

shall arrange machinery & equipment such as Dozer, Hydra, Cranes, Trailer, etc. wherever required for the purpose of fabrication, erection, and commissioning.

8.3 **Testing Equipment and Facilities:**

The contractor shall provide the necessary testing equipment and facilities.

8.4 **Testing of construction material at the site:**

Contractor shall make arrangements for the testing of construction material at the site wherever required, under the scope of services of the contract.

8.5 **First-aid**

The Contractor shall provide necessary first-aid facilities for all his employees, representatives and workmen working at the Site. Enough number of Contractor's personnel shall be trained in administering first-aid.

8.6 **Water**

Contractor shall make all arrangements himself for the supply of construction water as well as potable water for labour and other personnel at the worksite/colony.

9.0 FIRE PROTECTION

The work procedures that are to be used during the erection shall be those which minimize fire hazards to the extent practicable. Combustible materials, combustible waste and rubbish shall be collected and removed from the Site regularly. Fuels, oils and volatile or flammable materials shall be stored away from the construction and equipment and materials storage areas in safe containers. Untreated canvas, paper, plastic or other flammable flexible materials shall not at all be used at Site for any other purpose unless otherwise specified. If any such materials are received with the equipment at the Site, the same shall be removed and replaced with acceptable material before moving into the construction or storage area.

All materials used for storage or for handling of materials shall be of water proof and flame resistant type. All the other materials such as working drawings, plans etc. which are combustible but are essential for the works to be executed shall be protected against combustion resulting from welding sparks, cutting flames and other similar fire sources.

All the Contractor's supervisory personnel and sufficient number of workers shall be trained for fire-fighting and shall be assigned specific fire protection duties. Enough of such trained personnel must be available at the Site during the entire period of the Con- tract.

The Contractor shall provide suitable quantity & type fire protection equipment for the warehouses, office, temporary structures etc.

10.0 SECURITY

The Contractor shall have total responsibility for all equipment and materials in his custody stores, loose, semi-assembled and/or erected by him at Site. The Contractor shall make suitable security arrangements including employment of security personnel to ensure the protection of all materials, equipment and works from theft, fire, pilferage and any other damages and loss.

11.0 PACKAGING AND TRANSPORTATION

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The Contractor shall be responsible for any loss or damage during transportation, handling, and storage due to improper packing. The Contractor shall ascertain the availability of Railway wagon sizes from the Indian Railways or any other agency concerned in India well before effecting dispatch of equipment. Before dispatch it shall be ensured that complete processing and manufacturing of the components is carried out at shop, only restricted by transport limitation, in order to ensure that site works like grinding, welding, cutting & preassembly to bare minimum. The Employer's Inspector shall have right to insist for completion of works in shops before dispatch of materials for transportation.

12.0 CRATING

All equipment and materials shall be suitably coated, wrapped, or covered and boxed or crated for moist humid tropical shipment and to prevent damage or deterioration during handling and storage at the site.

Equipment shall be packed with suitable desiccants, sealed in water proof vapour-proof wrapping and packed in lumber of plywood enclosures, suitably braced, tied and skidded. Lumber enclosures shall be solid, not slatted.

Desiccants shall be either silica gel or calcium sulphate, sufficiently ground to provide the required surface area and activated prior to placing in the packaging. Calcium sulphate desiccants shall be of a chemical nature to absorb moisture. In any case, the desiccant shall not be of a type that will absorb enough moisture to go into solution. Desiccants shall be packed in porous containers, strong enough to withstand handling encountered during normal shipment. Enough desiccant shall be used for the volumes enclosed in wrapping.

Packaging or shipping units shall be designed within the limitations of unloading facilities and the equipment which will be used for transport. Complications involved with ocean shipment and the limitations of ports, railways and roads shall be considered. It shall be the Contractor's responsibility to investigate these limitations and to provide suitable packaging to permit safe handling during transit and at the job site.

Electrical equipment, control and instrumentation shall be protected against moisture and water damage. All external gasket surfaces and flange faces, couplings, motor pump

shafts, bearing and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection.

Equipment having antifriction or sleeve bearings shall be protected by weather tight enclosures.

Coated surfaces shall be protected against impact, abrasion, discolouration and other damage. Surfaces which are damaged shall be repaired.

All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors. All female threaded openings shall be closed with forged steel plugs. All pipings, tubing, and conduit equipment and other equipment openings shall be sealed with metallic or other rough usage covers and tapped to seal the interior of the equipment piping, tubing, or conduit.

Provisions shall be made to ensure that water does not enter any equipment during shipment or in storage at the plant site.

Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Contractor's expense.

While packaging the material, care shall be taken for the limitation from the point of view of availability of railway wagon sizes in India.

13.0 MATERIALS HANDLING AND STORAGE

13.1 All the equipment furnished under the Contract and arriving at Site shall be promptly received, unloaded and transported and stored in the storage spaces by the Contractor.

13.2 Contractor shall be solely responsible for any shortages or damage in transit, handling and / or in storage and erection of the equipment at Site. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

13.3 The equipment stored shall be properly protected to prevent damage either to the equipment or to the floor where they are stored. The equipment from the store shall be moved to the actual location at the appropriate time to avoid damage of such equipment at Site.

13.4 All electrical panels, controls gear, motors and such other devices shall be properly dried by heating before they are installed and energised. Motor bearings, slip rings, commutators and other exposed parts shall be protected against moisture ingress and corrosion during storage and periodically inspected. Heavy rotating parts in assembled conditions shall be periodically rotated to prevent corrosion due to prolonged storage.

13.5 All the electrical equipment such as motors, etc. shall be periodically tested for insulation resistance from the date of receipt till the date of commissioning and a record of such measured insulation values maintained by the Contractor. Such records shall be open for inspection by the Employer.

13.6 The Contractor shall ensure that all the packing materials and protection devices used for the various equipment during transit and storage are removed before the equipment are installed.

13.7 The consumables and other supplies likely to deteriorate due to storage must be thoroughly protected and stored in a suitable manner to prevent damage or deterioration in quality by storage.

13.8 All the materials stored in the open or dusty location must be covered with suitable weatherproof and flameproof covering material wherever applicable.

14.0 CONSTRUCTION MANAGEMENT

Contractor shall be responsible for performance of his works in accordance with the specified construction schedule. If at any time, the Contractor is falling behind the schedule, he shall take necessary action to make good for such delays by increasing his work force or by working overtime or otherwise accelerate the progress of the work to comply with the schedule and shall communicate such actions in writing to the Employer, satisfying that his action will compensate for the delay. The Contractor shall not be allowed any extra compensation for such action.

The Employer shall however not be responsible for provision of additional labour and/or materials or supply or any other services to the Contractor.

15.0 FIELD OFFICE RECORDS

The Contractor shall maintain at his Site Office up-to- date copies of all drawings, specifications and other Contract Documents and any other supplementary data complete with all the latest revisions thereto. The Contractor shall also maintain in addition the continuous record of all changes to the above Contract Documents, drawings, specifications, supplementary data, etc. effected at the field and on completion of his total assignment under the Contract shall incorporate all such changes on the drawings and other Engineering data to indicate as installed conditions of the equipment furnished and erected under the Contract. Such drawings and Engineering data shall be available for inspection & review to the Employer.

16.0 PROTECTION OF PROPERTY AND CONTRACTOR'S LIABILITY

16.1 The Contractor shall be responsible for any damage resulting from his operations. He shall also be responsible for protection of all persons including members of public and employees of the Employer and his own employees and all public and private property including structures, building, other plants and equipment and utilities either above or below the ground.

16.2 The Contractor will ensure provision of necessary safety equipment such as barriers, sign - boards, warning lights and alarms, etc. to provide adequate protection to persons and property.

17.0 PAINTING

All exposed metal parts of the equipment including pipings, structure railings, etc. wherever applicable, after installation unless otherwise surface protected, shall be first painted in accordance with relevant codes & standards, after thoroughly cleaning all such parts of all dirt, rust, scales, greases, oils and other foreign materials by wire brushing, scraping or sand blasting.

18.0 UNFAVOURABLE WORKING CONDITIONS

The Contractor shall confine all his field operations to those works which can be performed without subjecting the equipment and materials to adverse effects during inclement weather conditions, like monsoon, storms, etc. and during other unfavourable construction conditions. No field activities shall be performed by the Contractor under conditions which might adversely affect the quality and efficiency thereof, unless special precautions or measures are taken by the Contractor in a proper and satisfactory manner in the performance of such Works and with the concurrence of the Employer. Such unfavourable construction conditions will in no way relieve the Contractor of his responsibility to perform the Works as per the schedule.

19.0 PROTECTION OF MONUMENTS AND REFERENCE POINTS

The Contractor shall ensure that any finds such as relic, antiquity, coins, fossils, etc. which he may come across during the course of performance of his Works either during excavation or elsewhere, are properly protected and handed over to the Employer.

20.0 FOUNDATION DRESSING & GROUTING FOR EQUIPMENT/ EQUIPMENT BASES

The surfaces of foundations shall be dressed to bring the top surface of the foundations to the required level, prior to placement of equipment/equipment bases on the foundations.

All the equipment/ equipment bases shall be grouted and finished as per these specifications unless otherwise recommended by the equipment manufacturer.

The concrete foundation surfaces shall be properly prepared by chipping, grinding as required to bring the top of such foundation to the required level, to provide the necessary roughness for bondage and to assure enough bearing strength.

20.1 **GROUT**

The grout shall be high strength grout having a minimum characteristic compressive strength of 60 N/mm2 at 28 days. The grout shall be chloride - free, cement based, free flowing, non-metallic grout.

The Grout shall have good flowability even at very low water/ grout powder ratio.

The Grout shall have characteristics of controlled expansion to be able to occupy its original volume to fill the voids and to compensate for shrinkage. Grout shall be of pre-mix variety so that only water needs to be added before use.

The mixing of the Grout shall conform to the recommendations of the manufacturer of the Grout.

20.2 **PLACING OF GROUT**

After the base has been prepared, its alignment and level has been checked and approved and before actually placing the grout, a low dam shall be set around the base at a distance that will permit pouring and manipulation of the grout. The height of such dam shall be at least 25mm above the bottom of the base. Suitable size and number of chains shall be introduced under the base before placing the grout, so that such chains can be moved back & forth to push the grout into every part of the space under the base.

The grout shall be poured either through grout holes if provided or shall be poured at one side or at two adjacent sides to make the grout move in a solid mass under the base and out in the opposite side. Pouring shall be continued until the entire space below the base is thoroughly filled and the grout stands at least 25 mm higher all around than the bottom of the base. Enough care should be taken to avoid any air or water pockets beneath the bases.

In addition to the above, recommendations of Grout manufacturer shall also be followed.

20.3 **FINISHING OF THE EDGES OF THE GROUT**

The poured grout should be allowed to stand undisturbed until it is well set. Immediately thereafter, the dam shall be removed and grout which extends beyond the edges of the structural or equipment base plates shall be cut off, flushed and removed. The edges of the grout shall then be pointed and finished with 1:2 cement mortar pressed firmly to bond with the body of the grout and smoothened with a tool to present a smooth vertical surface. The work shall be done in a clean and scientific manner and the adjacent floor spaces, exposed edges of the foundations, and structural steel and equipment base plates shall be thoroughly cleaned of any spillage of the grout.

21.0 SHAFT ALIGNMENTS

All the shafts of rotating equipment shall be properly aligned to those of the matching equipment to as perfect accuracy as practicable. The equipment shall be free from excessive vibration to avoid overheating of bearings or other conditions which may tend to shorten the life of the equipment. The vibration level of rotating equipment measured at bearing housing shall conform to VDI 2056. All bearings, shafts and other rotating parts shall be thoroughly cleaned and suitably lubricated before starting.

22.0 DOWELLING

All the motors and other equipment shall be suitably doweled after alignment of shafts with tapered machined dowels as per the direction of the Employer.

23.0 CABLING

All cables shall be supported by conduits or cable tray run in air or in cable channels. These shall be installed in exposed runs parallel or perpendicular to dominant surfaces

with right angle turn made of symmetrical bends or fittings. When cables are run on cable trays, they shall be clamped at a minimum intervals of 2000mm.

Each cable, whether power or control, shall be provided with a metallic or plastic tag of an approved type, bearing a cable reference number indicated in the cable and conduit list (prepared by the Contractor), at every 5 meter run or part thereof and at both ends of the cable adjacent to the terminations. Cable routing is to be done in such a way that cables are accessible for any maintenance and for easy identification.

Sharp bending and kinking of cables shall be avoided. Installation of other cables like high voltage, coaxial, screened, compensating, mineral insulated shall be in accordance with the cable manufacturer's recommendations. Wherever cables cross roads and water, oil, sewage or gas lines, special care should be taken for the protection of the cables in designing the cable channels.

In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop fault at a later date.

Control cable terminations shall be made in accordance with wiring diagrams, using identifying codes subject to the Employer's approval. Multicore control cable jackets shall be removed as required to train and terminate the conductors. The cable jacket shall be left on the cable, as far as possible, to the point of the first conductor branch. The insulated conductors from which the jacket is removed shall be neatly twined in bundles and terminated. The bundles shall be firmly but not tightly tied utilizing plastic or nylon ties or specifically treated fungus protected cord made for this purpose. Control cable conductor insulation shall be securely and evenly cut.

The connectors for control cables shall be covered with a transparent insulating sleeve so as to prevent accidental contact with ground or adjacent terminals and shall preferably terminate in Elmex terminals and washers. The insulating sleeve shall be fire resistant and shall be long enough to over pass the conductor insulation. All control cables shall be fanned out and connection made to terminal blocks and test equipment for proper operation before cables are corded together.

24.0 EQUIPMENT INSTALLATION

A) GENERAL REQUIREMENTS

The Contractor shall furnish all construction materials, tools and equipment and shall perform all work required for complete installation of all control and instrument equipment furnished under this specification.

Contractor shall prepare detailed installation drawings for each equipment furnished under this specification. Installation of all equipment/systems furnished by this specification shall be as per installation drawings.

Erection procedures not specified herein shall be in accordance with the recommendations of the equipment manufacturers. The procedures shall be acceptable to the Employer.

The Contractor shall coordinate his work with other suppliers where their instruments and devices are to be installed under specifications.

B) INSTALLATION MATERIALS

All materials required for installation, testing and commissioning of the equipment shall be furnished by the Contractor.

C) REGULATORY REQUIREMENTS

All installation procedures shall confirm with the accepted good engineering practice and with all applicable governmental laws, regulations and codes.

D) CLEANING

All equipment shall be cleaned of all sand, dirt and other foreign materials immediately after removal from storage and before the equipment is installed.

E) INSTALLATION OF FIELD MOUNTED INSTRUMENTS/DEVICES AND NON-FREE

Standing Equipment

The installation drawings for all field mounted equipment/instrument/devices furnished under this specification shall meet the requirements of this specification, applicable codes and standards and recommendations of manufacturers of instruments/devices. In addition to above relevant Portion as specified elsewhere in technical specification may be referred.

Field mounted instruments and accessories shall be bracket or sub panel mounted on the nearest suitable firm steel work or masonry. The brackets, stands, supports and other miscellaneous hardware required for mounting instruments and accessories such as receiver gauge, air set, valve manifold, purge-meter etc. shall be furnished and installed. No field mounted instruments shall be installed such that it depends for support or rigidity on the impulse piping or on electrical connection to it.

All free standing instrumentation cabinets and panels shall be located within the construction tolerances of +/- 3 mm of the location dimensions indicated on the plant arrangement drawings.

Non-free standing local enclosures and cabinets shall be mounted in accessible locations on columns, walls, or stands. Bracket and stands shall be fabricated as required to install the local enclosures and cabinets in a workman like manner. Rough edges and welds on all fabricated supports shall be ground smooth. The supports shall be finished with two coats of primer and two coats of paint as specified in this part.

F) DEFECTS

All defects in erection shall be corrected to the satisfaction of the Employer and the Project Manager. The dismantling and reassembly of Contractor furnished equipment to

remove defective parts, replace parts, or make adjustments shall be included as a part of the work under these specifications.

The removal of control and instrument equipment in order to allow bench calibration, if required, and the re-installation of the said equipment after calibration shall also be included as a part of the work under these specifications.

G) EQUIPMENT PROTECTION

All equipment to be erected under these specifications shall be protected from damage of any kind from the time of contract award until commissioning of each unit.

The equipment shall be protected during storage as described herein.

Equipment shall be protected from weld spatter during construction.

Suitable guards shall be provided for protection of personnel on all exposed rotating or moving machine parts. All such guards with necessary spares and accessories shall be designed for easy removal and maintenance.

Equipment having glass components such as gauges, or equipment having other easily breakable components, shall be protected during the construction period with plywood enclosures or other suitable means. Broken, stolen, or lost components shall be replaced by the Contractor.

Machine finished surfaces, polished surfaces, or other bare metal surfaces which are not to be painted, such as machinery shafts and couplings shall be provided temporary protection during storage and constructional periods by a coating of a suitable non- drying, oily type, rust preventive compound.

25.0 DEVIATIONS DISPOSITIONING:

Any deviation to the contract and employer approved documents shall be properly recorded in the format prescribed by CIL. All the deviations shall be bought to the knowledge of employer's representative for suitable dispositioning.

26.0 STATUTORY REQUIREMENTS

In addition to the local laws and regulations, the Contractor shall also comply with the Minimum Wages Act and the Payment of Wages Act (both of the Government of India) and the rules made there under in respect of its labour and the labour of its sub- contractors currently employed on or connected with the contract.

All registration and statutory inspection fees, if any, in respect of his work pursuant to this Contract shall be to the account of the Contractor. However, any registration, statutory inspection fees lawfully payable under the provisions of any statutory laws and its amendments from time to time during erection in respect of the plant equipment ultimately to be owned by the Employer, shall be to the account of the Employer. Should any such inspection or registration need to be re-arranged due to the fault of the Contractor or his Sub-Contractor, the additional fees for such inspection and/or registration shall be borne by the Contractor.

27.0 EMPLOYMENT OF LABOUR

27.1 Contractors are to employ, to the extent possible (as per policy decision of the company valid from time to time), local project affected people and pay wages not less than the minimum wages as per minimum Wages Act or such other legislations or award of the minimum wage fixed by respective State Govt. or Central Govt. as may be in force. No female labour shall be employed after darkness. No persons below the age of eighteen years shall be employed.

27.2 All traveling expenses including provisions of all necessary transport to and from site lodging allowances and other payments to contractor's employees shall be the sole responsibility of the contractor.

27.3 The hour of work on the site shall be decided by the owner and the contractor shall adhere to it. Working hours will normally be eight (8) hours per dayMonday to Saturday.

27.4 Contractor's employees shall wear identification badges while on work at site.

27.5 Payment of Provident Fund for the workmen employed by him for the work as per the Law prevailing under provision of CMPF/EPF and allied scheme valid from time to time shall be responsibility of the Contractor which shall be in accordance with the given guidelines:
1. The Contractor must be mandatorily registered as employer under the CMPF Act and allied scheme and shall submit details of their workers with the CMPF number, wherever required. The contractor shall submit CMPF registration certificate before signing of agreement.
2. If any employee of a Contractor is not a member of any Provident Fund, he shall be required to become a member of CMPF scheme immediately, for availing benefits therefrom.
3. Where the employees of a Contractor are members of EPF scheme, the Contractor shall provide appropriate facilitation to those employees who voluntarily opt for conversion from EPF Schemes to CMPF Schemes. In addition to the above, the Contractor shall provide a copy of the updated passbook having entry made in the CMPF/EPF or Allied Scheme(s) of Provident fund as the case may be, to the Competent Authority annually or as and when asked. Bidder shall also submit copies of statutory returns. The contractor shall also comply with the provisions of the CMPF/ EPF and regularly deposit the contributions in accordance with the same. The Company shall have no liability whatsoever in this regard.

27.6 The Contractor shall comply with statutory requirements of various acts including Child Labour (Prohibition & Regulation) Act, 1986 as amended from time to time and all rules, regulations and schemes framed there under from time to time in addition to other applicable labour laws.

13.7	The payment to the contractor's labourers has to be made through Bank only.
13.8	Bonus is to be paid to the contract workers engaged by the Contractors as per the provisions of Payment of Bonus Act,1965 as amended from time to time.
13.9	The contractors shall register themselves on the Contract Labour Payment Management Portal (CLPMP) of CIL within 30 days of issue of Letter of Acceptance/work order and will have to enter and update periodically the following details in the portal: a. LOA/Work Order details b. Details of Contractor workers and payment of wages in respect of each Work Order each month.
13.10	All the contract workers shall be covered with the Bio-metric attendance system for payment of wages.
13.11	Contractors should deploy suitably experienced workers as mentioned in relevant Govt. circular.
28.0	**WORK & SAFETY REGULATIONS**

The Contractor shall ensure proper safety of all the workmen, materials, plant and equipment belonging to him or to Employer or to others, working at the Site. The Contractor shall also be responsible for provision of all safety notices and safety equipment required both by the relevant legislation and the Employer as he may deem necessary.

Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosives, the contractor shall be responsible for carrying-out such provision and/or storage in accordance with the rules and regulations laid down in petroleum act 1934, explosives act, 1948, and petroleum and carbide of calcium manual published by the chief inspector of explosives of India. All such storage shall have prior approval of the employer. In case, any approvals are necessary from the chief inspector (explosives) or any statutory authorities, the contractor shall be responsible for obtaining the same.

Where explosives are to be used, the same shall be used under the direct control and supervision of an expert, experienced, qualified and competent person strictly in accordance with the Code of Practices/Rules framed under Indian Explosives Act pertaining to handling, storage and use of explosives.

All equipment used in construction and erection by Contractor shall meet Indian/International Standards and where such standards do not exist, the Contractor shall ensure these to be absolutely safe. All construction and erection equipment shall be strictly operated and maintained by the Contractor in accordance with statutory safety regulations. Periodical Examinations and all tests for all lifting/ hoisting equipment & tackles shall be carried-out in accordance with the relevant provisions of Factories Act 1948, Indian Electricity Act 1910 and associated Laws/Rules in force from time to time.

The Contractor shall provide suitable safety equipment of prescribed standard to all employees and workmen according to the need, as may be directed by Employer who will

also have right to examine these safety equipments to determine their suitability, reliability, acceptability and adaptability.

(a) Working platforms should be fenced and shall have means of access.
(b) Ladders in accordance with stautory safety rules for construction and erection shall be used. Rungs shall not be welded on columns. All the stairs shall be provided with handrails immediately after its erection.

The Contractor shall provide safe working conditions to all workmen and employees at the Site including safe means of access, railings, stairs, ladders, scaffoldings etc. The scaffoldings shall be erected under the control and supervision of an experienced and competent person. For erection, good and standard quality of material only shall be used by the Contractor.

The Contractor employing workmen whether temporary, casual, probationer, regular or permanent or on contract, shall employ at least one full time officer exclusively as **Safety Steward** to supervise safety aspects of the equipment and workmen, who will co- ordinate with the Employer's Safety Officer. In case of work being carried out through sub-Contractors, the Sub-Contractor's workmen/employees will also be considered as the Contractor's employees/workmen for the above purpose

In case any accident occurs during the construction/ erection or other associated activities undertaken by the Contractor thereby causing any minor or major or fatal injury to his employees due to any reason, whatsoever, it shall be the responsibility of the Contractor to promptly inform the same to the Employer and also to all the authorities envisaged under the applicable laws.

28.1 The Contractor shall follow and comply with relevant provisions of applicable laws pertaining to the safety of workmen, employees plant and equipment as may be prescribed from time to time without any demur, protest or contest or reservation.

PART-B
H – MANDATORY SPARES

H-1 MANDATORY SPARES

1.0 GENERAL

The general requirements pertaining to the supply of mandatory spares is as under.

(a) The bidder shall indicate the prices for each and every item (except for items not applicable to the bidders design) in the 'Schedule of mandatory Spares' whether or not he considers it necessary for the Owner to have such spares. If the bidder fails to comply with the above or fails to quote the price of any spare item, the cost of such spares shall be deemed to be included in the contract price. The bidder shall furnish the population per unit of each item in the Bid Forms and Price Schedules. Whenever the quantity is mentioned in "sets" the bidder has to give the item details and prices of each item.

(b) Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the station (project), unless specified otherwise, and the fraction will be rounded off to the next higher whole number.

(c) Wherever the requirement has been specified as a 'set' it will include the total requirement of the item for a unit, module or the station or as specified. Where it is not specified a 'set' it will include the total requirement of the item for a unit, module or the station or a as specified. Where it is not specified a 'set' would mean the requirement for the single equipment/system as the case may be. Also one set for the particular equipment. e.g. 'set' of bearings for a pump would include the total number of bearings in a pump. Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.

(d) The Owner reserves the right to buy any or all the mandatory spares parts.

(e) The prices of mandatory spares indicated by the Bidder in the Bid Proposal sheets shall be used for bid evaluation purposes.

(f) All mandatory spares shall be delivered at site at least two months before scheduled commissioning of the solar plant. However, spares shall not be dispatched before dispatch of corresponding main equipment.

(g) Wherever quantity is specified both as a percentage and a value, the Bidder has to supply the higher quantity until and unless specified otherwise.

(h) The Mandatory Spares shall be handed over to the Bidder during O&M Period for use in the Plant Capacity Block through an Indemnity Bond (Format Attached). The spares shall be replenished by the bidder as and when it is used.

(i) The spares in total quantity shall be returned to the Employer in working condition at the end of the O&M Period.

PART-B
I – TENDER DRAWINGS & ANNEXURES

I-1 TENDER DRAWINGS & ANNEXURES

Annexures

1.	Attachment-1	Geotechnical Investigation Report
2.	Attachment-2	Plot Map
3.	Attachment-3	Hydrology & Hydrogeological Study Report
4.	Attachment-4	Tentative layout of KPS II pooling substation (SLD)

Attachment-1

FINAL GEOTECHNICAL REPORT

For,

Proposed

Solar/Wind/Hybrid Park

at Great Runn of Kutch

Area, Kutch, Gujarat

PROJECT NAME	Proposed Solar/Wind/Hybrid Park at Great Runn of Kutch Area, Kutch, Gujarat				
REFERENCE NO.	GIPCL/REPARK/Geotechnical/2020-21/1404, dated 19th October, 2020				
CLIENT					
GEOTECH CONSULTANT					
DOCUMENT NO.	**UES/2020-21/201130-108/144**				
REVISION NO.	RA-0	RA-1	RA-2	RA-3	
DATE OF ISSUE	19-01-2021	10-03-2021	14-04-2021	05-05-2021	
TOTAL NO. OF PAGES	217				

ACTION	**NAME**	**DESIGNATION**
PREPARED BY	DEEPA JETHVA	ENGINEER
CHECKED BY	KUNAL SHAH	TECHNICAL MANAGER

INDEX

1.0 INTRODUCTION

1.1 GENERAL

Gujarat Industries Power Company Ltd., Vadodara, Gujarat has engaged **Unique Engineering Services** to provide their Service vide their letter No: GIPCL/REPARK/Geotechnical/2020-21/1404, dated 19th October, 2020 to carry out detailed Geotechnical Investigation including laboratory testing works, technical report, etc for proposed Solar/Wind/Hybrid Park at Great Runn of Kutch Area, Kutch, Gujarat. The field testing was carried out from the 30th of November, 2020 to 19th of December 2020. This report includes 8 boreholes of 30.0m depth and 20 boreholes of 50.0m depth from respective ground levels, as per specifications.

1.2 PURPOSE

The objective of the geotechnical investigation was to explore the sub-soil profile up to a predetermined depth and to work out the bearing capacity/allowable pressure on the soil beneath at a required foundation depth for the proposed type of foundation.

Complete geotechnical investigation work was undertaken to obtain the required subsurface information to study and define the nature and behavior of soil, under the application of loads of proposed structures. Such information was obtained through the following steps:

- Drilling boreholes and collecting disturbed and undisturbed soil samples.
- Performing in-situ tests (e.g. SPT, CBR, ERT, Permeability Test, Trial Pit) and conducting laboratory tests to classify and determine the physical and engineering properties of soils.

2.0 SCOPE OF THE WORK

2.1 Exploration at various locations of the proposed site and conduct requisite in-situ tests.

2.2 Laboratory testing of representative samples obtained during the field investigation to evaluate relevant engineering parameters of the subsurface soils.

2.3 Preparation of this report includes:

- Bore logs and trial pits cross-sections

- Results of laboratory tests and field tests
- Recommendation of foundation types and depths
- Evaluation of Liquefaction potential

Table 1: Scope of work

Sr. No.	Description	Quantity
1	Boreholes	8 Nos. of 30.0 m depth & 20 Nos. of 50.0 m depth
2	Trial Pits	10 Nos.
3	Field California Bearing Ratio (CBR) Tests	15 Nos.
4	Electrical Resistivity Tests (ERT)	15 Nos.
5	Laboratory Tests, Analysis, and Submission of report	

3.0 FIELD INVESTIGATION

3.1 DRILLING WORK

The rotary drilling machine was mobilised at the site. The safety mechanisms were developed for the technical team and workers.

Twenty Eight boreholes of 100mm diameter were drilled to determine the sub-soil stratification and to test the samples of various depths for the physical and the engineering properties. The undisturbed samples were collected as per IS 1892:1979 (RA-2016) Code of practice for subsurface investigations for foundations. The boreholes were terminated at the termination criteria given in the specifications.

3.2 GROUNDWATER CONDITION

The top level of the groundwater was checked in the test boreholes after 24 hours of completion of drilling work. Ground water was encountered from 2.00m to 4.50m depth below EGL during subsurface investigation work carried out in the month of December'20. It may differ depending on the period of year and climatic conditions.

Table 2: Borehole Details

BH. No.	Reduced Level, m	Depth below EGL, m	Groundwater below EGL, m	42Q, Co-ordinates, m	
				N	E
1	4.701	50.0	2.20	2659249	558986
2	4.247	30.0	2.20	2658766	560446

BH. No.	Reduced Level, m	Depth below EGL, m	Groundwater below EGL, m	42Q, Co-ordinates, m	
				N	E
4	4.208	50.0	2.20	2658420	563002
5	4.288	50.0	2.00	2658086	559888
6	3.993	30.0	4.20	2657351	561330
7	4.100	50.0	2.20	2656232	562087
9	5.828	50.0	4.50	2661383	559525
10	5.207	50.0	4.00	2661089	560920
11	5.241	30.0	4.20	2660618	562465
12	4.855	50.0	4.50	2661281	564073
13	6.261	30.0	3.90	2662474	559509
14	7.118	50.0	4.40	2662677	561075
15	5.433	50.0	4.30	2662004	562554
16	5.062	50.0	4.30	2662169	564254
17	6.186	50.0	3.00	2663596	559482
18	6.141	50.0	2.50	2663906	560804
19	5.868	50.0	4.30	2663576	562593
20	5.511	50.0	4.40	2663509	564159
21	6.597	50.0	4.50	2664999	559688
22	6.901	30.0	4.40	2665252	561390
23	6.299	30.0	4.30	2664879	562834
24	6.046	50.0	4.40	2664666	563996
25	7.385	30.0	4.40	2665989	559725
26	7.739	50.0	4.00	2666558	561205
27	6.766	50.0	4.30	2666128	562981
28	7.829	35.0	3.30	2667219	559649
29	6.900	30.0	4.00	2667619	560896
30	7.066	50.0	4.30	2667442	562307

Table 3: Trial Pit Details

Sr. No.	Trial pit No.	Depth, m	42Q, Co-ordinates, m	
			N	E
1	TP-2	3.20	2658768	560441
2	TP-6	3.20	2657345	561329
3	TP-11	3.30	2660633	562474
4	TP-14	3.20	2662672	561093
5	TP-16	3.30	2662172	564254
6	TP-21	3.20	2665005	559690
7	TP-22	3.30	2665258	561392
8	TP-24	3.20	2664665	564000
9	TP-28	3.30	2667219	559651
10	TP-30	3.20	2667444	562311

Table 4: Field CBR Details

CBR No.	Depth, m	Type	42Q, Co-ordinates, m	
			N	E
1	0.200	Natural Moisture Content	2659623.3080	558633.2562
2	0.200		2658812.9316	561969.7025
3	0.200		2656902.2585	561188.5614
4	0.200		2658391.1808	560232.0232
5	0.200		2657549.9039	563210.4914
6	0.200		2661039.8338	560266.7423
7	0.200		2661187.7214	563195.3339
8	0.200		2663200.7089	564112.0968
9	0.200		2663360.0982	559776.7638
10	0.200		2663040.9362	562363.8018
11	0.200		2665485.2417	559567.1542
12	0.200		2665605.1657	563367.5849

13	0.200		2665074.6051	561691.7627
14	0.200		2667601.4842	560113.3624
15	0.200		2667102.3899	562355.2594

Table 5: ERT Details

ERT No.	42Q, Co-ordinates, m	
	N	E
1	2659227.5553	559579.5300
2	2658748.7022	563008.1730
3	2657984.1374	561584.1954
4	2657377.1758	560536.8644
5	2656372.4072	562303.6072
6	2661654.1315	559603.5859
7	2661531.5553	561820.2488
8	2661369.0500	563535.1994
9	2663721.1145	560157.4793
10	2663292.6739	563220.3234
11	2665085.4719	563657.7810
12	2665476.7237	560482.0592
13	2666960.9826	559586.5586
14	2667794.5955	561928.6945
15	2666315.2009	562276.3323

3.3 SAMPLING DESCRIPTION

The disturbed samples were collected from the borehole and the undisturbed samples were collected using a Shelby tube. The soil samples were visually identified and described in accordance with relevant IS codes and thereafter packed, labeled, sealed, and dispatched to our laboratory. The soil samples were transported to our laboratory in Gandhidham for testing.

3.3.1 DISTURBED SOIL SAMPLES

The disturbed soil samples were collected during the boring and also from the split spoon sampler. The samples recovered were labeled and placed in polythene bags and transported to the laboratory for testing.

3.3.2 UNDISTURBED SOIL SAMPLES

The undisturbed soil samples were collected in accordance with IS 2132:1986 (Reaffirmed-2016) Code of Practice for Thin-walled Tubed Sampling of Soil. The sampler used for sampling had a smooth surface, appropriate area ratio, and cutting edge angle thereby minimizing disturbance of the soil during sampling. The samples were collected starting from 3.00m depth at every 3.00m depth from EGL till hard strata have been recovered. The coating of oil was applied on both sides of the sampler to obtain undisturbed samples in the best possible manner. The sampler was then lowered into the borehole on a string of drill rods at a pre-determined level. The disturbed material in the upper end of the sampler, if any, was completely removed. The soil at the lower end of the sampler was trimmed to about 10 to 15 mm. The samples were sealed using the wax, labeled, and transported to our laboratory at Gandhidham for testing.

3.3.3 ROCK CORING

Heavy-duty rotary drilling rig having the capacity to drill up to 100 m has been used to drill through the rocky stratum. Tungsten Carbide (TC) / Diamond bits were used to drill through weathered rock / hard rock stratum. Recovered cores were measured and percentage Total Recovery and RQD has been calculated as under:

$$\%\ \text{Total Recovery} = \frac{\text{Length of core}}{\text{Length of run}} \text{ x } 100$$

$$\%\ \text{RQD} = \frac{\text{Length of core pieces of 100mm (4 inches and above)}}{\text{Length of run}} \text{ x } 100$$

3.4 STANDARD PENETRATION TEST (SPT)

The SPT has been conducted in accordance with IS 2131:1981 (Reaffirmed-2016) Method for Standard Penetration Test for Soils, in boreholes starting from 0.5 m ,1.50m depth from EGL at every change in strata or an interval of 3.00 m depth in uniform strata. The split spoon sampler has been seated 15 cm with the blows of the hammer weighing 63.5 kg,

falling freely through the height of 75 cm. Thereafter the split spoon sampler was further driven by 30 cm. The number of blows required to drive each 15 cm penetration has been recorded. The number of blows for the first 15 cm penetration is termed as a seating drive. The last 30 cm penetration is termed as penetration resistance N-Value.

Table 6: Co-relation of SPT value for cohesionless soil

SPT (N) value	0 – 4	4 – 10	10 – 30	30 – 50	>50
Consistency of soil	Very Loose	Loose	Medium	Dense	Very Dense

Table 7: Co-relation of SPT value for cohesive soil

SPT (N) value	0 – 2	2 – 4	4 – 8	8 – 15	15 – 30	>30
Consistency of soil	Very Soft	Soft	Medium	Stiff	Very Stiff	Hard

Table 8: Core recovery

Core Recovery (%)	<35	35 – 50	50 – 85	>85
Soundness	Soft Rock (disintegrated rock)	Intermediate Rock (between medium & soft)	Medium Rock	Sound Rock

Table 9: RQD (%) ***(Ref:*** *IS 4464-1985)*

RQD (%)	<25	25 – 50	50 – 75	75 – 90	>90
Diagnostic Description	Very Poor	Poor	Fair	Good	Excellent

3.5 ASSESSMENT OF LIQUEFACTION

Liquefaction of soils is phenomenon which occurs in saturated cohesionless soil (i.e sand stratum) during dynamic conditions in earthquakes.

According to IS-1893, Part-1, Cl. 3.16 “Liquefaction is a state in saturated cohesionless soil” and Cl. 6.3.5.2 states “In soil deposits consisting of submerged loose sands and soils falling under classification SP with standard penetration N-values less than 15 in seismic Zones III, IV, V and less than 10 in seismic Zone II, the vibration caused by earthquake may cause liquefaction or excessive total and differential settlements. Such sites should

preferably be avoided while locating new settlements or important projects. Otherwise, this aspect of the problem needs to be investigated and appropriate methods of compaction or stabilization adopted to achieve suitable N-values as indicated below". The seismic zone factor (Z) 0.36 and maximum earthquake magnitude (Mw) 7.5 has been considered for Bhuj city. The evaluation of the liquefaction potential in case of cohesionless soils shall be computed based on Annex-F from IS1893 (Part-1) : 2016. The same in case of clayey soils is given by Seed and Idriss (1982) who stated that clayey soils (i.e. plots above the A-line on the plasticity chart) could be susceptible to liquefaction only if all three of the following conditions are met: (1) Percent less than 5 mm < 15%, (2) LL < 35, and (3) wc/LL > 0.9. Due to its origin, this standard is known in the literature as the "Chinese Criteria".

4 The desirable minimum corrected field values of *N* shall be as specified below:

Seismic Zone	*Depth* (m) *below Ground Level*	*N Values*	*Remarks*
III, IV and V	≤ 5 ≥10	15 25	For values of depths between 5 m and 10 m, linear interpolation is recommended
II	≤ 5 ≥10	10 20	

3.6 FIELD CALIFORNIA BEARING RATIO (CBR) TEST

The field CBR test has been carried out at 0.200 m depth from EGL as per methodology given in IS 2720, Part-31:1990 RA 2010. This standard covers the method for the determination of Fearing ratio of soils in place for the evaluation of strengths of subgrade and bases for road pavements. The bearing ratio generally is known as CBR (California Bearing Ratio) is the ratio of force per unit area required to penetrate a soil mass with a standard circular piston at the rate of 1.25 mm/min to that required for corresponding penetration of a standard material.

$$\textbf{Bearing Ratio} = \frac{\mathbf{P_t}}{\mathbf{P_s}} \textbf{ x 100 } (\%)$$

$\mathbf{P_t}$ = Corrected unit (or total) test load corresponding to chosen penetration value read from the total penetration curve, in MPa or N.

$\mathbf{P_s}$ = Unit (or total) standard load for the same depth of penetration as per P_t in MPa or N.

3.7 ELECTRICAL RESISTIVITY TEST

The purpose of this investigation is to determine an average value of electrical resistivity of the soil for the design of a safety earthling system and corrosion allowance with the help of microprocessor-based electrical resistivity meter model no. SSR-MP-AT. The test is performed as per IS 3043-1987. The test was conducted by Wenner's four-electrode method.

3.7.1 Wenner's Configuration: This is one of the most commonly used arrays proposed by Wenner in 1916. Four electrodes A, B, M, and N are placed at the surface of the ground along a straight symmetrically about a point O. The observation point in such a way that the distance between AM = MN =NB = a, where 'a' is called electrode separation see fig. 1. The current 'I' is sent generally through outer electrodes A and B and the potential difference (V) is measured between M and N. The configuration factor (K) for this array is

$$\mathbf{K = 2\pi a}$$

And apparent resistivity, which is used for further analysis, is calculated with the formula:

$$\mathbf{a = KR = 2\pi aR}$$

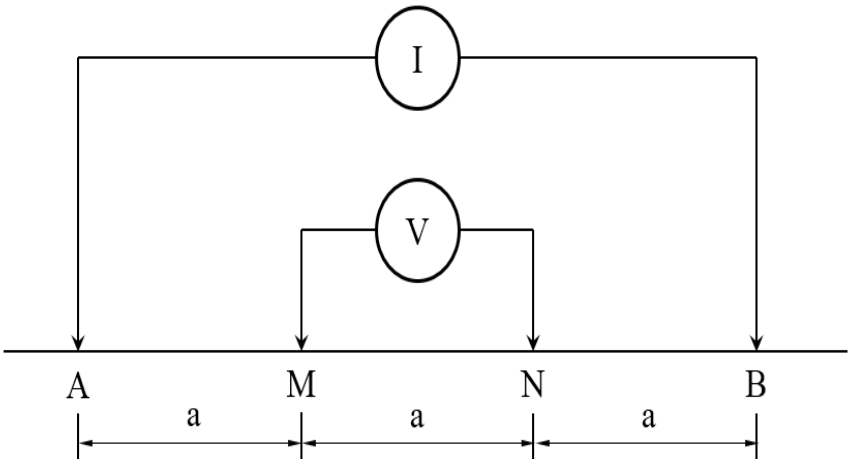


Figure 1 Wenner's Configuration

3.7.2 Survey Procedure: The resistivity soundings are used to determine the sub-surface stratification along the desired depth. In this method, the center of configuration is kept fixed and measurements are made by successively increasing the electrode spacing. The apparent resistivity values obtained with increasing values of electrode separations are used to estimate the thickness and resistivity of the subsurface formations. In the Wenner's configuration, all the four electrodes are arranged in a line at equal distance 'a' between the consecutive electrodes. The measurements are taken by increasing the electrode separation gradually changing from small value; say 1.0 m to several tens and hundreds of meters depending on the depth of the investigations required. The current is generally sent through the outer electrodes and the potential difference is measured between the inner electrodes. The resistance (R = V/I) is measured for each electrode separation and apparent resistivity is calculated by multiplying the value of 'R' with the Wenner's configuration factor ($2\pi a$). The computation of the sounding data is discussed in the subsequent section.

3.7.3 Computation of the Electrical Resistivity: When the electrical resistivity readings for different electrode spacing in a direction are within the range of 20 to 30%, the soil is considered to be uniform. When the spacing is increased gradually from low values, at a stage, it may be found that the resistivity readings are more or less constant irrespective of the increase in the electrode spacing. The resistivity for this spacing is noted and taken as the resistivity for that direction. Similarly, resistivity for at least eight equally spaced directions from the center of the site is measured. This resistivity is plotted in a graph sheet in the appropriate directions choosing a scale. A closed curve is plotted on the graph sheets jointing all the resistivity points plotted to get the polar resistivity curve. The area inside the polar resistivity curve is measured and an equivalent circle of the same area is found out. The radius of this equivalent circle is the average resistivity of the site under consideration. The average resistivity thus obtained may be used for the design of the earthing grid.

4.0 LABORATORY TESTING

The laboratory tests were performed in accordance with relevant IS codes along with the technical specification of the project, at our laboratory in Gandhidham. The summary of the laboratory test results of all boreholes is presented in Annexure.

Table 10: Laboratory Tests

Laboratory Test	IS Code
Moisture Content	IS 2720 Part 2:1973, RA-2015
Specific Gravity	IS 2720 Part 3:1980, RA-2016
Grain Size Analysis	IS 2720 Part 4:1985, RA-2015
Hydrometer	IS 2720 Part 4:1985, RA-2015
Atterberg's Limits	IS 2720 Part 5:1985, RA-2015
Shrinkage Limit	IS 2720 Part 6:1972, RA-2016
Standard Proctor	IS 2720 Part 7:1980, RA-2016
Unconfined Compressive Strength	IS 2720 Part 10:1991, RA-2015
Shear Parameters i.e. $c - \phi$	IS 2720 Part 11:1981, RA-2016 IS 2720 Part 13:1986, RA-2016
Consolidation	IS 2720 Part 15:1986, RA-2016
California Bearing Ratio	IS 2720 Part 16:1987, RA-2016
Free Swell Index	IS 2720 Part 40
Swell Pressure	IS 2720 Part 41
pH	IS 2720 Part 26
Chlorides	IS 2720 and 3025 Part 32
Sulphate	IS 2720 Part 27

4.1 SUB-SOIL PROFILE

Table 11: Sub-Soil Profile

Borehole No.	Depth, m		Soil Description	Type of Soil
	From	To		
1	0.00	3.00	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	3.00	9.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	9.00	10.50	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL

Borehole No	Depth, m		Soil Description	Type of Soil
	From	To		
1	10.50	21.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	21.00	43.50	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	43.50	50.50	Reddish Greyish consolidated Clayey Sand of low Plasticity mixed with little kankars in form of soft rock	SC
2	0.00	0.50	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	0.00	6.00	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL
	6.00	12.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	12.00	18.10	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL
	18.10	19.50	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	19.50	21.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	21.00	30.50	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	8.75	13.55	Greyish brownish non-plastic clayey silt mixed with little Fines	ML
	13.55	16.50	Greyish Silty Sand with Kankars	SM
4	0.00	3.00	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	3.00	6.00	Greyish Silt of Intermediate Plasticity Mixed With Little Fine Sand & Gravel	MI
	6.00	12.00	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	12.00	16.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	16.50	19.50	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL
	19.50	39.45	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	39.45	50.50	(Visual Clasification) Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI

Borehole No	Depth, m		Soil Description	Type of Soil
	From	To		
5	0.00	1.50	Brownish Silt of Intermediate Plasticity mixed with little Fine Sand & Gravel	MI
	1.50	10.51	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	10.51	13.50	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	13.50	19.46	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	19.46	30.55	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
6	0.00	0.50	Brownish Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	0.50	5.90	Greyish Silt of Intermediate Plasticity mixed with little Fine Sand & Gravel	MI
	5.90	22.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	22.50	30.57	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
7	0.00	5.90	Brownish Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	5.90	22.40	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	22.40	50.50	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
9	0.00	8.75	Brownish greyish Silty Clay of Low Plasticity Mixed With Kankars	CL
	8.75	13.55	Greyish brownish non-plastic clayey silt mixed with little Fines	ML
	13.55	16.50	Greyish Silty Sand with Kankars	SM
	16.50	25.51	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	25.51	48.00	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI
	48.00	50.00	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH
10	0.00	0.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	0.50	7.50	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI

Borehole No	Depth, m		Soil Description	Type of Soil
	From	To		
10	7.50	12.00	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL
	12.00	15.10	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	15.10	22.40	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	22.40	42.10	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	42.10	50.50	Brownish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH
11	0.00	1.40	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	1.40	16.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	16.50	21.10	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	21.10	30.50	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
12	0.00	0.30	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	0.30	2.50	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH
	2.50	7.50	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	7.50	23.60	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	23.60	50.50	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
13	0.00	7.40	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	7.40	10.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	10.50	13.40	Greyish Silty Sand with Kankars	SM
	13.40	17.70	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	17.70	25.30	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	25.30	30.60	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI

Borehole No	Depth, m		Soil Description	Type of Soil
	From	To		
14	0.00	18.00	Brownish Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	18.00	39.00	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI
	39.00	50.50	(Visual Classification) Greyish Silty Clay of High Plasticity mixed with Fine Grained Sand Particles	CH
15	0.00	3.00	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	3.00	7.45	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	7.45	15.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	15.00	24.00	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	24.00	50.50	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
16	0.00	1.50	Greyish Brownish Silty Clay of Low Plasticity mixed with Little Sand Particles	CL
	1.50	6.00	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	6.00	15.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	15.00	19.50	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	19.50	22.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	22.50	25.50	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel	CI
	25.50	28.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	28.50	50.50	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel	CI
17	0.00	0.30	Brownish Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	0.40	2.90	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH
	2.90	6.50	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	6.50	20.70	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML

Borehole No	Depth, m		Soil Description	Type of Soil
	From	To		
17	20.70	34.30	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	34.30	39.00	Greyish Consolidation Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH
	39.00	50.45	(Visual Clasification) Greyish Consolidation Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH
18	0.00	6.10	Brownish Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	6.10	15.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	15.00	26.90	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	26.90	41.80	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	41.80	48.90	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH
	48.90	50.50	Reddish Brownish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH
19	0.00	0.50	Greyish Silt of Intermediate Plasticity Mixed With Little Fine Sand & Gravel	MI
	0.50	6.00	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI
	6.00	10.50	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel	ML
	10.50	15.00	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL
	15.00	22.50	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel	ML
	22.50	24.00	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL
	24.00	50.50	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI
20	0.00	3.10	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL
	3.10	5.90	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	5.90	7.50	Greyish Silty Clay of High Plasticity mixed with Fine Grained Sand Particles	CH
	7.50	19.40	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML

Borehole No	Depth, m		Soil Description	Type of Soil
	From	To		
20	19.40	24.20	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CL
	24.20	50.50	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI
21	0.00	1.50	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	1.50	6.00	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL
	6.00	7.50	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	7.50	22.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	22.50	42.00	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	42.00	50.50	(Visual classification) Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
22	0.00	3.00	Greyish Brownish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL
	3.00	9.00	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	9.00	24.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	24.00	30.50	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
23	0.00	1.50	Greyish Brownish Silty Clay of High Plasticity	CH
	1.50	4.50	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	4.50	12.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	12.00	18.00	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL
	18.00	22.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	22.50	30.50	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
24	0.00	6.00	Greyish Brownish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL
	6.00	16.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML

Borehole No	Depth, m		Soil Description	Type of Soil
	From	To		
24	16.50	19.50	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI
	19.50	24.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	24.00	45.00	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI
	45.00	50.50	(Visual Classification) Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI
25	0.00	4.50	Greyish Silt of Intermediate Plasticity Mixed With Little Fine Sand	MI
	4.50	7.50	Greyish Silty Clay of Low Plasticity Mixed With Fine Grained Sand Particles	CL
	7.50	18.00	Greyish Clayey Silt of Low Plasticity mixed with little Fines	ML
	18.00	19.50	Greyish Silty Clay of Low Plasticity Mixed With Fine Grained Sand Particles	CL
	19.50	22.50	Greyish Clayey Silt of Low Plasticity mixed with little Fines	ML
	22.50	30.50	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI
26	0.00	6.00	Brownish Greyish Non - Plastic Silt Mixed With Little Fine Sand	MI
	6.00	9.00	Greyish Silty Sand mixed with kankars	SM
	9.00	24.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	24.00	43.50	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI
	43.50	50.50	(Visual Classification) Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI
27	0.00	1.50	Greyish Silty Clay of Low Plasticity Mixed With Kankars	CL
	1.50	6.00	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI
	6.00	12.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	12.00	15.00	Greyish Silty Clay of Low Plasticity Mixed With Kankars	CL
	15.00	22.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML

Borehole No	Depth, m		Soil Description	Type of Soil
	From	To		
27	22.50	28.50	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI
	28.50	39.00	Greyish Silty Clay of High Plasticity Mixed With Kankars	CH
	39.00	50.50	(Visual Classification) Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI
28	0.00	0.60	Brownish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	0.60	5.90	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI
	5.90	12.70	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	12.70	25.50	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL
	25.50	33.00	Brownish greyish Consolidated Clayey Sand of Low to Intermediate Plasticity mixed with little Gravel	SC
	33.00	35.00	Greyish Highly Weathered Over Consolidated Sand Stone Fragments	HWR
29	0.00	4.50	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
	4.50	13.50	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	13.50	24.00	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL
	24.00	27.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	27.00	30.50	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI
30	0.00	4.50	Greyish Brownish Non-Plastic Clayey Silt mixed with little Fines	ML
	4.50	18.00	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML
	18.00	27.00	Brownish Sandy Clay of Low Plasticity Mixed With Kankars	CL
	27.00	50.50	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI

5.0 LABORATORY AND FIELD TEST RESULTS

5.1 RESULTS OF CHEMICAL ANALYSIS

Table 12: Chemical Test Results of Soil

Sr. No.	Bore Hole	Depth from EGL, m	pH	Chloride, mg/L	Sulphate, %
1	BH-1	4.50	8.60	689	0.0273
2	BH-2	12.00	8.36	769	0.0593
3	BH-2	22.50	8.50	956	0.0263
4	BH-4	13.50	8.41	692	0.0319
5	BH-5	10.50	8.60	923	0.0416
6	BH-5	16.50	8.71	964	0.0326
7	BH-6	9.00	8.09	826	0.0246
8	BH-7	10.50	8.20	843	0.0263
9	BH-9	13.50	8.63	696	0.0254
10	BH-9	16.50	8.53	748	0.0312
11	BH-10	12.00	8.28	1667	0.0404
12	BH-10	16.50	8.45	604	0.0326
13	BH-11	15.00	8.23	720	0.0096
14	BH-12	24.00	8.30	772	0.0589
15	BH-13	16.50	8.69	682	0.0321
16	BH-14	9.00	8.26	696	0.0336
17	BH-15	16.50	8.63	952	0.0290
18	BH-15	24.00	8.10	923	0.0189
19	BH-16	18.00	8.90	883	0.0156
20	BH-17	6.00	8.30	852	0.0320
21	BH-20	36.00	8.08	2499	0.0254
22	BH-20	13.50	8.99	2199	0.0082
23	BH-21	18.00	8.58	1235	0.0374
24	BH-22	9.00	8.33	1060	0.0137
25	BH-23	6.00	8.57	2699	0.0552
26	BH-23	15.00	8.47	2899	0.0322
27	BH-24	15.00	8.23	988	0.0336
28	BH-24	12.00	8.71	3049	0.0308
29	BH-25	6.00	8.20	863	0.0283
30	BH-28	12.00	8.20	910	0.0415
Reference			As per IS 456 Table – 4 Class I		

Table 13: Chemical Test Results of Water

Sr. No.	Bore Hole	pH	Chloride, mg/L	Sulphate, mg/L	TDS, mg/L	Organic, mg/L	Carbonate, mg/L	Turbudity, NTU	Nitrete, mg/L
1	BH-1	6.81	60581	2181	108520	33652	Nil	800	7
2	BH-4	6.72	61235	2262	107321	34125	Nil	900	5
3	BH-4	6.90	100818	4277	112582	35418	Nil	1000	6
4	BH-6	7.00	127710	4032	108521	49256	Nil	1100	5
5	BH-7	6.62	102121	3528	107852	37254	Nil	1025	7
6	BH-7	6.69	104967	3398	102025	51378	Nil	700	6
7	BH-10	7.05	122062	2632	102641	49400	Nil	900	5
8	BH-11	6.71	112382	2305	107493	39521	Nil	1000	8
9	BH-12	6.92	118613	3064	105241	54016	Nil	800	5
10	BH-13	6.81	114464	3236	103210	43000	Nil	950	6
11	BH-14	6.53	101254	2218	108361	32541	Nil	1000	8
12	BH-15	6.61	103258	2205	105211	38211	Nil	900	5
13	BH-15	6.75	109521	3316	108161	37169	Nil	1400	7
14	BH-16	6.52	104582	2854	105923	40215	Nil	2200	6
15	BH-19	6.58	99852	2157	106852	41307	Nil	2400	7
16	BH-19	6.78	103212	2262	102681	40345	Nil	2300	7
17	BH-20	6.55	109414	3125	103794	39651	Nil	2100	5
18	BH-22	6.82	93871	2987	99871	41028	Nil	2600	6
19	BH-25	7.01	48585	2635	106194	36542	Nil	5800	8
20	BH-26	6.73	98993	2197	107932	38921	Nil	2200	7
21	BH-26	6.59	100121	2975	106521	40852	Nil	3800	9
22	BH-28	6.65	99328	2152	108126	38525	Nil	2700	6
23	BH-28	6.91	101253	3168	101585	36924	Nil	4200	9
24	BH-29	6.59	104214	2105	107623	40125	Nil	2800	7
25	BH-30	7.02	99856	2595	106321	39584	Nil	6900	10
IS 456 – 2005 RA:2016		> 6.00	500 mg/l Max (for RCC Work)	400 mg/l Max	--	200 mg/l	--	--	--

5.2 RESULTS OF STANDARD PROCTOR TEST

Table 14: Standard Proctor Test Results

Sr. No	Bore Hole	Depth from EGL, m	Type of Soil	M.D.D, gm/cc	O.M.C, %
1	BH-1	0.20	CI	1.636	19.8
2	BH-2	0.00	CI	1.642	19.2
3	BH-4	0.50	CI	1.649	22.2
4	BH-5	0.30	MI	1.619	22.9
5	BH-6	0.40	CL	1.643	18.3
6	BH-7	0.50	CL	1.636	18.9
7	BH-9	0.20	CL	1.641	19.6
8	BH-10	0.30	ML	1.621	22.6
9	BH-11	0.50	CL	1.635	18.6
10	BH-12	0.40	CH	1.611	23.9
11	BH-13	0.00	CL	1.623	20.3
12	BH-14	0.00	ML	1.619	22.5
13	BH-15	0.40	CL	1.633	18.1
14	BH-16	0.30	CL	1.639	20.3
15	BH-17	0.40	CH	1.610	24.6
16	BH-18	0.50	CI	1.631	21.9
17	BH-19	0.40	MI	1.635	22.2
18	BH-20	0.20	CL	1.643	17.9
19	BH-21	0.40	CI	1.623	20.2
20	BH-22	0.30	CL	1.620	19.4
21	BH-23	0.00	CH	1.612	23.5
22	BH-24	0.40	CL	1.635	20.4
23	BH-25	0.30	MI	1.628	21.6
24	BH-26	0.40	MI	1.636	21.9
25	BH-27	0.50	CL	1.643	19.6
26	BH-28	0.30	CL	1.629	19.1
27	BH-29	0.20	CI	1.639	19.8
28	BH-30	0.40	ML	1.648	21.8

Table 15: Field CBR Test Results

Sr. No.	Location	Depth from EGL, m	Type of Soil	F.D.D, g/cc	F.M.C, %	Natural Moisture CBR Value, %
1	CBR-1	0.200	CI	1.419	24.60	1.91
2	CBR-2	0.200	CI	1.512	23.80	3.34
3	CBR-3	0.200	MI	1.432	24.80	2.86
4	CBR-4	0.200	CL	1.532	24.90	4.77
5	CBR-5	0.200	CI	1.421	26.10	1.19
6	CBR-6	0.200	CL	1.539	23.80	3.82
7	CBR-7	0.200	CI	1.471	24.40	3.34
8	CBR-8	0.200	CL	1.506	26.00	4.29
9	CBR-9	0.200	CI	1.413	29.60	2.86
10	CBR-10	0.200	CL	1.418	24.50	3.82
11	CBR-11	0.200	CI	1.511	22.90	4.29
12	CBR-12	0.200	CI	1.536	23.40	4.77
13	CBR-13	0.200	CI	1.412	21.80	3.82
14	CBR-14	0.200	CL	1.421	23.10	3.82
15	CBR-15	0.200	CL	1.542	20.90	5.25

5.3 RESULTS OF ERT

Table 16: ERT Results

Sr. No.	Location	Average Resistance, Ohm-m
1	ERT-1	7.25
2	ERT-2	10.56
3	ERT-3	4.91

4	ERT-4	7.52
5	ERT-5	6.31
6	ERT-6	5.32
7	ERT-7	4.15
8	ERT-8	5.43
9	ERT-9	4.90
10	ERT-10	4.56
11	ERT-11	4.74
12	ERT-12	4.47
13	ERT-13	7.54
14	ERT-14	4.16
15	ERT-15	5.85

5.4 RESULTS OF FIELD PERMEABILITY

Table 17: Field Permeability Results

Sr. No.	Location	Field Permeability, cm/sec
1	BH-9	6.25 X 10^{-2}
2	BH-9	5.44 X 10^{-2}

6.0 FOUNDATION RECOMMENDATIONS

6.1 SBC based on Shear (IS 6403:1981, RA-2016): The ultimate net bearing capacity is evaluated after taking into consideration of shape factor and depth factor of the foundation in accordance with IS 6403-1981, RA-2016. The ultimate bearing capacity worked out using the following equations;

$$\mathbf{Qu = CN_cS_cd_c + q(N_q - 1)S_qd_q + 0.5B\gamma N_\gamma S_\gamma d_\gamma W'}$$ ___ ***General Shear Failure***

$$\mathbf{Qu = 0.67CN'_cS'_cd'_c + q(N'_q - 1)S'_qd'_q + 0.5B\gamma N'_\gamma S'_\gamma d'_\gamma W'}$$ ___ ***Local Shear Failure***

The ***Intermediate Shear Failure*** can be obtained by Interpolation between General Shear Failure and Local Shear Failure.

Where, $\mathbf{C}$ = Cohesion, T/m^2

$\mathbf{q}$ = Overburden Pressure, T/m^2

$\boldsymbol{\gamma}$ = Bulk Density, T/m^3

$\mathbf{B}$ = Width of the Footing, m

$\mathbf{N_c, N_q, N_\gamma}$ = Bearing Capacity Factors

$\mathbf{S_c, S_q, S_\gamma}$ = Shape Factors

$\mathbf{d_c, d_q, d_\gamma}$ = Depth Factors

$\mathbf{W'}$ = Water Table Correction Factor

6.2 Safe Bearing Pressure (IS 8009 Part-I:1976, RA-2018): The settlement calculation involves many simplifying assumptions. The total settlement is computed as the summation of immediate and secondary consolidation.

$$\mathbf{S_t = S_i + S_c}$$

'S_i' is Immediate Settlement

$$\mathbf{S_i = p\,B\,\frac{(1-\mu^2)}{E}\,I}$$

Where, $\mathbf{p}$ = Foundation Pressure, kg/cm^2

$\mathbf{B}$ = Width of Footing, m

$\boldsymbol{\mu}$ = Poisson's Ratio

$\mathbf{I}$ = Influence Factor

$\mathbf{E}$ = Modulus of Elasticity, kg/cm^2

'S_c' is Secondary Settlement

$$\mathbf{S_c = \frac{H_t}{(1+e_0)}\,C_c\,\log_{10}\frac{(p_0-\delta_p)}{p_0}}$$

Where, $\mathbf{H_t}$ = Thickness of Soil Layer, m

$\mathbf{C_c}$ = Compression Index

$\mathbf{e_0}$ = Initial Void Ratio

$\mathbf{p_0}$ = Initial Effective Pressure

$\boldsymbol{\delta_p}$ = Increase in Effective Pressure

6.3 DESIGN OF PILE:

Bored Cast *In-Situ* Pile design as per IS 2911 (Part 1/Sec II):2010, RA-2015

For Non-Cohesive Soils (Clause No. 6.3.1.1 – Appendix B 1)

$$Q_u = A_p\left(0.5\, D\, \gamma\, N_\gamma + P_d\, N_q\right) + K\, P_D \tan\delta\; A_s$$

For Cohesive Soils (Clause No. 6.3.1.1 – Appendix B 2)

$$Q_u = (A_p\, N_c\, C_p + \alpha\, C_s\, A_s)$$

Where,

A_p	=	Cross-sectional area of pile toe, m^2
D	=	Diameter of the stem, m
γ	=	Effective unit weight of soil at pile toe, kN/m^3
P_d	=	Effective overburden pressure at pile toe, kN/m^2
P_D	=	Effective overburden pressure at around stem, kN/m^2
N_q & N_γ	=	Bearing capacity factors
K	=	Coefficient of earth pressure
δ	=	Angle of wall friction between pile & soil
A_s	=	Surface area of pile stem, m^2
C_p	=	Average cohesion around pile toe, kN/m^2
α	=	Reduction factor
C_s	=	Average cohesion around pile stem, kN/m^2

6.4 Summary of the load-carrying capacity of the pile: Looking to the characteristics and behavior of soil, the capacity of the pile foundation is tabulated in the table below. The size and depth of the pile foundation may be selected as per the site feasibility.

Table 18: Parameters for the load capacity of a Short Pile

Bore Hole	Depth from EGL (m)	Type of soil	Bulk density (g/cc)	Cohesion, C (kg/cm^2)	Angle of internal friction, φ (degree)
BH-1	0.00 – 1.50	CI	1.740	0.21	0
	1.50 – 4.50	ML	1.771	0.00	15
BH-2	0.00 – 1.50	CL	1.769	0.23	0
	1.50 – 3.00	CL	1.769	0.33	0
BH-4	0.00 – 1.50	CI	1.742	0.40	0
	1.50 – 4.50	CI	1.817	0.00	12
BH-5	0.00 – 1.50	ML	1.719	0.00	18
	1.50 – 3.50	ML	1.719	0.00	15

Bore Hole	Depth from EGL (m)	Type of soil	Bulk density (g/cc)	Cohesion, C (kg/cm^2)	Angle of internal friction, φ (degree)
Bh-5	3.50 – 4.50	ML	1.719	0.00	15
BH-6	0.00 – 1.50	MI	1.750	0.00	13
	1.50 – 3.00	MI	1.750	0.00	13
	3.00 – 4.50	MI	1.750	0.00	15
BH-7	0.0 - 1.50	CL	1.776	0.27	0
	1.50 - 3.00	CL	1.776	0.33	0
	3.00 - 4.00	CL	1.776	0.33	0
BH-9	0.00 – 1.50	CL	1.761	0.24	0
	1.50 – 3.00	CL	1.761	0.23	0
BH-10	0.00 – 1.50	CI	1.755	0.25	0
	1.50 – 3.00	CI	1.755	0.27	0
BH-11	0.00 – 0.50	CL	1.745	0.00	13
	0.50 – 3.50	ML	1.770	0.00	16
BH-11	3.50 – 4.50	ML	1.770	0.00	16
BH-12	0.00 – 1.50	CH	1.680	0.33	0
	1.50 – 3.00	CH	1.680	0.33	0
BH-13	0.00 – 1.50	CL	1.731	0.13	0
	1.50 – 3.00	CL	1.731	0.19	0
BH-14	0.00 – 1.50	ML	1.704	0.00	15
	1.50 – 4.50	ML	1.704	0.00	15
BH-15	0.00 – 1.50	CL	1.735	0.34	0
	1.50 – 3.00	CL	1.735	0.41	0

Bore Hole	Depth from EGL (m)	Type of soil	Bulk density (g/cc)	Cohesion, C (kg/cm^2)	Angle of internal friction, φ (degree)
BH-16	0.00 – 1.50	CL	1.706	0.24	0
	1.50 – 3.00	CI	1.706	0.24	0
BH-17	0.00 – 1.50	CH	1.767	0.33	0
	1.50 – 3.00	CI	1.767	0.31	0
BH-18	0.00 – 1.50	CI	1.645	0.14	0
	1.50 – 3.00	CI	1.645	0.24	0
BH-19	0.00 – 1.50	CI	1.733	0.36	0
	1.50 – 3.00	CI	1.733	0.44	0
BH-20	0.00 – 1.50	CL	1.711	0.20	0
	1.50 – 3.00	CL	1.711	0.20	0
BH-21	0.00 – 0.50	CI	1.711	0.00	26
	0.50 – 1.50	CL	1.711	0.00	32
	1.50 – 3.00	CL	1.711	0.00	36
BH-22	0.00 – 1.50	CL	1.710	0.22	0
	1.50 – 3.00	CL	1.748	0.31	0
BH-23	0.00 – 0.50	CH	1.874	0.26	0
	0.50 – 1.50	CI	1.874	0.22	8
	1.50 – 3.00	CI	1.874	0.22	8
BH-24	0.00 – 1.50	CL	1.706	0.00	22
	1.50 – 3.00	CL	1.706	0.00	26
BH-25	0.00 – 1.50	MI	1.720	0.00	14
	1.50 – 3.00	MI	1.720	0.00	18

Bore Hole	Depth from EGL (m)	Type of soil	Bulk density (g/cc)	Cohesion, C (kg/cm^2)	Angle of internal friction, φ (degree)
BH-25	3.00 – 4.50	MI	1.735	0.15	13
BH-26	0.0 – 0.50	ML	1.701	0.00	12
	0.50 – 1.50	ML	1.701	0.00	16
	1.50 – 3.00	ML	1.701	0.05	17
BH-27	0.0 – 1.50	CI	1.799	0.00	35
	1.50 – 3.00	CI	1.799	0.14	6
BH-28	0.00 – 1.50	CI	1.730	0.29	0
	1.50 – 3.00	CI	1.730	0.26	11
BH-29	0.00 – 1.50	CI	1.819	0.32	0
	1.50 – 3.00	CI	1.819	0.18	13
BH-30	0.0 – 1.50	ML	1.708	0.00	11
	1.50 – 3.00	ML	1.708	0.00	13
	3.00 – 4.50	ML	1.708	0.00	15

Table 19: Load carrying capacity of a Short Pile

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL (m)	Pile Capacity		
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral (MT) (By Brom's Method)
						Free Head Condition
Bored Cast In-Situ Pile	BH-1	300	4.5	2.3	2.1	0.8
		350		2.7	2.6	1.0
	BH-2	300	3.0	4.1	3.1	2.6
		350		4.9	3.6	3.2

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL (m)	Pile Capacity		
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral (MT) (By Brom's Method) Free Head Condition
Bored Cast In-Situ Pile	BH-4	300	4.5	3.2	2.9	0.4
		350		3.7	3.5	0.6
	BH-5	300	4.5	1.1	1.2	0.4
		350		1.4	1.5	0.6
	BH-6	300	4.5	1.1	1.2	0.2
		350		1.4	1.5	0.3
	BH-7	300	3.0	4.3	3.2	2.1
		350		5.2	3.9	2.9
	BH-9	300	3.00	3.3	2.6	1.8
		350		4.0	3.1	2.3
	BH-10	300	3.00	3.8	2.9	2.1
		350		4.6	3.4	2.6
	BH-11	300	4.5	1.3	1.2	0.4
		350		1.6	1.5	0.6
	BH-12	300	3.00	4.7	3.5	2.6
		350		5.6	4.2	3.2
	BH-13	300	3.00	2.4	2.0	1.5
		350		2.9	2.3	1.9
	BH-14	300	4.5	1.1	1.2	0.5
		350		1.3	1.5	0.6
	BH-15	300	3.00	5.6	4.1	3.2
		350		6.7	4.8	4.0
	BH-16	300	3.00	3.4	2.6	1.9
		350		4.1	3.1	2.4
	BH-17	300	3.00	4.5	3.4	2.5
		350		5.4	4.1	3.0

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL (m)	Pile Capacity		
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral (MT) (By Brom's Method) Free Head Condition
Bored Cast In-Situ Pile	BH-18	300	3.00	2.8	2.2	1.9
		350		3.4	2.6	2.4
	BH-19	300	3.00	5.8	4.2	3.5
		350		7.0	4.9	4.3
	BH-20	300	3.00	2.8	2.3	1.6
		350		3.4	2.8	1.9
	BH-21	300	3.0	4.7	3.5	2.8
		350		5.7	4.1	3.5
	BH-22	300	3.0	3.9	2.9	2.5
		350		4.7	3.5	3.0
	BH-23	300	3.0	3.5	2.7	1.9
		350		4.2	3.1	2.4
	BH-24	300	3.0	3.5	2.7	2.1
		350		4.2	3.2	2.5
	BH-25	300	4.5	2.3	1.9	0.9
		350		2.8	2.3	1.2
	BH-26	300	3.0	1.1	0.9	1.7
		350		1.3	1.1	1.9
	BH-27	300	3.0	1.6	1.4	1.3
		350		2.0	1.7	1.6
	BH-29	300	3.0	3.8	3.0	1.8
		350		4.5	3.5	2.2
	BH-28	300	3.0	4.1	3.2	2.3
		350		5.0	3.8	2.9
	BH-30	300	4.5	1.1	1.1	0.3
		350		1.3	1.4	0.4

Table 20: Parameters for the load capacity of a Long Pile

Group	Depth, m	Type of soil	Bulk density, g/cc	Cohesion, kg/cm^2	Angle of internal friction, φ (degree)
BH-1	0.00 - 1.50	CI	1.740	0.21	0
	1.50 - 4.00	ML	1.771	0.00	15
	4.00 - 8.00	ML	1.893	0.00	15
	8.00 - 9.50	CL	1.813	0.05	14
	9.50 - 12.50	ML	1.819	0.00	18
	12.50 - 18.50	ML	1.919	0.00	22
	18.50 - 25.00	CI	1.862	0.20	13
	25.00 - 30.00	CI	1.831	0.51	10
BH-2	0.00 - 1.50	CL	1.769	0.23	0
	1.50 - 3.50	CL	1.769	0.33	0
	3.50 - 11.00	ML	1.848	0.00	14
	11.00 - 17.00	CL	1.837	0.25	12
	17.00 - 18.00	CI	1.878	0.53	8
	18.00 - 25.00	CI	1.885	0.61	6
	25.00 - 30.00	CI	1.937	0.61	6
BH-4	0.00 - 1.50	CI	1.742	0.40	0
	1.50 - 4.00	MI	1.817	0.00	12
	4.00 - 9.50	CI	1.908	0.24	10
	9.50 - 12.50	ML	1.825	0.00	20
	12.50 - 18.50	CL	1.937	0.29	10
	18.50 - 25.00	CI	1.898	0.43	8
	25.00 - 30.00	CI	1.954	0.59	6
BH-5	0.00 - 1.50	ML	1.719	0.00	18
	1.50 - 3.50	ML	1.719	0.00	15

Group	Depth, m	Type of soil	Bulk density, g/cc	Cohesion, kg/cm^2	Angle of internal friction, φ (degree)
BH-5	3.50 - 6.50	ML	1.719	0.00	18
	6.50 - 9.50	ML	1.850	0.00	21
	9.50 - 12.50	CI	1.722	0.21	13
	12.50 - 18.50	ML	1.809	0.00	23
	18.50 - 25.00	ML	1.941	0.52	6
	25.00 - 30.00	ML	1.958	0.52	6
BH-6	0.00 - 1.50	MI	1.750	0.00	13
	1.50 - 3.00	MI	1.750	0.00	13
	3.00 - 4.00	MI	1.750	0.00	15
	4.00 - 6.50	ML	1.867	0.02	19
	6.50 - 12.50	ML	1.905	0.03	22
	12.50 - 18.50	ML	1.950	0.03	22
	18.50 - 25.00	CI	1.970	0.42	10
	25.00 - 30.00	CI	2.039	0.58	8
BH-7	0.00 - 1.50	CL	1.776	0.27	0
	1.50 - 3.50	CL	1.776	0.33	0
	3.50 - 9.50	ML	1.881	0.00	16
	9.50 - 12.50	ML	2.006	0.00	18
	12.50 - 18.50	ML	2.006	0.00	21
	18.50 - 24.50	CI	1.873	0.31	10
	24.50 - 25.00	CI	1.873	0.31	10
	25.00 - 30.00	CI	2.053	0.53	9
BH-9	0.00 - 3.00	CL	1.761	0.23	0
	3.00 - 9.00	CL	1.702	0.54	0
	9.00 - 12.50	ML	1.832	0.05	19

Group	Depth, m	Type of soil	Bulk density, g/cc	Cohesion, kg/cm^2	Angle of internal friction, φ (degree)
BH-9	12.50 - 15.50	SM	1.886	0.05	25
	15.50 - 18.50	ML	1.857	0.05	21
	18.50 - 21.00	ML	1.946	0.05	22
	21.00 - 25.00	ML	1.918	0.05	22
	25.00 - 30.00	CI	1.919	0.58	4
BH-10	0.00 - 1.00	ML	1.755	0.25	0
	1.00 - 3.00	CI	1.755	0.27	0
	3.00 - 7.50	CI	1.755	0.52	0
	7.50 - 12.00	CL	1.779	0.63	0
	12.00 - 15.00	CI	1.737	0.63	0
	15.00 - 18.00	ML	1.979	0.01	21
	18.00 - 25.00	CI	1.948	0.30	7
	25.00 - 30.00	CI	1.950	0.30	7
BH-11	0.00 - 0.50	CL	1.745	0.00	13
	0.50 - 3.50	ML	1.770	0.00	15
	3.50 - 9.50	ML	1.881	0.00	20
	9.50 - 12.50	ML	1.840	0.00	19
	12.50 - 18.50	CL	1.917	0.19	16
	18.50 - 25.00	CI	1.923	0.15	17
	25.00 - 30.00	CI	1.927	0.15	17
BH-12	0.00 - 1.50	CH	1.709	0.33	0
	1.50 - 3.00	CH	1.709	0.33	0
	3.00 - 6.50	CH	1.709	0.47	0
	6.50 - 9.50	ML	1.822	0.03	16
	9.50 - 15.00	ML	1.772	0.05	19

Group	Depth, m	Type of soil	Bulk density, g/cc	Cohesion, kg/cm^2	Angle of internal friction, φ (degree)
BH-12	15.00 - 21.00	ML	1.847	0.02	22
	21.00 - 25.00	CI	1.851	0.49	6
	25.00 - 30.00	CI	1.851	0.49	6
BH-13	0.00 - 3.50	CL	1.731	0.13	0
	3.50 - 6.50	CL	1.763	0.14	13
	6.50 -9.50	ML	1.792	0.00	17
	9.50 - 12.50	SM	1.839	0.00	24
	12.50 - 18.50	CL	1.848	0.36	10
	18.50 - 24.50	CL	1.888	0.45	9
	24.50 - 25.00	CI	1.710	0.68	5
	25.00 - 30.00	CI	1.710	0.68	5
BH-14	0.00 - 3.50	ML	1.704	0.00	15
	3.50 - 6.50	ML	1.711	0.03	17
	6.50 - 15.50	ML	1.815	0.02	19
	15.50 - 17.00	ML	1.815	0.02	19
	17.00 - 18.50	CI	1.816	0.26	8
	18.50 - 21.00	CI	1.718	0.24	7
	21.00 - 25.00	CI	1.845	0.59	5
	25.00 - 30.00	CI	1.877	0.59	5
BH-15	0.00 - 0.50	CL	1.735	0.34	0
	0.50 - 3.00	CL	1.735	0.41	0
	3.00 - 6.50	CI	1.830	0.40	0
	6.50 - 9.50	ML	1.830	0.00	17
	9.50 - 15.00	ML	1.937	0.00	17
	15.00 - 23.00	CL	1.858	0.42	8

Group	Depth, m	Type of soil	Bulk density, g/cc	Cohesion, kg/cm^2	Angle of internal friction, φ (degree)
BH-15	23.00 - 25.00	CI	1.825	0.42	10
	25.00 - 30.00	CI	1.858	0.48	9
BH-16	0.00 - 0.50	CL	1.706	0.24	0
	0.50 - 3.00	CI	1.706	0.24	0
	3.00 - 5.00	CI	1.706	0.40	0
	5.00 - 6.50	ML	1.751	0.02	17
	6.50 - 12.00	ML	1.920	0.03	19
	12.00 - 18.50	CI	1.932	0.33	6
	18.50 - 25.00	CI	1.883	0.42	4
	25.00 - 30.00	CI	1.959	0.57	4
BH-17	0.00 - 1.50	CH	1.767	0.33	0
	1.50 - 3.50	CI	1.767	0.31	0
	3.50 - 6.50	CI	1.767	0.41	0
	6.50 - 9.50	ML	1.789	0.00	17
	9.50 - 18.50	ML	1.854	0.00	23
	18.50 - 25.00	CI	1.732	0.41	8
	25.00 - 30.00	CI	1.858	0.53	4
BH-18	0.00 - 1.50	CI	1.645	0.14	0
	1.50 - 3.50	CI	1.645	0.24	0
	3.50 - 6.50	ML	1.679	0.00	20
	6.50 - 9.50	ML	1.843	0.00	20
	9.50 - 12.50	ML	1.994	0.00	23
	12.50 - 25.00	CL	1.821	0.37	15
	25.00 - 30.00	CL	1.821	0.37	15

Group	Depth, m	Type of soil	Bulk density, g/cc	Cohesion, kg/cm^2	Angle of internal friction, φ (degree)
BH-19	0.00 - 1.00	CI	1.733	0.36	0
	1.00 - 2.00	CI	1.733	0.44	0
	2.00 - 6.50	ML	1.864	0.02	17
	6.50 - 9.50	ML	1.995	0.02	17
	9.50 - 12.50	CL	1.874	0.10	14
	12.50 - 18.00	ML	1.778	0.02	21
	18.00 - 25.00	CI	1.851	0.49	8
	25.00 - 30.00	CI	1.887	0.56	4
BH-20	0.00 - 1.50	CL	1.777	0.20	0
	1.50 - 5.50	ML	1.777	0.20	0
	5.50 - 7.00	CH	1.777	0.67	0
	7.00 - 9.50	ML	1.873	0.02	17
	9.50 - 12.00	ML	1.907	0.02	17
	12.00 - 18.00	ML	1.828	0.01	20
	18.00 - 25.00	CI	1.886	0.49	10
	25.00 - 30.00	CI	1.913	0.49	10
BH-21	0.00 - 1.00	CL	1.711	0.26	0
	1.00 - 5.00	CL	1.711	0.36	0
	5.00 - 6.50	CI	1.787	0.18	6
	6.50 - 12.00	ML	1.780	0.03	17
	12.00 - 18.00	ML	1.875	0.07	20
	18.00 - 22.00	ML	1.875	0.07	20
	22.00 - 25.00	CI	1.794	0.22	5
	25.00 - 30.00	CI	1.802	0.22	5

Group	Depth, m	Type of soil	Bulk density, g/cc	Cohesion, kg/cm^2	Angle of internal friction, φ (degree)
BH-22	0.00 - 1.50	CL	1.710	0.22	0
	1.50 - 3.50	CI	1.748	0.31	0
	3.50 - 9.00	CI	1.723	0.21	11
	9.00 - 12.00	ML	1.931	0.04	23
	12.00 - 18.00	ML	1.915	0.03	26
	18.00 - 21.00	ML	1.850	0.03	26
	21.00 - 25.00	CI	1.913	0.33	10
	25.00 - 30.00	CI	1.913	0.33	10
BH-23	0.00 - 0.50	CH	1.854	0.26	0
	0.50 - 3.00	CI	1.854	0.22	8
	3.00 - 11.00	ML	1.983	0.00	19
	11.00 - 16.50	CL	1.827	0.20	10
	16.50 - 18.50	ML	1.987	0.00	23
	18.50 - 22.00	ML	1.987	0.00	23
	22.00 - 25.00	CI	2.002	0.34	10
	25.00 - 30.00	CI	2.025	0.42	5
BH-24	0.00 - 1.50	CL	1.706	0.22	0
	1.50 - 5.00	CL	1.706	0.39	0
	5.00 - 12.50	ML	1.779	0.02	16
	12.50 - 15.50	ML	1.901	0.06	19
	15.50 - 19.50	CI	1.777	0.26	11
	19.50 - 25.00	CI	1.916	0.31	6
	25.00 - 30.00	CI	1.994	0.31	6

Group	Depth, m	Type of soil	Bulk density, g/cc	Cohesion, kg/cm^2	Angle of internal friction, φ (degree)
BH-25	0.0 - 1.50	MI	1.720	0.00	14
	1.50 - 3.00	MI	1.720	0.00	18
	3.00 - 4.50	CL	1.735	0.15	13
	4.50 - 6.50	CL	1.735	0.15	13
	6.50 - 17.00	ML	1.808	0.00	19
	17.00 - 19.00	CL	1.812	0.11	6
	19.00 - 25.00	CI	1.803	0.42	8
	25.00 - 30.00	CI	1.861	0.42	8
BH-26	0.00 - 0.50	MI	1.702	0.00	12
	0.50 - 5.50	MI	1.702	0.05	17
	5.50 - 8.00	SM	2.000	0.00	25
	8.00 - 12.00	ML	1.820	0.06	20
	12.00 - 18.00	ML	1.845	0.00	22
	18.00 - 23.00	ML	1.845	0.00	22
	23.00 - 25.00	CI	1.864	0.31	7
	25.00 - 30.00	CI	1.861	0.39	5
BH-27	0.00 - 2.00	CL	1.799	0.00	35
	2.00 - 5.00	CI	1.799	0.14	6
	5.00 - 11.00	ML	1.795	0.00	18
	11.00 - 15.00	ML	1.875	0.00	22
	15.00 - 21.00	ML	1.875	0.00	23
	21.00 - 25.00	CI	1.872	0.37	10
	25.00 - 30.00	CH	1.930	0.63	4

Group	Depth, m	Type of soil	Bulk density, g/cc	Cohesion, kg/cm^2	Angle of internal friction, φ (degree)
BH-28	0.00 - 1.50	CL	1.730	0.29	0
	1.50 - 3.00	CL	1.730	0.26	11
	3.00 - 6.50	ML	1.857	0.00	16
	6.50 - 9.50	ML	1.876	0.00	20
	9.50 - 18.50	CL	1.844	0.33	10
	18.50 - 24.00	CL	1.815	0.46	12
	24.00 - 25.00	SC	1.943	0.31	20
	25.00 - 30.00	SC	1.943	0.31	20
BH-29	0.00 - 1.00	CI	1.819	0.32	0
	1.00 - 3.00	CI	1.819	0.18	13
	3.00 - 6.50	ML	1.873	0.00	17
	6.50 - 13.00	ML	1.873	0.00	20
	13.00 - 18.00	CL	1.804	0.13	18
	18.00 - 22.00	CL	1.804	0.13	18
	22.00 - 25.00	ML	1.766	0.00	22
	25.00 - 30.00	CI	1.915	0.59	0
BH-30	0.00 - 1.50	ML	1.708	0.00	11
	1.50 - 3.00	ML	1.708	0.00	13
	3.00 - 4.50	ML	1.758	0.00	15
	4.50 - 17.00	ML	1.800	0.17	20
	17.00 - 21.00	CL	1.893	0.38	14
	21.00 - 25.00	CL	1.939	0.38	14
	25.00 - 30.00	CI	1.899	0.48	6

Table 21: Load Carrying Capacity of Long Pile

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL, m	Pile Capacity			
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral Capacity (MT)	
						Fixed Head	Free Head
Bored Cast In-Situ Pile	BH-1	750	25	75.27	71.65	8.49	3.30
			30	102.92	94.79		
		900	25	100.78	95.51	11.37	4.41
			30	135.12	124.58		
		1000	25	118.53	111.94	13.45	5.22
			30	157.99	145.65		
	BH-2	750	25	93.57	83.64	3.78	1.47
			30	116.58	105.90		
		900	25	117.74	105.55	5.05	1.96
			30	146.12	133.66		
		1000	25	134.56	120.75	5.98	2.32
			30	166.17	152.58		
	BH-4	750	25	98.05	89.14	4.82	1.87
			30	123.19	111.56		
		900	25	123.24	112.63	6.45	2.50
			30	154.06	140.55		
		1000	25	140.58	128.73	7.63	2.96
			30	175.46	160.68		
	BH-5	750	25	83.06	76.22	4.82	1.87
			30	105.53	98.03		
		900	25	106.39	98.20	6.45	2.50
			30	133.58	125.31		
		1000	25	123.06	113.84	7.63	2.96
			30	153.65	144.84		

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL, m	Pile Capacity			
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral Capacity (MT)	
						Fixed Head	Fixed Head
Bored Cast In-Situ Pile	BH-6	750	25	87.00	79.60	2.49	0.97
			30	112.50	102.41		
		900	25	116.28	105.92	3.33	1.29
			30	147.84	134.67		
		1000	25	135.23	122.95	3.95	1.53
			30	171.24	156.13		
	BH-7	750	25	84.13	78.58	2.49	0.97
			30	111.13	101.57		
		900	25	112.60	104.69	3.33	1.29
			30	146.63	133.86		
		1000	25	131.70	122.17	3.95	1.53
			30	170.78	155.83		
	BH-9	750	25	99.15	89.08	2.49	0.97
			30	120.04	110.50		
		900	25	138.70	121.15	3.33	1.29
			30	160.19	147.88		
		1000	25	166.54	143.03	3.95	1.53
			30	187.41	173.47		
	BH-10	750	25	101.45	94.09	5.72	2.22
			30	120.44	113.00		
		900	25	127.90	119.56	7.66	2.97
			30	151.40	143.60		
		1000	25	146.32	137.44	9.07	3.52
			30	172.89	165.08		

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL, m	Pile Capacity			
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral Capacity (MT)	
						Fixed Head	Fixed Head
Bored Cast In-Situ Pile	BH-11	750	25	83.15	76.11	4.82	1.87
			30	103.59	96.23		
		900	25	110.23	99.77	6.45	2.50
			30	137.20	126.70		
		1000	25	129.90	116.41	7.63	2.96
			30	161.82	148.50		
	BH-12	750	25	94.01	85.79	2.49	0.97
			30	115.98	107.19		
		900	25	123.52	112.97	3.33	1.29
			30	150.38	139.81		
		1000	25	143.74	131.74	3.95	1.53
			30	173.88	162.36		
	BH-13	750	25	94.57	84.80	6.54	2.54
			30	117.36	106.88		
		900	25	120.19	108.10	8.76	3.40
			30	148.12	135.83		
		1000	25	137.46	123.84	10.37	4.02
			30	168.75	155.42		
	BH-14	750	25	72.08	67.39	3.78	1.47
			30	94.57	89.22		
		900	25	94.70	88.91	5.05	1.96
			30	121.80	115.94		
		1000	25	111.79	105.06	5.98	2.32
			30	142.48	136.13		

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL, m	Pile Capacity			
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral Capacity (MT)	
						Fixed Head	Free Head
Bored Cast In-Situ Pile	BH-15	750	25	98.29	88.66	6.54	2.54
			30	122.17	111.16		
		900	25	125.20	113.05	8.76	3.40
			30	154.46	141.26		
		1000	25	146.26	131.45	10.37	4.02
			30	179.96	164.37		
	BH-16	750	25	90.13	83.47	3.78	1.47
			30	114.59	104.95		
		900	25	114.19	106.30	5.06	1.96
			30	144.59	133.21		
		1000	25	129.71	121.33	5.98	2.32
			30	164.16	151.99		
	BH-17	750	25	94.42	86.69	6.54	2.54
			30	117.23	108.02		
		900	25	121.37	111.87	8.76	3.40
			30	149.06	138.53		
		1000	25	141.01	130.12	10.37	4.02
			30	171.86	160.44		
	BH-18	750	25	95.85	86.15	5.72	2.22
			30	119.60	109.03		
		900	25	125.46	111.43	7.66	2.97
			30	156.26	141.56		
		1000	25	144.48	127.34	9.07	3.52
			30	180.28	162.68		

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL, m	Pile Capacity			
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral Capacity (MT)	
						Fixed Head	Fixed Head
Bored Cast In-Situ Pile	BH-19	750	25	93.39	84.14	7.30	2.83
			30	115.51	105.69		
		900	25	120.18	108.45	9.77	3.79
			30	146.71	135.29		
		1000	25	139.05	125.41	11.57	4.49
			30	168.47	155.98		
	BH-20	750	25	93.10	83.81	2.49	0.97
			30	116.89	106.73		
		900	25	121.11	108.76	3.33	1.29
			30	150.63	137.80		
		1000	25	140.97	126.26	3.95	1.53
			30	174.66	159.82		
	BH-21	750	25	81.10	78.59	6.54	2.54
			30	94.97	93.24		
		900	25	105.71	103.36	8.76	3.40
			30	123.20	122.39		
		1000	25	122.76	120.67	10.37	4.02
			30	142.84	142.90		
	BH-22	750	25	96.16	88.84	2.49	0.97
			30	116.96	109.27		
		900	25	131.05	120.37	3.33	1.29
			30	157.42	146.80		
		1000	25	154.11	141.29	3.95	1.53
			30	184.34	171.98		

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL, m	Pile Capacity			
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral Capacity (MT)	
						Fixed Head	Free Head
Bored Cast In-Situ Pile	BH-23	750	25	90.76	82.85	5.72	2.22
			30	111.50	103.64		
		900	25	120.34	109.47	7.66	2.97
			30	145.19	135.67		
		1000	25	142.12	128.81	9.07	3.52
			30	169.43	158.70		
	BH-24	750	25	81.68	78.04	2.49	0.97
			30	100.24	96.60		
		900	25	106.92	102.64	3.33	1.29
			30	130.15	126.45		
		1000	25	122.65	118.40	3.95	1.53
			30	148.84	145.71		
	BH-25	750	25	70.05	66.40	3.78	1.47
			30	91.75	87.57		
		900	25	92.06	87.53	5.06	1.96
			30	118.92	114.36		
		1000	25	108.17	102.89	5.98	2.32
			30	138.46	133.62		
	BH-26	750	25	80.59	76.04	2.49	0.97
			30	101.84	96.23		
		900	25	104.07	98.99	3.33	1.29
			30	130.03	124.29		
		1000	25	123.11	117.12	3.95	1.53
			30	152.13	145.94		

Pile Type	Bore Hole	Pile Diameter (mm)	Length Below EGL, m	Pile Capacity			
				Vertical Capacity (MT)	Uplift Capacity (MT)	Lateral Capacity (MT)	
						Fixed Head	Free Head
Bored Cast In-Situ Pile	BH-27	750	25	80.04	74.81	8.01	3.11
			30	105.04	96.70		
		900	25	107.28	100.10	10.72	4.16
			30	137.72	127.40		
		1000	25	129.44	120.10	12.69	4.92
			30	163.40	151.20		
	BH-28	750	25	103.49	89.16	4.82	1.87
			30	129.78	114.16		
		900	25	133.80	112.93	6.45	2.50
			30	168.15	146.01		
		1000	25	156.20	129.68	7.63	2.96
			30	196.60	168.84		
	BH-29	750	25	89.86	79.34	8.49	3.30
			30	108.36	100.06		
		900	25	124.91	107.15	11.37	4.41
			30	142.95	132.74		
		1000	25	149.78	125.85	13.45	5.22
			30	166.02	154.83		
	BH-30	750	25	93.73	84.65	3.78	1.47
			30	114.48	106.10		
		900	25	121.76	109.54	5.06	1.96
			30	145.96	136.41		
		1000	25	142.46	127.59	5.98	2.32
			30	168.47	158.12		

Table 22: Parameters for SBC Calculation

Footing Size, m - 1.0 x 1.0 x 1.0			
Parameters	**Design Value**		**Reference**
	BH-7	**BH-20**	
Bulk density, Υ_b, gm/cm^3	1.776	1.777	UDS recovered
Dry density, Υ_d, gm/cm^3	1.396	1.373	UDS recovered
Moisture content, %	27.2	29.4	UDS recovered
Cohesion, C, kg/cm^2	0.27	0.20	From Foundation Design Manual, by N V Nayak
Angle of internal friction, ∅, °	0	0	
Specific gravity, G	2.594	2.588	Lab Test
SPT, N-value	3	3	Depth - 1.5 m
Compression index, C_c	0.173	0.178	Assumed
Modulus of elasticity, E, kg/cm^2	24	24	From Schultz and Muh's Graph
Poisson's ratio, μ	0.30	0.30	From J E Bowle's Foundation Analysis and Design
Depth of water below EGL, m	0.00	0.00	--
Factor of safety	2.5	2.5	--
Type of shear failure	Local	Local	--

Table 19: Net Safe Bearing Capacity

FOUNDATION DETAILS				Net Safe Bearing Capacity based on Shear, T/m^2	Safe Bearing Pressure for 25mm Settlement, T/m^2	Recommended Net SBC, T/m^2
Type	**BH No.**	**Size, m**	**Depth, m**			
R.C.C Isolated Footing	7	1.0 X 1.0	1.0	5.80	3.06	3.06
		1.5 X 1.5		5.48	1.74	1.74
		1.0 X 1.0	1.5	6.29	3.93	3.93
		1.5 X 1.5		6.45	2.27	2.27
	20	1.0 X 1.0	1.0	4.30	2.98	2.98
		1.5 X 1.5		4.06	1.80	1.80
		1.0 X 1.0	1.5	4.66	4.14	4.14
		1.5 X 1.5		4.30	2.38	2.38

7.0 DISCUSSION & RECOMMENDATIONS: -

- The top level of the groundwater was encountered from 4.0 to 4.5 m depth from EGL at the time of field investigation in December 2020. It should be noted that the groundwater levels are subject to variation caused by seasonal variations or local drainage/pumping conditions and so may be significantly different from those measured during the investigation.
- The factor of safety for vertical and uplift capacity is considered as 2.5 and 3.0 respectively.
- Adequacy of pile capacity shall be checked by a static pile load test at 2.5 times of design load.
- Lateral capacity is evaluated for permissible deflection of 5 mm.
- The working pile shall be checked at 1.5 times the design load for the permissible settlement as per IS 2911 Part-4, 2013.
- Proper precautions shall be taken for short piles, to not to erode soil from the top due to any environmental or other manual reasons, by providing plinth protection, etc.
- The raft/open foundation is not recommended wherever the SPT value and density are very low, also the soil is of silty clayey type. The places where the N-Value are enough to support raft or after soil stabilization treatment, there it can be provided but a detailed engineering survey is recommended.
- From Table 12,13, Due to high chloride and Sulphate content in the soil, it is recommended to use Portland Slag Cement confirming to IS 455 having more than 50% slag or a blend of OPC and slag may be used. The minimum cement content should be 340 kg/m^3 and the maximum water-cement ratio of 0.45 as Per IS 456 Table 5 and minimum grade M35 for RCC work.
- The standard proctor test results for the given locations are varying from M.D.D. – 1.610 g/cc to 1.649 g/cc and O.M.C. – 17.9% to 24.6%, given in table-14.
- Field California Bearing Ratio (CBR) value at natural condition and F.D.D – 1.412 g/cc to 1.542 g/cc and F.M.C – 20.90% to 26.10% at a depth 0.200 m from E.G.L varies from 1.43% to 5.25%, given in table-15.
- As per IRC 37 (2018), the pavement thickness (mm) is 570 mm for 5% CBR & 10 msa traffic volume. But where the CBR value is less than 5%, the prior ground improvement is required to achieve more than 5% CBR value, and then the above pavement thickness is adopted. The ground can be improved by using either good quality filling material, quarry dust, or CNS layer. The final verification of the CBR may be done by performing the field CBR test.

- Electrical Resistivity Test results for given locations vary from 4.154-10.55 Ohm-m, given in table-16.
- The field permeability values vary from 5.44 X 10^{-2} to 6.25 X 10^{-2} cm/sec.
- The soil strata are permeable. So before the construction of soak pits, lagoons, and reservoirs the provision of impervious lining is recommended.
- The probable drainage outlet has been located in the contour map (Annexure-9). A detailed study of the contour map is recommended at the time of the final design of the drainage system and stormwater drain.
- The soil in the entire area is composed of clayey and silty types. The computation of liquefaction potential has been shown in Annexure-7. The strata which are formed of silty soil are susceptible to liquefaction looking at the SPT N-value and the variation in groundwater level.
- The chances of liquefaction may be there, so it should be taken care of during a detailed investigation and during the design of foundations for the individual plot.
- Wherever the strata are liquefiable, care should be taken during pile designing.
- The subsoil is not suitable for backfilling purposes or for any construction activities.
- The side slope for any cutting is recommended as 1V:1.5H.
- It is recommended to provide suitable ground improvement techniques wherever the strata are liquefiable. The report presented is representative of the bore locations and does not represent the entire area of construction as a whole.

General Remarks: -

1. During boring for the pile foundation, it is suggested to verify the subsoil stratum for any variation and the same shall be reported for any further recommendations or amendments.
2. Looking at the site condition and previous history, the groundwater table is considered at 0.0m for the calculation purpose.
3. The total pile length assumed in calculations is without considering the cut-off length.
4. The comments are given in this report and the opinion expressed is based on the ground conditions encountered during the site work and based on the results of tests made on-site and in the laboratory. There may, however, special conditions prevailing at the site which may not have been disclosed by the investigation and which may not have been taken into account in

the report. Any variation in stratification in any of the foundation location shall be studied thoroughly before executing the foundation work.

For **Unique Engineering Services, Gandhidham**

Authorized Signatory

ANNEXURE 1: BORELOGS

BH-01

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 18-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 20-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-01	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 2.20 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2659249, E 0558986
Reduced Level	: 4.701 m				

Depth (m) R.L - 4.701 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	% Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
4.201				DS	144-01-01	0.00	0.50	--	--	--	--	--	0	3	97	--		43.0	21.7	21.3	--	--	--	--	--	--	--	--	--	--	CI
1 3.701				SPT	144-01-02	0.50	0.95	14	14	--	--	--	0	2	98	56	42	42.6	24.4	18.3	--	--	--	--	--	--	--	--	--	CI
3.201	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	3.00																										
2 2.701				SPT	144-01-03	1.50	1.95	11	11	--	--	--	0	1	99	58	41	35.6	20.6	15.0	2.563	--	*0.21	0	16	--	--	--	--	CI
2.201																														
3 1.701																														
1.201				UDS	144-01-04	3.00	3.60	--	--	1.771	1.419	24.8	0	10	90	79	11	29.1	NP		--	DUU	0.0	15	Nil	--	--	--	--	ML
4 0.701																														
0.201																														
5 -0.299				SPT	144-01-05	4.50	4.95	16	16	--	--	--	0	7	93	--		31.1	NP		2.671	--	--	--	--	--	--	--	--	ML
-0.799																														
6 -1.299	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	6.00																											
-1.799				UDS	144-01-06	6.00	6.60	--	--	1.893	1.472	28.6	0	10	90	--		31.6	NP		--	--	--	--	Nil	--	--	--	--	ML
7 -2.299																														
-2.799																														
8 -3.299				SPT	144-01-07	7.50	7.95	22	22	--	--	--	0	4	96	--		30.4	NP		--	--	--	--	--	--	--	--	--	ML
-3.799																														
9 -4.299																														
-4.799				UDS	144-01-08	9.00	9.60	--	--	1.813	1.449	25.1	0	6	94	60	34	30.8	17.9	12.8	2.542	DUU	0.05	14	--	--	--	--	--	CL
10 -5.299	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	1.50																											
-5.799																														
11 -6.299				SPT	144-01-09	10.50	10.95	25	25	--	--	--	0	12	88	--		29.4	NP		--	--	--	--	--	--	--	--	--	ML
-6.799																														
12 -7.299																														
-7.799				UDS	144-01-10	12.00	12.60	--	--	1.819	1.456	24.9	0	20	80	69	11	33.0	NP		--	DUU	0	18	Nil	--	--	--	--	ML
13 -8.299																														
-8.799																														
14 -9.299				SPT	144-01-11	13.50	13.95	39	39	--	--	--	0	21	79	--		32.1	NP		--	--	--	--	--	--	--	--	--	ML
-9.799																														
15 -10.299																														
-10.799				UDS-F+ SPT	144-01-12	15.00	15.45	35	35	--	--	--	0	18	82	--		31.4	NP		--	--	--	--	--	--	--	--	--	ML
16 -11.299	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	10.50																											
-11.799																														
17 -12.299				SPT	144-01-13	16.50	16.95	41	41	--	--	--	0	22	78	--		30.7	NP		--	--	--	--	--	--	--	--	--	ML
-12.799																														
18 -13.299																														
-13.799				UDS	144-01-14	18.00	18.60	--	--	1.919	1.545	24.2	2	22	76	--		26.8	NP		2.663	DUU	0	22	Nil	--	--	--	--	ML
19 -14.299																														
-14.799																														
20 -15.299				SPT	144-01-15	19.50	19.95	56	56	--	--	--	1	28	71	--		28.6	NP		--	--	--	--	--	--	--	--	--	ML
-15.799																														
21 -16.299																														

BH-01

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 18-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 20-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-01	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 2.20 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2659249, E 0558986
Reduced Level	: 4.701 m				

Depth (m) / R.L. - 4.701 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: % Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-16.799				SPT	144-01-16	21.00	21.45	27	27	--	--	--	0	2	98	--		37.2	21.8	15.4	--	--	--	--	--	--	--	--	--	--	CI
22 -17.299																														
-17.799																														
23 -18.299				SPT	144-01-17	22.50	22.95	31	31	--	--	--	0	3	97	58	39	36.2	20.9	15.3	--	--	--	--	--	--	--	--	--	CI
-18.799																														
24 -19.299																														
-19.799				UDS	144-01-18	24.00	24.60	--	--	1.862	1.519	22.6	0	1	99	--		37.6	20.5	17.1	2.605	TUU	0.20	13	--	0.101	0.53	14.8	0.62	CI
25 -20.299																														
-20.799																														
26 -21.299				SPT	144-01-19	25.50	25.95	27	27	--	--	--	0	3	97	52	45	41.3	22.7	18.6	--	--	--	--	--	--	--	--	--	CI
-21.799																														
27 -22.299																														
-22.799				SPT	144-01-20	27.00	27.45	21	21	--	--	--	0	2	98	--		44.3	24.6	19.7	--	--	--	--	--	--	--	--	--	CI
28 -23.299																														
-23.799																														
29 -24.299				SPT	144-01-21	28.50	28.95	23	23	--	--	--	0	1	99	53	46	46.4	25.1	21.3	--	--	--	--	--	--	--	--	--	CI
-24.799																														
30 -25.299																														
-25.799				UDS	144-01-22	30.00	30.60	--	--	1.831	1.479	23.8	0	1	99	--		46.9	25.7	21.2	2.613	TUU	0.51	10	--	--	--	--	0.88	CI
31 -26.299																														
-26.799																														
32 -27.299				SPT	144-01-23	31.50	31.95	24	24	--	--	--	0	2	98	--		46.2	25.1	21.1	--	--	--	--	--	--	--	--	--	CI
-27.799	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	22.50																											
33 -28.299																														
-28.799				SPT	144-01-24	33.00	33.45	21	21	--	--	--	0	1	99	--		46.5	25.3	21.2	--	--	--	--	--	--	--	--	--	CI
34 -29.299																														
-29.799																														
35 -30.299				SPT	144-01-25	34.50	34.95	25	25	--	--	--	0	3	97	--		43.4	24.4	19.0	--	--	--	--	--	--	--	--	--	CI
-30.799																														
36 -31.299																														
-31.799				UDS	144-01-26	36.00	36.60	--	--	1.884	1.549	21.6	0	0	100	--		43.6	24.6	19.0	2.592	TUU	0.61	5	--	--	--	--	--	CI
37 -32.299																														
-32.799																														
38 -33.299				SPT	144-01-27	37.50	37.95	25	25	--	--	--	0	1	99	--		47.9	25.9	22.0	--	--	--	--	--	--	--	--	--	CI
-33.799																														
39 -34.299																														
-34.799				SPT	144-01-28	39.00	39.45	29	29	--	--	--	0	0	100	--		40.3	23.1	17.2	--	--	--	--	--	--	--	--	--	CI
40 -35.299																														
-35.799																														
41 -36.299				SPT	144-01-29	40.50	40.95	29	29	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
-36.799																														
42 -37.299																														
-37.799				UDS	144-01-30	42.00	42.60	--	--	1.943	1.675	16.0	1	40	60	--		35.3	21.2	14.1	--	--	--	--	--	--	--	--	--	CI
43 -38.299																														
-38.799																														
44 -39.299				SPT	144-01-31	43.50	43.64	>100 (14 cm)	>100 (14 cm)	--	--	--	0	53	47	--		32.1	20.3	11.8	2.645	--	--	--	--	--	--	--	--	SC
-39.799																														
45 -40.299																														
-40.799				SPT	144-01-32	45.00	45.10	>100 (10 cm)	>100 (10 cm)	--	--	--	3	60	37	--		30.6	18.9	11.7	--	--	--	--	--	--	--	--	--	SC
46 -41.299																														
-41.799																														
47 -42.299	Reddish Greyish consolidated Clayey Sand of low Plasticity mixed with little kankars in form of soft rock	SC	7.00	SPT	144-01-33	46.50	46.62	>100 (12 cm)	>100 (12 cm)	--	--	--				--					--	--	--	--	--	--	--	--	--	SC
-42.799																														
48 -43.299																														
-43.799				SPT	144-01-34	48.00	48.08	>100 (8 cm)	>100 (8 cm)	--						--					--	--	--	--	--	--	--	--	--	SC
49 -44.299																														
-44.799																														
50 -45.299																														
-45.799				SPT	144-01-35	50.00	50.07	>100 (7 cm)	>100 (7 cm)	--	--	--				--					--	--	--	--	--	--	--	--	--	SC

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-02

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 19-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 20-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-02	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 2.20 m	**Depth of Boring**	: 30 m	**Co-Ordinates**	: 42 Q, N 2658766, E 0560446
Reduced Level	: 4.247 m				

Depth (m) / R.L.-4.247 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	%Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
3.747	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	0.5	DS	144-02-01	0.00	0.50	--	--	--	--	--	0	1	99	--		37.1	21.1	16.0	--	--	--	--	--	--	--	--	--	CI
1 3.247				SPT	144-02-02	0.50	0.95	4	4	--	--	--	0	3	97	62	35	34.4	20.6	13.8	--	--	--	--	--	--	--	--	--	CL
2.747																														
2 2.247				SPT	144-02-03	1.50	1.95	6	6	--	--	--	0	2	98	55	43	34.7	21.8	12.9	2.591	--	*0.23	0	Nil	--	--	--	--	CL
1.747																														
3 1.247																														
0.747	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	5.5	UDS	144-02-04	3.00	3.60	--	--	1.769	1.395	26.8	0	6	94	--		31.4	19.8	11.6	--	--	*0.33	0	--	--	--	12.8	--	CL
4 0.247																														
-0.253																														
5 -0.753				SPT	144-02-05	4.50	4.95	8	8	--	--	--	0	7	93	--		31.6	19.8	11.8	--	--	--	--	--	--	--	--	--	CL
-1.253																														
6 -1.753																														
-2.253				UDS	144-02-06	6.00	6.60	--	--	1.848	1.426	29.6	0	19	81	71	10	32.3	NP		2.662	DUU	0.0	14	Nil	--	--	--	--	ML
7 -2.753																														
-3.253																														
8 -3.753				SPT	144-02-07	7.50	7.95	16	16	--	--	--	0	11	89	--		32.1	NP		--	--	--	--	--	--	--	--	--	ML
-4.253																														
9 -4.753	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	6.0																											
-5.253				UDS-F + SPT	144-02-08	9.00	9.45	21	18	--	--	--	0	9	91	--		30.8	NP		--	--	--	--	--	--	--	--	--	ML
10 -5.753																														
-6.253																														
11 -6.753				SPT	144-02-09	10.50	10.95	32	24	--	--	--	0	8	92	--		33.4	NP		--	--	--	--	Nil	--	--	--	--	ML
-7.253																														
12 -7.753																														
-8.253				UDS	144-02-10	12.00	12.60	--	--	1.837	1.498	22.6	0	5	95	58	37	34.5	20.1	14.4	2.610	TUU	0.25	12	--	0.138	0.51	--	0.47	CL
13 -8.753																														
-9.253																														
14 -9.753				SPT	144-02-11	13.50	13.95	33	33	--	--	--	0	7	93	--		30.1	15.8	14.3	--	--	--	--	13	--	--	--	--	CL
-10.253																														
15 -10.753	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	6.1																											
-11.253				SPT	144-02-12	15.00	15.45	43	43	--	--	--	0	1	99	--		33.1	19.7	13.4	--	--	--	--	--	--	--	--	--	CL
16 -11.753																														
-12.253																														
17 -12.753				SPT	144-02-13	16.50	16.95	49	49	--	--	--	0	3	97	62	35	32.8	19.5	13.3	--	--	--	--	--	--	--	--	--	CL
-13.253																														
18 -13.753																														
-14.253				UDS	144-02-14	18.00	18.60	--	--	1.878	1.511	24.3	0	2	98	56	42	41.4	23.2	18.2	2.599	TUU	0.53	8	--	--	--	--	0.86	CI
19 -14.753	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	1.4																											
-15.253																														
20 -15.753				SPT	144-02-15	19.50	19.95	27	24	--	--	--	0	42	58	--		28.1	NP		--	--	--	--	--	--	--	--	--	ML
-16.253	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	1.5																											
21 -16.753																														
-17.253				SPT	144-02-16	21.00	21.45	33	33	--	--	--	0	8	92	--		40.2	21.8	18.4	--	--	--	--	--	--	--	--	--	CI
22 -17.753																														
-18.253																														
23 -18.753				SPT	144-02-17	22.50	22.95	35	35	--	--	--	0	11	89	50	39	43.1	23.4	19.7	--	--	--	--	--	--	--	--	--	CI
-19.253																														
24 -19.753																														
-20.253				UDS	144-02-18	24.00	24.60	--	--	1.885	1.523	23.8	0	17	83	--		42.3	22.4	19.9	2.618	TUU	0.61	6	--	--	--	--	--	--	CI
25 -20.753																														
-21.253																														
26 -21.753	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	9.5	SPT	144-02-19	25.50	25.95	27	27	--	--	--	0	1	99	53	46	44.2	23.9	20.3	--	--	--	--	--	--	--	--	--	CI
-22.253																														
27 -22.753																														
-23.253				SPT	144-02-20	27.00	27.45	25	25	--	--	--	--								--	--	--	--	--	--	--	--	--	--	CI
28 -23.753																														
-24.253																														
29 -24.753				SPT	144-02-21	28.50	28.95	17	17	--	--	--	--								--	--	--	--	--	--	--	--	--	--	CI
-25.253																														
30 -25.753																														
-26.253				UDS	144-02-22	30.00	30.60	--	--	1.937	1.551	24.9	0	1	99	52	47	46.0	25.7	20.3			--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-04

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 19-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 21-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-04	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 2.20 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2658420, E 0563002
Reduced Level	: 4.208 m				

Depth (m) R.L - 4.208 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	%Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
3.708				DS	144-04-01	0.00	0.50	--	--	--	--	--	0	2	98	--		49.4	25.3	24.1	--	--	--	--	--	--	--	--	--	CI
1 3.208				SPT	144-04-02	0.50	0.95	6	6	--	--	--	0	1	99	53	46	38.2	21.0	17.2	--	--	--	--	--	--	--	--	--	CI
2.708	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	3.00																										
2 2.208				SPT	144-04-03	1.50	1.95	8	8	--	--	--	0	1	99	57	42	36.1	20.4	15.7	2.585	--	*0.40	0	--	--	--	13	--	CI
1.708																													
3 1.208																													
0.708				UDS	144-04-04	3.00	3.60	--	--	1.817	1.413	28.6	0	3	97	87	10	37.9	NP		2.663	DUU	0	12	Nil	--	--	--	--	MI
4 0.208																													
-0.292	Greyish Silt of Intermediate Plasticity Mixed With Little Fine Sand & Gravel	MI	3.00																										
5 -0.792				SPT	144-04-05	4.50	4.95	14	14	--	--	--	0	4	96	--		37.1	NP		--	--	--	--	--	--	--	--	--	MI
-1.292																													
6 -1.792																													
-2.292				UDS-F+SPT	144-04-06	6.00	6.45	11	11	--	--	--	0	2	98	--		37.2	21.3	15.9	--	--	--	--	21	--	--	--	--	CI
7 -2.792																													
-3.292																													
8 -3.792				SPT	144-04-07	7.50	7.95	36	36	--	--	--	0	2	98	59	39	36.5	20.8	15.7	--	--	--	--	--	--	--	--	--	CI
-4.292																													
9 -4.792	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	6.00																										
-5.292				UDS	144-04-08	9.00	9.60	--	--	1.908	1.544	23.6	0	3	97	55	42	37.4	21.5	15.9	2.597	TUU	0.24	10	18	0.108	0.53	--	0.52	CI
10 -5.792																													
-6.292																													
11 -6.792				SPT	144-04-09	10.50	10.95	25	25	--	--	--	0	6	94	--		37.1	20.6	16.5	--	--	--	--	--	--	--	--	--	CI
-7.292																													
12 -7.792																													
-8.292				UDS	144-04-10	12.00	12.60	--	--	1.825	1.462	24.8	0	9	91	--		26.1	NP		2.668	DUU	0.00	20	Nil	--	--	--	--	ML
13 -8.792																													
-9.292																													
14 -9.792				SPT	144-04-11	13.50	13.95	46	31	--	--	--	0	26	74	--		28.4	NP		--	--	--	--	--	--	--	--	--	ML
-10.292	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	4.50																										
15 -10.792																													
-11.292				SPT	144-04-12	15.00	15.45	70	43	--	--	--	3	47	50	--		34.1	NP		--	--	--	--	--	--	--	--	--	ML
16 -11.792																													
-12.292																													
17 -12.792				SPT	144-04-13	16.50	16.95	41	41	--	--	--	0	14	86	--		30.2	18.8	11.4	--	--	--	--	--	--	--	--	--	CL
-13.292																													
18 -13.792	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	3.00																										
-14.292				UDS	144-04-14	18.00	18.60	--	--	1.937	1.505	28.7	0	20	80	41	39	30.8	17.5	13.3	2.606	TUU	0.29	10	--	--	--	--	0.63	CL
19 -14.792																													
-15.292																													

BH-04

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 19-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 21-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-04	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 2.20 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2658420, E 0563002
Reduced Level	: 4.208 m				

Depth (m) R.L - 4.208 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of Internal Friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
20 -15.792				SPT	144-04-15	19.50	19.95	20	20	--	--	--	0	1	99	--		37.2	20.4	16.8	--	--	--	--	--	--	--	--	--	--	CI
-16.292																														
21 -16.792																														
-17.292				SPT	144-04-16	21.00	21.45	22	22	--	--	--	0	2	98	52	46	37.6	20.5	17.1	--	--	--	--	--	--	--	--	--	CI
22 -17.792																														
-18.292																														
23 -18.792				SPT	144-04-17	22.50	22.95	20	20	--	--	--	0	3	97	--		39.2	20.9	18.3	--	--	--	--	--	--	--	--	--	CI
-19.292																														
24 -19.792																														
-20.292				UDS	144-04-18	24.00	24.60	--	--	1.898	1.517	25.1	0	1	99	56	43	41.0	22.2	18.8	2.579	TUU	0.43	8	--	--	--	--	--	CI
25 -20.792																														
-21.292																														
26 -21.792				SPT	144-04-19	25.50	25.95	27	27	--	--	--	0	2	98	--		42.2	21.8	20.4	--	--	--	--	--	--	--	--	--	CI
-22.292																														
27 -22.792																														
-23.292				SPT	144-04-20	27.00	27.45	23	23	--	--	--	0	1	99	--		44.3	22.7	21.6	--	--	--	--	--	--	--	--	--	CI
28 -23.792																														
-24.292																														
29 -24.792				SPT	144-04-21	28.50	28.95	30	30	--	--	--	0	3	97	--		44.8	23.1	21.7	--	--	--	--	--	--	--	--	--	CI
-25.292																														
30 -25.792	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles																													
-26.292				UDS	144-04-22	30.00	30.60	--	--	1.954	1.582	23.5	0	2	98	--		47.5	24.9	22.6	2.593	TUU	0.59	6	--	--	--	--	--	CI
31 -26.792																														
-27.292																														
32 -27.792				SPT	144-04-23	31.50	31.95	23	23	--	--	--	0	1	99	--		45.2	24.6	20.6		--	--	--	--	--	--	--	--	CI
-28.292																														
33 -28.792																														
-29.292				SPT	144-04-24	33.00	33.45	23	23	--	--	--	0	2	98	--		46.1	24.9	21.2	--	--	--	--	--	--	--	--	--	CI
34 -29.792																														
-30.292																														
35 -30.792		CI	31.00	SPT	144-04-25	34.50	34.95	30	30	--	--	--	0	3	97	--		43.5	22.9	20.6	--	--	--	--	--	--	--	--	--	CI
-31.292																														
36 -31.792																														
-32.292				UDS-F + SPT	144-04-26	36.00	36.45	31	31	--	--	--	0	1	99	--		47.1	25.6	21.5	--	--	--	--	--	--	--	--	--	CI
37 -32.792																														
-33.292																														
38 -33.792				SPT	144-04-27	37.50	37.95	26	26	--	--	--	0	5	95	--		46.5	24.1	22.4	--	--	--	--	--	--	--	--	--	CI
-34.292																														
39 -34.792																														
-35.292				SPT	144-04-28	39.00	39.45	25	25	--	--	--	0	1	99	--		44.5	24.7	19.8	--	--	--	--	--	--	--	--	--	CI
40 -35.792																														
-36.292																														
41 -36.792				SPT	144-04-29	40.50	40.95	22	22	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
-37.292																														
42 -37.792																														
-38.292				UDS	144-04-30	42.00	42.60	--	--	1.882	1.524	23.5	--								--	--	--	--	--	--	--	--	--	CI
43 -38.792																														
-39.292																														
44 -39.792				SPT	144-04-31	43.50	43.95	22	22	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
-40.292	(Visual Clasification) Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles																													
45 -40.792				SPT	144-04-32	45.00	45.45	63	63	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
-41.292																														
46 -41.792																														
-42.292																														
47 -42.792				SPT	144-04-33	46.50	46.95	40	40	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
-43.292																														
48 -43.792																														
-44.292				UDS	144-04-34	48.00	48.60	--	--	1.992	1.592	25.1	--								--	--	--	--	--	--	--	--	--	CI
49 -44.792																														
-45.292																														
50 -45.792																														
-46.292				SPT	144-04-35	50.00	50.45	32	32	--	--	--	--								--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-05

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 18-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 19-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-05	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 2.0 m	**Depth of Boring**	: 30 m	**Co-Ordinates**	: 42 Q, N 2658086, E 0559888
Reduced Level	: 4.288 m				

Depth (m) R.L. - 4.288 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: % Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
3.788	Brownish Silt of Intermediate Plasticity mixed with little Fine Sand & Gravel	MI	1.50	DS	144-05-01	0.00	0.50	--	--	--	--	--	0	12	88	--		36.8	NP		--	--	--	--	--	--	--	--	--	--	MI
1 3.288				SPT	144-05-02	0.50	0.95	6	6	--	--	--	0	3	97	--		37.2	NP		--	--	--	--	--	--	--	--	--	--	MI
2.788																														
2 2.288	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	9.01	SPT	144-05-03	1.50	1.95	15	15	--	--	--	0	2	98	86	12	33.2	NP		2.653	--	0	*18	Nil	--	--	--	--	ML
1.788																														
3 1.288																														
0.788				UDS-F+SPT	144-05-04	3.00	3.45	11	11	--	--	--	0	4	96	87	9	34.1	NP		--	--	0	*15	Nil	--	--	13.6	--	ML
4 0.288																														
-0.212																														
5 -0.712				SPT	144-05-05	4.50	4.95	11	11	--	--	--	0	1	99	--		34.6	NP		--	--	--	--	--	--	--	--	--	ML
-1.212																														
6 -1.712																														
-2.212				UDS	144-05-06	6.00	6.60	--	--	1.719	1.401	22.7	0	40	60	--		29.6	NP		2.651	DUU	0	18	Nil	--	--	--	--	ML
7 -2.712																														
-3.212																														
8 -3.712				SPT	144-05-07	7.50	7.95	14	14	--	--	--	0	31	69	--		30.1	NP		--	--	--	--	--	--	--	--	--	ML
-4.212																														
9 -4.712																														
-5.212				UDS	144-05-08	9.00	9.60	--	--	1.850	1.502	23.2	0	19	81	--		30.3	NP		2.652	DUU	0	21	--	--	--	--	--	ML
10 -5.712																														
-6.212																														
11 -6.712				SPT	144-05-09	10.50	10.95	14	14	--	--	--	0	16	84	55	29	37.8	19.3	18.5	--	--	--	--	18	--	--	--	--	CI
-7.212																														
12 -7.712	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	2.99																											
-8.212				UDS	144-05-10	12.00	12.60	--	--	1.722	1.442	19.4	0	7	93	48	44	40.1	21.2	18.9	2.579	TUU	0.21	13	--	0.128	0.58	--	0.53	CI
13 -8.712																														
-9.212																														
14 -9.712				SPT	144-05-11	13.50	13.95	45	30	--	--	--	0	21	79	--		31.6	NP		--	--	--	--	--	--	--	--	--	ML
-10.212																														
15 -10.712																														
-11.212				SPT	144-05-12	15.00	15.45	27	21	--	--	--	0	20	80	--		31.8	NP		2.666	--	--	--	--	--	--	--	--	ML
16 -11.712																														
-12.212	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	5.96																											
17 -12.712				SPT	144-05-13	16.50	16.95	41	28	--	--	--	0	16	84	--		32.1	NP		--	--	--	--	--	--	--	--	--	ML
-13.212																														
18 -13.712																														
-14.212				UDS	144-05-14	18.00	18.60	--	--	1.809	1.437	25.9	0	0	100	--		32.1	NP		2.684	DUU	0	23	--	--	--	--	--	ML
19 -14.712																														
-15.212																														
20 -15.712				SPT	144-05-15	19.50	19.95	29	29	--	--	--	0	2	98	56	42	43.7	23.1	20.6	--	--	--	--	--	--	--	--	--	CI
-16.212																														
21 -16.712																														
-17.212				SPT	144-05-16	21.00	21.45	25	25	--	--	--	0	1	99	53	46	43.9	23.3	20.6	--	--	--	--	--	--	--	--	--	CI
22 -17.712																														
-18.212																														
23 -18.712				SPT	144-05-17	22.50	22.95	29	29	--	--	--	0	1	99	59	40	40.6	22.8	17.8	--	--	--	--	--	--	--	--	--	CI
-19.212																														
24 -19.712																														
-20.212				UDS	144-05-18	24.00	24.60	--	--	1.941	1.596	21.6	0	2	98	54	44	40.3	22.5	17.9	2.591	TUU	0.52	6	--	--	--	--	1.01	CI
25 -20.712	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	11.09																											
-21.212																														
26 -21.712				SPT	144-05-19	25.50	25.95	25	25	--	--	--	0	3	97	55	42	43.6	23.1	20.5	--	--	--	--	--	--	--	--	--	CI
-22.212																														
27 -22.712																														
-23.212				SPT	144-05-20	27.00	27.45	20	20	--	--	--	--								--	--	--	--	--	--	--	--	--	--	CI
28 -23.712																														
-24.212																														
29 -24.712				SPT	144-05-21	28.50	28.95	25	25	--	--	--	--								--	--	--	--	--	--	--	--	--	--	CI
-25.212																														
30 -25.712																														
-26.212				UDS	144-05-22	30.00	30.60	--	--	1.958	1.601	22.3	0	1	99	--		48.3	25.1	23.2	--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-06

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 18-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 19-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-06	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 4.20 m	**Depth of Boring**	: 30 m	**Co-Ordinates**	: 42 Q, N 2657351, E 0561330
Reduced Level	: 3.993 m				

Depth (m) R.L - 3.993 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) To	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
3.493	Brownish Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	0.50	DS	144-06-01	0.00	0.50	--	--	--	--	--	0	6	94	--		34.6	19.1	15.5	--	--	--	--	--	--	--	--	--	CL
1 2.993				SPT	144-06-02	0.50	0.95	3	3	--	--	--	0	4	96	--		43.6	NP		--	--	--	--	--	--	--	--	--	MI
2.493																														
2 1.993				SPT	144-06-03	1.50	1.95	6	6	--	--	--	0	10	90	79	11	35.6	NP		--	--	--	--	--	--	--	--	--	MI
1.493																														
3 0.993	Greyish Silt of Intermediate Plasticity mixed with little Fine Sand & Gravel	MI	5.40																											
0.493				UDS	144-06-04	3.00	3.60	--	--	1.750	1.395	25.5	0	8	92	--		35.8	NP		2.655	--	0.00	*13	Nil	--	--	10	--	MI
4 -0.007																														
-0.507																														
5 -1.007				SPT	144-06-05	4.50	4.95	7	7	--	--	--	0	7	93	--		35.9	NP		--	--	0.0	*15	Nil	--	--	--	--	MI
-1.507																														
6 -2.007																														
-2.507				UDS	144-06-06	6.00	6.60	--	--	1.867	1.502	24.3	0	23	77	--		28.1	NP		2.663	DUU	0.02	19	--	--	--	--	--	ML
7 -3.007																														
-3.507																														
8 -4.007				SPT	144-06-07	7.50	7.95	24	20	--	--	--	0	28	72	--		29.1	NP		--	--	--	--	--	--	--	--	--	ML
-4.507																														
9 -5.007																														
-5.507				UDS	144-06-08	9.00	9.60	--	--	1.940	1.546	25.5	0	27	73	--		34.2	NP		2.678	--	--	--	Nil	--	--	--	--	ML
10 -6.007																														
-6.507																														
11 -7.007				SPT	144-06-09	10.50	10.95	36	26	--	--	--	0	23	77	--		33.6	NP		--	--	--	--	--	--	--	--	--	ML
-7.507																														
12 -8.007																														
-8.507				UDS	144-06-10	12.00	12.60	--	--	1.905	1.559	22.2	0	48	52	--		33.2	NP		2.680	DUU	0.03	22	--	--	--	--	--	ML
13 -9.007																														
-9.507																														
14 -10.007				SPT	144-06-11	13.50	13.95	58	37	--	--	--	0	20	80	--		31.9	NP		--	--	--	--	--	--	--	--	--	ML
-10.507	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	16.60																											
15 -11.007																														
-11.507				SPT	144-06-12	15.00	15.45	46	31	--	--	--	0	18	82	--		33.1	NP		--	--	--	--	--	--	--	--	--	ML
16 -12.007																														
-12.507																														
17 -13.007				SPT	144-06-13	16.50	16.95	49	32	--	--	--	0	17	83	--		33.3	NP		--	--	--	--	--	--	--	--	--	ML
-13.507																														
18 -14.007																														
-14.507				UDS	144-06-14	18.00	18.60	--	--	1.950	1.609	21.2	0	49	51	--		31.1	NP		2.685	--	--	--	--	--	--	--	--	ML
19 -15.007																														
-15.507																														
20 -16.007				SPT	144-06-15	19.50	19.95	33	24	--	--	--	0	13	87	--		32.9	NP		--	--	--	--	--	--	--	--	--	ML
-16.507																														
21 -17.007																														
-17.507				SPT	144-06-16	21.00	21.45	35	25	--	--	--	0	16	84	--		32.4	NP		--	--	--	--	--	--	--	--	--	ML
22 -18.007																														
-18.507																														
23 -19.007				SPT	144-06-17	22.50	22.95	32	32	--	--	--	0	4	96	--		46.9	25.1	21.8	--	--	--	--	--	--	--	--	--	CI
-19.507																														
24 -20.007																														
-20.507				UDS	144-06-18	24.00	24.60	--	--	1.970	1.653	19.2	0	1	99	52	47	46.6	25.8	20.8	2.592	TUU	0.42	10	--	--	--	--	0.74	CI
25 -21.007																														
-21.507																														
26 -22.007				SPT	144-06-19	25.50	25.95	33	33	--	--	--	0	1	99	53	46	48.3	26.1	22.2	--	--	--	--	--	--	--	--	--	CI
-22.507	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	8.00																											
27 -23.007																														
-23.507				SPT	144-06-20	27.00	27.45	26	26	--	--	--	0	2	98	58	40	47.6	24.5	23.1	--	--	--	--	--	--	--	--	--	CI
28 -24.007																														
-24.507																														
29 -25.007				SPT	144-06-21	28.50	28.95	29	29	--	--	--	0	1	99	61	38	45.6	24.1	21.5	--	--	--	--	--	--	--	--	--	CI
-25.507																														
30 -26.007																														
-26.507				UDS	144-06-22	30.00	30.60	--	--	2.039	1.699	20.0	0	1	99	55	44	48.9	25.3	23.6	2.587	TUU	0.58	8	--	--	--	--	0.99	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-07

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 18-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 20-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-07	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 2.20 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2656232, E 0562087
Reduced Level	: 4.100				

Depth (m) R.L - 4.100 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction ϕ	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
3.600	Brownish Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL	5.94	DS	144-07-01	0.00	0.50	--	--	--	--	--	0	1	99	--		34.3	19.3	15.0	--	--	--	--	--	--	--	--	--	CL
1 3.100				SPT	144-07-02	0.50	0.95	6	6	--	--	--	0	2	98	65	33	32.6	18.9	13.7	--	--	--	--	--	--	--	--	--	CL
2.600																														
2 2.100				SPT	144-07-03	1.50	1.95	3	3	--	--	--	0	1	99	--		34.6	19.7	14.9	--	--	*0.27	0	15	--	--	--	--	CL
1.600																														
3 1.100																														
0.600				UDS	144-07-04	3.00	3.60	--	--	1.776	1.396	27.2	0	1	99	--		32.1	22.3	9.8	2.594	--	*0.33	0	--	--	--	--	--	CL
4 0.100																														
-0.400																														
5 -0.900				SPT	144-07-05	4.50	4.95	7	7	--	--	--	0	1	99	--		32.6	21.6	11.0	--	--	--	--	11	--	--	--	--	CL
-1.400																														
6 -1.900																														
-2.400	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	16.49	UDS	144-07-06	6.00	6.60	--	--	1.860	1.477	25.9	0	9	91	82	9	32.9	NP		2.659	DUU	0	16	--	--	--	--	--	ML
7 -2.900																														
-3.400																														
8 -3.900				SPT	144-07-07	7.50	7.95	21	18	--	--	--	0	12	88	--		32.1	NP		--	--	--	--	Nil	--	--	--	--	ML
-4.400																														
9 -4.900																														
-5.400				UDS	144-07-08	9.00	9.60	--	--	1.903	1.517	25.5	0	35	65	--		34.0	NP		2.672	--	--	--	--	--	--	--	--	ML
10 -5.900																														
-6.400																														
11 -6.900				SPT	144-07-09	10.50	10.95	34	25	--	--	--	0	21	79	--		32.6	NP		--	--	--	--	Nil	--	--	--	--	ML
-7.400																														
12 -7.900																														
-8.400				UDS	144-07-10	12.00	12.60	--	--	2.006	1.585	26.6	0	19	81	--		33.7	NP		--	DUU	0	18	--	--	--	--	--	ML
13 -8.900																														
-9.400																														
14 -9.900				SPT	144-07-11	13.50	13.95	39	27	--	--	--	0	15	85	--		33.1	NP		2.663	--	--	--	--	--	--	--	--	ML
-10.400																														
15 -10.900																														
-11.400				UDS-F+ SPT	144-07-12	15.00	15.45	46	31	--	--	--	0	19	81	--		33.8	NP		--	--	--	--	--	--	--	--	--	ML
16 -11.900																														
-12.400																														
17 -12.900				SPT	144-07-13	16.50	16.95	52	34	--	--	--	0	17	83	--		32.9	NP		--	--	--	--	--	--	--	--	--	ML
-13.400																														
18 -13.900																														
-14.400				UDS	144-07-14	18.00	18.60	--	--	2.006	1.593	25.9	0	14	86	--		30.0	NP		2.66	DUU	0	21	--	--	--	--	--	ML
19 -14.900																														
-15.400																														
20 -15.900				SPT	144-07-15	19.50	19.95	48	32	--	--	--	0	16	84	--		31.2	NP		--	--	--	--	--	--	--	--	--	ML
-16.400																														
21 -16.900																														
-17.400				SPT	144-07-16	21.00	21.60	35	25	--	--	--	0	18	82	--		34.2	NP		--	--	--	--	--	--	--	--	--	ML
22 -17.900																														
-18.400																														

BH-07

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 18-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 20-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-07	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 2.20 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2656232, E 0562087
Reduced Level	: 4.100 m				

Depth (m) R.L - 4.100 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of Internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
23 -18.900	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles			SPT	144-07-17	22.50	22.95	38	38	--	--	--	0	7	93	--		39.3	22.3	17.0	--	--	--	--	--	--	--	--	--	CI
-19.400																														
24 -19.900																														
-20.400				UDS	144-07-18	24.00	24.60	--	--	1.873	1.540	21.6	0	6	94	58	36	38.6	22.5	16.1	2.589	TUU	0.31	10	--	0.119	0.59	--	0.73	CI
25 -20.900																														
-21.400																														
26 -21.900				SPT	144-07-19	25.50	25.95	28	28	--	--	--	0	2	98	--		43.6	22.7	20.9	--	--	--	--	--	--	--	16.3	--	CI
-22.400																														
27 -22.900																														
-23.400				SPT	144-07-20	27.00	27.45	24	24	--	--	--	0	1	99	52	47	46.3	22.9	23.4	--	--	--	--	--	--	--	--	--	CI
28 -23.900																														
-24.400																														
29 -24.900				SPT	144-07-21	28.50	28.95	24	24	--	--	--	0	2	98	--		46.6	23.1	23.5	--	--	--	--	--	--	--	--	--	CI
-25.400																														
30 -25.900																														
-26.400				UDS	144-07-22	30.00	30.60	--	--	2.053	1.558	31.8	0	1	99	55	44	45.7	24.3	21.4	2.591	TUU	0.53	9	--	--	--	--	1.11	CI
31 -26.900																														
-27.400																														
32 -27.900				SPT	144-07-23	31.50	31.95	25	25	--	--	--	0	1	99	--		46.6	24.2	22.4	--	--	--	--	--	--	--	--	--	CI
-28.400																														
33 -28.900																														
-29.400				SPT	144-07-24	33.00	33.45	17	17	--	--	--	0	2	98	56	42	45.9	23.6	22.3	--	--	--	--	--	--	--	--	--	CI
34 -29.900																														
-30.400																														
35 -30.900				SPT	144-07-25	34.50	34.95	16	16	--	--	--	0	2	98	--		45.7	23.2	22.5	2.605	--	--	--	--	--	--	--	--	CI
-31.400																														
36 -31.900																														
-32.400		CI	28.10	UDS	144-07-26	36.00	36.60	--	--	1.888	1.521	24.1	0	1	99	--		46.7	25.6	21.1	--	--	--	--	--	--	--	--	--	CI
37 -32.900																														
-33.400																														
38 -33.900				SPT	144-07-27	37.50	37.95	28	28	--	--	--	0	2	98	55	43	45.3	25.4	19.9	--	--	--	--	--	--	--	--	--	CI
-34.400																														
39 -34.900																														
-35.400				SPT	144-07-28	39.00	39.45	33	33	--	--	--	0	1	99	--		47.1	25.8	21.3	--	--	--	--	--	--	--	--	--	CI
40 -35.900																														
-36.400																														
41 -36.900				SPT	144-07-29	40.50	40.95	28	28	--	--	--	0	1	99	--		45.9	24.2	21.7	2.611	--	--	--	--	--	--	--	--	CI
-37.400																														
42 -37.900																														
-38.400	(Visual Clasification) Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles			UDS	144-07-30	42.00	42.60	--	--	1.942	1.569	23.8	--								--	--	--	--	--	--	--	--	--	CI
43 -38.900																														
-39.400																														
44 -39.900				SPT	144-07-31	43.50	43.95	25	25	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
-40.400																														
45 -40.900																														
-41.400				SPT	144-07-32	45.00	45.42	30	30	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
46 -41.900																														
-42.400																														
47 -42.900				SPT	144-07-33	46.50	46.92	29	29	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
-43.400																														
48 -43.900																														
-44.400				UDS-F + SPT	144-07-34	48.00	48.45	35	35	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
49 -44.900																														
-45.400																														
50 -45.900																														
-46.400				SPT	144-07-35	50.00	50.45	42	42	--	--	--	--								--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-9

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 30-11-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 03-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-09	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 4.50 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2661383, E 0559525
Reduced Level	: 5.828 m				

Depth (m) R.L - 5.828 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N-Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	%Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
5.828																														
1 5.328				SPT	144-09-01	0.50	0.95	4	4	--	--	--	0	2	98	56	42	34.9	22.6	12.3	--	--	--	--	--	--	--	--	--	CL
4.828																														
2 4.328				SPT	144-09-02	1.50	1.95	5	5	--	--	--	0	8	92	55	37	32.5	22.3	10.2	--	--	*0.24	0	Nil	--	--	--	--	CL
3.828																														
3 3.328																														
2.828				UDS	144-09-03	3.00	3.60	--	--	1.761	1.368	28.7	0	5	95	--		32.4	22.0	10.4	--	--	0.23	0	--	--	--	--	--	CL
4 2.328																														
1.828	Brownish greyish Silty Clay of Low Plasticity Mixed With Kankars	CL	8.75																											
5 1.328				SPT	144-09-04	4.50	4.95	10	10	--	--	--	0	4	96	52	44	30.2	21.8	8.4	2.606	--	*0.54	0	Nil	--	--	--	--	CL
0.828																														
6 0.328																														
-0.172				UDS	144-09-05	6.00	6.60	--	--	1.702	1.409	20.8	0	1	99	59	40	35.0	21.6	13.4	--	--	--	--	--	--	--	--	--	CL
7 -0.672																														
-1.172																														
8 -1.672				SPT	144-09-06	7.50	7.95	6	6	--	--	--	0	3	97	--		30.0	20.7	9.3	--	--	--	--	Nil	--	--	--	--	CL
-2.172																														
9 -2.672																														
-3.172				UDS	144-09-07	9.00	9.60	--	--	1.786	1.463	22.1	1	1	98	--		28.8	NP		--	--	--	--	--	--	--	--	--	ML
10 -3.672																														
-4.172																														
11 -4.672				SPT	144-09-08	10.50	10.95	41	28	--	--	--	0	12	88	--		33.9	NP		2.581	--	--	--	--	--	--	--	--	ML
-5.172	Greyish brownish non-plastic clayey silt mixed with little Fines	ML	4.80																											
12 -5.672																														
-6.172				UDS	144-09-09	12.00	12.60	--	--	1.832	1.504	21.8	0	13	87	76	11	29.3	NP		--	DUU	0.05	19	Nil	--	--	--	--	ML
13 -6.672																														
-7.172																														
14 -7.672				SPT	144-09-10	13.50	13.95	65	40	--	--	--	0	62	38	--		28.6	NP		--	--	--	--	--	--	--	--	--	SM
-8.172																														
15 -8.672	Greyish Silty Sand with Kankars	SM	2.95																											
-9.172				UDS	144-09-11	15.00	15.60	--	--	1.886	1.569	20.2	0	64	36	--		33.7	NP		2.658	DUU	0.05	25	--	--	--	--	--	SM
16 -9.672																														
-10.172																														
17 -10.672				SPT	144-09-12	16.50	16.95	58	37	--	--	--	0	39	61	--		33.0	NP		--	--	--	--	--	--	--	--	--	ML
-11.172																														
18 -11.672																														
-12.172				UDS	144-09-13	18.00	18.60	--	--	1.857	1.512	22.9	2	22	76	--		34.2	NP		--	DUU	0.05	21	--	--	--	--	--	ML
19 -12.672																														
-13.172																														
20 -13.672				SPT	144-09-14	19.50	19.95	>100 (12 cm)	--	--	--	--	0	40	60	--		34.4	NP		--	--	--	--	--	--	--	--	--	ML
-14.172																														
21 -14.672	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	6.06																											
-15.172				UDS	144-09-15	21.00	21.60	--	--	1.946	1.562	24.6	0	38	62	--		31.4	NP		--	DUU	0.05	22	--	--	--	--	--	ML
22 -15.672																														
-16.172																														
23 -16.672				SPT	144-09-16	22.50	22.95	40	28	--	--	--	0	8	92	--		31.5	NP		--	--	--	--	--	--	--	--	--	ML
-17.172																														
24 -17.672																														
-18.172				UDS	144-09-17	24.00	24.60	--	--	1.918	1.553	23.5	0	6	94	--		33.9	NP		--	--	--	--	--	--	--	--	--	ML
25 -18.672																														
-19.172																														

BH-9

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) | **Date Started** : 30-11-2020 | **Type of Bit used** : TC Bit

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat | **Date Completed** : 03-12-2020 | **Bearing of Hole** : 90^0 with Horizontal Plane

Bore Hole No. : BH-09 | **Diameter of Boring** : 150 mm | **Type of Boring** : Rotary Drilling

Top Level of Water Below EGL : 4.50 m | **Depth of Boring** : 50 m | **Co-Ordinates** : 42 Q, N 2661383, E 0559525

Reduced Level : 5.828 m

Depth (m) R.L - 5.828 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N-Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	%Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
26 -19.672	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI	25.44	SPT	144-09-18	25.50	25.95	50	--	--	--	--	0	2	98	56	42	36.2	21.0	15.3	--	--	--	--	Nil	--	--	--	--	CI
-20.172																														
27 -20.672																														
-21.172				UDS	144-09-19	27.00	27.60	--	--	1.920	1.529	25.6	0	2	98	62	36	42.5	23.6	18.9	--	TUU	0.52	6	--	--	--	16.2	0.99	CI
28 -21.672																														
-22.172																														
29 -22.672				SPT	144-09-20	28.50	28.95	35	--	--	--	--	0	0	100	52	48	46.6	24.9	21.7	2.473	--	--	--	15	--	--	--	--	CI
-23.172																														
30 -23.672																														
-24.172				UDS	144-09-21	30.00	30.60	--	--	1.919	1.534	25.1	0	1	99	--		48.6	26.3	22.3	--	TUU	0.58	4	--	--	--	--	1.01	CI
31 -24.672																														
-25.172																														
32 -25.672																														
-26.172																														
33 -26.672																														
-27.172				SPT	144-09-22	33.00	33.45	30	--	--	--	--	0	1	99	56	43	48.3	26.0	22.3	2.513	--	--	--	Nil	--	--	--	--	CI
34 -27.672																														
-28.172																														
35 -28.672																														
-29.172																														
36 -29.672																														
-30.172				UDS-F + SPT	144-09-23	36.00	36.45	40	--	--	--	--	0	1	99	--		47.0	24.8	22.2	--	--	--	--	Nil	--	--	--	--	CI
37 -30.672																														
-31.172																														
38 -31.672																														
-32.172																														
39 -32.672																														
-33.172				SPT	144-09-24	39.00	39.45	33	--	--	--	--	0	1	99	--		48.1	24.7	23.4	--	--	--	--	--	--	--	--	--	CI
40 -33.672																														
-34.172																														
41 -34.672																														
-35.172																														
42 -35.672																														
-36.172				UDS-F + SPT	144-09-25	42.00	42.45	28	--	--	--	--	0	1	99	--		46.7	24.2	22.5	2.663	--	--	--	--	--	--	--	--	CI
43 -36.672																														
-37.172																														
44 -37.672																														
-38.172																														
45 -38.672																														
-39.172				SPT	144-09-26	45.00	45.45	59	--	--	--	--	0	0	100	--		44.9	23.9	21.0	--	--	--	--	--	--	--	--	--	CI
46 -39.672																														
-40.172																														
47 -40.672																														
-41.172																														
48 -41.672																														
-42.172	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH	2.50	UDS-F + SPT	144-09-27	48.00	48.45	37	--	--	--	--	0	5	95	--		100.2	41.4	58.8	--	--	--	--	--	--	--	--	--	CH
49 -42.672																														
-43.172																														
50 -43.672																														
-44.172				SPT	144-09-28	50.00	50.45	84	--	--	--	--	0	4	96	26	70	83.0	35.6	47.4	--	--	--	--	--	--	--	--	--	CH

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Graph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-10

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 30-11-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 03-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-10	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 4.0 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2661089, E 0560920
Reduced Level	: 5.207 m				

Depth (m) / R.L - 5.207 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
5.207	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	0.50	DS	144-10-01	0.00	0.50	--		--	--	--	0	1	99	--		32.8	NP		--	--	--	--	--	--	--	--	--	ML
1 4.707	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	7.00	SPT	144-10-02	0.50	0.95	7	7	--	--	--	0	3	97	57	40	41.6	23.1	18.6	--	--	*0.25	0	--	--	--	--	--	CI
2 4.207																														
3.707				SPT	144-10-03	1.50	1.95	8	8	--	--	--	0	2	98	61	37	42.6	23.4	19.2	2.601	--	--	--		--	--	--	--	CI
3 3.207																														
2.707				UDS-F + SPT	144-10-04	3.00	3.45	12	12	--	--	--	0	3	97	--		45.7	24.6	21.1	--	--	0.27	0	--	--	--	--	--	CI
4 2.207																														
1.707				SPT	144-10-05	4.50	4.95	14	14	--	--	--	0	4	96	--		44.8	24.1	20.7	--	--	*0.52	0	--	--	--	--	--	CI
5 1.207									--																					
0.707				UDS	144-10-06	6.00	6.60	--	--	1.755	1.412	24.3	0	2	98	60	38	36.2	22.1	14.1	2.631	--	--	--	9	--	--	15.9	--	CI
6 0.207																														
-0.293				SPT	144-10-07	7.50	7.95	17	17	--	--	--	0	1	99	55	44	32.4	20.6	11.8	--	--	--	--	--	--	--	--	--	CL
7 -0.793																														
-1.293				UDS	144-10-08	9.00	9.60	--	--	1.779	1.459	21.9	0	1	99	--		33.4	22.9	10.5	--	--	--	--	--	--	--	--	--	CL
8 -1.793																														
-2.293	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL	4.50																											
9 -2.793																														
-3.293				SPT	144-10-09	10.50	10.95	23	23	--	--	--	0	1	99	--		31.4	20.2	11.2	--	--	--	--	--	--	--	--	--	CL
10 -3.793																														
-4.293				UDS	144-10-10	12.00	12.60	--	--	1.737	1.419	22.4	0	3	97	53	44	40.8	23.6	17.2	2.643	--	*0.63	0	Nil	--	--	--	--	CI
11 -4.793																														
-5.293				SPT	144-10-11	13.50	13.95	15	15	--	--	--	0	0	100	--		42.9	23.8	19.1	--	--	--	--	--	--	--	--	--	CI
12 -5.793																														
-6.293				UDS	144-10-12	15.00	15.60	--	--	1.979	1.641	20.6	0	43	57	48	9	32.6	NP		--	--	--	--	--	--	--	--	--	ML
13 -6.793																														
-7.293	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	3.10																											
14 -7.793																														
-8.293				SPT	144-10-13	16.50	16.95	55	35	--	--	--	0	48	52	--		31.2	NP		--	--	--	--	--	--	--	--	--	ML
15 -8.793																														
-9.293				UDS	144-10-14	18.00	18.60	--	--	1.979	1.637	20.9	0	31	69	--		31.8	NP		2.611	DUU	0.01	21	Nil	--	--	--	--	ML
16 -9.793																														
-10.293	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	7.30																											
17 -10.793																														
-11.293				SPT	144-10-15	19.50	19.92	58	37	--	--	--	0	35	65	--		32.6	NP		--	--	--	--	--	--	--	--	--	ML
18 -11.793																														
-12.293				UDS	144-10-16	21.00	21.60	--	--	1.940	1.595	21.6	0	25	75	--		33.5	NP		--	--	--	--	--	--	--	--	--	ML
19 -12.793																														
-13.293																														
20 -13.793																														
-14.293																														
21 -14.793																														
-15.293																														
22 -15.793																														
-16.293																														
-16.793																														

BH-10

Name of Owner : Gujarat Industries Power Company Limited (GIPCL)
Date Started : 30-11-2020
Type of Bit used : TC Bit

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat
Date Completed : 03-12-2020
Bearing of Hole : 90^0 with Horizontal Plane

Bore Hole No. : BH-10
Diameter of Boring : 150 mm
Type of Boring : Rotary Drilling

Top Level of Water Below EGL : 4.0 m
Depth of Boring : 50 m
Co-Ordinates : 42 Q, N 2661089, E 0560920

Reduced Level : 5.207 m

Depth (m) R.L - 5.207 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	% Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
23 -17.293				SPT	144-10-17	22.50	22.95	28	28	--	--	--	1	3	96	--		36.8	20.4	16.4	--	--	--	--	--	--	--	--	--	CI
-17.793																														
24 -18.293																														
-18.793				UDS	144-10-18	24.00	24.60	--	--	1.875	1.532	22.4	2	2	96	49	47	43.9	24.5	19.4	2.586	TUU	0.30	7	--	--	--	--	0.70	CI
25 -19.293																														
-19.793																														
26 -20.293				SPT	144-10-19	25.50	25.95	33	33	--	--	--	0	2	98	--		41.2	22.6	18.6	--	--	--	--	--	--	--	--	--	CI
-20.793																														
27 -21.293																														
-21.793				UDS + SPT	144-10-20	27.00	27.45	30	30	1.948	1.581	23.2	0	4	96	--		46.5	24.8	21.7	--	--	--	--	--	--	--	--	--	CI
28 -22.293																														
-22.793																														
29 -23.293				SPT	144-10-21	28.50	28.95	31	31	--	--	--	0	3	97	--		46.6	24.1	22.6	--	--	--	--	--	--	--	--	--	CI
-23.793																														
30 -24.293																														
-24.793				UDS	144-10-22	30.00	30.60	--	--	1.950	1.589	22.7	0	22	77	53	24	40.3	22.8	17.5	--	--	--	--	--	--	--	--	--	CI
31 -25.293																														
-25.793																														
32 -26.293																														
-26.793	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	19.70																											
33 -27.293																														
-27.793				SPT	144-10-23	33.00	33.45	25	25	--	--	--	0	14	86	--		48.5	25.6	23.0	--	--	--	--	--	--	--	--	--	CI
34 -28.293																														
-28.793																														
35 -29.293																														
-29.793																														
36 -30.293																														
-30.793				UDS	144-10-24	36.00	36.60	--	--	1.873	1.507	24.3	0	1	99	--		48.2	25.9	22.3	2.569	TUU	0.52	5	--	--	--	--	0.91	CI
37 -31.293																														
-31.793																														
38 -32.293																														
-32.793																														
39 -33.293																														
-33.793				SPT	144-10-25	39.00	39.27	>100 (12 cm)	--	--	--	--	0	1	99	--		45.6	25.0	20.6	--	--	--	--	--	--	--	--	--	CI
40 -34.293																														
-34.793																														
41 -35.293																														
-35.793																														
42 -36.293																														
-36.793				UDS	144-10-26	42.00	42.60	--	--	1.965	1.591	23.5	3	42	55	--		56.4	26.7	29.7	--	--	--	--	--	--	--	--	--	CH
43 -37.293																														
-37.793																														
44 -38.293																														
-38.793																														
45 -39.293																														
-39.793				SPT	144-10-27	45.00	45.28	>100 (13 cm)	--	--	--	--	4	40	56	--		65.8	26.2	39.6	2563	--	--	--	--	--	--	--	--	--	CH
46 -40.293																														
-40.793	Brownish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH	8.40																											
47 -41.293																														
-41.793																														
48 -42.293																														
-42.793				UDS	144-10-28	48.00	48.60	--	--	2.028	1.621	25.1	1	4	95	--		58.3	29.6	28.7	--	--	--	--	--	--	--	--	--	CH
49 -43.293																														
-43.793																														
50 -44.293																														
-44.793				SPT	144-10-29	50.00	50.45	33	33	--	--	--	0	26	74	--		96.5	39.3	57.3	--	--	--	--	--	--	--	--	--	CH

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Graph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-11

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 16-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 17-12-2020	**Bearing of Hole**	: 90° with Horizontal Plane
Bore Hole No.	: BH-11	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 4.20m	**Depth of Boring**	: 30 m	**Co-Ordinates**	: 42 Q, N 2660618, E 562465
Reduced Level	: 5.241 m				

Depth (m) R.L - 5.241 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C_u kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
4.741	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	1.40	DS	144-11-01	0.00	0.50	--	--	--	--	--	2	11	87	52	35	31.6	18.6	13.0	--	--	--	--	--	--	--	--	--	CL
1 4.241				SPT	144-11-02	0.50	0.95	6	6	--	--	--	1	10	89	42	47	34.2	19.3	14.9	--	--	--	--	--	--	--	--	--	CL
3.741																														
2 3.241	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	15.10	SPT	144-11-03	1.50	1.95	10	10	--	--	--	0	5	95	--		33.6	NP		--	--	0	*13	--	--	--	--	--	ML
2.741																														
3 2.241																														
1.741				UDS	144-11-04	3.00	3.60	--	--	1.770	1.402	26.3	0	10	90	78	12	34.6	NP		2.65	DUU	0	16	Nil	--	--	--	--	ML
4 1.241																														
0.741																														
5 0.241				SPT	144-11-05	4.50	4.95	22	19	--	--	--	0	20	80	--		32.9	NP		--	--	--	--	Nil	--	--	--	--	ML
-0.259																														
6 -0.759																														
-1.259				UDSF+ SPT	144-11-06	6.00	6.60	19	17	--	--	--	0	13	87	--		34.2	NP		--	--	--	--	--	--	--	--	--	ML
7 -1.759																														
-2.259																														
8 -2.759				SPT	144-11-07	7.50	7.95	25	20	--	--	--	0	15	85	--		33.4	NP		--	--	--	--	Nil	--	--	--	--	ML
-3.259																														
9 -3.759																														
-4.259				UDS	144-11-08	9.00	9.60	--	--	1.881	1.505	25.0	0	24	77	--		34.3	NP		2.66	DUU	0	20	--	--	--	--	--	ML
10 -4.759																														
-5.259																														
11 -5.759				SPT	144-11-09	10.50	10.95	30	23	--	--	--	0	25	75	--		32.9	NP		--	--	--	--	--	--	--	--	--	ML
-6.259																														
12 -6.759																														
-7.259				UDS	144-11-10	12.00	12.60	--	--	1.840	1.501	22.6	0	5	95	--		28.3	NP		2.67	DUU	0	19	--	--	--	--	--	ML
13 -7.759																														
-8.259																														
14 -8.759				SPT	144-11-11	13.50	13.95	25	20	--	--	--	0	6	94	--		29.6	NP		--	--	--	--	--	--	--	--	--	ML
-9.259																														
15 -9.759																														
-10.259				SPT	144-11-12	15.00	15.45	29	22	--	--	--	0	9	91	--		31.2	NP		--	--	--	--	--	--	--	--	--	ML
16 -10.759																														
-11.259																														
17 -11.759	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	4.60	SPT	144-11-13	16.50	16.95	31	31	--	--	--	0	9	91	49	42	30.9	17.2	13.7	--	--	--	--	--	--	--	--	--	CL
-12.259																														
18 -12.759																														
-13.259				UDS	144-11-14	18.00	18.60	--	--	1.917	1.586	20.9	0	3	97	52	45	31.9	17.7	14.3	2.59	TUU	0.2	16	20	0.13	0.44	13	0.4	CL
19 -13.759																														
-14.259																														
20 -14.759				SPT	144-11-15	19.50	19.95	32	32	--	--	--	0	4	96	56	40	33.2	18.6	14.6	--	--	--	--	--	--	--	--	--	CL
-15.259																														
21 -15.759																														
-16.259	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	9.40	SPT	144-11-16	21.00	21.45	22	22	--	--	--	0	6	94	52	42	36.6	20.1	16.5	--	--	--	--	--	--	--	--	--	CI
22 -16.759																														
-17.259																														
23 -17.759				SPT	144-11-17	22.50	22.95	21	21	--	--	--	0	3	97	56	41	39.6	20.6	19.0	--	--	--	--	--	--	--	--	--	CI
-18.259																														
24 -18.759																														
-19.259				UDS	144-11-18	24.00	24.60	--	--	1.923	1.574	22.2	0	2	98	51	47	44.5	21.4	23.1	2.6	TUU	0.2	17	--	--	--	--	0.4	CI
25 -19.759																														
-20.259																														
26 -20.759				SPT	144-11-19	25.50	25.95	19	19	--	--	--	0	1	99	53	46	46.3	24.1	22.2	--	--	--	--	--	--	--	--	--	CI
-21.259																														
27 -21.759																														
-22.259				SPT	144-11-20	27.00	27.45	23	23	--	--	--	0	2	98	--		48.3	25.6	22.7	--	--	--	--	--	--	--	--	--	CI
28 -22.759																														
-23.259																														
29 -23.759				SPT	144-11-21	28.50	28.95	16	16	--	--	--	0	3	97	53	44	48.1	24.3	23.8	--	--	--	--	--	--	--	--	--	CI
-24.259																														
30 -24.759																														
-25.259				UDS	144-11-22	30.00	30.60	--	--	1.927	1.569	22.8	0	1	99	--		48.2	24.8	23.4		--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-12

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 30-11-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 03-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-12	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.0 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2661287, E 0564073
Reduced Level	: 4.855 m				

Depth (m) R.L - 4.855 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
4.355	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	0.30	DS	144-12-01	0.00	0.50	--		--	--	--	2	16	82	--		33.7	22.4	11.3	--	--	--	--	--	--	--	--	--	--	CL
1 3.855				SPT	144-12-02	0.50	0.95	3	3	--	--	--	1	11	88	26	62	53.4	25.3	28.1	--	--	--	--	--	--	--	--	--	CH
3.355	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH	2.20																											
2 2.855				SPT	144-12-03	1.50	1.95	5	5	--	--	--	5	18	77	--		52.4	22.7	29.7	2.597	--	*0.33	0	20	--	--	21	--	CH
2.355																														
3 1.855				UDS-F + SPT	144-12-04	3.00	3.45	8	8	--	--	--	3	8	89	50	39	34.9	22.1	12.8	--	--	*0.42	0	--	--	--	--	--	CL
1.355	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	5.00																											
4 0.855																														
0.355				SPT	144-12-05	4.50	4.95	4	4	--	--	--	0	1	99	--		30.8	21.2	9.6	--	--	--	--	10	--	--	--	--	CL
5 -0.145																														
-0.645																														
6 -1.145																														
-1.645				UDS	144-12-06	6.00	6.60	--	--	1.709	1.394	22.6	1	3	96	--		34.3	20.1	14.2	--	--	*0.47	0	--	--	--	--	--	CL
7 -2.145																														
-2.645																														
8 -3.145				SPT	144-12-07	7.50	7.95	9	9	--	--	--	0	2	98	--		30.8	NP		--	--	--	--	--	--	--	--	--	ML
-3.645																														
9 -4.145																														
-4.645				UDS	144-12-08	9.00	9.60	--	--	1.822	1.451	25.6	1	3	96	87	9	31.6	NP		2.608	DUU	0.03	16	Nil	--	--	--	--	ML
10 -5.145																														
-5.645																														
11 -6.145				SPT	144-12-09	10.50	10.95	21	18	--	--	--	2	4	94	--		30.1	NP		--	--	--	--	--	--	--	--	--	ML
-6.645																														
12 -7.145																														
-7.645				UDS	144-12-10	12.00	12.60	--	--	1.768	1.476	19.8	0	3	97	--		34.8	NP		--	--	--	--	--	--	--	--	--	ML
13 -8.145																														
-8.645																														
14 -9.145				SPT	144-12-11	13.50	13.95	28	22	--	--	--	0	6	94	--		27.4	NP		--	--	--	--	--	--	--	--	--	ML
-9.645																														
15 -10.145																														
-10.645				UDS	144-12-12	15.00	15.60	--	--	1.772	1.507	17.6	0	24	75	--		22.9	NP		2.611	DUU	0.05	19	--	--	--	--	--	ML
16 -11.145	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	16.10																											
-11.645																														
17 -12.145				SPT	144-12-13	16.50	16.95	50	33	--	--	--	0	37	63	--		25.2	NP		--	--	--	--	--	--	--	--	--	ML
-12.645																														
18 -13.145																														
-13.645				UDS	144-12-14	18.00	18.60	--	--	1.846	1.511	22.2	0	48	52	--		31.1	NP		--	--	--	--	--	--	--	--	--	ML
19 -14.145																														
-14.645																														
20 -15.145				SPT	144-12-15	19.50	19.95	72	44	--	--	--	0	50	50	--		31.5	NP		--	--	--	--	--	--	--	--	--	ML
-15.645																														
21 -16.145																														
-16.645				UDS	144-12-16	21.00	21.60	--	--	1.847	1.519	21.6	1	34	65	--		32.1	NP		2.613	DUU	0.02	22	Nil	--	--	--	--	ML
22 -17.145																														
-17.645																														
23 -18.145				SPT	144-12-17	22.50	22.90	>100 (10 cm)	--	--	--	--	0	19	81	--		33.1	NP		--	--	--	--	--	--	--	--	--	ML
-18.645																														
24 -19.145																														

BH-12

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 30-11-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 03-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-12	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.0 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2661287, E 0564073
Reduced Level	: 4.855 m				

Depth (m) R.L - 4.855 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-19.645				UDS	144-12-18	24.00	24.60	--	--	1.883	1.536	22.6	6	4	90	43	47	44.8	24.2	20.6	--	--	--	--	--	--	--	--	--	--	CI
25 -20.145																														
-20.645																														
26 -21.145				SPT	144-12-19	25.50	25.95	51	--	--	--	--	0	2	98	--		39.4	21.5	17.9	--	--	--	--	--	--	--	--	--	--	CI
-21.645																														
27 -22.145																														
-22.645				UDS-F + SPT	144-12-20	27.00	27.45	43	--	--	--	--	1	3	96	48	48	38.6	20.9	17.7	--	--	--	--	--	--	--	--	--	--	CI
28 -23.145																														
-23.645																														
29 -24.145				SPT	144-12-21	28.50	28.95	74	--	--	--	--	0	1	99	--		46.3	25.8	20.5	2.591	--	--	--	--	--	--	--	--	--	CI
-24.645																														
30 -25.145																														
-25.645				UDS	144-12-22	30.00	30.60	--	--	1.851	1.539	20.3	0	2	98	--		42.2	23.4	18.8	--	TUU	0.49	6	--	--	--	--	0.99	CI
31 -26.145																														
-26.645																														
32 -27.145																														
-27.645																														
33 -28.145																														
-28.645				SPT	144-12-23	33.00	33.45	52	--	--	--	--	1	2	97	55	42	40.2	20.8	19.4	--	--	--	--	--	--	--	--	--	CI
34 -29.145																														
-29.645																														
35 -30.145																														
-30.645																														
36 -31.145																														
-31.645				UDS	144-12-24	36.00	36.60	--	--	1.860	1.523	22.1	0	1	99	--		47.9	25.1	22.8	2.601	TUU	0.56	3	--	--	--	--	1.01	CI
37 -32.145																														
-32.645	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	26.90																											
38 -33.145																														
-33.645																														
39 -34.145																														
-34.645				SPT	144-12-25	39.00	39.45	43	--	--	--	--	0	2	98	56	42	47.0	24.7	22.3	--	--	--	--	--	--	--	--	--	CI
40 -35.145																														
-35.645																														
41 -36.145																														
-36.645																														
42 -37.145																														
-37.645				UDS-F + SPT	144-12-26	42.00	42.45	43	--	--	--	--	0	0	100	--		48.4	25.5	22.9	--	--	--	--	--	--	--	--	--	CI
43 -38.145																														
-38.645																														
44 -39.145																														
-39.645																														
45 -40.145																														
-40.645				SPT	144-12-27	45.00	45.45	57	--	--	--	--	0	1	99	55	44	46.9	24.6	22.3	2.631	--	--	--	--	--	--	--	--	CI
46 -41.145																														
-41.645																														
47 -42.145																														
-42.645																														
48 -43.145																														
-43.645				UDS	144-12-28	48.00	48.60	--	--	1.944	1.574	23.5	0	1	99	--		46.3	25.1	21.2	--	--	--	--	--	--	--	--	--	CI
49 -44.145																														
-44.645																														
50 -45.145																														
-45.645				SPT	144-12-29	50.00	50.45	53	--	--	--	--	0	11	89	41	48	41.2	23.2	18.0	--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Graph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-13

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 12-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 15-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-13	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 3.9m	**Depth of Boring**	: 30 m	**Co-Ordinates**	: 42 Q, N 2662474, E 559509
Reduced Level	: 6.261 m				

Depth (m) R.L - 6.261 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
5.761				DS	144-13-01	0.00	0.50	--	--	--	--	--	0	7	93	--		34.3	22.3	12.0	--	--	--	--	--	--	--	--	--	--	CL
1 5.261				SPT	144-13-02	0.50	0.95	8	8	--	--	--	0	2	98	--		32.6	21.1	11.5	--	--		--	--	--	--	--	--	--	CL
4.761																														
2 4.261				SPT	144-13-03	1.50	1.95	11	11	--	--	--	0	5	95	55	40	33.6	21.3	12.3	--	--	*0.13	0	18	--	--	--	--	CL
3.761																														
3 3.261																														
2.761				UDS	144-13-04	3.00	3.60	--	--	1.731	1.374	26.0	0	2	98	--		33.7	21.4	12.3	2.568	--	*0.19	0	--	--	--	--	--	--	CL
4 2.261	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	7.40																											
1.761																														
5 1.261				SPT	144-13-05	4.50	4.95	13	13	--	--	--	0	4	96	51	45	32.9	20.5	12.4	--	--	--	--	15	--	--	--	--	CL
0.761																														
6 0.261																														
-0.239				UDS	144-13-06	6.00	6.60	--	--	1.763	1.422	24.0	0	1	99	--		33.1	21.2	11.9	2.572	TUU	0.14	13	--	0.123	0.51	13.1	0.46	CL
7 -0.739																														
-1.239																														
8 -1.739				SPT	144-13-07	7.50	7.95	32	24	--	--	--	0	39	61	--		33.5	NP		--	--	--	--	--	--	--	--	--	--	ML
-2.239																														
9 -2.739	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	3.10																											
-3.239				UDS	144-13-08	9.00	9.60	--	--	1.792	1.453	23.3	0	36	64	52	12	34.3	NP		--	DUU	0	17	Nil	--	--	--	--	ML
10 -3.739																														
-4.239																														
11 -4.739				SPT	144-13-09	10.50	10.95	29	22	--	--	--	0	56	44	--		33.6	NP		--	--	--	--	--	--	--	--	--	--	SM
-5.239																														
12 -5.739	Greyish Silty Sand with Kankars	SM	2.90																											
-6.239				UDS	144-13-10	12.00	12.60	--	--	1.839	1.573	16.9	0	54	46	--		33.4	NP		2.645	DUU	0	24	Niil	--	--	--	--	SM
13 -6.739																														
-7.239																														
14 -7.739				SPT	144-13-11	13.50	13.95	35	25	--	--	--	0	46	54	--		33.6	NP		--	--	--	--	--	--	--	--	--	--	ML
-8.239																														
15 -8.739																														
-9.239				SPT	144-13-12	15.00	15.45	29	22	--	--	--	0	40	60	--		31.3	NP		2.673	--	0	*20	--	--	--	--	--	ML
16 -9.739	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	4.30																											
-10.239																														
17 -10.739				SPT	144-13-13	16.50	16.95	35	25	--	--	--	1	15	84	--		33.2	NP		--	--	--	--	--	--	--	--	--	--	ML
-11.239																														
18 -11.739																														
-12.239				UDS	144-13-14	18.00	18.60	--	--	1.848	1.561	18.4	0	11	89	49	40	33.9	21.0	12.9	2.616	TUU	0.36	10	--	--	--	--	0.56	CL
19 -12.739																														
-13.239																														
20 -13.739				SPT	144-13-15	19.50	19.95	27	27	--	--	--	0	1	99	57	42	31.9	19.4	12.5	--	--	--	--	--	--	--	--	--	CL
-14.239																														
21 -14.739																														
-15.239				SPT	144-13-16	21.00	21.45	38	38	--	--	--	0	2	98	--		31.2	18.9	12.3	--	--	--	--	--	--	--	--	--	--	CL
22 -15.739	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	7.60																											
-16.239																														
23 -16.739				SPT	144-13-17	22.50	22.95	50	50	--	--	--	0	1	99	59	40	31.8	19.3	12.5	--	--	--	--	--	--	--	--	--	CL
-17.239																														
24 -17.739																														
-18.239				UDS	144-13-18	24.00	24.60	--	--	1.888	1.572	20.1	0	1	99	53	46	34.1	21.4	12.7	--	TUU	0.45	9	--	--	--	--	--	CL
25 -18.739																														
-19.239																														
26 -19.739				SPT	144-13-19	25.50	25.95	25	25	--	--	--	0	1	99	--		48.3	24.6	23.7	2.622	--	--	--	--	--	--	--	--	--	CI
-20.239																														
27 -20.739																														
-21.239				SPT	144-13-20	27.00	27.45	19	19	--	--	--	0	2	98	--		46.6	23.8	22.8	--	--	--	--	--	--	--	--	--	--	CI
28 -21.739	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	5.30																											
-22.239																														
29 -22.739				SPT	144-13-21	28.50	28.95	18	18	--	--	--	0	1	99	--		47.6	24.2	23.4	--	--	--	--	--	--	--	--	--	--	CI
-23.239																														
30 -23.739																														
-24.239				UDS	144-13-22	30.00	30.60	--	--	1.710	1.279	33.7	0	1	99	--		46.1	23.5	22.7		TUU	0.68	5	--	--	--	--	1.35	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-14

Name of Owner : Gujarat Industries Power Company Limited (GIPCL)
Date Started : 04-12-2020
Type of Bit used : TC Bit

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat
Date Completed : 06-12-2020
Bearing of Hole : 90^0 with Horizontal Plane

Bore Hole No. : BH-14
Diameter of Boring : 150 mm
Type of Boring : Rotary Drilling

Top Level of Water Below EGL : 2.40 m
Depth of Boring : 50 m
Co-Ordinates : 42 Q, N 2662677, E 0561075

Reduced Level : 7.118 m

Depth (m) R.L - 7.118 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	% Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
6.618				DS	144-14-01	0.00	0.50	--	--	--	--	--	0	21	79	--		33.6	NP		--	--	--	--	--	--	--	--	--	ML
1 6.118				SPT	144-14-02	0.50	0.95	7	7	--	--	--	1	11	88	--		31.6	NP		--	--	--	--	--	--	--	--	--	ML
5.618																														
2 5.118				SPT	144-14-03	1.50	1.95	12	12	--	--	--	2	28	70	59	11	33.8	NP		--	--	--	--	--	--	--	--	--	ML
4.618																														
3 4.118																														
3.618				UDS	144-14-04	3.00	3.60	--	--	1.704	1.332	27.9	0	33	67	--		34.8	NP		2.562	--	0.0	*15	Nil	--	--	--	--	ML
4 3.118																														
2.618																														
5 2.118				SPT	144-14-05	4.50	4.95	16	16	--	--	--	0	33	67	--		34.2	NP		--	--	--	--	--	--	--	--	--	ML
1.618																														
6 1.118																														
0.618				UDS	144-14-06	6.00	6.60	--	--	1.711	1.349	26.8	0	47	53	--		33.5	NP		2.579	--	0.0	*17.0	Nil	--	--	--	--	ML
7 0.118																														
-0.382																														
8 -0.882				SPT	144-14-07	7.50	7.95	44	30	--	--	--	2	34	64	--		31.6	NP		--	--	--	--	--	--	--	--	--	ML
-1.382																														
9 -1.882	Brownish Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	18.00																											
-2.382				UDS-F + SPT	144-14-08	9.00	9.45	33	24	--	--	--	0	28	72	60	12	34.3	NP		--	--	--	--	Nil	--	--	--	--	ML
10 -2.882																														
-3.382																														
11 -3.882				SPT	144-14-09	10.50	10.95	39	27	--	--	--	0	31	69	--		32.8	NP		2.603	--	--	--	--	--	--	--	--	ML
-4.382																														
12 -4.882																														
-5.382				UDS-F + SPT	144-14-10	12.00	12.45	32	24	--	--	--	0	31	69	--		32.8	NP		--	--	--	--	--	--	--	--	--	ML
13 -5.882																														
-6.382																														
14 -6.882				SPT	144-14-11	13.50	13.95	33	24	--	--	--	0	34	66	--		32.1	NP		--	--	--	--	--	--	--	--	--	ML
-7.382																														
15 -7.882																														
-8.382				UDS	144-14-12	15.00	15.60	--	--	1.815	1.427	27.2	0	50	50	--		29.4	NP		--	DUU	0.02	19	Nil	--	--	--	--	ML
16 -8.882																														
-9.382																														
17 -9.882				SPT	144-14-13	16.50	16.95	64	40	--	--	--	0	41	59	--		30.6	NP		--	--	--	--	--	--	--	--	--	ML
-10.382																														
18 -10.882																														

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Geaph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-14

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) | **Date Started** : 04-12-2020 | **Type of Bit used** : TC Bit

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat | **Date Completed** : 06-12-2020 | **Bearing of Hole** : 90° with Horizontal Plane

Bore Hole No. : BH-14 | **Diameter of Boring** : 150 mm | **Type of Boring** : Rotary Drilling

Top Level of Water Below EGL : 2.40 m | **Depth of Boring** : 50 m | **Co-Ordinates** : 42 Q, N 2662677, E 0561075

Reduced Level : 7.118 m

Depth (m) R.L - 7.118 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm²	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm²	Shrinkage Limit, %	UCS, kg/cm²	CLASSIFICATION
-11.382				UDS	144-14-14	18.00	18.60	--	--	1.816	1.502	20.9	2	26	72	31	41	40.3	22.8	17.5	2.609	TUU	0.26	8	32	--	--	13.6	0.66	CI
19 -11.882																														
-12.382																														
20 -12.882				SPT	144-14-15	19.50	19.95	74	74	--	--	--	0	3	97	--		42.1	23.1	19.0	--	--	--	--	--	--	--	--	--	--	CI
-13.382																														
21 -13.882																														
-14.382				UDS	144-14-16	21.00	21.60	--	--	1.718	1.447	18.7	0	4	96	55	41	37.6	20.4	17.2	2.589	TUU	0.24	7	--	--	--	--	--	--	CI
22 -14.882																														
-15.382																														
23 -15.882				SPT	144-14-17	22.50	22.95	32	32	--			0	3	97	--		42.1	23.1	19.0	--	--	--	--	--	--	--	--	--	--	CI
-16.382																														
24 -16.882																														
-17.382				UDS	144-14-18	24.00	24.60	--	--	1.799	1.473	22.1	1	2	98	56	42	45.2	24.3	20.9	--	--	--	--	--	--	--	--	--	CI
25 -17.882																														
-18.382																														
26 -18.882				SPT	144-14-19	25.50	25.95	27	27	--	--	--	0	4	96	51	45	43.4	23.6	19.8	--	--	--	--	--	--	--	--	--	CI
-19.382																														
27 -19.882																														
-20.382				UDS	144-14-20	27.00	27.60	--	--	1.845	1.495	23.4	0	2	98	--		49.1	25.8	23.3	2.601	TUU	0.59	5	--	--	--	--	0.98	CI
28 -20.882																														
-21.382	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI	21.00																											
29 -21.882				SPT	144-14-21	28.50	28.95	30	30	--	--	--	0	6	94	50	44	46.7	26.2	20.5	--	--	--	--	--	--	--	--	--	CI
-22.382																														
30 -22.882																														
-23.382				UDS	144-14-22	30.00	30.60	--	--	1.877	1.511	24.2	0	2	98	52	46	48.7	25.1	23.6	--	--	--	--	--	--	--	--	--	CI
31 -23.882																														
-24.382																														
32 -24.882																														
-25.382																														
33 -25.882																														
-26.382				SPT	144-14-23	33.00	33.45	26	26	--	--	--	0	4	96	--		48.4	27.2	21.2	--	--	--	--	--	--	--	--	--	CI
34 -26.882																														
-27.382																														
35 -27.882																														
-28.382																														
36 -28.882																														
-29.382				UDS	144-14-24	36.00	36.60	--	--	1.926	1.521	26.6	--								2.603	TUU	0.62	3	--	--	--	--	--	CI
37 -29.882																														
-30.382																														
38 -30.882																														
-31.382																														
39 -31.882																														
-32.382				SPT	144-14-25	39.00	39.13	>100 (13 cm)	--	--	--	--	--								--	--	--	--	--	--	--	--	--	CH
40 -32.882																														
-33.382																														
41 -33.882																														
-34.382																														
42 -34.882																														
-35.382				UDS	144-14-26	42.00	42.60	--	--	1.981	1.591	24.5	--								--	--	--	--	--	--	--	--	--	CH
43 -35.882																														
-36.382																														
44 -36.882																														
-37.382	(Visual Clasification)																													
45 -37.882	Greyish Silty Clay of High Plasticity mixed with Fine Grained Sand Particles	CH	11.50																											
-38.382				SPT	144-14-27	45.00	45.40	>100 (10 cm)	--	--	--	--	--								--	--	--	--	--	--	--	--	--	CH
46 -38.882																														
-39.382																														
47 -39.882																														
-40.382																														
48 -40.882																														
-41.382				UDS-F + SPT	144-14-28	48.00	48.07	>100 (7cm)	--	--	--	--	--								--	--	--	--	--	--	--	--	--	CH
49 -41.882																														
-42.382																														
50 -42.882																														
-43.382				SPT	144-14-29	50.00	50.12	>100 (12 cm)	--	--	--	--	--								--	--	--	--	--	--	--	--	--	CH

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Graph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-15

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 30-11-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 04-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-15	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.0 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2662004, E 0562554
Reduced Level	: 5.433 m				

Depth (m) / R.L - 5.433 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	% Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
5.433				DS	144-15-01	0.00	0.50	--	--	--	--	--	1	16	83	--		32.2	17.6	14.6	--	--	--	--	--	--	--	--	--	--	CL
1 4.933				SPT	144-15-02	0.50	0.95	8	8	--	--	--	2	11	87	--		33.5	18.1	15.4	--	--	*0.34	0	--	--	--	--	--	--	CL
4.433	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	3.00																											
2 3.933				SPT	144-15-03	1.50	1.95	10	10	--	--	--	0	10	90	41	49	34.1	18.6	15.5	--	--	*0.41	0	20	--	--	--	--	CL
3.433																														
3 2.933																														
2.433				UDS	144-15-04	3.00	3.60	--	--	1.735	1.365	27.1	1	2	97	52	45	38.0	18.8	19.2	2.659	--	--	--	--	--	--	--	--	CI
4 1.933																														
1.433																														
5 0.933				SPT	144-15-05	4.50	4.95	6	6	--	--	--	0	4	96	--		37.9	17.8	20.1	--	--	*0.40	0	28	--	--	14.3	--	CI
0.433	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	4.45																											
6 -0.067																														
-0.567				UDS	144-15-06	6.00	6.60	--	--	1.830	1.455	25.8	2	3	95	52	43	38.5	21.9	16.6	--	--	--	--	--	--	--	--	--	CI
7 -1.067																														
-1.567																														
8 -2.067				SPT	144-15-07	7.50	7.95	15	15	--	--	--	1	4	95	83	12	32.2	NP		--	--	--	--	Nil	--	--	--	--	ML
-2.567																														
9 -3.067																														
-3.567				UDS	144-15-08	9.00	9.60	--	--	1.830	1.452	26.1	0	19	81	--		31.8	NP		2.632	DUU	0	17	--	--	--	--	--	ML
10 -4.067																														
-4.567																														
11 -5.067				SPT	144-15-09	10.50	10.95	31	23	--	--	--	1	22	77	--		28.6	NP		--	--	--	--	Nil	--	--	--	--	ML
-5.567	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	7.55																											
12 -6.067																														
-6.567				UDS	144-15-10	12.00	12.60	--	--	1.937	1.517	27.7	0	29	70	--		32.7	NP		--	--	--	--	--	--	--	--	--	ML
13 -7.067																														
-7.567																														
14 -8.067				SPT	144-15-11	13.50	13.95	28	22	--	--	--	2	18	80	--		30.7	NP		--	--	--	--	--	--	--	--	--	ML
-8.567																														
15 -9.067																														
-9.567				UDS-F + SPT	144-15-12	15.00	15.60	35	25	--	--	--	0	15	85	--		34.2	18.7	15.5	--	--	--	--	13	--	--	--	--	CL
16 -10.067																														
-10.567																														
17 -11.067				SPT	144-15-13	16.50	16.95	33	33	--	--	--	0	10	90	--		32.9	19.2	13.7	--	--	--	--	--	--		--	--	CL
-11.567																														
18 -12.067																														
-12.567				UDS	144-15-14	18.00	18.60	--	--	1.858	1.503	23.6	2	2	96	55	41	31.9	17.5	14.4	2.569	TUU	0.42	8	--	0.121	0.39	--	0.76	CL
19 -13.067																														
-13.567	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	9.00																											
20 -14.067				SPT	144-15-15	19.50	19.92	27	27	--	--	--	0	3	97	--		34.2	21.6	12.6	--	--	--	--	--	--	--	--	--	CL
-14.567																														
21 -15.067																														
-15.567				UDS-F + SPT	144-15-16	21.00	21.45	26	26	--	--	--	1	4	95	--		33.4	20.1	13.3	--	--	--	--	--	--	--	--	--	CL
22 -16.067																														
-16.567																														
23 -17.067				SPT	144-15-17	22.50	22.95	11	11	--	--	--	1	3	96	--		33.9	21.3	12.6	--	--	--	--	--	--	--	--	--	CL
-17.567																														
24 -18.067																														

BH-15

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 30-11-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 04-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-15	**Diameter of Boring**	: 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.0 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	:	42 Q, N 2662004, E 0562554
Reduced Level	: 5.433 m					

Depth (m) R.L - 5.433 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-18.567				UDS-F + SPT	144-15-18	24.00	24.45	17	16	--	--	--	0	2	98	--		41.2	21.8	19.4	--	--	--	--	--	--	--	--	--	--	CI
25 -19.067																														
-19.567																														
26 -20.067				SPT	144-15-19	25.50	25.95	23	19	--	--	--	1	1	98	53	45	44.3	23.8	20.5	--	--	--	--	--	--	--	--	--	CI
-20.567																														
27 -21.067																														
-21.567				UDS	144-15-20	27.00	27.60	--		1.825	1.492	22.3	1	12	87	--		47.4	24.6	22.8	--	TUU	0.42	10	--	--	--	--	0.91	CI
28 -22.067																														
-22.567																														
29 -23.067				SPT	144-15-21	28.50	28.95	23	19	--	--	--	0	6	94	--		43.2	22.5	20.7	--	--	--	--	--	--	--	--	--	CI
-23.567																														
30 -24.067																														
-24.567				UDS	144-15-22	30.00	30.60	--	--	1.858	1.501	23.8	0	1	99	51	48	48.0	24.3	23.7	2.531	TUU	0.48	9	--	--	--	--	CI
31 -25.067																														
-25.567																														
32 -26.067																														
-26.567																														
33 -27.067																														
-27.567				SPT	144-15-23	33.00	33.45	30	23	--	--	--	0	2	98	--		46.1	22.7	23.4	--	--	--	--	--	--	--	--	--	CI
34 -28.067																														
-28.567																														
35 -29.067																														
-29.567																														
36 -30.067																														
-30.567				UDS	144-15-24	36.00	36.60	--	--	1.850	1.513	22.3	0	1	99	--		49.3	25.1	24.2	--	TUU	0.61	3	--	--	--	--	CI
37 -31.067																														
-31.567	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	26.50																											
38 -32.067																														
-32.567																														
39 -33.067																														
-33.567				SPT	144-15-25	39.00	39.45	30	23	--	--	--	0	2	98	56	42	47.1	23.6	23.5	--	--	--	--	--	--	--	--	--	CI
40 -34.067																														
-34.567																														
41 -35.067																														
-35.567																														
42 -36.067																														
-36.567				UDS	144-15-26	42.00	42.60	--	--	1.894	1.532	23.6	0	1	99	--		48.5	26.8	21.7	--	--	--	--	--	--	--	--	--	CI
43 -37.067																														
-37.567																														
44 -38.067																														
-38.567																														
45 -39.067																														
-39.567				SPT	144-15-27	45.00	45.45	33	24	--	--	--	1	1	98	--		48.1	24.9	23.2	--	--	--	--	--	--	--	--	--	CI
46 -40.067																														
-40.567																														
47 -41.067																														
-41.567																														
48 -42.067																														
-42.567				UDS	144-15-28	48.00	48.60	--	--	1.912	1.591	20.2	0	0	100	--		43.8	24.0	19.8	--	--	--	--	--	--	--	--	--	CI
49 -43.067																														
-43.567																														
50 -44.067																														
-44.567				SPT	144-15-29	50.00	50.45	33	24	--	--	--	0	1	99	56	43	45.7	24.2	21.5	--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Graph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-16

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) | **Date Started** : 03-12-2020 | **Type of Bit used** : TC Bit

Name of Project : Geotechnical Investigation and Topographical survey of \proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat | **Date Completed** : 04-12-2020 | **Bearing of Hole** : 90^0 with Horizontal Plane

Bore Hole No. : BH-16 | **Diameter of Boring** : 150 mm | **Type of Boring** : Rotary Drilling

Top Level of Water Below EGL : 2.0 m | **Depth of Boring** : 50 m | **Co-Ordinates** : 42 Q, N 2662169, E 0564254

Reduced Level : 5.062 m

Depth (m) R.L - 5.062 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	%Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
4.562	Greyish Brownish Silty Clay of Low Plasticity mixed with Little Sand Particles	CL	1.50	DS	144-16-01	0.00	0.50	--	--	--	--	--	0	1	99	--		32.3	21.4	10.9	--	--	--	--	--	--	--	--	--	CL
1 4.062				SPT	144-16-02	0.50	0.95	5	5	--	--	--	0	0	100	--		31.6	21.7	9.9	--	--	--	--	--	--	--	--	--	CL
3.562																														
2 3.062	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	4.50	SPT	144-16-03	1.50	1.95	5	5	--	--	--	0	1	99	52	47	43.6	22.2	21.4	--	--	*0.24	0	13	--	--	--	--	CI
2.562																														
3 2.062																														
1.562				UDS	144-16-04	3.00	3.60	--	--	1.706	1.377	23.9	0	2	98	--		42.5	23.9	18.6	2.596	--	--	--	--	--	--	14.1	--	CI
4 1.062																														
0.562																														
5 0.062				SPT	144-16-05	4.50	4.95	6	6	--	--	--	0	2	98	53	45	46.5	24.2	22.3	--	--	*0.40	0	--	--	--	--	--	CI
-0.438																														
6 -0.938																														
-1.438	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	9.00	UDS	144-16-06	6.00	6.60	--	--	1.751	1.381	26.8	1	5	95	--		32.4	NP		--	--	--	--	Nil	--	--	--	--	ML
7 -1.938																														
-2.438																														
8 -2.938				SPT	144-16-07	7.50	7.95	18	17	--	--	--	0	4	96	--		28.8	NP		--	--	--	--	--	--	--	--	--	ML
-3.438																														
9 -3.938																														
-4.438				UDS	144-16-08	9.00	9.60	--	--	1.810	1.456	24.3	0	5	95	82	13	30.8	NP		2.610	DUU	0.02	17	Nil	--	--	--	--	ML
10 -4.938																														
-5.438																														
11 -5.938				SPT	144-16-09	10.50	10.95	35	25	--	--	--	0	8	92	--		29.4	NP		--	--	--	--	--	--	--	--	--	ML
-6.438																														
12 -6.938																														
-7.438				UDS	144-16-10	12.00	12.60	--	--	1.920	1.529	25.6	0	7	93	--		32.6	NP		2.632	DUU	0.03	19	--	--	--	--	--	ML
13 -7.938																														
-8.438																														
14 -8.938				SPT	144-16-11	13.50	13.95	45	30	--	--	--	0	4	96	--		29.8	NP		--	--	--	--	--	--	--	--	--	ML
-9.438																														
15 -9.938																														
-10.438	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	4.50	UDS	144-16-12	15.00	15.60	--	--	1.912	1.538	24.3	0	2	98	--		37.9	20.6	17.4	2.599	TUU	0.33	6	--	0.118	0.43	--	0.63	CI
16 -10.938																														
-11.438																														
17 -11.938				SPT	144-16-13	16.50	16.95	20	20	--	--	--	0	5	95	46	49	37.5	21.2	16.3	--	--	--	--	--	--	--	--	--	CI
-12.438																														
18 -12.938																														
-13.438				UDS	144-16-14	18.00	18.60	--	--	1.932	1.547	24.9	1	37	62	--		41.3	22.8	18.5	--	--	--	--	--	--	--	--	--	CI
19 -13.938																														
-14.438																														
20 -14.938	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	3.00	SPT	144-16-15	19.50	19.92	29	22	--	--	--			100	--		31.8	NP		--	--	--	--	--	--	--	--	--	ML
-15.438																														
21 -15.938																														
-16.438				UDS	144-16-16	21.00	21.60	--	--	2.056	1.632	26.0	0	18	82	--		31.4	NP		--	--	--	--	--	--	--	--	--	ML
22 -16.938																														
-17.438																														
23 -17.938	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel	CI	3.00	SPT	144-16-17	22.50	22.95	37	37	--	--	--	0	1	99	--		36.2	20.8	15.4	--	--	--	--	--	--	--	--	--	CI
-18.438																														
24 -18.938																														
-19.438				UDS	144-16-18	24.00	24.60	--	--	1.883	1.565	20.3	0	3	97	55	42	45.5	22.2	23.3	--	TUU	0.42	4	--	--	--	--	0.85	CI
25 -19.938																														
-20.438																														
26 -20.938	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	3.00	SPT	144-16-19	25.50	25.95	26	21	--	--	--	0	2	98	--		29.3	NP		--	--	--	--	--	--	--	--	--	ML
-21.438																														
27 -21.938																														
-22.438				UDS-F + SPT	144-16-20	27.00	27.45	24	20	--	--	--	0	1	99	--		28.6	NP		2.641	--	--	--	--	--	--	--	--	ML
28 -22.938																														
-23.438																														

BH-16

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) | **Date Started** : 03-12-2020 | **Type of Bit used** : TC Bit

Name of Project : Geotechnical Investigation and Topographical survey of \proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat | **Date Completed** : 04-12-2020 | **Bearing of Hole** : 90^0 with Horizontal Plane

Bore Hole No. : BH-16 | **Diameter of Boring** : 150 mm | **Type of Boring** : Rotary Drilling

Top Level of Water Below EGL : 2.0 m | **Depth of Boring** : 50 m | **Co-Ordinates** : 42 Q, N 2662169, E 0564254

Reduced Level : 5.062 m

Depth (m) R.L - 5.062 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C_r kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
29 -23.938				SPT	144-16-21	28.50	28.95	27	27	--	--	--	0	3	97	53	44	43.5	22.8	20.7	--	--	--	--	--	--	--	--	--	CI
-24.438																														
30 -24.938																														
-25.438				UDS-F + SPT	144-16-22	30.00	30.45	25	25	--	--	--	0	1	99	--		49.6	26.2	23.4	--	--	--	--	--	--	--	--	--	CI
31 -25.938																														
-26.438																														
32 -26.938																														
-27.438																														
33 -27.938																														
-28.438				SPT	144-16-23	33.00	33.45	24	24	--	--	--	0	2	98	--		44.6	23.5	21.1	--	--	--	--	--	--	--	--	--	CI
34 -28.938																														
-29.438																														
35 -29.938																														
-30.438																														
36 -30.938																														
-31.438				UDS	144-16-24	36.00	36.60	--	--	1.959	1.591	23.1	1	1	98	--		47.6	24.0	23.6	--	TUU	0.57	4	--	--	--	--	--	CI
37 -31.938																														
-32.438																														
38 -32.938																														
-33.438																														
39 -33.938																														
-34.438	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel	CI	22.00	SPT	144-16-25	39.00	39.45	27	27	--	--	--	0	2	98	53	45	44.6	23.5	21.1	2.652	--	--	--	--	--	--	--	CI
40 -34.938																														
-35.438																														
41 -35.938																														
-36.438																														
42 -36.938																														
-37.438				UDS-F + SPT	144-16-26	42.00	42.45	37	37	--	--	--	0	1	99	--		45.7	23.8	21.9	--	--	--	--	--	--	--	--	--	CI
43 -37.938																														
-38.438																														
44 -38.938																														
-39.438																														
45 -39.938																														
-40.438				SPT	144-16-27	45.00	45.45	36	36	--	--	--	0	2	98	55	43	42.8	22.9	19.9	--	--	--	--	--	--	--	--	--	CI
46 -40.938																														
-41.438																														
47 -41.938																														
-42.438																														
48 -42.938																														
-43.438				UDS-F + SPT	144-16-28	48.00	48.45	55	55	--	--	--	0	2	98	--		40.8	23.0	17.8	--	--	--	--	--	--	--	--	--	CI
49 -43.938																														
-44.438																														
50 -44.938																														
-45.438				SPT	144-16-29	50.00	50.45	78	78	--	--	--	0	4	96	55	41	39.8	21.8	18.0	--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Graph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-17

Name of Owner	:	Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 12-12-2020	**Type of Bit used**	:	TC Bit
Name of Project	:	Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 16-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	:	BH-17	**Diameter of Boring**	: 150 mm	**Type of Boring**	:	Rotary Drilling
Depth of water Below EGL	:	3.0 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	:	42 Q, N 2663596, E 559482
Reduced Level	:	6.186 m					

Depth (m) R.L - 6.186 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	%Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc (kg/cm^2)	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
5.686	Brownish Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	0.40	DS	144-17-01	0.00	0.50	--	--	--	--	--	0	10	90	--		36.6	22.6	14.0	--	--	--	--	--	--	--	--	--	CI
1 5.186	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH	2.50	SPT	144-17-02	0.50	0.95	11	11	--	--	--	0	2	98	41	57	52.6	26.1	26.5	--	--	--	--	--	--	--	--	--	CH
4.686																														
2 4.186				SPT	144-17-03	1.50	1.95	8	8	--	--	--	0	8	92	36	56	51.6	25.3	26.3	--	--	*0.33	0	--	--	--	15.8	--	CH
3.686																														
3 3.186																														
2.686				UDS	144-17-04	3.00	3.60	--	--	1.767	1.362	29.7	0	0	100	59	41	39.9	22.8	17.1	2.595	--	*0.31	0	20	--	--	--	--	CI
4 2.186																														
1.686																														
5 1.186				SPT	144-17-05	4.50	4.95	18	18	--	--	--	0	3	97	54	43	41.3	23.3	18.0	--	--	--	--	23	--	--	--	--	CI
0.686	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	3.60																											
6 0.186																														
-0.314				UDSF+ SPT	144-17-06	6.00	6.60	12	12	--	--	--	0	6	94	46	48	39.6	22.1	17.5	2.561	--	*0.41	--	--	--	--	--	--	CI
7 -0.814																														
-1.314																														
8 -1.814				SPT	144-17-07	7.50	7.95	16	16	--	--	--	0	21	79	--		32.1	NP		--	--	--	--	Nil	--	--	--	--	ML
-2.314																														
9 -2.814																														
-3.314				UDS	144-17-08	9.00	9.60	--	--	1.789	1.459	22.6	0	23	77	--		31.9	NP		2.662	DUU	0	17	Nil	--	--	--	--	ML
10 -3.814																														
-4.314																														
11 -4.814				SPT	144-17-09	10.50	10.95	36	26	--	--	--	0	16	84	--		31.6	NP		--	--	--	--	--	--	--	--	--	ML
-5.314																														
12 -5.814																														
-6.314				UDSF+ SPT	144-17-10	12.00	12.60	--	--	--	--	--	0	18	82	68	14	31.2	NP		--	--	--	--	--	--	--	--	--	ML
13 -6.814																														
-7.314																														
14 -7.814				SPT	144-17-11	13.50	13.95	39	27	--	--	--	0	13	87	--		31.8	NP		2.654	--	--	--	--	--	--	--	--	ML
-8.314	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	17.10																											
15 -8.814																														
-9.314				SPT	144-17-12	15.00	15.45	47	31	--	--	--	0	15	85	--		31.5	NP		--	--	--	--	--	--	--	--	--	ML
16 -9.814																														
-10.314																														
17 -10.814				SPT	144-17-13	16.50	16.95	44	30	--	--	--	0	10	90	--		29.6	NP		--	--	--	--	--	--	--	--	--	ML
-11.314																														
18 -11.814																														
-12.314				UDS	144-17-14	18.00	18.60	--	--	1.854	1.516	22.3	0	5	95	--		28.8	NP		2.661	DUU	0	23	--	--	--	--	--	ML
19 -12.814																														
-13.314																														
20 -13.814				SPT	144-17-15	19.50	19.95	49	32	--	--	--	0	3	97	--		29.3	NP		--	--	--	--	--	--	--	--	--	ML
-14.314																														
21 -14.814																														

BH-17

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 12-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 16-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-17	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 3.0 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2663596, E 559482
Reduced Level	: 6.186 m				

Depth (m) R.L - 6.186 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-15.314																														
22 -15.814																														
-16.314																														
23 -16.814				SPT	144-17-17	22.50	22.95	16	16	--	--	--	0	1	99	--		37.3	20.1	17.2	--	--	--	--	--	--	--	--	--	CI
-17.314																														
24 -17.814																														
-18.314				UDS	144-17-18	24.00	24.60	--	--	1.732	1.453	19.2	0	2	98	57	41	38.3	21.9	16.4	2.591	TUU	0.41	8	--	--	--	--	0.88	CI
25 -18.814																														
-19.314																														
26 -19.814				SPT	144-17-19	25.50	25.95	19	19	--	--	--	0	0	100	54	46	46.9	24.8	22.1	--	--	--	--	--	--	--	--	--	CI
-20.314																														
27 -20.814																														
-21.314				SPT	144-17-20	27.00	27.45	17	17	--	--	--	0	0	100	--		45.9	25.2	20.7	--	--	--	--	--	--	--	--	--	CI
28 -21.814	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	13.70																											
-22.314																														
29 -22.814				SPT	144-17-21	28.50	28.95	20	20	--	--	--	0	0	100	--		48.3	25.5	22.8	--	--	--	--	--	--	--	--	--	CI
-23.314																														
30 -23.814																														
-24.314				UDS	144-17-22	30.00	30.60	--	--	1.858	1.503	23.6	0	0	100	--		46.5	24.6	21.9	2.604	TUU	0.53	4	--	--	--	--	1.02	CI
31 -24.814																														
-25.314																														
32 -25.814				SPT	144-17-23	31.50	31.95	26	26	--	--	--	0	0	100	--		46.7	24.8	21.9	--	--	--	--	--	--	--	--	--	CI
-26.314																														
33 -26.814																														
-27.314				SPT	144-17-24	33.00	33.45	27	27	--	--	--	0	0	100	56	44	47.1	24.9	22.2	--	--	--	--	--	--	--	--	--	CI
34 -27.814																														
-28.314																														
35 -28.814				SPT	144-17-25	34.50	34.95	29	29	--	--	--	0	2	98	--		51.6	23.9	27.7	--	--	--	--	--	--	--	--	--	CH
-29.314																														
36 -29.814																														
-30.314	Greyish Consolidation Clay of High Plasticity Mixed With Little Gravel and Sand Particles			UDS	144-17-26	36.00	36.60	--	--	1.920	1.545	24.3	0	4	96	42	54	51.1	25.3	25.8	2.538	TUU	0.75	6	--	--	--	--	--	CH
37 -30.814																														
-31.314																														
38 -31.814				SPT	144-17-27	37.50	37.95	34	34	--	--	--	0	5	95	43	52	52.3	25.9	26.4	--	--	--	--	--	--	--	--	--	CH
-32.314																														
39 -32.814																														
-33.314				SPT	144-17-28	39.00	39.45	>100 (13cm)	>100 (13cm)	--	--	--	--					--			--	--	--	--	--	--	--	--	--	CH
40 -33.814																														
-34.314																														
41 -34.814				SPT	144-17-29	40.50	40.95	>100 (8cm)	>100 (8cm)	--	--	--	--					--			--	--	--	--	--	--	--	--	--	CH
-35.314																														
42 -35.814																														
-36.314		CH	13.10	UDSF+ SPT	144-17-30	42.00	42.45	>100 (5cm)	>100 (5cm)	--	--	--	--					--			--	--	--	--	--	--	--	--	--	CH
43 -36.814																														
-37.314																														
44 -37.814				SPT	144-17-31	43.50	43.95	>100 (5cm)	>100 (5cm)	--	--	--	--					--			--	--	--	--	--	--	--	--	--	CH
-38.314	(Visual Clasification) Greyish Consolidation Clay of High Plasticity Mixed With Little Gravel and Sand Particles																													
45 -38.814																														
-39.314				SPT	144-17-32	45.00	45.45	>100 (10 cm)	>100 (10 cm)	--	--	--	--					--			--	--	--	--	--	--	--	--	--	CH
46 -39.814																														
-40.314																														
47 -40.814				SPT	144-17-33	46.50	46.95	>100 (10 cm)	>100 (10 cm)	--	--	--	--					--			--	--	--	--	--	--	--	--	--	CH
-41.314																														
48 -41.814																														
-42.314				UDSF+ SPT	144-17-34	48.00	48.45	>100 (3 cm)	>100 (3 cm)	--	--	--	--					--			--	--	--	--	--	--	--	--	--	CH
49 -42.814																														
-43.314																														
50 -43.814																														
-44.314				SPT	144-17-35	50.00	50.45	>100 (3 cm)	>100 (3 cm)	--	--	--	--					--			--	--	--	--	--	--	--	--	--	CH

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-18

Name of Owner : Gujarat Industries Power Company Limited (GIPCL)
Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat
Bore Hole No. : BH-18
Depth of water Below EGL : 2.50 m
Reduced Level : 6.141 m

Date Started : 12-12-2020
Date Completed : 13-12-2020
Diameter of Boring : 150 mm
Depth of Boring : 50 m

Type of Bit used : TC Bit
Bearing of Hole : 90° with Horizontal Plane
Type of Boring : Rotary Drilling
Co-Ordinates : 42 Q, N 2663906, E 560804

Depth (m) R.L - 6.141 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm²	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm²	Shrinkage Limit, %	UCS, kg/cm²	CLASSIFICATION
5.641	Brownish Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	6.10	DS	144-18-01	0.00	0.50	--	--	--	--	--	0	8	92	--		48.3	24.9	23.4	--	--	--	--	--	--	--		--	CI
1 5.141				SPT	144-18-02	0.50	0.95	8	8	--	--	--	0	6	94	--		49.6	25.1	24.5	--	--	--	--	--	--	--	--	--	CI
4.641																														
2 4.141				SPT	144-18-03	1.50	1.95	11	11	--	--	--	0	5	95	54	41	36.9	23.3	13.6		--	*0.14	0	16	--	--	--	--	CI
3.641																														
3 3.141																														
2.641				UDS	144-18-04	3.00	3.60	--	--	1.645	1.310	25.6	0	0	100	58	42	36.0	24.0	12.0	2.589	--	0.24	0	--	--	--	13.2	--	CI
4 2.141																														
1.641																														
5 1.141				SPT	144-18-05	4.50	4.95	7	7	--	--	--	0	0	100	--		36.2	23.8	12.4	--	--	--	--	18	--	--	--	--	CI
0.641																														
6 0.141																														
-0.359	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	8.90	UDS	144-18-06	6.00	6.60	--	--	1.679	1.350	24.4	0	29	71	--		32.8	NP		2.658	--	--	--	Nil	--	--	--	--	ML
7 -0.859																														
-1.359																														
8 -1.859				SPT	144-18-07	7.50	7.95	38	38	--	--	--	0	32	68	--		31.4	NP		--	--	--	--	--	--	--	--	--	ML
-2.359																														
9 -2.859																														
-3.359				UDS	144-18-08	9.00	9.60	--	--	1.843	1.495	23.3	0	0	100	--		32.1	NP		2.668	DUU	0	20	Nil	--	--	--	--	ML
10 -3.859																														
-4.359																														
11 -4.859				SPT	144-18-09	10.50	10.95	71	71	--	--	--	0	6	94	83	11	31.9	NP		--	--	--	--	--	--	--	--	--	ML
-5.359																														
12 -5.859																														
-6.359				UDS	144-18-10	12.00	12.60	--	--	1.994	1.563	27.6	0	1	99	--		34.4	NP		--	--	--	--	--	--	--	--	--	ML
13 -6.859																														
-7.359																														
14 -7.859				SPT	144-18-11	13.50	13.95	62	62	--	--	--	0	23	77	--		32.6	NP		2.673	--	--	--	--	--	--	--	--	--	ML
-8.359																														
15 -8.859																														
-9.359	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	11.90	SPT	144-18-12	15.00	15.45	20	20	--	--	--	0	6	94	--		31.6	20.6	11.0	--	--	--	--	10	--	--	--	--	CL
16 -9.859																														
-10.359																														
17 -10.859				SPT	144-18-13	16.50	16.95	22	22	--	--	--	0	5	95	--		32.2	19.7	12.5	--	--	--	--	--	--	--	--	--	CL
-11.359																														
18 -11.859																														
-12.359				UDSF+ SPT	144-18-14	18.00	18.60	56	56	--	--	--	0	8	92	--		32.9	20.1	12.8	--	--	--	--	--	--	--	--	--	CL
19 -12.859																														
-13.359																														
20 -13.859				SPT	144-18-15	19.50	19.95	48	48	--	--	--	0	7	93	55	38	30.3	19.4	10.9	--	--	--	--	--	--	--	--	--	CL
-14.359																														
21 -14.859																														
-15.359				SPT	144-18-16	21.00	21.45	34	34	--	--	--	0	8	92	--		33.6	22.2	11.4	--	--	--	--	--	--	--	--	--	CL
22 -15.859																														
-16.359																														
23 -16.859				SPT	144-18-17	22.50	22.95	47	47	--	--	--	0	27	73	--		29.6	17.9	11.7	--	--	--	--	--	--	--	--	--	CL
-17.359																														
24 -17.859																														
-18.359				UDS	144-18-19	24.00	24.60	--	--	1.821	1.499	21.5	0	7	93	51	42	32.7	23.6	9.1	2.599	TUU	0.37	15	--	0.12	0.48	--	0.72	CL
25 -18.859																														
-19.359																														
26 -19.859				SPT	144-18-20	25.50	25.95	25	25	--	--	--	0	13	87	--		31.6	22.9	8.7	--	--	--	--	--	--	--	--	--	CL
-20.359																														
27 -20.859																														

BH-18

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 12-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 13-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-18	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 2.50 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2663906, E 560804
Reduced Level	: 6.141 m				

Depth (m) R.L - 6.141 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-21.359	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	14.90	SPT	144-18-21	27.00	27.45	28	28	--	--	--	0	2	98	--		49.1	24.1	25.0	--	--	--	--	--	--	--	--	--	CI
28 -21.859																														
-22.359																														
29 -22.859				SPT	144-18-22	28.50	28.95	23	23	--	--	--	0	1	99	--		49.3	24.3	25.0	--	--	--	--	--	--	--	--	--	CI
-23.359																														
30 -23.859																														
-24.359				UDS	144-18-23	30.00	30.60	--	--	1.935	1.465	32.1	0	0	100	52	48	49.8	24.6	25.2	2.607	TUU	0.51	7	--	--	--	--	0.91	CI
31 -24.859																														
-25.359																														
32 -25.859				SPT	144-18-24	31.50	31.95	27	27	--	--	--	0	1	99	--		49.6	23.6	26.0	--	--	--	--	--	--	--	--	--	CI
-26.359																														
33 -26.859																														
-27.359				SPT	144-18-25	33.00	33.45	23	23	--	--	--	0	3	97	--		49.9	24.6	25.3	--	--	--	--	--	--	--	--	--	CI
34 -27.859																														
-28.359																														
35 -28.859				SPT	144-18-26	34.50	34.95	26	26	--	--	--	0	5	95	--		49.3	23.5	25.8	--	--	--	--	--	--	--	--	--	CI
-29.359																														
36 -29.859																														
-30.359				UDS	144-18-27	36.00	36.60	--	--	1.881	1.513	24.3	0	0	100	53	47	49.9	25.7	24.2	2.611	TUU	0,55	4	--	--	--	--	--	CI
37 -30.859																														
-31.359																														
38 -31.859				SPT	144-18-28	37.50	37.95	29	29	--	--	--	0	8	92	--		41.6	22.6	19.0	--	--	--	--	--	--	--	--	--	CI
-32.359																														
39 -32.859																														
-33.359				SPT	144-18-29	39.00	39.45	41	41	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
40 -33.859																														
-34.359																														
41 -34.859				SPT	144-18-30	40.50	40.95	47	47	--	--	--	0	3	97	--		46.3	23.9	22.4	--	--	--	--	--	--	--	--	--	CI
-35.359																														
42 -35.859																														
-36.359	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles	CH	7.10	UDSF+ SPT	144-18-31	42.00	42.45	47	47	--	--	--	0	16	84	26	58	52.6	25.6	27.0	--	--	--	--	--	--	--	--	--	CH
43 -36.859																														
-37.359																														
44 -37.859				SPT	144-18-32	43.50	43.95	53	53	--	--	--	0	12	88	29	59	53.6	25.9	27.7	--	--	--	--	--	--	--	--	--	CH
-38.359																														
45 -38.859																														
-39.359				SPT	144-18-33	45.00	45.45	60	60	--	--	--	--								--	--	--	--	--	--	--	--	--	CH
46 -39.859																														
-40.359																														
47 -40.859				SPT	144-18-34	46.50	46.95	>100 (10cm)	>100 (10cm)	--	--	--	--								--	--	--	--	--	--	--	--	--	CH
-41.359																														
48 -41.859																														
-42.359				UDS	144-18-35	48.00	48.60	--	--	2.037	1.623	25.5	--								--	--	--	--	--	--	--	--	--	CH
49 -42.859																														
-43.359	Reddish Brownish Clay of High Plasticity Mixed With Little Gravel and Sand Particles		1.60																											
50 -43.859																														
-44.359				SPT	144-18-36	50.00	50.45	>100 (10cm)	>100 (10cm)	--	--	--	0	10	90	--		59.6	27.9	31.7	--	--	--	--	--	--	--	--	--	CH

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Graph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-19

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 04-12-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 06-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-19	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.0 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2663576, E 0562593
Reduced Level	: 5.868 m				

Depth (m) / R.L. - 5.868 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C_c kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
5.368	Greyish Silt of Intermediate Plasticity Mixed With Little Fine Sand & Gravel	MI	0.50	DS	144-19-01	0.00	0.50	--	--	--	--	--	0	1	99	--		37.7	NP		--	--	--	--	--	--	--	--	--	MI
1 4.868	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI	5.50	SPT	144-19-02	0.50	0.95	9	9	--	--	--	0	2	98	--		39.3	18.7	20.6	--	--	*0.36	0	--	--	--	--	--	CI
4.368																														
2 3.868				SPT	144-19-03	1.50	1.95	10	10	--	--	--	0	2	98	--		37.3	20.0	17.3	--	--	*0.44	0	26	--	--	18	--	CI
3.368																														
3 2.868				UDS + SPT	144-19-04	3.00	3.45	10	10	1.733	1.385	25.1	0	1	99	57	42	37.2	20.0	17.2	2.619	--	*0.44	0	--	--	--	--	--	CI
2.368																														
4 1.868																														
1.368																														
5 0.868				SPT	144-19-05	4.50	4.95	10	10	--	--	--	0	0	100	--		38.0	20.4	17.6	--	--	--	--	29	--	--	--	--	CI
0.368																														
6 -0.132																														
-0.632	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel	ML	4.50	UDS	144-19-06	6.00	6.60	--	--	1.864	1.461	27.6	0	17	83	73	10	33.5	NP		2.639	DUU	0.02	17	--	--	--	--	--	ML
7 -1.132																														
-1.632																														
8 -2.132				SPT	144-19-07	7.50	7.95	34	25	--	--	--	0	26	74	--		34.6	NP		--	--	--	--	Nil	--	--	--	--	ML
-2.632																														
9 -3.132																														
-3.632				UDS	144-19-08	9.00	9.60	--	--	1.995	1.588	25.6	2	42	56	42	14	32.6	NP		--	--	--	--	Nil	--	--	--	--	ML
10 -4.132																														
-4.632	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL	4.50	SPT	144-19-09	10.50	10.95	22	22	--	--	--	0	3	97	--		29.4	17.6	11.8	2.586	--	--	--	--	--	--	--	--	CL
11 -5.132																														
-5.632																														
12 -6.132				UDS	144-19-10	12.00	12.60	--	--	1.874	1.521	23.2	0	2	98	54	44	30.0	19.8	10.2	--	DUU	0.10	14	--	--	--	--	0.36	CL
-6.632																														
13 -7.132																														
-7.632				SPT	144-19-11	13.50	13.95	20	20	--	--	--	0	3	97	55	42	28.6	18.6	10.0	--	--	--	--	--	--	--	--	--	CL
14 -8.132																														
-8.632																														
15 -9.132	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel	ML	7.50	UDS	144-19-12	15.00	15.60	--	--	1.765	1.413	24.9	0	16	84	72	12	30.6	NP		--	--	--	--	Nil	--	--	--	--	ML
-9.632																														
16 -10.132																														
-10.632																														
17 -11.132				SPT	144-19-13	16.50	16.95	30	23	--	--	--	0	1	99	--		27.7	NP		--	--	--	--	--	--	--	--	--	ML
-11.632																														
18 -12.132																														
-12.632				UDS	144-19-14	18.00	18.60	--	--	1.778	1.421	25.1	0	9	91	79	12	30.5	NP		--	DUU	0.02	21	--	--	--	--	--	ML
19 -13.132																														
-13.632																														
20 -14.132				SPT	144-19-15	19.50	19.95	20	18	--	--	--	0	5	95	--		28.7	NP		--	--	--	--	--	--	--	--	--	ML
-14.632																														
21 -15.132																														
-15.632				UDS	144-19-16	21.00	21.60	--	--	1.869	1.470	27.1	0	3	97	83	14	31.6	NP		2.654	--	--	--	--	--	--	--	--	--	ML
22 -16.132																														
-16.632																														
23 -17.132	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL	1.50	SPT	144-19-17	22.50	22.95	37	37	--	--	--	0	2	98	52	46	34.0	22.6	11.4	--	--	--	--	--	--	--	--	--	CL
-17.632																														
24 -18.132																														

BH-19

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 04-12-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 06-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-19	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.0 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2663576, E 0562593
Reduced Level	: 5.868 m				

Depth (m) R.L - 5.868 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	% Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal Friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-18.632				UDS	144-19-18	24.00	24.60	--	--	1.851	1.468	26.1	0	1	99	--		45.0	24.9	20.1	--	TUU	0.49	8	--	--	--	--	--	--	CI
25 -19.132																														
-19.632																														
26 -20.132				SPT	144-19-19	25.50	25.95	14	14	--	--	--	0	0	100	59	41	42.8	22.1	20.7	--	--	--	--	--	--	--	--	--	CI
-20.632																														
27 -21.132																														
-21.632				UDS-F + SPT	144-19-20	27.00	27.60	24	24	--	--	--	0	1	99	53	46	42.6	21.9	20.7	2.530	--	--	--	--	--	--	--	--	CI
28 -22.132																														
-22.632																														
29 -23.132				SPT	144-19-21	28.50	28.95	24	24	--	--	--	0	1	100	--		46.1	23.8	22.3	--	--	--	--	--	--	--	--	--	CI
-23.632																														
30 -24.132																														
-24.632				UDS	144-19-22	30.00	30.60	--	--	1.887	1.508	25.1	0	1	98	--		48.6	24.6	24.0	--	TUU	0.56	4	-	0.115	0.43	--	0.69	CI
31 -25.132																														
-25.632																														
32 -26.132																														
-26.632																														
33 -27.132																														
-27.632				SPT	144-19-23	33.00	33.45	22	22	--	--	--	0	0	100	53	47	45.7	23.4	22.3	--	--	--	--	--	--	--	--	--	CI
34 -28.132																														
-28.632																														
35 -29.132																														
-29.632																														
36 -30.132																														
-30.632				UDS	144-19-24	36.00	36.60	--	--	2.142	1.602	33.7	0	1	99	--		48.2	24.3	23.9	--	--	--	--	--	--	--	--	--	CI
37 -31.132																														
-31.632	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI	26.50																											
38 -32.132																														
-32.632																														
39 -33.132																														
-33.632				SPT	144-19-25	39.00	39.45	26	26	--	--	--	0	3	97	55	42	46.4	24.2	22.2	--	--	--	--	--	--	--	--	--	CI
40 -34.132																														
-34.632																														
41 -35.132																														
-35.632																														
42 -36.132																														
-36.632				UDS-F + SPT	144-19-26	42.00	42.45	31	31	--	--	--	0	0	100	--		45.7	23.9	21.8	--	--	--	--	--	--	--	--	--	CI
43 -37.132																														
-37.632																														
44 -38.132																														
-38.632																														
45 -39.132																														
-39.632				SPT	144-19-27	45.00	45.45	35	35	--	--	--	0	1	99	--		42.1	22.8	19.3	--	--	--	--	--	--	--	--	--	CI
46 -40.132																														
-40.632																														
47 -41.132																														
-41.632																														
48 -42.132																														
-42.632				UDS	144-19-28	48.00	48.60	--	--	2.098	1.634	28.4	0	1	99	--		45.5	24.4	21.2	--	--	--	--	--	--	--	--	--	CI
49 -43.132																														
-43.632																														
50 -44.132																														
-44.632				SPT	144-19-29	50.00	50.45	24	24	--	--	--	0	2	98	--		41.2	20.5	20.7	--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Geaph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-20

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) | **Date Started** : 04-12-2020 | **Type of Bit used** : TC Bit

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat | **Date Completed** : 07-12-2020 | **Bearing of Hole** : 90^0 with Horizontal Plane

Bore Hole No. : BH-20 | **Diameter of Boring** : 150 mm | **Type of Boring** : Rotary Drilling

Top Level of Water Below EGL : 2.0 m | **Depth of Boring** : 50 m | **Co-Ordinates** : 42 Q, N 2663509, E 0564159

Reduced Level : 5.511 m

Depth (m) R.L. - 5.511 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	% Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
5.011				DS	144-20-01	0.00	0.50	--	--	--	--	--	0	2	98	63	35	30.2	18.8	11.4	--	--	--	--	--	--	--	--	--	CL
1 4.511				SPT	144-20-02	0.50	0.95	2	2	--	--	--	0	3	97	66	31	31.4	19.6	11.8	--	--	--	--	--	--	--	--	--	CL
4.01	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL	3.10																										
2 3.51				SPT	144-20-03	1.50	1.95	3	3	--	--	--	0	1	99	52	47	31.1	19.4	11.7	--	--	*0.20	0	11	--	--	12.2	--	CL
3.01																													
3 2.51																													
2.01				UDS-F + SPT	144-20-04	3.00	3.45	4	4	--	--	--	0	6	94	--		27.2	NP		2.615	--	--	--	Nil	--	--	--	--	ML
4 1.51																													
1.01	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	2.80																										
5 0.51				SPT	144-20-05	4.50	4.95	4	4	--	--	--	0	6	94	82	12	27.2	NP		--	--	--	--	--	--	--	--	--	ML
0.01																													
6 -0.49																													
-0.99				UDS	144-20-06	6.00	6.60	--	--	1.777	1.373	29.4	0	1	99	24	75	59.7	28.3	31.4	2.588	--	*0.67	0	--	--	--	--	--	CH
7 -1.49	Greyish Silty Clay of High Plasticity mixed with Fine Grained Sand Particles	CH	1.60																										
-1.99																													
8 -2.49				SPT	144-20-07	7.50	7.95	15	15	--	--	--	1	4	95	--		34.5	NP		--	--	--	--	Nil	--	--	--	--	ML
-2.99																													
9 -3.49																													
-3.99				UDS	144-20-08	9.00	9.60	--	--	1.873	1.446	29.5	1	41	59	--		34.8	NP		2.611	DUU	0.02	17	--	--	--	--	--	ML
10 -4.49																													
-4.99																													
11 -5.49				SPT	144-20-09	10.50	10.95	27	21	--	--	--	1	15	84	72	12	30.5	NP		--	--	--	--	Nil	--	--	--	--	ML
-5.99																													
12 -6.49																													
-6.99				UDS	144-20-10	12.00	12.60	--	--	1.907	1.509	26.4	1	41	59	50	9	30.1	NP		2.606	--	--	--	--	--	--	--	--	ML
13 -7.49																													
-7.99	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	11.90																										
14 -8.49				SPT	144-20-11	13.50	13.95	41	28	--	--	--	0	10	90	78	12	31.2	NP		--	--	--	--	--	--	--	--	--	ML
-8.99																													
15 -9.49																													
-9.99				UDS-F + SPT	144-20-12	15.00	15.45	33	24	--	--	--	0	11	89	79	10	32.4	NP		--	--	--	--	--	--	--	--	--	ML
16 -10.49																													
-10.99																													
17 -11.49				SPT	144-20-13	16.50	16.95	46	31	--	--	--	0	21	79	--		31.6	NP		--	--	--	--	--	--	--	--	--	ML
-11.99																													
18 -12.49																													
-12.99				UDS	144-20-14	18.00	18.60	--	--	1.828	1.479	23.6	0	25	75	62	13	33.1	NP		2.615	DUU	0.01	20	--	--	--	--	--	ML
19 -13.49																													
-13.99																													
20 -14.49				SPT	144-20-15	19.50	19.95	61	61	--	--	--	0	4	96	52	44	31.7	20.8	10.9	--	--	--	--	--	--	--	--	--	CL
-14.99																													
21 -15.49																													
-15.99				UDS	144-20-16	21.00	21.60	--	--	2.063	1.512	36.4	0	2	98	56	42	32.5	22.2	10.3	--	--	--	--	--	--	--	--		CL
22 -16.49	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CL	4.80																										
-16.99																													
23 -17.49				SPT	144-20-17	22.50	22.90	55	55	--			0	1	99	--		34.8	22.8	12.0	--	--	--	--	--	--	--	--	--	CL
-17.99																													
24 -18.49																													

BH-20

Name of Owner : Gujarat Industries Power Company Limited (GIPCL)
Date Started : 04-12-2020
Type of Bit used : TC Bit

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat
Date Completed : 07-12-2020
Bearing of Hole : 90^0 with Horizontal Plane

Bore Hole No. : BH-20
Diameter of Boring : 150 mm
Type of Boring : Rotary Drilling

Top Level of Water Below EGL : 2.0 m
Depth of Boring : 50 m
Co-Ordinates : 42 Q, N 2663509, E 0564159

Reduced Level : 5.511 m

Depth (m) R.L - 5.511 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-18.99				UDS	144-20-18	24.00	24.60	--	--	1.886	1.439	31.1	0	3	97	51	46	44.8	24.2	20.6	2.587	TUU	0.49	10	--	0.136	0.53	--	1.10	CI
25 -19.49																														
-19.99																														
26 -20.49				SPT	144-20-19	25.50	25.95	37	37	--	--	--	0	6	94	--		42.6	24.1	18.5	--	--	--	--	--	--	--	--	--	--	CI
-20.99																														
27 -21.49																														
-21.99				UDS	144-20-20	27.00	27.60	--	--	1.913	1.521	25.8	0	4	96	48	48	43.4	23.1	20.3	--	--	--	--	--	--	--	--	--	1.12	CI
28 -22.49																														
-22.99																														
29 -23.49				SPT	144-20-21	28.50	28.95	32	32	--	--	--	0	3	97	48	49	40.6	22.6	18.0	--	--	--	--	--	--	--	--	--	CI
-23.99																														
30 -24.49																														
-24.99				UDS-F + SPT	144-20-22	30.00	30.45	54	54	--	--	--	0	1	99	55	44	41.2	22.9	18.3		--	--	--	--	--	--	--	--	CI
31 -25.49																														
-25.99																														
32 -26.49																														
-26.99																														
33 -27.49																														
-27.99				SPT	144-20-23	33.00	33.45	39	39	--	--	--	0	1	99	--		44.4	23.5	20.9	--	--	--	--	--	--	--	--	--	--	CI
34 -28.49																														
-28.99																														
35 -29.49																														
-29.99																														
36 -30.49																														
-30.99				UDS	144-20-24	36.00	36.60	--	--	1.961	1.542	27.2	0	4	96	--		48.2	26.1	22.1	2.592	--	--	--	--	0.133	0.27			CI
37 -31.49																														
-31.99	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI	26.30																											
38 -32.49																														
-32.99																														
39 -33.49																														
-33.99				SPT	144-20-25	39.00	39.45	41	41	--	--	--	0	2	98	--		43.8	23.6	20.2	--	--	--	--	--	--	--	--	--	--	CI
40 -34.49																														
-34.99																														
41 -35.49																														
-35.99																														
42 -36.49																														
-36.99				UDS	144-20-26	42.00	42.60	--	--	2.014	1.597	26.1	0	1	99	53	46	47.5	24.6	22.8	2.577	--	--	--	--	--	--	--	--	--	CI
43 -37.49																														
-37.99																														
44 -38.49																														
-38.99																														
45 -39.49																														
-39.99				SPT	144-20-27	45.00	45.45	49	49	--	--	--	0	1	99	--		46.4	24.2	22.2	--	--	--	--	--	--	--	--	--	--	CI
46 -40.49																														
-40.99																														
47 -41.49																														
-41.99																														
48 -42.49																														
-42.99				UDS	144-20-28	48.00	48.60	--	--	2.061	1.638	25.8	0	0	100	--		48.8	26.1	22.7	--	--	--	--	--	--	--	--	--	--	CI
49 -43.49																														
-43.99																														
50 -44.49																														
-44.99				SPT	144-20-29	50.00	50.45	57	57	--	--	--	0	1	99	--		44.6	23.9	20.7	--	--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value
UDS : Undisturbed Sample
* Values obtained from Geaph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-21

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 10-12-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 12-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-21	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.50 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2664999, E 0559688
Reduced Level	: 6.597 m				

Depth (m) R.L - 6.597 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	% Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
6.097	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	1.50	DS	144-21-01	0.00	0.50	--	--	--	--	--	0	6	94	--		47.1	25.9	21.2	--	--	--	--	--	--	--	--	--	CI
1 5.597				SPT	144-21-02	0.50	0.95	8	8	--	--	--	0	4	96	--		49.3	26.2	23.1	--	--	*0.26	--	--	--	--	--	--	CI
5.097																														
2 4.597	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	4.50	SPT	144-21-03	1.50	1.95	9	9	--	--	--	1	18	81	46	35	28.7	18.1	10.6	--	--	*0.32	--	Nil	--	--	--	--	CL
4.097																														
3 3.597																														
3.097				UDS	144-21-04	3.00	3.60	--	--	1.711	1.378	24.2	1	17	82	48	34	29.1	18.5	10.6	2.596	--	*0.36	--	--	--	--	--	--	CL
4 2.597																														
2.097																														
5 1.597				SPT	144-21-05	4.50	4.95	8	8	--	--	--	0	14	86	--		33.2	19.0	14.2	--	--	--	--	13	--	--	14.0	--	CL
1.097																														
6 0.597																														
0.097	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	1.50	UDS	144-21-06	6.00	6.60	--	--	1.787	1.403	27.4	0	2	98	52	46	40.7	23.6	17.1	2.591	TUU	0.18	6	--	--	--	--	--	CI
7 -0.403																														
-0.903																														
8 -1.403	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	15.00	SPT	144-21-07	7.50	7.95	18	17	--	--	--	0	10	90	78	12	32.6	NP		--	--	--	--	Nil	--	--	--	--	ML
-1.903																														
9 -2.403																														
-2.903				UDS	144-21-08	9.00	9.60	--	--	1.783	1.358	31.3	0	2	98	--		34.1	NP		2.605	DUU	0.03	17.0	--	--	--	--	--	--	ML
10 -3.403																														
-3.903																														
11 -4.403				SPT	144-21-09	10.50	10.95	31	23	--	--	--	0	4	96	--		30.2	NP		--	--	--	--	Nil	--	--	--	--	ML
-4.903																														
12 -5.403																														
-5.903				UDS	144-21-10	12.00	12.60	--	--	1.780	1.384	28.6	0	5	95	--		29.2	NP		--	--	--	--	--	--	--	--	--	ML
13 -6.403																														
-6.903																														
14 -7.403				SPT	144-21-11	13.50	13.95	30	23	--	--	--	0	4	96	--		31.4	NP		2.611	--	--	--	--	--	--	--	--	ML
-7.903																														
15 -8.403																														
-8.903				SPT	144-21-12	15.00	15.45	48	32	--	--	--	0	11	89	--		30.1	NP		--	--	--	--	--	--	--	--	--	ML
16 -9.403																														
-9.903																														
17 -10.403				SPT	144-21-13	16.50	16.95	39	27	--	--	--	0	8	92	--		31.2	NP		--	--	--	--	--	--	--	--	--	ML
-10.903																														
18 -11.403																														
-11.903				UDS	144-21-14	18.00	18.60	--	--	1.875	1.519	23.5	0	16	84	--		33.0	NP		2.621	DUU	0.07	20	--	--	--	--	--	--	ML
19 -12.403																														
-12.903																														
20 -13.403				SPT	144-21-15	19.50	19.95	47	31	--	--	--	0	14	86	--		32.4	NP		--	--	--	--	--	--	--	--	--	ML
-13.903																														
21 -14.403																														
-14.903				SPT	144-21-16	21.00	21.60	39	27	--	--	--	0	13	87	--		29.1	NP		2.625	--	--	--	--	--	--	--	--	ML
22 -15.403																														
-15.903																														

BH-21

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 10-12-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 12-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-21	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.50 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2664999, E 0559688
Reduced Level	: 6.597 m				

Depth (m) R.L - 6.597 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
23 -16.403	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	28.00	SPT	144-21-17	22.50	22.95	31	31	--	--	--	0	3	97	56	41	37.1	19.6	17.5	--	--	--	--	--	--	--	--	--	CI
-16.903																														
24 -17.403																														
-17.903				UDS	144-21-18	24.00	24.60	--	--	1.794	1.509	18.9	0	2	98	54	44	37.0	19.4	17.6	2.628	TUU	0.22	5	--	0.102	0.38	--	0.59	CI
25 -18.403																														
-18.903																														
26 -19.403				SPT	144-21-19	25.50	25.95	26	26	--	--	--	0	3	97	--		36.4	19.1	17.3	--	--	--	--	--	--	--	--	--	CI
-19.903																														
27 -20.403																														
-20.903				SPT	144-21-20	27.00	27.45	21	21	--	--	--	0	2	98	--		38.1	20.4	17.7	--	--	--	--	--	--	--	--	--	CI
28 -21.403																														
-21.903																														
29 -22.403				SPT	144-21-21	28.50	28.95	18	18	--	--	--	0	4	96	47	49	36.8	19.4	17.4	--	--	--	--	--	--	--	--	--	CI
-22.903																														
30 -23.403																														
-23.903				UDS	144-21-22	30.00	30.60	--	--	1.802	1.532	17.6	0	6	94	52	42	35.4	18.8	16.6	2.589	--	--	--	--	--	--	--	0.73	CI
31 -24.403																														
-24.903																														
32 -25.403				SPT	144-21-23	31.50	31.95	20	20	--	--	--	0	2	98	--		37.6	20.1	17.5		--	--	--	--	--	--	--	--	CI
-25.903																														
33 -26.403																														
-26.903				SPT	144-21-24	33.00	33.45	21	21	--	--	--	0	2	98	--		40.2	21.4	18.8	--	--	--	--	--	--	--	--	--	CI
34 -27.403																														
-27.903																														
35 -28.403				SPT	144-21-25	34.50	34.95	24	24	--	--	--	0	5	95	--		44.8	23.6	21.2	--	--	--	--	--	--	--	--	--	CI
-28.903																														
36 -29.403																														
-29.903				UDS	144-21-26	36.00	36.60	--	--	1.882	1.541	22.1	0	1	99	--		47.0	23.8	23.2	--	--	--	--	--	--	--	--	--	CI
37 -30.403																														
-30.903																														
38 -31.403				SPT	144-21-27	37.50	37.95	22	22	--	--	--	0	6	94	--		45.3	24.1	21.2	--	--	--	--	--	--	--	--	--	CI
-31.903																														
39 -32.403																														
-32.903				SPT	144-21-28	39.00	39.45	22	22	--	--	--	0	8	92	--		42.6	22.8	19.8	2.606	--	--	--	--	--	--	--	--	--	CI
40 -33.403																														
-33.903																														
41 -34.403				SPT	144-21-29	40.50	40.95	20	20	--	--	--	0	4	96	--		40.6	21.6	19.0	--	--	--	--	--	--	--	--	--	CI
-34.903																														
42 -35.403																														
-35.903	(Visual classification) Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles			UDS	144-21-30	42.00	42.60	--	--	1.910	1.538	24.2	--									--	--	--	--	--	--	--	--	--	CI
43 -36.403																														
-36.903																														
44 -37.403				SPT	144-21-31	43.50	43.95	25	25	--	--	--	--									--	--	--	--	--	--	--	--	--	CI
-37.903																														
45 -38.403																														
-38.903				SPT	144-21-32	45.00	45.42	>100 (12 cm)	>100 (12 cm)	--	--	--	--									--	--	--	--	--	--	--	--	--	CI
46 -39.403																														
-39.903																														
47 -40.403				SPT	144-21-33	46.50	46.92	>100 (12 cm)	>100 (12 cm)	--	--	--	--									--	--	--	--	--	--	--	--	--	CI
-40.903																														
48 -41.403																														
-41.903				UDS-F +SPT	144-21-34	48.00	48.40	>100 (10 cm)	>100 (10 cm)	--	--	--	--									--	--	--	--	--	--	--	--	--	CI
49 -42.403																														
-42.903																														
50 -43.403																														
-43.903				SPT	144-21-35	50.00	50.41	>100 (11 cm)	>100 (11 cm)	--	--	--	--									--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Geaph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-22

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 08-12-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 09-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-22	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 4.40 m	**Depth of Boring** : 30 m	**Co-Ordinates**	:	42 Q, N 2665252, E 0561390
Reduced Level	: 6.901 m				

Depth (m) R.L - 6.901 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	% Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
6.401				DS	144-22-01	0.00	0.50	--	--	--	--	--	0	0	100	--		34.6	20.1	14.5	--	--	--	--	--	--	--	--	--	CL
1 5.901	Greyish Brownish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	3.00	SPT	144-22-02	0.50	0.95	4	4	--	--	--	0	3	97	58	39	34.2	19.8	14.4	--	--	--	--	--	--	--	--	CL
5.401																													
2 4.901				SPT	144-22-03	1.50	1.95	5	5	--	--	--	0	2	98	60	38	33.8	19.4	14.4	--	--	*0.22	0	20	--	--	--	--	CL
4.401																													
3 3.901																													
3.401				UDS	144-22-04	3.00	3.60	--	--	1.748	1.369	27.7	6	3	92	49	43	36.2	21.6	14.6	2.621	--	*0.31	0	25	--	--	--	--	CI
4 2.901																													
2.401																													
5 1.901				SPT	144-22-05	4.50	4.95	7	7	--	--	--	0	4	96	51	45	36.1	21.3	14.8	--	--	--	--	--	--	--	--	CI
1.401																													
6 0.901	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	6.00																										
0.401				UDS	144-22-06	6.00	6.60	--	--	1.723	1.405	22.6	0	2	98	57	41	35.8	20.8	15.0	2.556	TUU	0.21	11	27	0.121	0.52	12.9	0.56	CI
7 -0.099																													
-0.599																													
8 -1.099				SPT	144-22-07	7.50	7.95	13	13	--	--	--	0	0	100	59	41	35.2	20.6	14.6	--	--	--	--	--	--	--	--	CI
-1.599																													
9 -2.099																													
-2.599				UDS	144-22-08	9.00	9.60	--	--	1.877	1.515	23.9	0	16	84	72	12	32.3	NP		2.606	DUU	0.08	21	Nil	--	--	--	--	ML
10 -3.099																													
-3.599																													
11 -4.099				SPT	144-22-09	10.50	10.95	24	20	--	--	--	0	11	89	--		32.6	NP		--	--	--	--	--	--	--	--	ML
-4.599																													
12 -5.099																													
-5.599				UDS	144-22-10	12.00	12.60	--	--	1.931	1.541	25.3	5	10	85	--		30.1	NP		--	--	--	--	--	--	--	--	ML
13 -6.099																													
-6.599																													
14 -7.099				SPT	144-22-11	13.50	13.95	27	21	--	--	--	0	9	91	--		33.4	NP		--	--	--	--	--	--	--	--	ML
-7.599																													
15 -8.099																													
-8.599				UDS	144-22-12	15.00	15.60	--	--	1.935	1.578	22.6	0	12	88	--		34.6	NP		2.596	DUU	0.04	23	Nil	--	--	--	--	ML
16 -9.099																													
-9.599	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	15.00																										
17 -10.099				SPT	144-22-13	16.50	16.95	57	36	--	--	--	--								--	--	--	--	--	--	--	--	ML
-10.599																													
18 -11.099																													
-11.599				UDS	144-22-14	18.00	18.60	--	--	1.915	1.592	20.3	2	16	82	--		29.3	NP		2.610	DUU	0.03	26	--	--	--	--	--	ML
19 -12.099																													
-12.599																													
20 -13.099				SPT	144-22-15	19.50	19.95	63	39	--	--	--	--								--	--	--	--	--	--	--	--	ML
-13.599																													
21 -14.099																													
-14.599				UDS	144-22-16	21.00	21.60	--	--	1.850	1.552	19.2	0	12	88	--		32.4	NP		--	--	--	--	--	--	--	--	ML
22 -15.099																													
-15.599																													
23 -16.099				SPT	144-22-17	22.50	22.90	45	30	--	--	--	0	9	91	--		31.8	NP		--	--	--	--	--	--	--	--	ML
-16.599																													
24 -17.099																													
-17.599				UDS	144-22-18	24.00	24.60	--	--	1.896	1.603	18.3	0	4	95	--		38.3	19.8	18.5	2.603	TUU	0.33	10	--	--	--	--	0.7	CI
25 -18.099																													
-18.599																													
26 -19.099				SPT	144-22-19	25.50	25.95	28	28	--	--	--	0	3	97	53	44	38.1	19.7	18.4	--	--	--	--	--	--	--	--	CI
-19.599																													
27 -20.099																													
-20.599	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	6.50	UDS	144-22-20	27.00	27.60	--	--	1.913	1.632	17.2	0	1	99	--		39.8	21.4	18.4	--	--	--	--	--	--	--	--	CI
28 -21.099																													
-21.599																													
29 -22.099				SPT	144-22-21	28.50	28.95	15	15	--	--	--	--								--	--	--	--	--	--	--	--	CI
-22.599																													
30 -23.099																													
-23.599				UDS	144-22-22	30.00	30.60	--	--	1.816	1.512	20.1	--								--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Geaph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-23

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 07-12-2020	**Type of Bit use**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 08-12-2020	**Bearing of Hol**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-23	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 4.30 m	**Depth of Boring**	: 30 m	**Co-Ordinates**	: 42 Q, N 2664879, E 0562834
Reduced Level	: 6.299 m				

Depth (m) R.L - 6.299 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
5.799	Greyish Brownish Silty Clay of High Plasticity	CH	1.50	DS	144-23-01	0.00	0.50	--	--	--	--	--	0	1	99	--		54.4	25.1	29.3	--	--	--	--	--	--	--	--	--	CH
1 5.299				SPT	144-23-02	0.50	0.95	7	7	--	--	--	0	0	100	42	58	51.0	23.2	27.8	--	--	*0.26	0	--	--	--	--	--	CH
4.799																														
2 4.299	Greyish Brownish Silty Clay of High Plasticity	CI	3.00	SPT	144-23-03	1.50	1.95	11	11	--	--	--	0	2	98	54	44	40.1	21.6	18.5	2.539	--	--	--	--	--	--	--	--	CI
3.799																														
3 3.299																														
2.799				UDS	144-23-04	3.00	3.60	--	--	1.854	1.422	30.4	1	2	97	52	45	40.6	23.4	17.2	2.548	TUU	0.22	8	32	0.131	0.42	14.3	--	CI
4 2.299																														
1.799																														
5 1.299	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	7.50	SPT	144-23-05	4.50	4.95	13	13	--	--	--	0	4	96	--		30.1	NP		--	--	--	--	Nil	--	--	--	--	ML
0.799																														
6 0.299																														
-0.201				UDS	144-23-06	6.00	6.60	--	--	1.904	1.506	26.4	0	9	91	80	11	29.3	NP		2.606	DUU	0.0	19	Nil	--	--	--	--	ML
7 -0.701																														
-1.201																														
8 -1.701				SPT	144-23-07	7.50	7.95	30	23	--	--	--	0	4	96	--		30.1	NP		--	--	--	--	--	--	--	--	--	ML
-2.201																														
9 -2.701																														
-3.201				UDS	144-23-08	9.00	9.60	--	--	1.983	1.523	30.2	0	10	90	--		31.6	NP		2.611	--	--	--	--	--	--	--	--	ML
10 -3.701																														
-4.201																														
11 -4.701				SPT	144-23-09	10.50	10.95	16	16	--	--	--	0	5	95	--		32.4	NP		--	--	--	--	--	--	--	--	--	ML
-5.201																														
12 -5.701																														
-6.201	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	6.00	UDS	144-23-10	12.00	12.60	--	--	1.827	1.548	18.0	0	4	96	61	35	30.3	19.0	11.3	2.583	DUU	0.20	10	--	--	--	--	0.40	CL
13 -6.701																														
-7.201																														
14 -7.701				SPT	144-23-11	13.50	13.95	14	14	--	--	--	0	6	94	55	39	31.3	19.6	11.7	--	--	--	--	--	--	--	--	--	CL
-8.201																														
15 -8.701																														
-9.201				UDS-F + SPT	144-23-12	15.00	15.45	18	18	--	--	--	0	5	95	--		32.1	20.0	12.1	--	--	--	--	--	--	--	--	--	CL
16 -9.701																														
-10.201																														
17 -10.701				SPT	144-23-13	16.50	16.95	21	21	--	--	--	0	11	89	--		29.9	18.4	11.5	--	--	--	--	--	--	--	--	--	CL
-11.201																														
18 -11.701																														
-12.201	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	4.50	UDS	144-23-14	18.00	18.60	--	--	1.987	1.608	23.6	0	8	92	--		27.5	NP		2.619	DUU	0	23	--	--	--	--	--	ML
19 -12.701																														
-13.201																														
20 -13.701				SPT	144-23-15	19.50	19.95	50	33	--	--	--	0	6	94	--		30.4	NP		---	--	--	--	--	--	--	--	--	ML
-14.201																														
21 -14.701																														
-15.201				UDS-F + SPT	144-23-16	21.00	21.45	45	30	--	--	--	0	1	99	--		29.4	NP		--	--	--	--	--	--	--	--	--	ML
22 -15.701																														
-16.201																														
23 -16.701	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI	8.00	SPT	144-23-17	22.50	22.90	14	14	--	--	--	0	6	94	--		34.8	20.5	14.3	--	--	--	--	--	--	--	--	--	CL
-17.201																														
24 -17.701																														
-18.201				UDS	144-23-18	24.00	24.60	--	--	2.002	1.621	23.5	0	2	98	55	43	47.0	24.0	22.9	2.563	TUU	0.34	10	--	--	--	--	0.76	CI
25 -18.701																														
-19.201																														
26 -19.701				SPT	144-23-19	25.50	25.95	17	17	--	--	--	--			--					--	--	--	--	--	--	--	--	--	CI
-20.201																														
27 -20.701																														
-21.201				UDS	144-23-20	27.00	27.60	--	--	2.004	1.651	21.4	0	6	94	51	43	46.2	23.6	22.6	--	TUU	0.42	5	--	--	--	--	--	CI
28 -21.701																														
-22.201																														
29 -22.701				SPT	144-23-21	28.50	28.95	23	23	--	--	--	--			--					--	--	--	--	--	--	--	--	--	CI
-23.201																														
30 -23.701																														
-24.201				UDS	144-23-22	30.00	30.60	--	--	2.025	1.657	22.2	0	6	94	49	45	41.7	21.6	20.1		--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Geaph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-24

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 05-12-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 07-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-24	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.30 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2664666, E 0563996
Reduced Level	: 6.046 m				

Depth (m) R.L - 6.046 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
5.546				DS	144-24-01	0.00	0.50	--	--	--	--	--	0	2	98	--		30.2	19.6	10.6	--	--	--	--	--	--	--	--	--	--	CL
1 5.046				SPT	144-24-02	0.50	0.95	4	4	--	--	--	0	1	99	--		32.6	20.2	12.4	--	--	--	--	--	--	--	--	--	--	CL
4.546																														
2 4.046				SPT	144-24-03	1.50	1.95	5	5	--	--	--	0	2	98	59	39	34.5	20.7	13.8	--	--	*0.22	--	13	--	--	--	--	CL
3.546																														
3 3.046	Greyish Brownish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL	6.00																											
2.546				UDS-F + SPT	144-24-04	3.00	3.45	7	7	--	--	--	0	1	99	--		34.6	20.9	13.7	2.569	--	*0.26	--	--	--	--	12.7	--	CL
4 2.046																														
1.546																														
5 1.046				SPT	144-24-05	4.50	4.95	9	9	--	--	--	0	1	99	63	36	33.4	20.6	12.8	--	--	*0.39	--	16	--	--	--	--	CL
0.546																														
6 0.046																														
-0.454				UDS	144-24-06	6.00	6.60	--	--	1.692	1.350	25.3	2	7	91	--		34.6	NP		--	DUU	0.00	14	Nil	--	--	--	--	ML
7 -0.954																														
-1.454																														
8 -1.954				SPT	144-24-07	7.50	7.95	29	22	--	--	--	0	6	94	82	12	33.7	NP		--	--	--	--	--	--	--	--	--	ML
-2.454																														
9 -2.954																														
-3.454				UDS+ SPT	144-24-08	9.00	9.45	50	33	1.779	1.411	26.1	0	11	89	--		30.6	NP		2.559	--	--	--	Nil	--	--	--	--	ML
10 -3.954																														
-4.454																														
11 -4.954				SPT	144-24-09	10.50	10.95	28	22	--	--	--	0	15	85	--		31.6	NP		--	--	--	--	--	--	--	--	--	ML
-5.454	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	10.50																											
12 -5.954																														
-6.454				UDS	144-24-10	12.00	12.60	--	--	1.852	1.448	27.9	1	48	51	41	10	33.2	NP		--	DUU	0.02	16	--	--	--	--	--	ML
13 -6.954																														
-7.454																														
14 -7.954				SPT	144-24-11	13.50	13.95	33	24	--	--	--	0	10	90	--		31.2	NP		--	--	--	--	--	--	--	--	--	ML
-8.454																														
15 -8.954																														
-9.454				UDS	144-24-12	15.00	15.60	--	--	1.901	1.483	28.2	0	8	92	--		30.9	NP		2.606	DUU	0.06	19	Nil	--	--	--	--	ML
16 -9.954																														
-10.454																														
17 -10.954				SPT	144-24-13	16.50	16.95	46	46	--	--	--	0	1	98	--		36.5	21.6	14.9	--	--	--	--	--	--	--	--	--	CI
-11.454																														
18 -11.954	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI	3.00																											
-12.454				UDS+ SPT	144-24-14	18.00	18.45	41	41	1.777	1.446	22.9	0	2	98	56	42	38.5	24.2	14.3	2.613	TUU	0.26	11	--	0.084	0.29	--	0.55	CI
19 -12.954																														
-13.454																														
20 -13.954				SPT	144-24-15	19.50	19.95	53	34	--	--	--	0	10	90	--		28.6	NP		--	--	--	--	--	--	--	--	--	ML
-14.454																														
21 -14.954																														
-15.454				UDS	144-24-16	21.00	21.60	--	--	1.762	1.468	20.1	2	8	91	80	11	22.4	NP		--	--	--	--	--	--	--	--	--	ML
22 -15.954	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	4.50																											
-16.454																														
23 -16.954				SPT	144-24-17	22.50	22.95	78	47	--	--	--	0	3	97	--		29.4	NP		--	--	--	--	--	--	--	--	--	ML
-17.454																														
24 -17.954																														

BH-24

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started** : 05-12-2020	**Type of Bit used**	:	TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed** : 07-12-2020	**Bearing of Hole**	:	90^0 with Horizontal Plane
Bore Hole No.	: BH-24	**Diameter of Boring** : 150 mm	**Type of Boring**	:	Rotary Drilling
Top Level of Water Below EGL	: 2.30 m	**Depth of Boring** : 50 m	**Co-Ordinates**	:	42 Q, N 2664666, E 0563996
Reduced Level	: 6.046 m				

Depth (m) R.L - 6.046 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-18.454				UDS	144-24-18	24.00	24.60	--	--	1.805	1.496	20.6	0	1	98	--		45.8	23.6	22.2	--	--	--	--	--	--	--	--	--	--	CI
25 -18.954																														
-19.454																														
26 -19.954				SPT	144-24-19	25.50	25.95	31	31	--	--	--	0	2	98	--		40.6	22.8	17.8	2.601	--	--	--	--	--	--	--	--	--	CI
-20.454																														
27 -20.954																														
-21.454				UDS	144-24-20	27.00	27.60	--	--	1.916	1.569	22.1	0	7	93	48	45	38.5	20.2	18.3	--	--	--	--	--	--	--	--	--	--	CI
28 -21.954																														
-22.454																														
29 -22.954				SPT	144-24-21	28.50	28.95	35	35	--	--	--	0	2	98	--		38.7	20.5	18.2	--	--	--	--	--	--	--	--	--	CI
-23.454																														
30 -23.954																														
-24.454				UDS	144-24-22	30.00	30.60	--	--	1.994	1.616	23.4	0	1	98	--		39.6	24.1	15.5	2.591	TUU	0.31	6	--	--	--	--	0.67	CI
31 -24.954																														
-25.454																														
32 -25.954																														
-26.454																														
33 -26.954																														
-27.454				SPT	144-24-23	33.00	33.45	35	35	--	--	--	0	1	99	--		42.6	23.1	19.5	--	--	--	--	--	--	--	--	--	CI
34 -27.954																														
-28.454	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI																												
35 -28.954																														
-29.454																														
36 -29.954																														
-30.454				UDS	144-24-24	36.00	36.60	--	--	2.041	1.645	24.1	1	2	97	--		45.4	26.7	18.6	2.594	TUU	0.52	4	--	--	--	--	--	CI
37 -30.954																														
-31.454			26.5																											
38 -31.954																														
-32.454																														
39 -32.954																														
-33.454				SPT	144-24-25	39.00	39.45	28	28	--	--	--	0	1	99	56	43	44.4	24.0	20.4	--	--	--	--	--	--	--	--	--	CI
40 -33.954																														
-34.454																														
41 -34.954																														
-35.454																														
42 -35.954																														
-36.454				UDS	144-24-26	42.00	42.60	--	--	2.104	1.675	25.6	1	1	98	--		46.8	26.8	20.0	--	--	--	--	--	--	--	--	--	CI
43 -36.954																														
-37.454																														
44 -37.954																														
-38.454																														
45 -38.954																														
-39.454				SPT	144-24-27	45.00	45.45	80	80	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
46 -39.954																														
-40.454																														
47 -40.954																														
-41.454	(Visual Classification)																													
48 -41.954	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI																												
-42.454				UDS-F + SPT	144-24-28	48.00	48.45	86	86	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
49 -42.954																														
-43.454																														
50 -43.954																														
-44.454				SPT	144-24-29	50.00	50.45	74	74	--	--	--	--								--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Geaph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-25

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 08-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 09-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-25	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 4.40 m	**Depth of Boring**	: 30 m	**Co-Ordinates**	: 42 Q, N 2665989, E 0559725
Reduced Level	: 7.385 m				

Depth (m) R.L - 7.385 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
6.885				DS	144-25-01	0.00	0.50	--	--	--	--	--	0	1	99	--		38.6	NP		--	--	--	--	--	--	--	--	--	--	MI
1 6.385				SPT	144-25-02	0.50	0.95	15	15	--	--	--	0	1	99	87	12	36.2	NP		--	--	--	--	--	--	--	--	--	--	MI
5.885																														
2 5.385				SPT	144-25-03	1.50	1.95	13	13	--	--	--	0	5	95	--		39.5	NP		--	--	0.0	*14	Nil	--	--	--	--	MI
4.885	Greyish Silt of Intermediate Plasticity Mixed With Little Fine Sand	MI	4.5																											
3 4.385																														
3.885				UDS	144-25-04	3.00	3.60	--	--	1.720	1.321	30.2	0	7	93	--		41.2	NP		2.563	--	0.0	*18	Nil	--	--	--	--	MI
4 3.385																														
2.885																														
5 2.385				SPT	144-25-05	4.50	4.95	11	11	--	--	--	0	1	99	60	39	34.5	20.7	13.8	--	--	--	--	--	--	--	--	--	CL
1.885																														
6 1.385	Greyish Silty Clay of Low Plasticity Mixed With Fine Grained Sand Particles	CL	3.0																											
0.885				UDS	144-25-06	6.00	6.60	--	--	1.735	1.408	23.2	0	2	98	61	37	33.8	22.7	11.1	2.601	DUU	0.15	13	10	0.14	0.49	13.2	--	CL
7 0.385																														
-0.115																														
8 -0.615				SPT	144-25-07	7.50	7.95	12	12	--	--	--	0	3	97	--		34.5	NP		--	--	--	--	--	--	--	--	--	ML
-1.115																														
9 -1.615																														
-2.115				UDS	144-25-08	9.00	9.60	--	--	1.793	1.421	26.2	0	9	91	81	10	35.0	NP		2.621	DUU	0.0	19	Nil	--	--	--	--	ML
10 -2.615																														
-3.115																														
11 -3.615				SPT	144-25-09	10.50	10.95	22	19	--	--	--	0	7	93	--		34.2	NP		--	--	--	--	--	--	--	--	--	ML
-4.115																														
12 -4.615																														
-5.115				UDS	144-25-10	12.00	12.60	--	--	1.808	1.407	28.5	0	6	94	--		31.8	NP		--	--	--	--	--	--	--	--	--	ML
13 -5.615	Greyish Clayey Silt of Low Plasticity mixed with little Fines	ML	10.5																											
-6.115																														
14 -6.615				SPT	144-25-11	13.50	13.95	24	20	--	--	--	0	1	99	--		32.4	NP		2.591	--	--	--	--	--	--	--	--	ML
-7.115																														
15 -7.615																														
-8.115				UDS-F+ SPT	144-25-12	15.00	15.45	31	23	--	--	--	1	4	95	--		32.1	NP		--	--	--	--	--	--	--	--	--	ML
16 -8.615																														
-9.115																														
17 -9.615				SPT	144-25-13	16.50	16.95	24	20	--	--	--	1	2	97	--		31.6	NP		--	--	--	--	--	--	--	--	--	ML
-10.115																														
18 -10.615																														
-11.115				UDS	144-25-14	18.00	18.60	--	--	1.812	1.437	26.1	0	9	91	52	39	32.5	19.3	13.2	2.611	TUU	0.11	6	--	--	--	--	0.39	CL
19 -11.615	Greyish Silty Clay of Low Plasticity Mixed With Fine Grained Sand Particles	CL	1.5																											
-12.115																														
20 -12.615				SPT	144-25-15	19.50	19.95	35	25	--	--	--	0	7	93	--		24.2	NP		--	--	--	--	--	--	--	--	--	ML
-13.115																														
21 -13.615	Greyish Clayey Silt of Low Plasticity mixed with little Fines	ML	3.0																											
-14.115				SPT	144-25-16	21.00	21.45	22	19	--	--	--	0	11	89	--		27.8	NP		--	--	--	--	--	--	--	--	--	ML
22 -14.615																														
-15.115																														
23 -15.615				SPT	144-25-17	22.50	22.95	17	17	--	--	--	1	5	94	53	41	42.1	23.4	18.7	--	--	--	--	--	--	--	--	--	CI
-16.115																														
24 -16.615																														
-17.115				UDS	144-25-18	24.00	24.60	--	--	1.803	1.474	22.3	0	1	99	55	44	47.2	25.7	21.5	2.619	TUU	0.42	8	--	--	--	--	0.62	CI
25 -17.615																														
-18.115																														
26 -18.615				SPT	144-25-19	25.50	25.95	21	21	--	--	--	0	2	98	--		35.5	19.8	15.7	--	--	--	--	--	--	--	--	--	CI
-19.115	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI	8.0																											
27 -19.615																														
-20.115				SPT	144-25-20	27.00	27.45	19	19	--	--	--				--					--	--	--	--	--	--	--	--	--	--	CI
28 -20.615																														
-21.115																														
29 -21.615				SPT	144-25-21	28.50	28.95	18	18	--	--	--				--					--	--	--	--	--	--	--	--	--	--	CI
-22.115																														
30 -22.615																														
-23.115				UDS	144-25-22	30.00	30.60	--	--	1.861	1.557	19.5	0	4	96	--		35.9	20.2	15.7		--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Geaph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-26

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 10-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 11-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-26	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilli
Depth of water Below EGL	: 4.0 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2666558, E 0561205
Reduced Level	: 7.739 m				

Depth (m) R.L - 7.739 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	% Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
7.239				DS	144-26-01	0.00	0.50	--	--	--	--	--	0	1	99	--		36.4	NP		--	--	--	--	--	--	--	--	--	MI
1 6.739				SPT	144-26-02	0.50	0.95	4	4	--	--	--	0	2	98	85	13	36.6	NP		--	--	0.0	*12	--	--	--	--	--	MI
6.239																														
2 5.739				SPT	144-26-03	1.50	1.95	16	16	--	--	--	0	1	99	--		36.8	NP		--	--	0.0	*16	--	--	--	--	--	MI
5.239																														
3 4.739	Brownish Greyish Non - Plastic Silt Mixed With Little Fine Sand	MI	6.00																											
4.239				UDS	144-26-04	3.00	2.60	--	--	1.702	1.404	21.2	0	1	98	87	11	36.7	NP		2.612	DUU	0.05	17	Nil	--	--	--	--	MI
4 3.739																														
3.239																														
5 2.739				SPT	144-26-05	4.50	4.95	35	25	--	--	--	0	4	96	--		36.2	NP		--	--	--	--	Nil	--	--	--	--	MI
2.239																														
6 1.739																														
1.239				UDS	144-26-06	6.00	6.60	--	--	2.000	1.596	25.3	0	58	42	--		33.9	NP		2.652	DUU	0.00	25	Nil	--	--	--	--	SM
7 0.739																														
0.239	Greyish Silty Sand mixed with kankars	SM	3.00																											
8 -0.261				SPT	144-26-07	7.50	7.95	38	27	--	--	--	0	51	49	--		34.1	NP		--	--	--	--	--	--	--	--	--	SM
-0.761																														
9 -1.261																														
-1.761				UDS	144-26-08	9.00	9.60	--	--	1.826	1.463	24.8	1	39	60	47	13	33.4	NP		--	--	--	--	--	--	--	--	--	ML
10 -2.261																														
-2.761																														
11 -3.261				SPT	144-26-09	10.50	10.95	50	33	--	--	--	1	34	65	--		32.8	NP		--	--	--	--	--	--	--	--	--	ML
-3.761																														
12 -4.261																														
-4.761				UDS	144-26-10	12.00	12.60	--	--	1.820	1.472	23.6	0	31	69	59	10	31.4	NP		2.613	DUU	0.06	20	--	0.148	0.62	--	--	ML
13 -5.261																														
-5.761																														
14 -6.261				SPT	144-26-11	13.50	13.88	> 100 (8 cm)	> 100 (8 cm)	--	--	--	0	18	82	--		32.4	NP		--	--	--	--	--	--	--	--	--	ML
-6.761																														
15 -7.261																														
-7.761				UDS-F+ SPT	144-26-12	15.00	15.45	73	44	--	--	--	0	15	85	--		32.9	NP		--	--	--	--	--	--	--	--	--	ML
16 -8.261																														
-8.761	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	15.00																											
17 -9.261				SPT	144-26-13	16.50	16.95	77	46	--	--	--	0	15	85	--		34.2	NP		--	--	--	--	--	--	--	--	--	ML
-9.761																														
18 -10.261																														
-10.761				UDS	144-26-14	18.00	18.60	--	--	1.845	1.501	22.9	0	11	89	--		26.9	NP		2.621	DUU	0	22	--	--	--	--	--	ML
19 -11.261																														
-11.761																														
20 -12.261				SPT	144-26-15	19.50	19.95	30	23	--	--	--	0	15	85	--		25.4	NP		--	--	--	--	--	--	--	--	--	ML
-12.761																														
21 -13.261																														
-13.761				SPT	144-26-16	21.00	21.45	31	23	--	--	--	0	5	95	--		25.1	NP		--	--	--	--	--	--	--	--	--	ML
22 -14.261																														
-14.761																														
23 -15.261				SPT	144-26-17	22.50	22.95	26	21	--	--	--	0	8	92	--		24.7	NP		--	--	--	--	--	--	--	--	--	ML
-15.761																														
24 -16.261																														

BH-26

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 10-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 11-12-2020	**Bearing of Hole**	: 90^{0} with Horizontal Plane
Bore Hole No.	: BH-26	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilli
Depth of water Below EGL	: 4.0 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2666558, E 0561205
Reduced Level	: 7.739 m				

Depth (m) / R.L - 7.739 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-16.761	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI	26.50	UDS	144-26-18	24.00	24.60	--	--	1.864	1.529	21.9	2	2	95	53	42	41.4	22.7	18.7	2.585	TUU	0.31	7	--	--	--	14.5	0.65	CI
25 -17.261																														
-17.761																														
26 -18.261				SPT	144-26-19	25.50	25.95	23	23	--	--	--	1	1	98	54	44	41.3	22.4	18.9	--	--	--	--	--	--	--	--	--	CI
-18.761																														
27 -19.261																														
-19.761				SPT	144-26-20	27.00	27.60	26	26	--	--	--	0	1	99	--		41.6	22.2	19.4	--	--	--	--	--	--	--	--	--	CI
28 -20.261																														
-20.761																														
29 -21.261				SPT	144-26-21	28.50	28.95	29	29	--	--	--	1	1	98	--		41.3	22.4	18.9	--	--	--	--	--	--	--	--	--	CI
-21.761																														
30 -22.261																														
-22.761				UDS-F + SPT	144-26-22	30.00	30.45	21	21	--	--	--	0	1	99	57	42	42.1	23.2	18.9	--	--	--	--	--	--	--	--	--	CI
31 -23.261																														
-23.761																														
32 -24.261				SPT	144-26-23	31.50	31.95	25	25	--	--	--	1	1	98	--		42.4	23.6	18.8	--	--	--	--	--	--	--	--	--	CI
-24.761																														
33 -25.261																														
-25.761				SPT	144-26-24	33.00	33.45	24	24	--	--	--	0	1	99	--		44.1	23.4	20.7	2.655	--	--	--	--	--	--	--	--	--	CI
34 -26.261																														
-26.761																														
35 -27.261				SPT	144-26-25	34.50	34.95	24	24	--	--	--	0	3	97	--		46.9	24.6	22.3	--	--	--	--	--	--	--	--	--	CI
-27.761																														
36 -28.261																														
-28.761				UDS	144-26-26	36.00	36.60	--	--	1.956	1.601	22.2	0	2	98	--		44.0	23.2	20.8	--	TUU	0.39	5	--	--	--	--	0.80	CI
37 -29.261																														
-29.761																														
38 -30.261				SPT	144-26-27	37.50	37.95	35	35	--	--	--	0	1	99	--		44.1	23.4	20.7	--	--	--	--	--	--	--	--	--	CI
-30.761																														
39 -31.261																														
-31.761				SPT	144-26-28	39.00	39.45	32	32	--	--	--	0	3	97	--		42.6	22.8	19.8	--	--	--	--	--	--	--	--	--	CI
40 -32.261																														
-32.761																														
41 -33.261				SPT	144-26-29	40.50	40.95	42	42	--	--	--	0	2	98	--		43.6	23.0	20.6	--	--	--	--	--	--	--	--	--	CI
-33.761																														
42 -34.261																														
-34.761				UDS	144-26-30	42.00	42.60	--	--	1.970	1.621	21.5	0	1	99	--		40.5	23.5	17.0	2.697	--	--	--	--	--	--	--	--	--	CI
43 -35.261																														
-35.761																														
44 -36.261	(Visual Classification) Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI		SPT	144-26-31	43.50	43.95	76	76	--	--	--	--									--	--	--	--	--	--	--	--	--	CI
-36.761																														
45 -37.261																														
-37.761				SPT	144-26-32	45.00	45.41	>100 (11 cm)	>100 (11 cm)	--	--	--	--									--	--	--	--	--	--	--	--	--	CI
46 -38.261																														
-38.761																														
47 -39.261				SPT	144-26-33	46.50	46.95	34	34	--	--	--	--									--	--	--	--	--	--	--	--	--	CI
-39.761																														
48 -40.261																														
-40.761				UDS-F+SPT	144-26-34	48.00	48.45	62	62	--	--	--	--									--	--	--	--	--	--	--	--	--	CI
49 -41.261																														
-41.761																														
50 -42.261																														
-42.761				SPT	144-26-35	50.00	50.44	>100 (14 cm)	>100 (14 cm)	--	--	--	--									--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Geaph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-27

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 08-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area,	**Date Completed**	: 10-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-27	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 4.3 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2666128, E 0562987
Reduced Level	: 6.766 m				

Depth (m) R.L - 6.766 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
6.266				DS	144-27-01	0.00	0.50	--	--	--	--	--	0	1	98	--		33.4	21.9	11.5	--	--	--	--	--	--	--	--	--	--	CL
1 5.766	Greyish Silty Clay of Low Plasticity Mixed With Kankars	CL	1.5	SPT	144-27-02	0.50	0.95	10	10	--	--	--	0	2	98	58	40	31.2	21.2	10.0	--	--	--	--	--	--	--	--	--	CL
5.266																														
2 4.766				SPT	144-27-03	1.50	1.95	10	10	--	--	--	0	2	98	56	42	41.2	22.0	19.1	--	--	*0.35	0	--	--	--	--	--	CI
4.266																														
3 3.766																														
3.266				UDS	144-27-04	3.00	3.45	--	--	1.799	1.438	25.1	0	3	97	--		35.9	22.2	13.7	2.569	TUU	0.14	6	11	0.133	0.39	12.7	--	CI
4 2.766	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI	4.5																											
2.266																														
5 1.766				SPT	144-27-05	4.50	4.95	10	10	--	--	--	0	1	99	60	39	35.1	21.8	13.3	--	--	--	--	--	--	--	--	--	CI
1.266																														
6 0.766																														
0.266				UDS	144-27-06	6.00	6.60	--	--	1.832	1.453	26.1	0	21	79	--		29.7	NP		2.616	DUU	0	16	Nil	--	--	--	--	ML
7 -0.234																														
-0.734																														
8 -1.234				SPT	144-27-07	7.50	7.95	31	23	--	--	--	0	20	80	--		31.2	NP		--	--	--	--	Nil	--	--	--	--	ML
-1.734																														
9 -2.234	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	6.0																											
-2.734				UDS	144-27-08	9.00	9.60	--	--	1.795	1.468	22.3	0	18	82	68	14	29.1	NP		2.621	DUU	0	18	Nil	0.143	0.41	--	--	ML
10 -3.234																														
-3.734																														
11 -4.234				SPT	144-27-09	10.50	10.95	35	25	--	--	--	0	19	81	--		30.4	NP		--	--	--	--	--	--	--	--	--	ML
-4.734																														
12 -5.234																														
-5.734				UDS-F + SPT	144-27-10	12.00	12.45	27	27	--	--	--	0	17	83	--		31.4	20.2	11.1	--	--	--	--	--	--	--	--	--	CL
13 -6.234																														
-6.734	Greyish Silty Clay of Low Plasticity Mixed With Kankars	CL	3.0																											
14 -7.234				SPT	144-27-11	13.50	13.95	39	39	--	--	--	0	14	86	47	39	32.1	20.4	11.7	--	--	--	--	--	--	--	--	--	CL
-7.734																														
15 -8.234																														
-8.734				UDS	144-27-12	15.00	15.60	--	--	1.875	1.511	24.1	0	18	82	69	13	33.5	NP		2.632	DUU	0	22	--	--	--	--	--	ML
16 -9.234																														
-9.734																														
17 -10.234				SPT	144-27-13	16.50	16.95	57	36	--	--	--	2	28	70	--		34.2	NP		--	--	--	--	--	--	--	--	--	ML
-10.734																														
18 -11.234																														
-11.734				UDS	144-27-14	18.00	18.60	--	--	1.878	1.532	22.6	1	10	89	77	12	31.2	NP		--	--	--	--	--	--	--	--	--	ML
19 -12.234	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	7.5																											
-12.734																														
20 -13.234				SPT	144-27-15	19.50	19.95	51	33	--	--	--	2	16	82	--		32.1	NP		--	--	--	--	--	--	--	--	--	ML
-13.734																														
21 -14.234																														
-14.734				UDS	144-27-16	21.00	21.60	--	--	1.875	1.543	21.5	1	18	81	--		30.5	NP		2.638	DUU	0	23	--	--	--	--	--	ML
22 -15.234																														
-15.734																														
23 -16.234				SPT	144-27-17	22.50	22.90	33	33	--			3	22	75	--		37.3	20.1	17.2	--	--	--	--	--	--	--	--	--	CI
-16.734																														
24 -17.234																														
-17.734				UDS	144-27-18	24.00	24.60	--	--	1.872	1.528	22.5	1	5	94	--		39.0	20.9	18.2	2.591	TUU	0.37	10	--	--	--	--	0.68	CI
25 -18.234																														
-18.734	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI	6.0																											
26 -19.234				SPT	144-27-19	25.50	25.95	27	27	--	--	--	0	8	92	48	44	40.2	21.8	18.4	--	--	--	--	--	--	--	--	--	CI
-19.734																														
27 -20.234																														
-20.734				UDS-F + SPT	144-27-20	27.00	27.45	32	32	--	--	--	1	10	89	--		43.4	22.5	20.9	--	--	--	--	--	--	--	--	--	CI
28 -21.234																														
-21.734																														

BH-27

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 08-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area,	**Date Completed**	: 10-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-27	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 4.3 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2666128, E 0562987
Reduced Level	: 6.766 m				

Depth (m) R.L - 6.766 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
29 -22.234				SPT	144-27-21	28.50	28.95	21	21	--	--	--	2	15	83	--		50.9	24.6	26.3	--	--	--	--	--	--	--	--	--	--	CH
-22.734																														
30 -23.234																														
-23.734				UDS+ SPT	144-27-22	30.00	30.45	22	22	1.930	1.563	23.5	0	11	89	--		51.2	26.8	24.4	2.586	TUU	0.63	4	--	--	--	--	1.01	CH
31 -24.234																														
-24.734																														
32 -25.234																														
-25.734																														
33 -26.234																														
-26.734				SPT	144-27-23	33.00	33.45	30	30	--	--	--	3	10	87	--		51.1	26.6	24.5	--	--	--	--	--	--	--	--	--	CH
34 -27.234	Greyish Silty Clay of High Plasticity Mixed With Kankars	CH	10.5																											
-27.734																														
35 -28.234																														
-28.734																														
36 -29.234																														
-29.734				UDS+S PT	144-27-24	36.00	36.45	43	43	2.00	1.613	24.2	0	1	99	51	48	51.4	26.9	24.5	--	--	--	--	--	--	--	--	--	CH
37 -30.234																														
-30.734																														
38 -31.234																														
-31.734																														
39 -32.234																														
-32.734				SPT	144-27-25	39.00	39.45	46	46	--	--	--	0	3	97	--		41.2	22.1	19.1	--	--	--	--	--	--	--	--	--	CI
40 -33.234																														
-33.734																														
41 -34.234																														
-34.734																														
42 -35.234																														
-35.734				UDS-F +SPT	144-27-26	42.00	42.45	55	55	--	--	--	--								--	--	--	--	--	--	--	--	--	CI
43 -36.234																														
-36.734																														
44 -37.234																														
-37.734	(Visual Classification)																													
45 -38.234	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars	CI	11.5																											
-38.734				UDS-F +SPT	144-27-27	45.00	45.45	67	67	--	--	--									--	--	--	--	--	--	--	--	--	CI
46 -39.234																														
-39.734																														
47 -40.234																														
-40.734																														
48 -41.234																														
-41.734				SPT	144-27-28	48.00	48.45	45	45	--	--	--									--	--	--	--	--	--	--	--	--	CI
49 -42.234																														
-42.734																														
50 -43.234																														
-43.734				SPT	144-27-29	50.00	50.45	27	27	--	--	--									--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Geaph of N-value v/s Cohesion Relationship *(Ref: Foundation Design Manual, Nayak N.V.)*

BH-28

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 16-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 18-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-28	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 3.30 m	**Depth of Boring**	: 35 m	**Co-Ordinates**	: 42 Q, N 2667219, E 0559649
Reduced Level	: 7.829 m				

Depth (m) R.L - 7.829 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	%Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
7.329	Brownish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	0.60	DS	144-28-01	0.00	0.50	--	--	--	--	--	0	16	84	--		32.9	19.2	13.7	--	--	--	--	--	--	--	--	--	CL
1 6.829				SPT	144-28-02	0.50	0.95	4	4	--	--	--	0	1	99	33	66	36.1	20.9	15.2	--	--	--	--	--	--	--	--	--	CI
6.329																														
2 5.829				SPT	144-28-03	1.50	1.95	6	6	--	--	--	0	2	98	53	45	35.6	20.5	15.1	--	--	*0.29	0	13	--	--	13.8	--	CI
5.329																														
3 4.829	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles	CI	5.30	UDS	144-28-04	3.00	3.60	--	--	1.730	1.412	22.6	0	1	99	--		35.3	20.2	15.2	2.597	TUU	0.26	11	--	--	--	--	0.38	CI
4.329																														
4 3.829																														
3.329																														
5 2.829				SPT	144-28-05	4.50	4.95	9	9	--	--	--	0	5	95	--		35.2	19.9	15.3	--	--	--	--	--	10	--	--	--	--	CI
2.329																														
6 1.829																														
1.329				UDS	144-28-06	6.00	6.60	--	--	1.857	1.495	24.2	0	6	94	62	32	32.6	NP		2.665	DUU	0.0	16	Nil	--	--	--	--	ML
7 0.829																														
0.329																														
8 -0.171				SPT	144-28-07	7.50	7.95	14	14	--	--	--	0	4	96	--		33.1	NP		--	--	--	--	--	--	--	--	--	ML
-0.671																														
9 -1.171	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	6.80																											
-1.671				UDS	144-28-08	9.00	9.60	--	--	1.876	1.502	24.9	0	1	99	--		34.2	NP		2.672	DUU	0.0	20	Nil	--	--	--	--	ML
10 -2.171																														
-2.671																														
11 -3.171				SPT	144-28-09	10.50	10.95	18	18	--	--	--	0	2	98	--		34.0	NP		--	--	--	--	--	--	--	--	--	ML
-3.671																														
12 -4.171																														
-4.671				UDS	144-28-10	12.00	12.60	--	--	1.821	1.485	22.6	0	4	96	52	44	32.2	19.5	12.6	2.622	--	--	--	--	--	--	--	--	CL
13 -5.171																														
-5.671																														
14 -6.171				SPT	144-28-11	13.50	13.95	13	13	--	--	--	0	2	98	56	42	32.9	19.9	13.0	--	--	--	--	--	--	--	--	CL
-6.671																														
15 -7.171																														
-7.671				SPT	144-28-12	15.00	15.45	46	46	--	--	--	0	4	96	58	38	31.9	19.3	12.6	--	--	--	--	--	--	--	--	CL
16 -8.171																														
-8.671																														
17 -9.171				SPT	144-28-13	16.50	16.95	42	42	--	--	--	0	1	99	--		34.3	20.6	13.7	--	--	--	--	--	--	--	--	CL
-9.671																														
18 -10.171																														
-10.671				UDS	144-28-14	18.00	18.60	--	--	1.868	1.537	21.5	0	10	90	--		32.6	18.3	14.3	2.626	TUU	0.33	10	--	--	--	--	0.59	CL
19 -11.171	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle	CL	12.80																											
-11.671																														
20 -12.171				SPT	144-28-15	19.50	19.95	37	37	--	--	--	0	16	84	--		31.6	18.7	12.9	--	--	--	--	--	--	--	--	CL
-12.671																														
21 -13.171																														
-13.671				SPT	144-28-16	21.00	21.45	31	31	--	--	--	0	1	99	56	43	32.6	19.3	13.3	--	--	--	--	--	--	--	--	CL
22 -14.171																														
-14.671																														
23 -15.171				SPT	144-28-17	22.50	22.95	44	44	--	--	--	0	1	99	--		32.9	19.6	13.3	--	--	--	--	--	--	--	--	CL
-15.671																														
24 -16.171																														
-16.671				UDS	144-28-18	24.00	24.60	--	--	1.815	1.585	14.5	19	30	51	25	26	30.1	18.3	11.8	2.646	TUU	0.46	12	--	--	--	--	--	CL
25 -17.171																														
-17.671																														
26 -18.171				SPT	144-28-19	25.50	25.95	>100 (3 cm)	>100 (3 cm)	--	--	--	18	40	42	--		41.6	21.8	19.8	--	--	--	--	--	--	--	--	SC
-18.671																														
27 -19.171																														
-19.671				SPT+ Soil Core	144-28-20	27.00	27.45	>100 (6 cm)	>100 (6 cm)	1.943	1.638	18.6	9	46	45	--		41.9	22.1	19.8	2.665	TUU	0.31	20	--	--	--	--	--	SC
28 -20.171																														
-20.671																														
29 -21.171				SPT	144-28-21	28.50	28.95	>100 (9 cm)	>100 (9 cm)	--	--	--	12	49	39	--		38.3	19.8	18.5	--	--	--	--	--	--	--	--	SC
-21.671	Brownish greyish Consolidated Clayey Sand of Low to Intermediate Plasticity mixed with little Gravel	SC	7.50																											
30 -22.171																														
-22.671				SPT	144-28-22	30.00	30.45	>100 (7 cm)	>100 (7 cm)	--	--	--	10	52	38	--		38.7	20.3	18.4	--	--	--	--	--	--	--	--	SC
31 -23.171																														
-23.671																														
32 -24.171				SPT	144-28-23	31.50	31.95	>100 (6 cm)	>100 (6 cm)	--	--	--	5	49	46	--		43.6	22.3	21.3	--	--	--	--	--	--	--	--	SC
-24.671																														
33 -25.171																														
-25.671				CORE PCS	144-28-24	33.00	33.06	--	--	--	--	--	NOT APPLICABLE								--	--	--	--	--	--	--	--	--	HWR
34 -26.171	Greyish Highly Weathered Over Consolidated Sand Stone Fragments	HWR	2.00																											
-26.671																														
35 -27.171				CORE PCS	144-28-25	34.50	34.95	--	--	--	--	--	NOT APPLICABLE								--	--	--	--	--	--	--	--	--	HWR

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Graph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-29

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 10-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch	**Date Completed**	: 11-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-29	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Top Level of Water Below EGL	: 4.0 m	**Depth of Boring**	: 30 m	**Co-Ordinates**	: 42 Q, N 2667619, E 0560896
Reduced Level	: 6.900 m				

Depth (m) R.L - 6.900 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	%Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction (ϕ	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc (kg/cm^2)	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
6.400				DS	144-29-01	0.00	0.50	--	--	--	--	--	0	1	99	--		41.7	21.6	20.1	--	--	--	--	--	--	--	--	--	CI
1 5.900				SPT	144-29-02	0.50	0.95	11	11	--	--	--	0	1	99	58	41	46.3	24.3	22.0	--	--	*0.32	0	--	--	--	--	--	CI
5.400																														
2 4.900	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	4.5	SPT	144-29-03	1.50	1.95	11	11	--	--	--	0	1	99	54	45	44.2	22.6	21.6	--	--	--	--	--	--	--	--	CI
4.400																														
3 3.900																														
3.400				UDS	144-29-04	3.00	3.60	--	--	1.819	1.473	23.5	1	4	95	53	42	35.3	22.3	13.0	2.611	TUU	0.18	13	18	0.101	0.43	11.8	--	CI
4 2.900																														
2.400																														
5 1.900				SPT	144-29-05	4.50	4.95	13	13	--	--	--	0	36	64	--		31.5	NP		--	--	--	--	--	--	--	--	--	ML
1.400																														
6 0.900																														
0.400				UDS	144-29-06	6.00	6.60	--	--	1.837	1.453	26.4	0	41	59	46	13	27.3	NP		2.593	DUU	0.0	17	Nil	--	--	--	--	ML
7 -0.100																														
-0.600																														
8 -1.100				SPT	144-29-07	7.50	7.95	38	27	--	--	--	0	40	61	50	11	27.6	NP		--	--	--	--	--	--	--	--	--	ML
-1.600																														
9 -2.100	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	9.0																											
-2.600				UDS	144-29-08	9.00	9.60	--	--	1.873	1.501	24.8	0	32	68	--		28.1	NP		2.629	DUU	0.0	20	Nil	--	--	--	--	ML
10 -3.100																														
-3.600																														
11 -4.100				SPT	144-29-09	10.50	10.95	29	22	--	--	--	0	35	65	--		29.2	NP		--	--	--	--	--	--	--	--	--	ML
-4.600																														
12 -5.100																														
-5.600				UDS-F +SPT	144-29-10	12.00	12.45	31	23	--	--	--	0	33	67	--		27.4	NP		--	--	--	--	--	--	--	--	--	ML
13 -6.100																														
-6.600																														
14 -7.100				SPT	144-29-11	13.50	13.95	35	35	--	--	--	0	30	70	32	38	30.0	18.6	11.5	--	--	--	--	--	--	--	--	--	CL
-7.600																														
15 -8.100																														
-8.600				SPT	144-29-12	15.00	15.45	69	69	--	--	--	0	29	71	--		30.6	19.1	11.5	2.613	--	--	--	--	--	--	--	--	CL
16 -9.100																														
-9.600																														
17 -10.100				SPT	144-29-13	16.50	16.95	40	40	--	--	--	0	27	73	38	35	31.4	20.3	11.1	--	--	--	--	--	--	--	--	--	CL
-10.600																														
18 -11.100																														
-11.600				UDS	144-29-14	18.00	18.60	--	--	1.804	1.521	18.6	0	30	70	--		29.3	17.7	11.6	2.642	TUU	0.13	18	--	--	--	--	0.44	CL
19 -12.100	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	10.5																											
-12.600																														
20 -13.100				SPT	144-29-15	19.50	19.95	46	46	--	--	--	0	28	72	36	36	30.4	18.9	11.5	--	--	--	--	--	--	--	--	--	CL
-13.600																														
21 -14.100																														
-14.600				SPT	144-29-16	21.00	21.45	34	34	--	--	--	0	24	76	--		31.6	18.4	13.2	2.651	--	--	--	--	--	--	--	--	CL
22 -15.100																														
-15.600																														
23 -16.100				SPT	144-29-17	22.50	22.95	28	28	--	--	--	0	22	78	--		32.2	20.6	11.6	--	--	--	--	--	--	--	--	--	CL
-16.600																														
24 -17.100																														
-17.600				UDS	144-29-18	24.00	24.60	--	--	1.766	1.420	24.4	1	20	79	--		29.1	NP		--	DUU	0.0	22	--	--	--	--	--	--	ML
25 -18.100																														
-18.600	Greyish Non-Plastic Clayey Silt mixed with little Fines	ML	3.0																											
26 -19.100				SPT	144-29-19	25.50	25.95	38	27	--	--	--	1	18	81	--		30.1	NP		--	--	--	--	--	--	--	--	--	ML
-19.600																														
27 -20.100																														
-20.600				SPT	144-29-20	27.00	27.45	28	28	--	--	--	0	21	79	--		43.8	21.8	22.0	--	--	--	--	--	--	--	--	--	CI
28 -21.100																														
-21.600	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	3.5																											
29 -22.100				SPT	144-29-21	28.50	28.95	33	33	--	--	--	0	23	77	36	41	42.3	21.2	21.1	2.619	--	--	--	--	--	--	--	--	--	CI
-22.600																														
30 -23.100																														
-23.600				UDS	144-29-22	30.00	30.60	--	--	1.915	1.585	20.8	0	1	99	--		49.9	24.7	25.2		TUU	0.59	0	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample

* Values obtained from Geaph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-30

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 07-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 09-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-30	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 4.30 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2667442, E 0562307
Reduced Level	: 7.066 m				

Depth (m) R.L - 7.066 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Lab.No.	Depth (m): From	Depth (m): TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	%Sand	% Silt & Clay	Hydrometer: % Silt	% Clay	Atterberg's Limit: Liquid limit, %	Plastic limit, %	Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
6.566				DS	144-30-01	0.00	0.50	--	--	--	--	--	0	17	83	--		33.8	NP		--	--	--	--	--	--	--	--	--	ML
1 6.066				SPT	144-30-02	0.50	0.95	5	5	--	--	--	1	15	84	72	12	34.2	NP		--	--	--	--	--	--	--	--	--	--	ML
5.566																														
2 5.066				SPT	144-30-03	1.50	1.95	8	8	--	--	--	0	20	80	--		34.1	NP		2.569	--	0.00	*11	Nil	--	--	--	--	ML
4.566	Greyish Brownish Non-Plastic Clayey Silt mixed with little Fines		4.5																										
3 4.066																													
3.566				UDS-F + SPT	14430-04	3.00	3.60	--	--	--	--	--	0	38	62	--		34.7	NP		--	--	0.00	*13	Nil	--	--	--	--	ML
4 3.066																													
2.566																													
5 2.066				SPT	144-30-05	4.50	4.95	11	11	--	--	--	0	5	95	--		33.8	NP		--	--	--	--	--	--	--	--	--	ML
1.566																													
6 1.066																													
0.566				UDS	144-30-06	6.00	6.60	--	--	1.758	1.422	23.6	0	4	96	85	11	32.6	NP		2.572	DUU	0.00	15	Nil	--	--	--	--	ML
7 0.066																													
-0.434																													
8 -0.934				SPT	144-30-07	7.50	7.95	10	10	--	--	--	0	7	93	--		30.4	NP		--	--	--	--	Nil	--	--	--	--	ML
-1.434																													
9 -1.934		ML																											
-2.434				UDS	144-30-08	9.00	9.60	--	--	1.865	1.496	24.7	0	2	98	--		30.0	NP		2.597	TUU	0.17	20	--	0.094	0.45	--	--	ML
10 -2.934																													
-3.434																													
11 -3.934				SPT	144-30-09	10.50	10.95	16	16	--	--	--	0	4	96	--		30.4	NP		--	--	--	--	--	--	--	--	--	ML
-4.434	Greyish Non-Plastic Clayey Silt mixed with little Fines		13.5																										
12 -4.934																													
-5.434				UDS	144-30-10	12.00	12.60	--	--	1.800	1.513	19.0	0	5	95	--		31.4	NP		--	--	--	--	--	--	--	--	--	ML
13 -5.934																													
-6.434																													
14 -6.934				SPT	144-30-11	13.50	13.95	30	23	--	--	--	0	2	98	--		32.4	NP		--	--	--	--	Nil	--	--	--	--	ML
-7.434																													
15 -7.934																													
-8.434				UDS-F + SPT	144-30-12	15.00	15.45	26	21	--	--	--	0	7	93	--		31.6	NP		--	--	--	--	--	--	--	--	--	ML
16 -8.934																													
-9.434																													
17 -9.934				SPT	144-30-13	16.50	16.95	33	24	--	--	--	0	6	94	--		30.8	NP		--	--	--	--	--	--	--	--	--	ML
-10.434																													
18 -10.934																													
-11.434				UDS	144-30-14	18.00	18.60	--	--	1.845	1.522	21.2	0	4	96	--		30.1	16.3	13.8	2.602	TUU	0.28	13	--	0.113	0.35	12.3	0.51	CL
19 -11.934																													
-12.434																													
20 -12.934				SPT	144-30-15	19.50	19.95	37	37	--	--	--	0	6	94	52	42	33.2	20.1	13.1	--	--	--	--	--	--	--	--	--	CL
-13.434																													
21 -13.934																													
-14.434				UDS	144-30-16	21.00	21.60	--	--	1.893	1.576	20.1	0	10	90	50	40	33.6	19.2	14.4	--	--	--	--	--	--	--	--	--	CL
22 -14.934																													
-15.434	Brownish Sandy Clay of Low Plasticity Mixed With Kankars	CL	9.0																										
23 -15.934				SPT	144-30-17	22.50	22.90	52	52	--			0	8	92	48	44	31.6	19.8	11.8	--	--	--	--	--	--	--	--	--	CL
-16.434																													
24 -16.934																													
-17.434				UDS	144-30-18	24.00	24.60	--	--	1.939	1.561	24.2	0	11	89	52	37	32.3	20.1	12.3	2.611	TUU	0.38	14	--	--	--	--	0.68	CL
25 -17.934																													
-18.434																													
26 -18.934				SPT	144-30-19	25.50	25.95	47	47	--	--	--	0	10	90	--		33.2	18.5	14.7	--	--	--	--	--	--	--	--	--	CL
-19.434																													
27 -19.934																													

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Geaph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

BH-30

Name of Owner	: Gujarat Industries Power Company Limited (GIPCL)	**Date Started**	: 07-12-2020	**Type of Bit used**	: TC Bit
Name of Project	: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat	**Date Completed**	: 09-12-2020	**Bearing of Hole**	: 90^0 with Horizontal Plane
Bore Hole No.	: BH-30	**Diameter of Boring**	: 150 mm	**Type of Boring**	: Rotary Drilling
Depth of water Below EGL	: 4.30 m	**Depth of Boring**	: 50 m	**Co-Ordinates**	: 42 Q, N 2667442, E 0562307
Reduced Level	: 7.066 m				

Depth (m) R.L - 7.066 m	Description of Strata	Legend	Stratum Thickness (mt)	Sampling: Type	Sampling: Lab.No.	Sampling: Depth (m) From	Sampling: Depth (m) TO	SPT N Value	Corrected SPT N Value	Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis: % Gravel	Grain Size Analysis: %Sand	Grain Size Analysis: % Silt & Clay	Hydrometer: % Silt	Hydrometer: % Clay	Atterberg's Limit: Liquid limit, %	Atterberg's Limit: Plastic limit, %	Atterberg's Limit: Plasticity Index, %	Specific Gravity	Type of Test	Cohesion, C, kg/cm^2	Angle of internal friction Ø	Free Swell Index, %	Consolidation: Cc	Consolidation: Pc kg/cm^2	Shrinkage Limit, %	UCS, kg/cm^2	CLASSIFICATION
-20.434				SPT	144-30-20	27.00	27.45	45	45	--	--	--	0	6	94	53	41	43.2	23.2	20.0	--	--	--	--	--	--	--	--	--	--	CI
28 -20.934																														
-21.434																														
29 -21.934				SPT	144-30-21	28.50	28.95	37	37	--	--	--	0	3	97	--		44.1	24.6	19.5	--	--	--	--	--	--	--	--	--	--	CI
-22.434																														
30 -22.934																														
-23.434				UDS	144-30-22	30.00	30.60	--	--	1.899	1.539	23.4	0	8	92	49	43	46.7	26.1	20.6	2.601	TUU	0.48	6	--	--	--	--	--	--	CI
31 -23.934																														
-24.434																														
32 -24.934																														
-25.434																														
33 -25.934																														
-26.434				SPT	144-30-23	33.00	33.45	29	29	--	--	--	0	7	93	51	42	44.0	26.4	17.6	--	--	--	--	--	--	--	--	--	--	CI
34 -26.934																														
-27.434																														
35 -27.934																														
-28.434																														
36 -28.934																														
-29.434	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars			UDS-F + SPT	144-30-24	36.00	36.60	38	38	--	--	--	1	10	89	--		41.6	23.6	18.0	--	--	--	--	--	--	--	--	--	--	CI
37 -29.934																														
-30.434																														
38 -30.934																														
-31.434																														
39 -31.934		CI	23.5																											
-32.434				SPT	144-30-25	39.00	39.45	27	27	--	--	--	--								--	--	--	--	--	--	--	--	--	--	CI
40 -32.934																														
-33.434																														
41 -33.934																														
-34.434																														
42 -34.934																														
-35.434				UDS	144-30-26	42.00	42.60	--	--	1.890	1.548	22.1	0	2	98	55	43	43.0	20.3	22.7	2.615	TUU	0.51	4	--	--	--	--	--	--	CI
43 -35.934																														
-36.434																														
44 -36.934																														
-37.434																														
45 -37.934																														
-38.434				SPT	144-30-27	45.00	45.45	37	37	--	--	--	--								--	--	--	--	--	--	--	--	--	--	CI
46 -38.934	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars																													
-39.434																														
47 -39.934																														
-40.434																														
48 -40.934																														
-41.434				UDS	144-30-28	48.00	48.60	--	--	1.971	1.595	23.6	0	10	90	--		47.5	24.3	23.2	--	--	--	--	--	--	--	--	--	--	CI
49 -41.934																														
-42.434																														
50 -42.934																														
-43.434				SPT	144-30-29	50.00	50.45	43	43	--	--	--	--								--	--	--	--	--	--	--	--	--	--	CI

SPT : Standard Penetration Value **UDS :** Undisturbed Sample * Values obtained from Geaph of N-value v/s Cohesion Relationship ***(Ref: Foundation Design Manual, Nayak N.V.)***

ANNEXURE 2: TRIAL PITS

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.20 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-1 (Near to BH-2) **Co-Ordinates :** 42Q, N 2658768, E 560441

Depth of water Below EGL : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Greyish Brownish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	3.20													
0.5																
1.0				CORE	144-02-01	1.0	1.876	1.491	25.8	0	0	100	33.7	20.2	13.5	CL
1.5																
2.0				CORE	144-02-02	2.0	2.482	1.863	33.2	0	0	100	34.7	20.8	13.9	CL
2.5																
3.0				CORE	144-02-03	3.0	2.045	1.656	23.5	0	0	100	34.6	20.4	14.2	CL

DS : Disturbed sample **SPT :** Standard Penetration Value **Note: Trial Pit Terminated at 3.20 m depth**

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.30 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-2(Near to BH-11) **Co-Ordinates :** 42Q, N 2660633, E 562474

Depth of water Below EGL : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Brownish Greyish Clayey Silt of Intermediate Plasticity mixed with little Fines	MI	3.30													
0.5																
1.0				CORE	144-11-01	1.0	1.906	1.462	30.4	0	2	98	40.7	NP		MI
1.5																
2.0				CORE	144-11-02	2.0	1.761	1.358	29.7	0	5	95	37.1	NP		MI
2.5																
3.0				CORE	144-11-03	3.0	2.069	1.424	45.3	0	2	98	39.2	NP		MI

DS : Disturbed sample **SPT :** Standard Penetration Value **Note: Trial Pit Terminated at 3.30 m depth**

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.20 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-3 (Near to BH-6) **Co-Ordinates :** 42Q, N 2657345, E 561329

Depth of water Below EGL : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	3.0													
0.5																
1.0				CORE	144-06-01	1.0	1.896	1.566	21.1	0	0	100	39.4	23.8	15.6	CI
1.5																
2.0				CORE	144-06-02	2.0	1.913	1.477	29.5	0	0	100	38.7	23.4	15.2	CI
2.5																
3.0				CORE	144-06-03	3.0	2.012	1.592	26.4	0	1	99	38.1	22.4	15.7	CI

DS : Disturbed sample **SPT :** Standard Penetration Value **Note:** Trial Pit Terminated at 3.20 m depth

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.30 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-4(Near to BH-26) **Co-Ordinates :** 42Q, N 2667219, E 559651

Depth of water Below EGL : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	3.30													
0.5																
1.0				CORE	144-28-01	1.0	1.924	1.543	24.7	0	1	99	35.2	21.4	13.8	CI
1.5																
2.0				CORE	144-28-02	2.0	1.859	1.500	23.9	0	0	100	35.6	21.7	13.9	CI
2.5																
3.0				CORE	144-28-03	3.0	1.918	1.482	29.4	0	1	99	36.2	21.9	14.3	CI

DS : Disturbed sample **SPT :** Standard Penetration Value **Note: Trial Pit Terminated at 3.30 m depth**

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.20 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-5 (Near to BH-30) **Co-Ordinates :** 42Q, N 2667444, E 562311

Depth of water Below EGL : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Brownish Greyish Clayey Silt of Intermediate Plasticity mixed with little Fines	MI	3.20													
0.5																
1.0				CORE	144-30-01	1.0	1.453	1.370	6.0	0	20	80	39.2	NP		MI
1.5																
2.0				CORE	144-30-02	2.0	1.815	1.613	12.5	0	29	71	37.5	NP		MI
2.5																
3.0				CORE	144-30-03	3.0	1.720	1.540	11.7	0	23	77	37.3	NP		MI

DS : Disturbed sample **SPT :** Standard Penetration Value **Note: Trial Pit Terminated at 3.20 m depth**

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.30 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-6 (Near to BH-22) **Co-Ordinates :** 42Q, N 2665258, E 561392

Depth of water Below EGL : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Greyish Brownish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	0.5													
0.5																
1.0	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	3.30	CORE	144-22-01	1.0	1.915	1.445	32.5	0	1	99	44.6	22.4	22.2	CI
1.5																
2.0				CORE	144-22-02	2.0	1.991	1.519	31.1	0	0	100	36.0	20.1	15.9	CI
2.5																
3.0				CORE	144-22-03	3.0	1.962	1.560	25.8	0	1	99	37.9	21.2	16.7	CI

DS : Disturbed sample **SPT :** Standard Penetration Value **Note: Trial Pit Terminated at 3.30 m depth**

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.20 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-7 (Near to BH-21) **Co-Ordinates :** 42Q, N 2665005, E 5659690

Depth of water Below EGL : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	0.5													
0.5																
1.0	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	2.7	CORE	144-21-01	1.0	1.958	1.490	31.4	0	0	100	29.1	18.8	10.3	CL
1.5																
2.0				CORE	144-21-02	2.0	1.841	1.491	23.5	0	1	99	30.2	19.2	11.0	CL
2.5																
3.0				CORE	144-21-03	3.0	1.941	1.465	32.5	0	1	99	29.2	19.2	10.0	CL

DS : Disturbed sample **SPT :** Standard Penetration Value **Note: Trial Pit Terminated at 3.20 m depth**

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.30 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-8 (Near to BH-16) **Co-Ordinates :** 42Q, N 2662172, E 564254

Depth of water Below EGL : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Greyish Brownish Silty Clay of Low Plasticity mixed with fine grained sand particles	CL	0.50													
0.5																
1.0	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles	CI	3.30	CORE	144-16-01	1.0	1.787	1.362	31.2	0	0	100	45.4	24.2	21.2	CI
1.5																
2.0				CORE	144-16-02	2.0	1.982	1.787	10.9	0	0	100	47.9	24.6	23.3	CI
2.5																
3.0				CORE	144-16-03	3.0	1.778	1.373	29.5	0	1	99	45.5	25.8	19.8	CI

DS : Disturbed sample **SPT :** Standard Penetration Value **Note: Trial Pit Terminated at 3.30 m depth**

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.20 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-9 (Near to BH-14) **Co-Ordinates :** 42Q, N 2662672, E 561093

Depth of water Below EGL : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Brownish Greyish Clayey Silt of Intermediate Plasticity mixed with little Fines	MI	3.2													
0.5																
1.0				CORE	144-14-01	1.0	1.788	1.509	18.5	0	8	92	40.0	NP		MI
1.5																
2.0				CORE	144-14-02	2.0	1.822	1.379	32.1	0	23	77	38.4	NP		MI
2.5																
3.0				CORE	144-14-03	3.0	2.010	1.544	30.2	0	39	61	32.0	NP		ML

DS : Disturbed sample **SPT :** Standard Penetration Value **Note: Trial Pit Terminated at 3.20 m depth**

Trial Pit

Name of Owner : Gujarat Industries Power Company Limited (GIPCL) **Depth of Pit:** 3.20 m

Name of Project : Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat **Method of Sampling:** Excavated Pit

Trial Pit No. : TP-10 (Near to BH-24) **Co-Ordinates :** 42Q, N 2664665, E 564000

Depth of water Below EG : Not Encountered

Depth (m)	Description of Strata	Legend	Stratum Thickness (mt)	Sampling			Bulk Density, g/cc	Field Dry Density, g/cc	Field Moisture Content, %	Grain Size Analysis			Atterberg's Limit			CLASSIFICATION
				Type	Lab.No.	Depth (m)				% Gravel	%Sand	% Silt & Clay	Liquid limit, %	Plastic limit, %	Plasticity Index, %	
0.0	Greyish Brownish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles	CL	0.50													
0.5																
1.0	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles	CI	2.52	CORE	144-24-01	1.0	1.944	1.532	26.9	0	0	100	39.1	21.1	18.1	CI
1.5																
2.0				CORE	144-24-02	2.0	1.906	1.464	30.2	0	0	100	44.3	23.8	20.5	CI
2.5																
3.0				CORE	144-24-03	3.0	1.897	1.465	29.5	0	0	100	44.8	22.8	22.0	CI

DS : Disturbed sample **SPT :** Standard Penetration Value **Note: Trial Pit Terminated at 3.20 m depth**

ANNEXURE 3: LABORATORY TEST RESULTS & GRAPHS

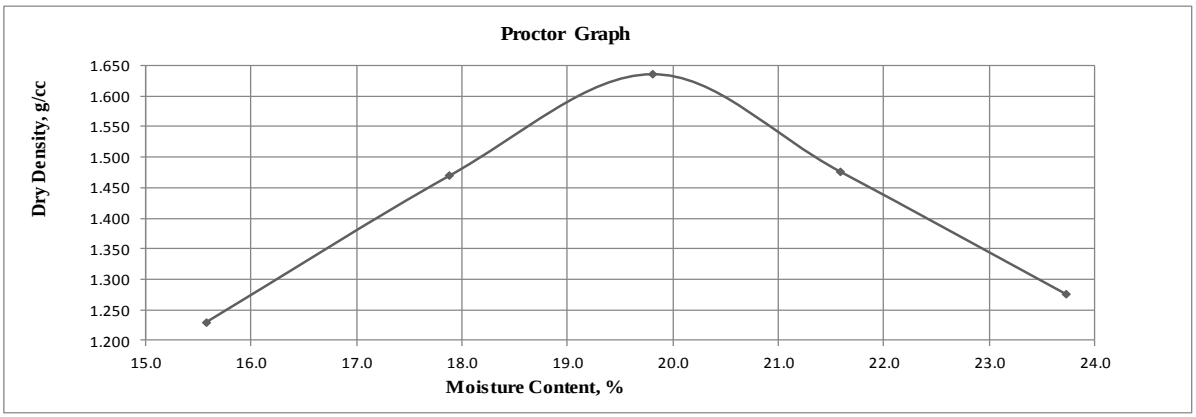
STANDARD PROCTOR GRAPH

TEST REPORT

Source of Sample & Sample ID : BH-1 , Depth: 0.20 m(CI Type)

TEST RESULTS:

Standard Proctor	
M.D.D. gm/cc	**O.M.C %**
1.636	19.8

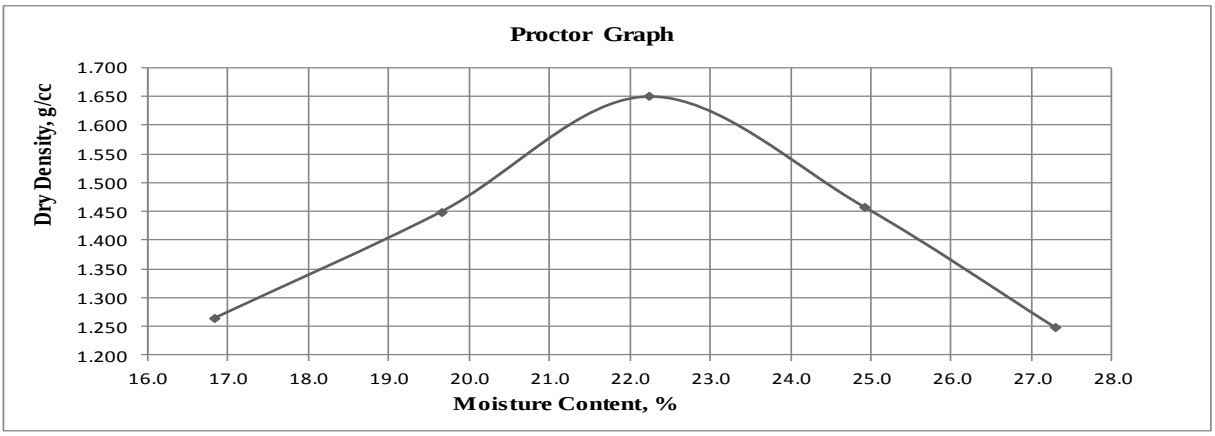


TEST REPORT

Source of Sample & Sample ID: BH-4 , Depth: 0.50 m(CI Type)

TEST RESULTS:

Standard Proctor	
M.D.D. gm/cc	**O.M.C %**
1.649	22.2

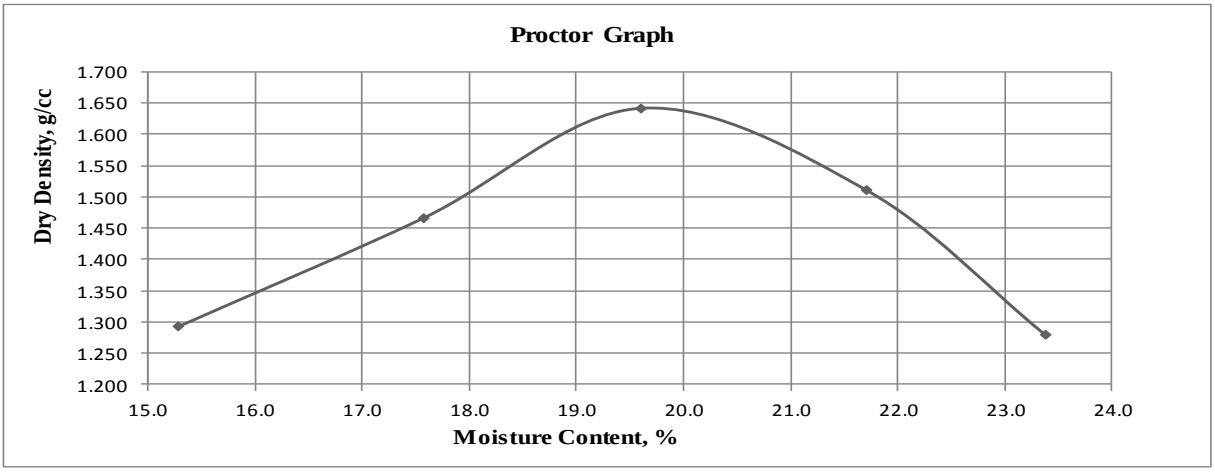


TEST REPORT

Source of Sample & Sample ID : BH-9 , Depth: 0.20 m(CL Type)

TEST RESULTS:

Standard Proctor	
M.D.D. gm/cc	**O.M.C %**
1.641	19.6

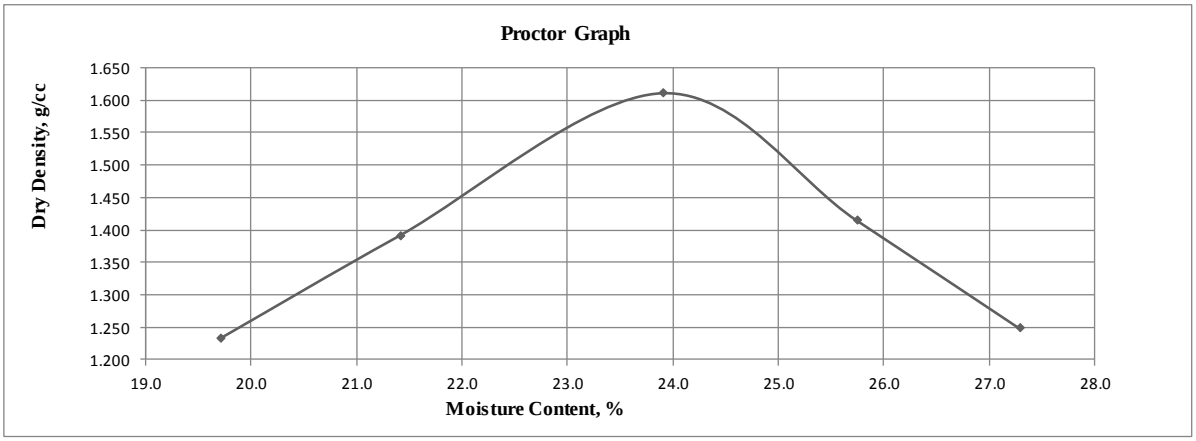


TEST REPORT

Source of Sample & Sample ID : BH-12 , Depth: 0.40 m(CH Type)

TEST RESULTS:

Standard Proctor	
M.D.D. gm/cc	**O.M.C %**
1.611	23.9

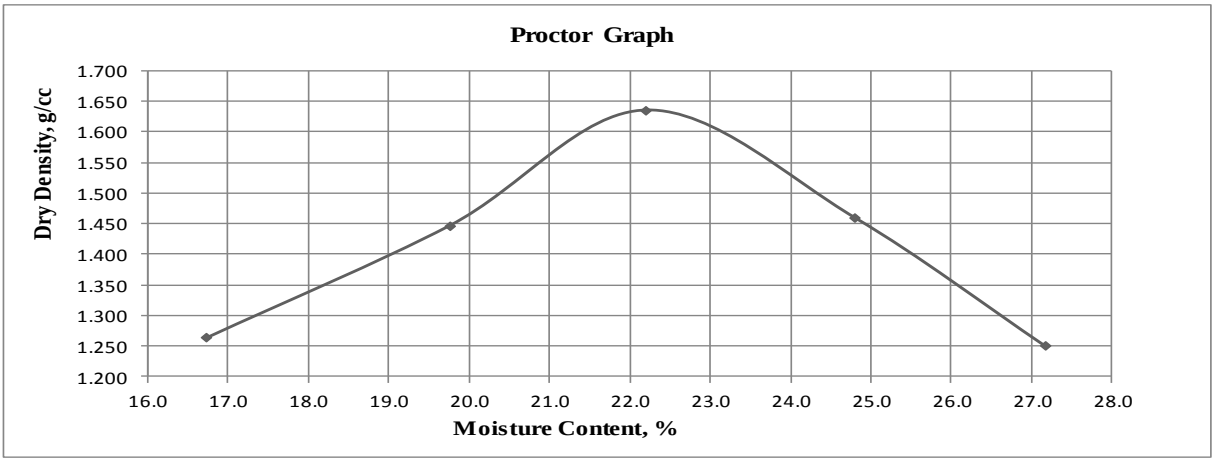


TEST REPORT

Source of Sample & Sample ID: BH-19 , Depth: 0.40 m(MI Type)

TEST RESULTS:

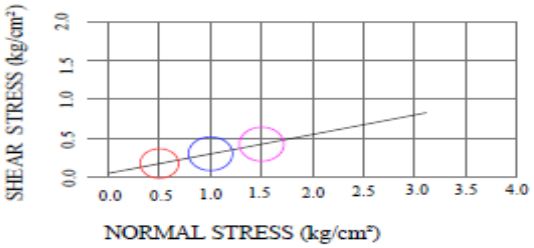
Standard Proctor	
M.D.D. gm/cc	**O.M.C %**
1.635	22.2



TRIAXIAL (T.U.U) & DIRECT SHEAR (D.U.U) TEST

BH-01, Depth - 9.00 m(DUU)

Sr. No.	Normal Stress kg/cm²	Shear Stress kg/cm²
1	0.5	0.17
2	1.0	0.30
3	1.5	0.42

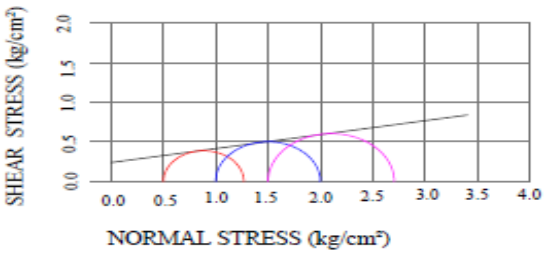


COHESION INTERCEPT 'C' (kg/cm²) = 0.05

ANGLE OF SHEARING RESISTANCE = 14.0°

BH-04, Depth - 9.00 m(TUU)

Sr. No.	Normal Stress kg/cm²	Shear Stress kg/cm²
1	0.5	0.77
2	1.0	1.00
3	1.5	1.21

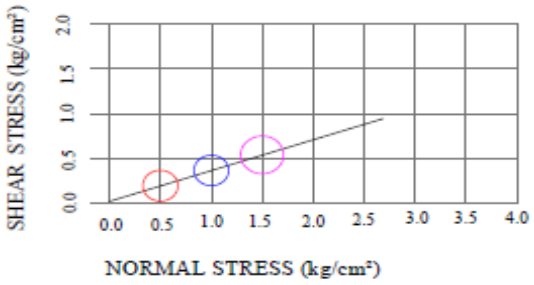


COHESION INTERCEPT 'C' (kg/cm²) = 0.24

ANGLE OF SHEARING RESISTANCE = 10.0°

BH-06, Depth - 6.00 m(DUU)

Sr. No.	Normal Stress kg/cm²	Shear Stress kg/cm²
1	0.5	0.17
2	1.0	0.34
3	1.5	0.52

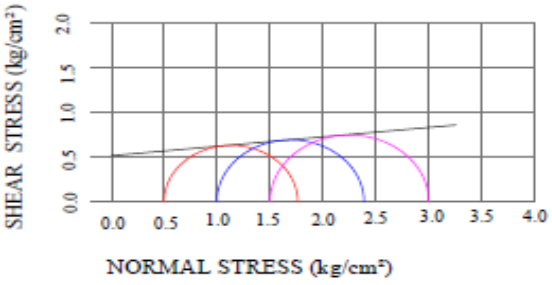


COHESION INTERCEPT 'C' (kg/cm²) = 0.02

ANGLE OF SHEARING RESISTANCE = 19.0°

BH-09, Depth - 27.00 m(TUU)

Sr. No.	Normal Stress kg/cm²	Shear Stress kg/cm²
1	0.5	1.26
2	1.0	1.39
3	1.5	1.50

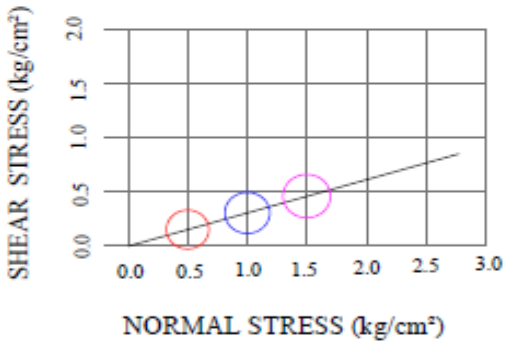


COHESION INTERCEPT 'C' (kg/cm²) = 0.52

ANGLE OF SHEARING RESISTANCE = 6.0°

BH-15, Depth - 9.00 m(DUU)

Sr. No.	Normal Stress kg/cm²	Shear Stress kg/cm²
1	0.5	0.15
2	1.0	0.31
3	1.5	0.46



COHESION INTERCEPT 'C' (kg/cm²) = 0.00

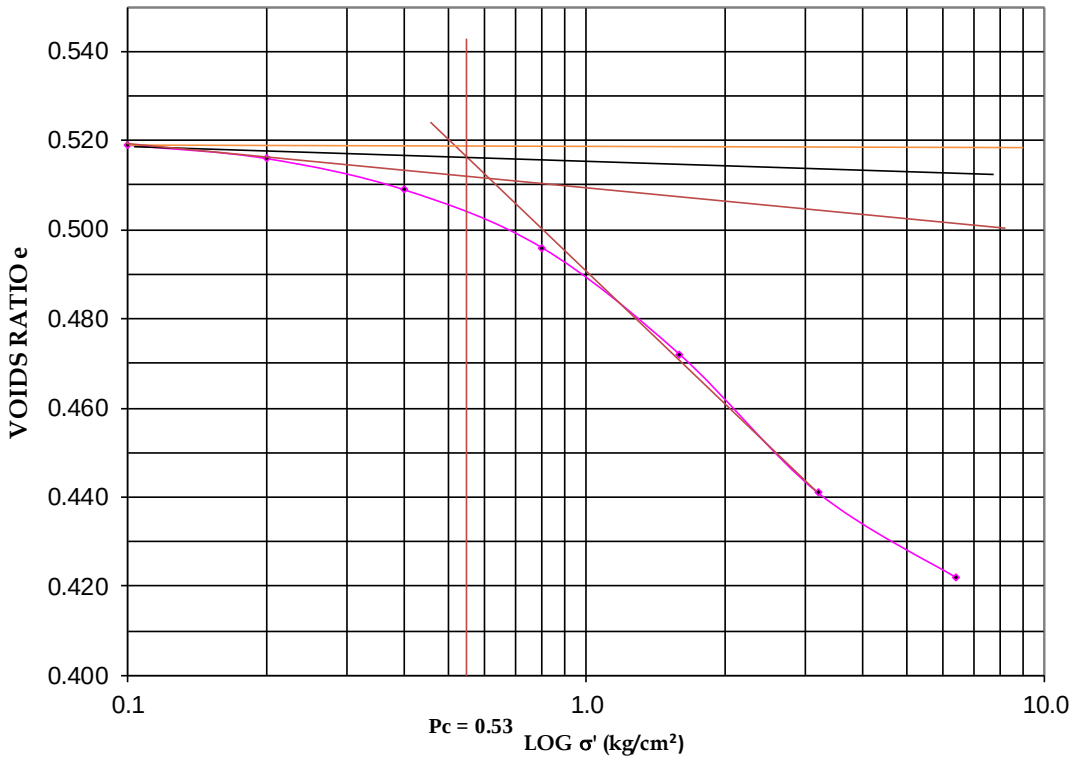
ANGLE OF SHEARING RESISTANCE = 17.0°

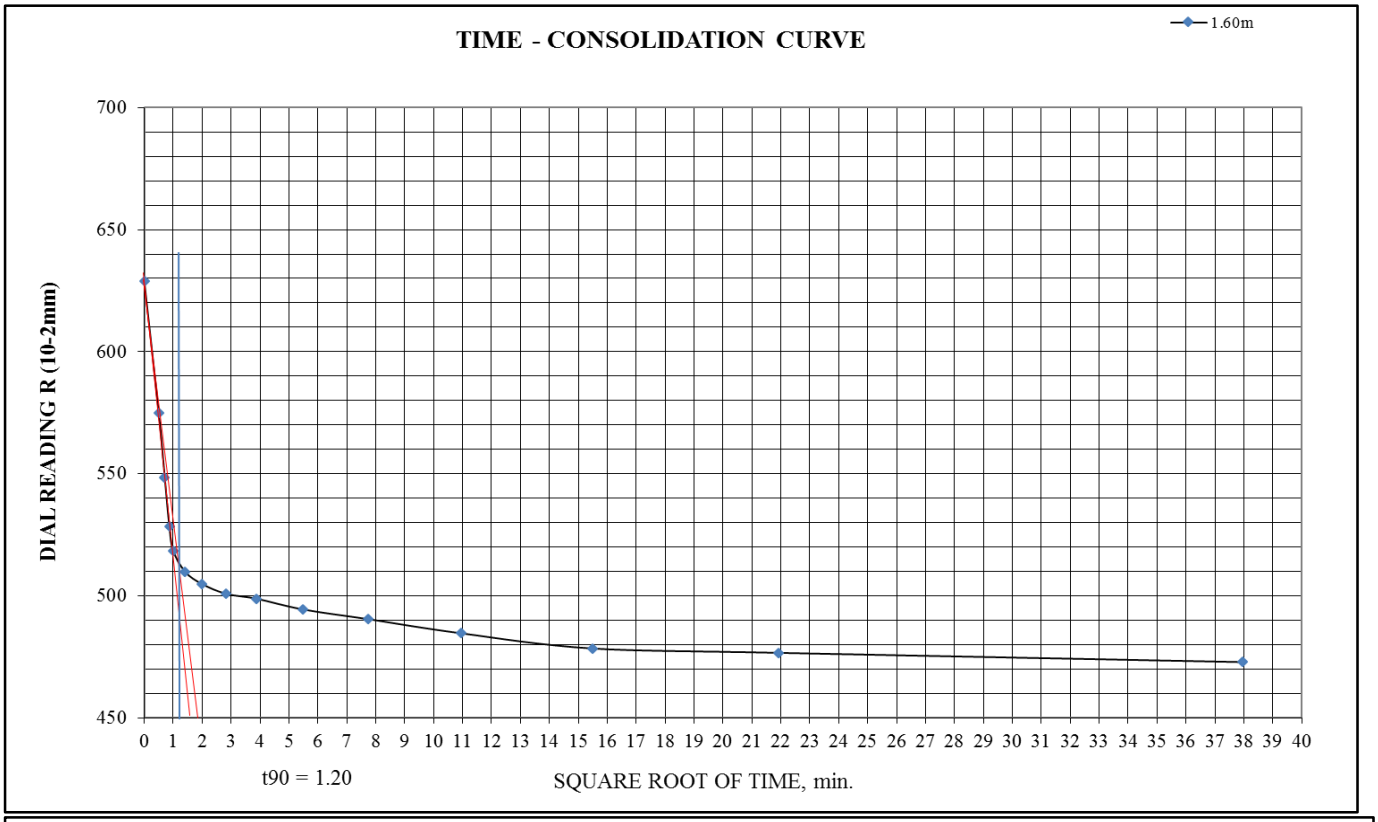
CONSOLIDATION TEST

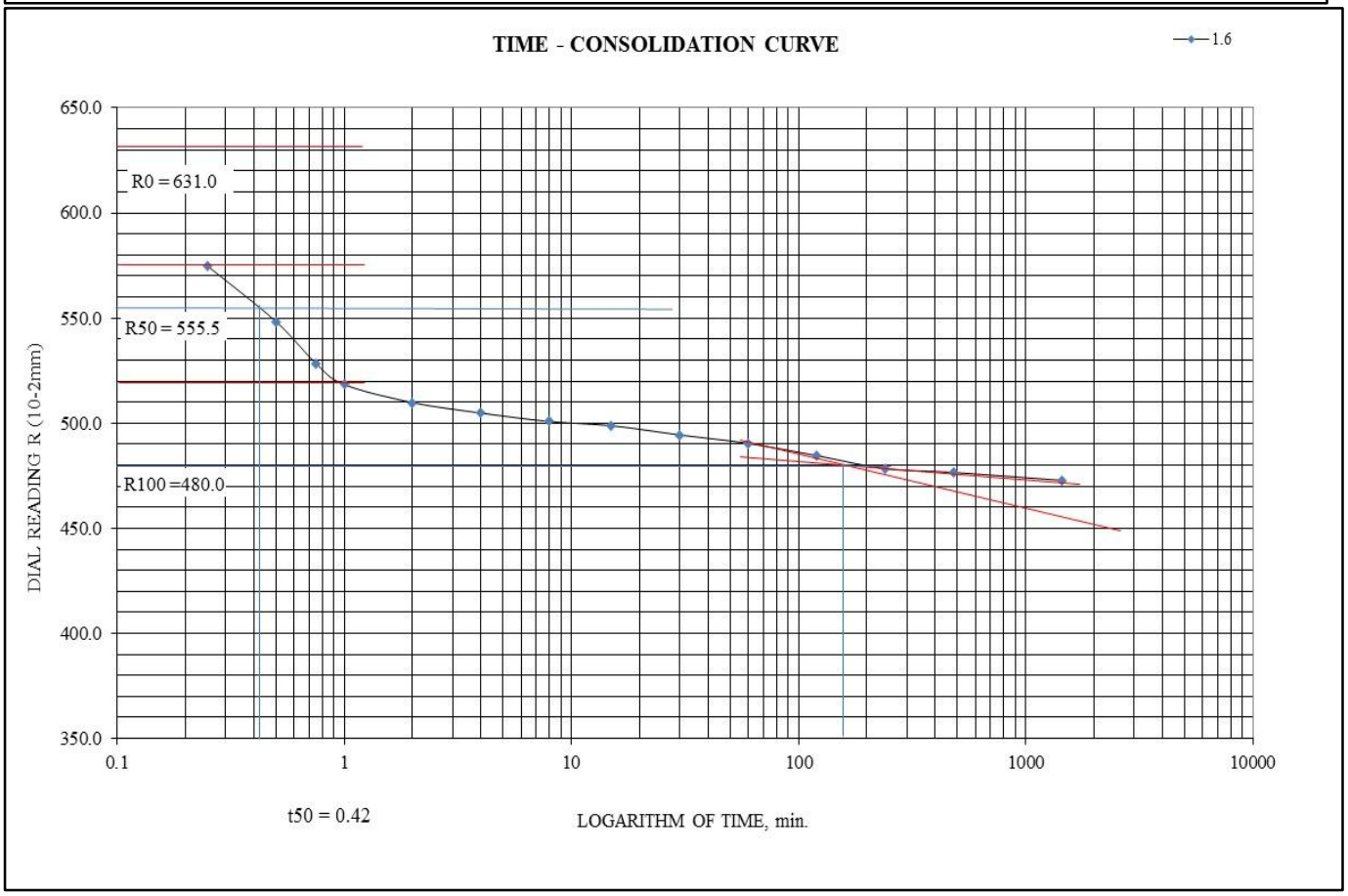
BH : - 1
Depth :- 24.00m
Dry Density : 1.519 gm/cc
Moiture Content :- 22.6 %

APPLIED PRESSURE kg/cm^2	VOID RATIO [e] (H - Hs) / Hs
0.10	0.519
0.20	0.516
0.40	0.509
0.80	0.496
1.60	0.472
3.20	0.441
6.40	0.422

Cc = 0.101
Pc = 0.53, kg/cm^2




TIME - CONSOLIDATION CURVE
1.60m
DIAL READING R (10-2mm)
700
650
600
550
500
450
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
t90 = 1.20
SQUARE ROOT OF TIME, min.

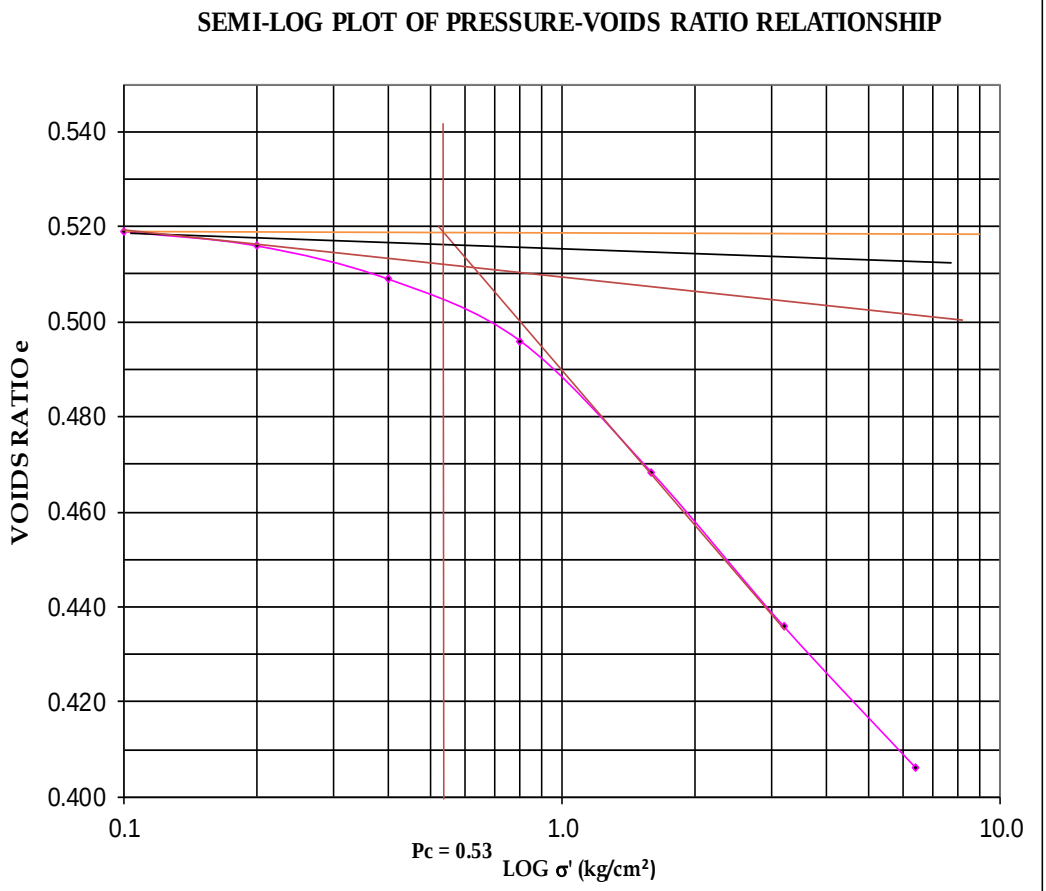

TIME - CONSOLIDATION CURVE
1.6
DIAL READING R (10-2mm)
650.0
600.0
550.0
500.0
450.0
400.0
350.0
R0 = 631.0
R50 = 555.5
R100 = 480.0
0.1
1
10
100
1000
10000
t50 = 0.42
LOGARITHM OF TIME, min.

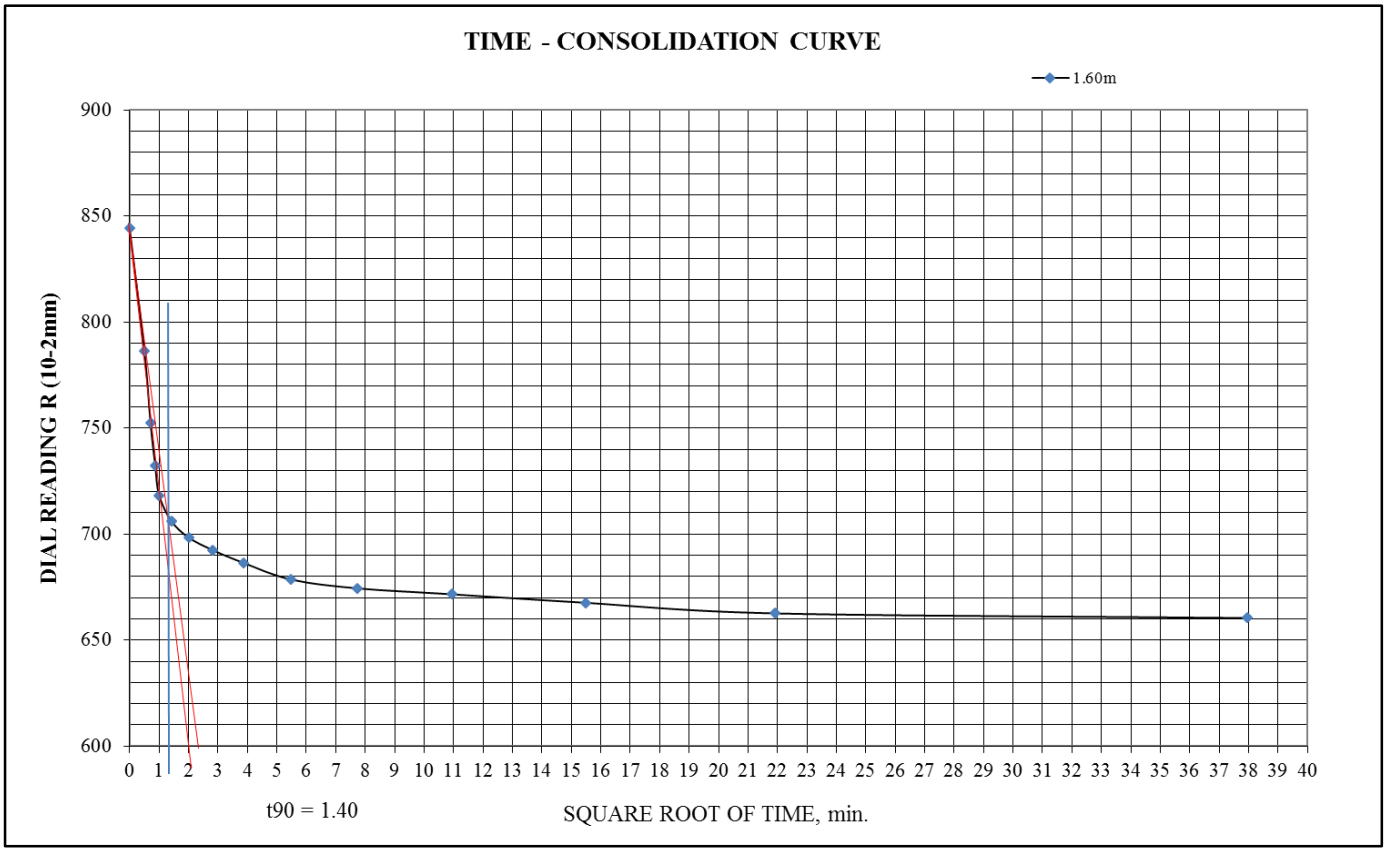
BH : - 4
Depth :- 9.00m
Dry Density : 1.544 gm/cc
Moiture Content :- 23.6 %

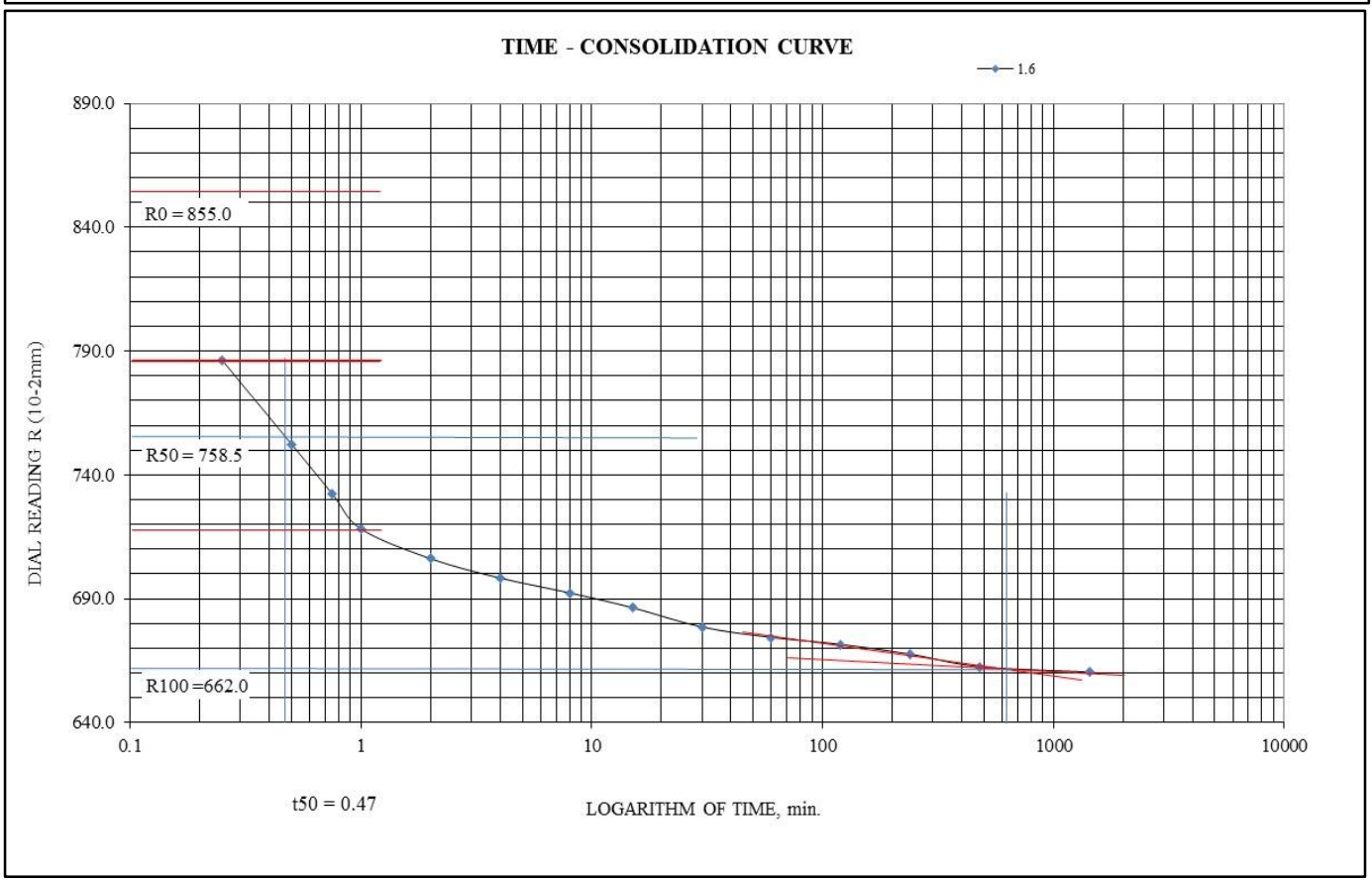
APPLIED PRESSURE kg/cm^2	VOID RATIO [e] (H - Hs) / Hs
0.10	0.519
0.20	0.516
0.40	0.509
0.80	0.496
1.60	0.468
3.20	0.436
6.40	0.406

Cc = 0.108

Pc = 0.53, kg/cm^2




TIME - CONSOLIDATION CURVE
1.60m
DIAL READING R (10-2mm)
900
850
800
750
700
650
600
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
t90 = 1.40
SQUARE ROOT OF TIME, min.

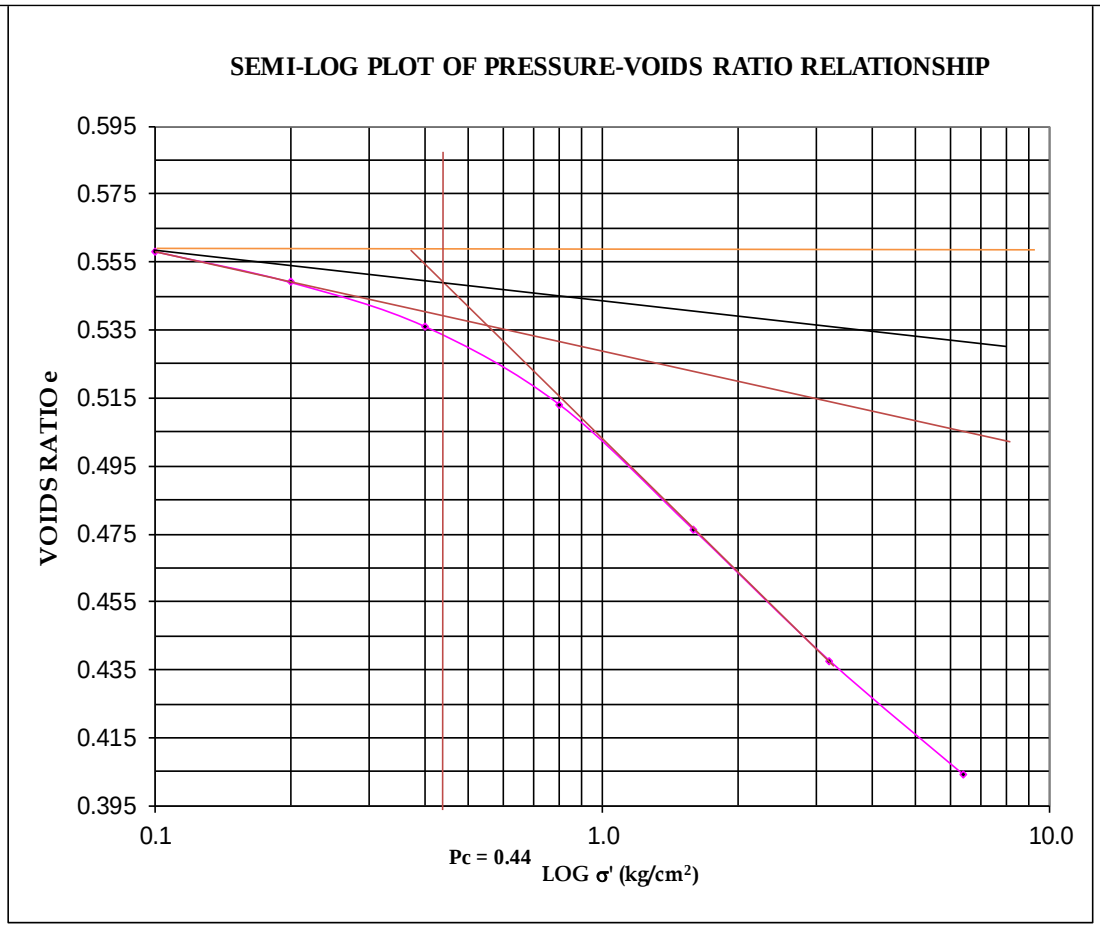

TIME - CONSOLIDATION CURVE
1.6
DIAL READING R (10-2mm)
890.0
840.0
790.0
740.0
690.0
640.0
R0 = 855.0
R50 = 758.5
R100 =662.0
0.1
1
10
100
1000
10000
t50 = 0.47
LOGARITHM OF TIME, min.

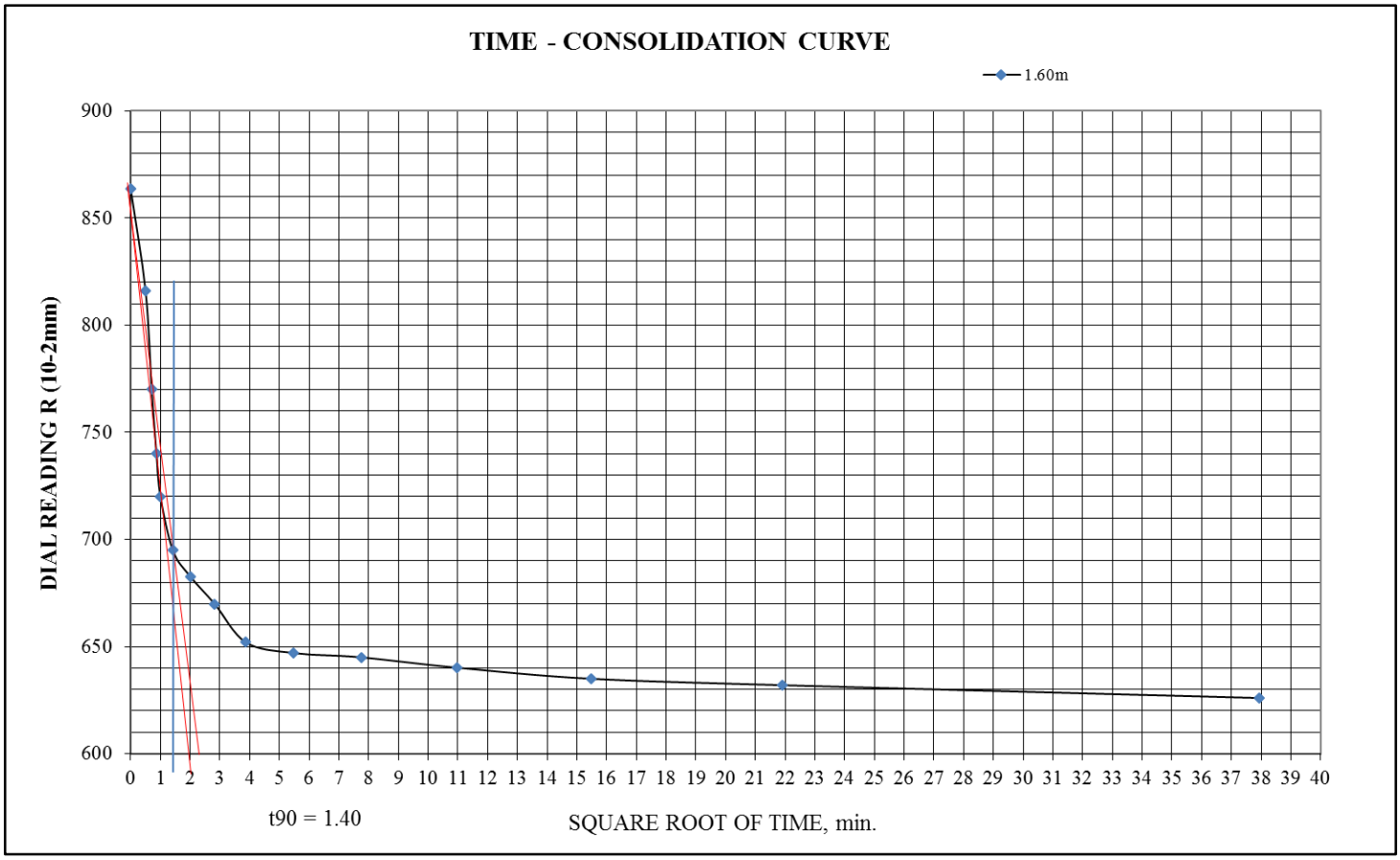
BH : - 11
Depth :- 18.00m
Dry Density : 1.586 gm/cc
Moiture Content :- 20.9 %

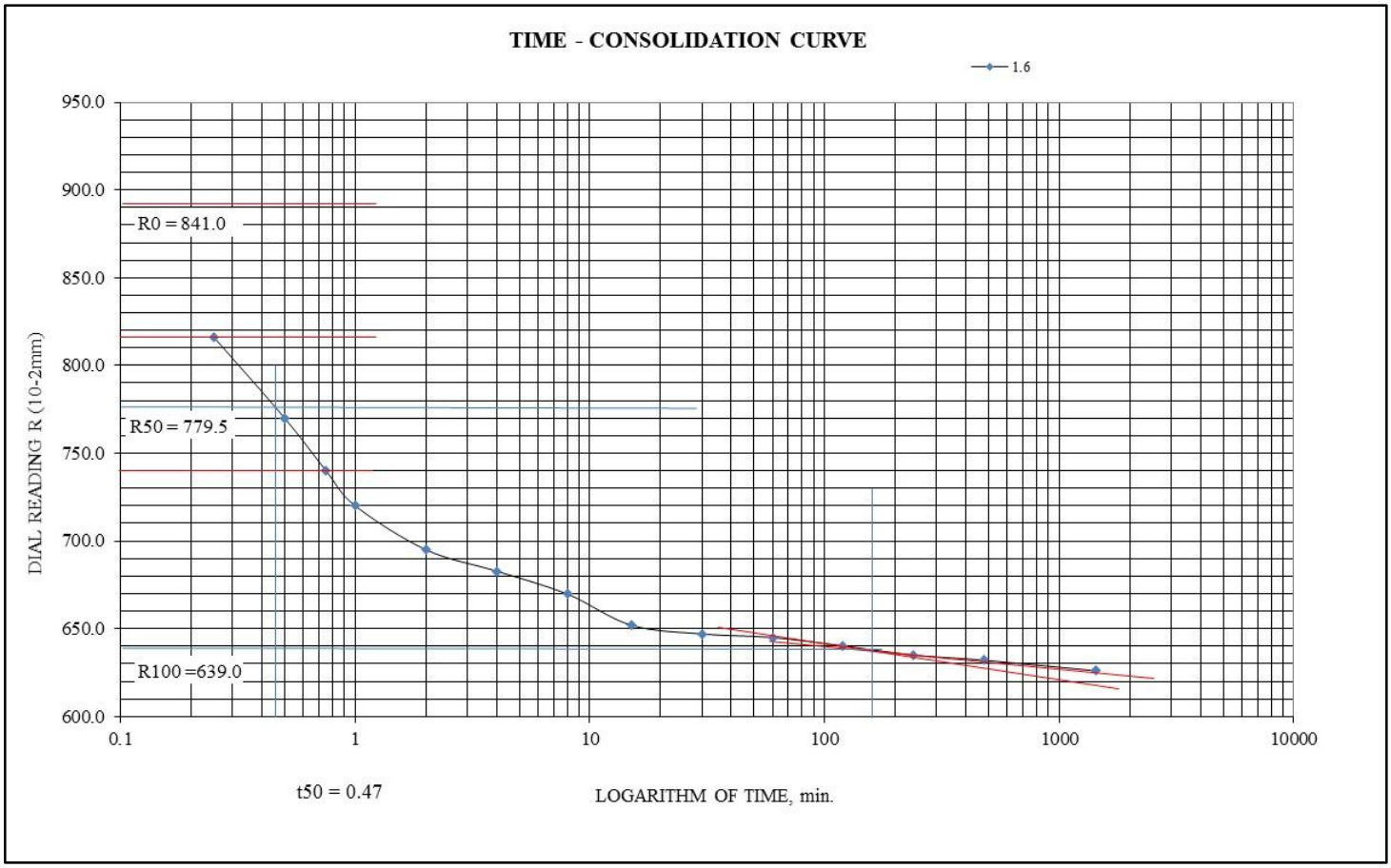
APPLIED PRESSURE kg/cm^2	VOID RATIO [e] (H - Hs) / Hs
0.10	0.558
0.20	0.549
0.40	0.536
0.80	0.513
1.60	0.476
3.20	0.438
6.40	0.404

Cc = 0.127

Pc = 0.44, kg/cm^2



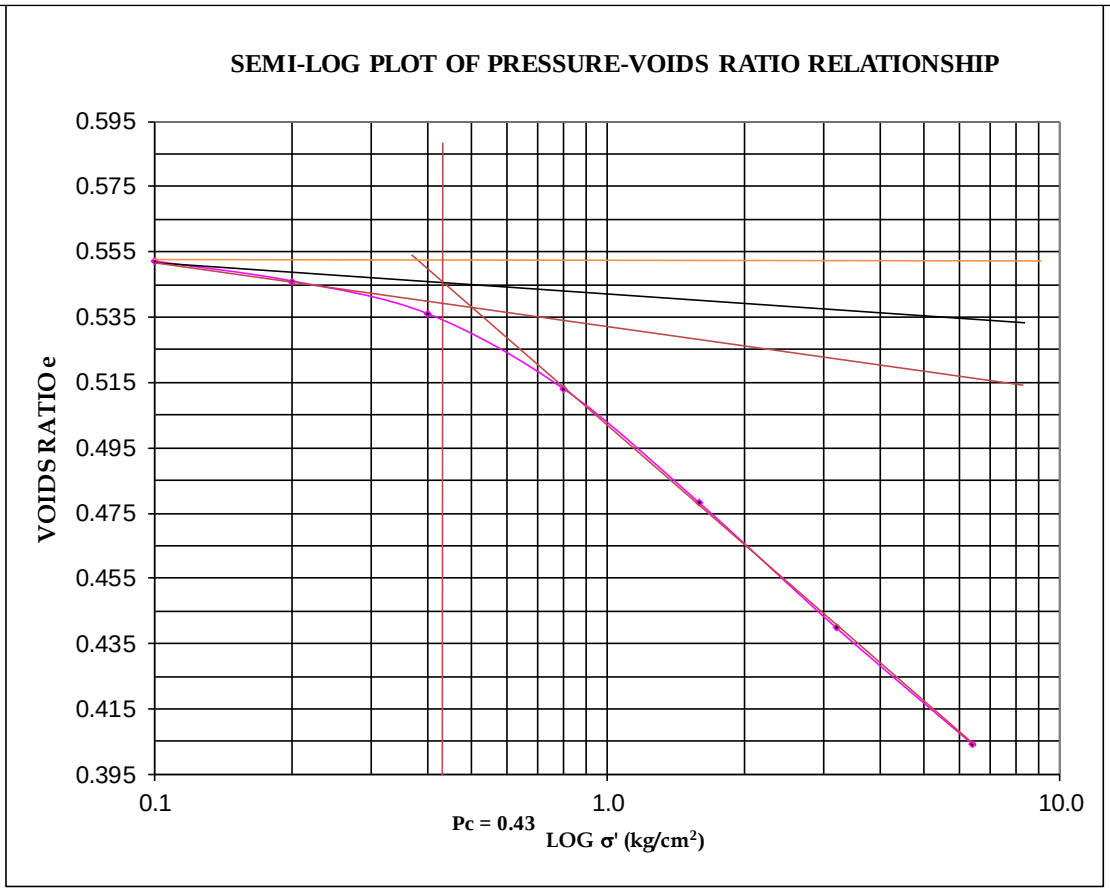

TIME - CONSOLIDATION CURVE
1.60m
DIAL READING R (10-2mm)
900
850
800
750
700
650
600
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
t90 = 1.40
SQUARE ROOT OF TIME, min.

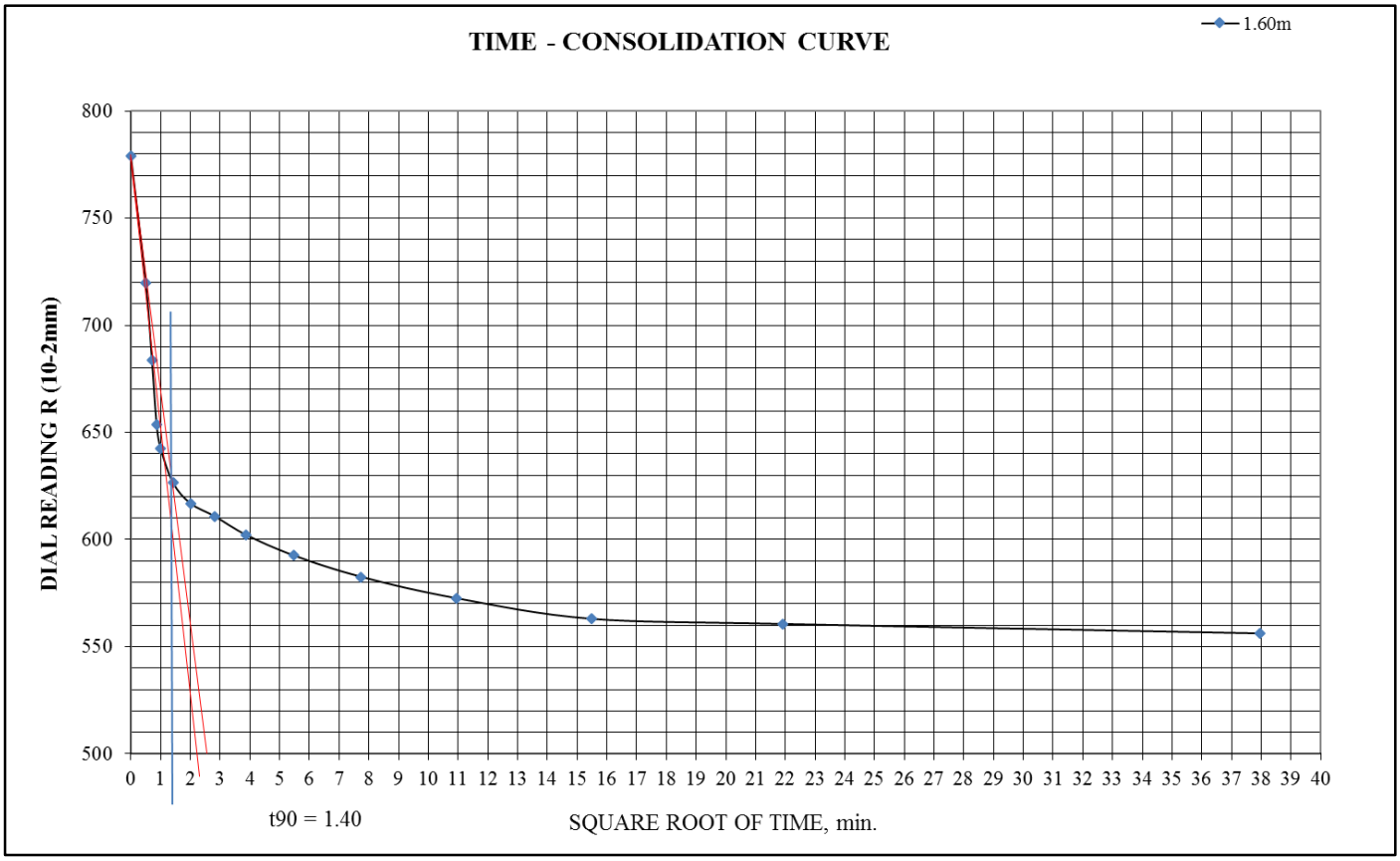

TIME - CONSOLIDATION CURVE
1.6
950.0
900.0
850.0
800.0
750.0
700.0
650.0
600.0
R0 = 841.0
R50 = 779.5
R100 =639.0
DIAL READING R (10-2mm)
0.1
1
10
100
1000
10000
t50 = 0.47
LOGARITHM OF TIME, min.

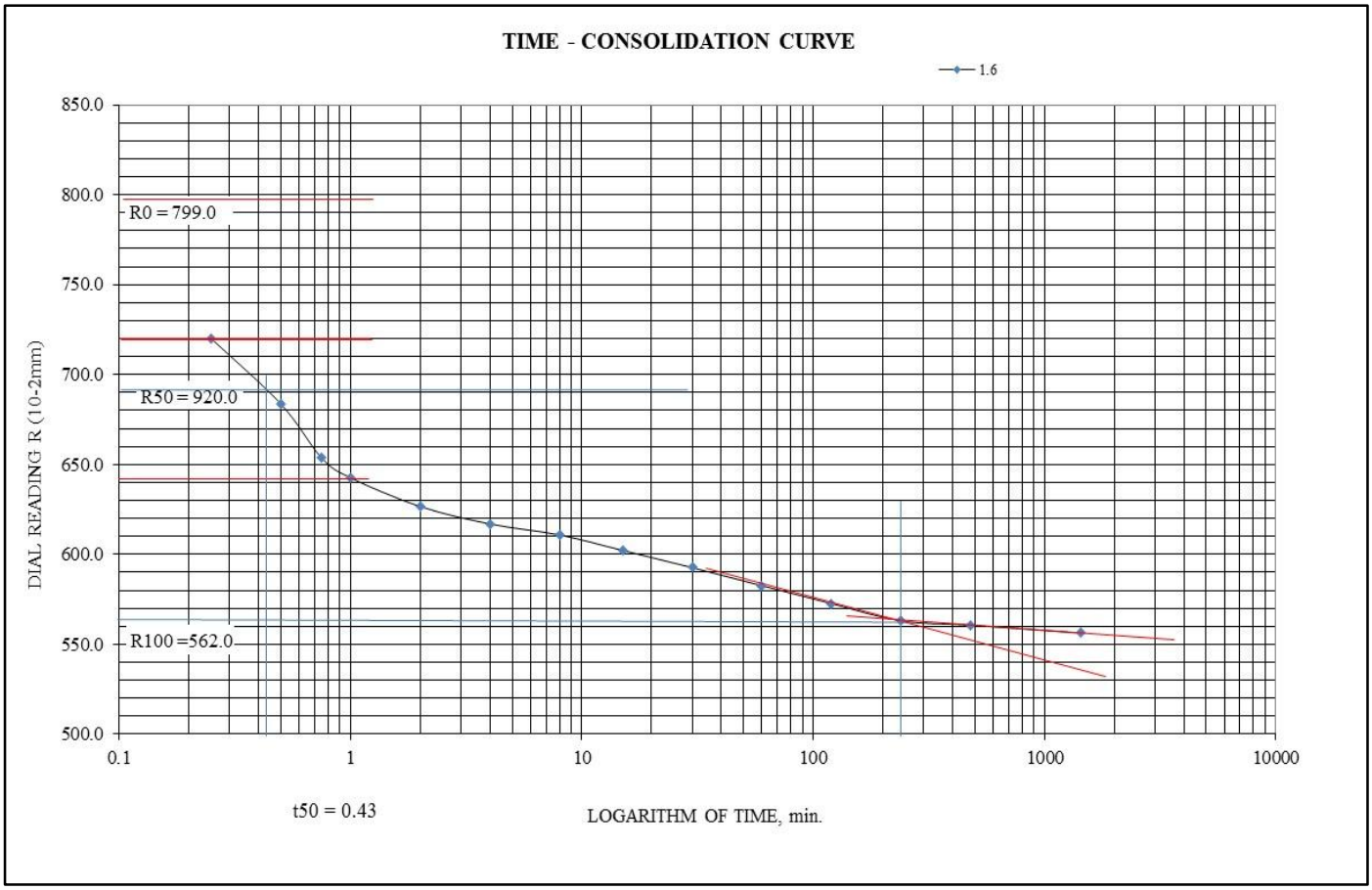
BH : - 16
Depth :- 15.00m
Dry Density : 1.538 gm/cc
Moiture Content :- 24.3 %

APPLIED PRESSURE kg/cm^2	VOID RATIO [e] (H - Hs) / Hs
0.10	0.552
0.20	0.546
0.40	0.536
0.80	0.513
1.60	0.478
3.20	0.440
6.40	0.404

Cc = 0.118
Pc = 0.43, kg/cm^2




TIME - CONSOLIDATION CURVE
1.60m
DIAL READING R (10-2mm)
800
750
700
650
600
550
500
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
t90 = 1.40
SQUARE ROOT OF TIME, min.

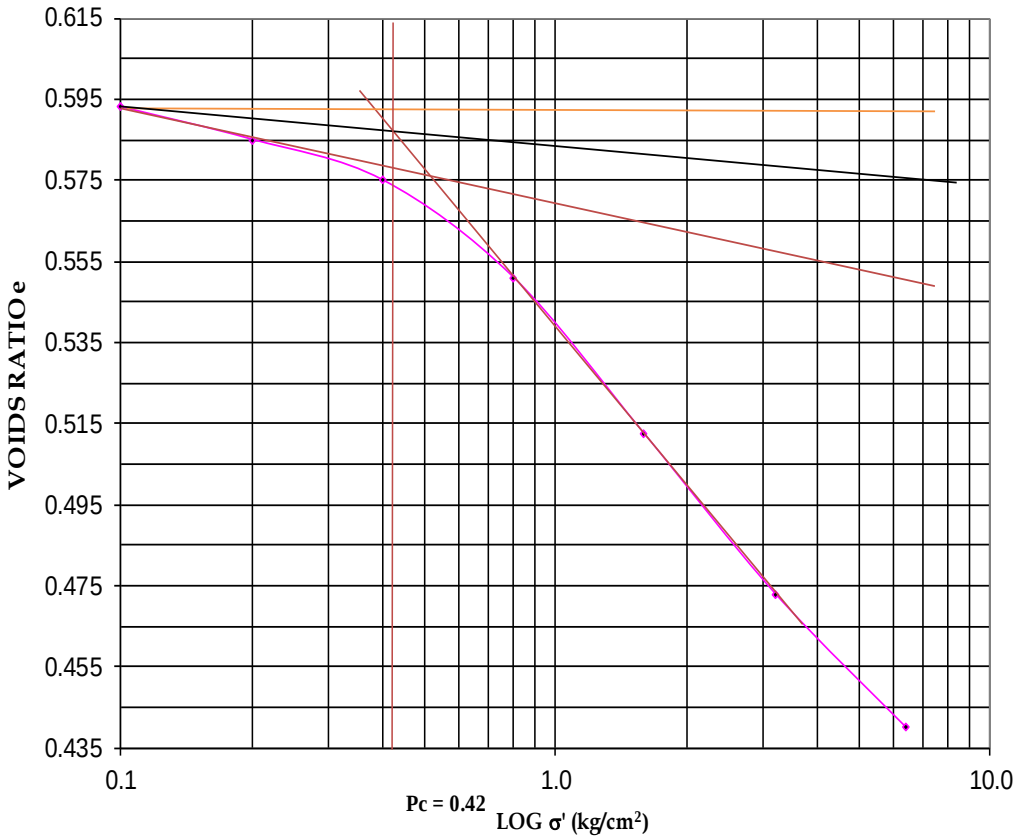

TIME - CONSOLIDATION CURVE
1.6
850.0
800.0
750.0
700.0
650.0
600.0
550.0
500.0
R0 = 799.0
R50 = 920.0
R100 =562.0
DIAL READING R (10-2mm)
0.1
1
10
100
1000
10000
t50 = 0.43
LOGARITHM OF TIME, min.

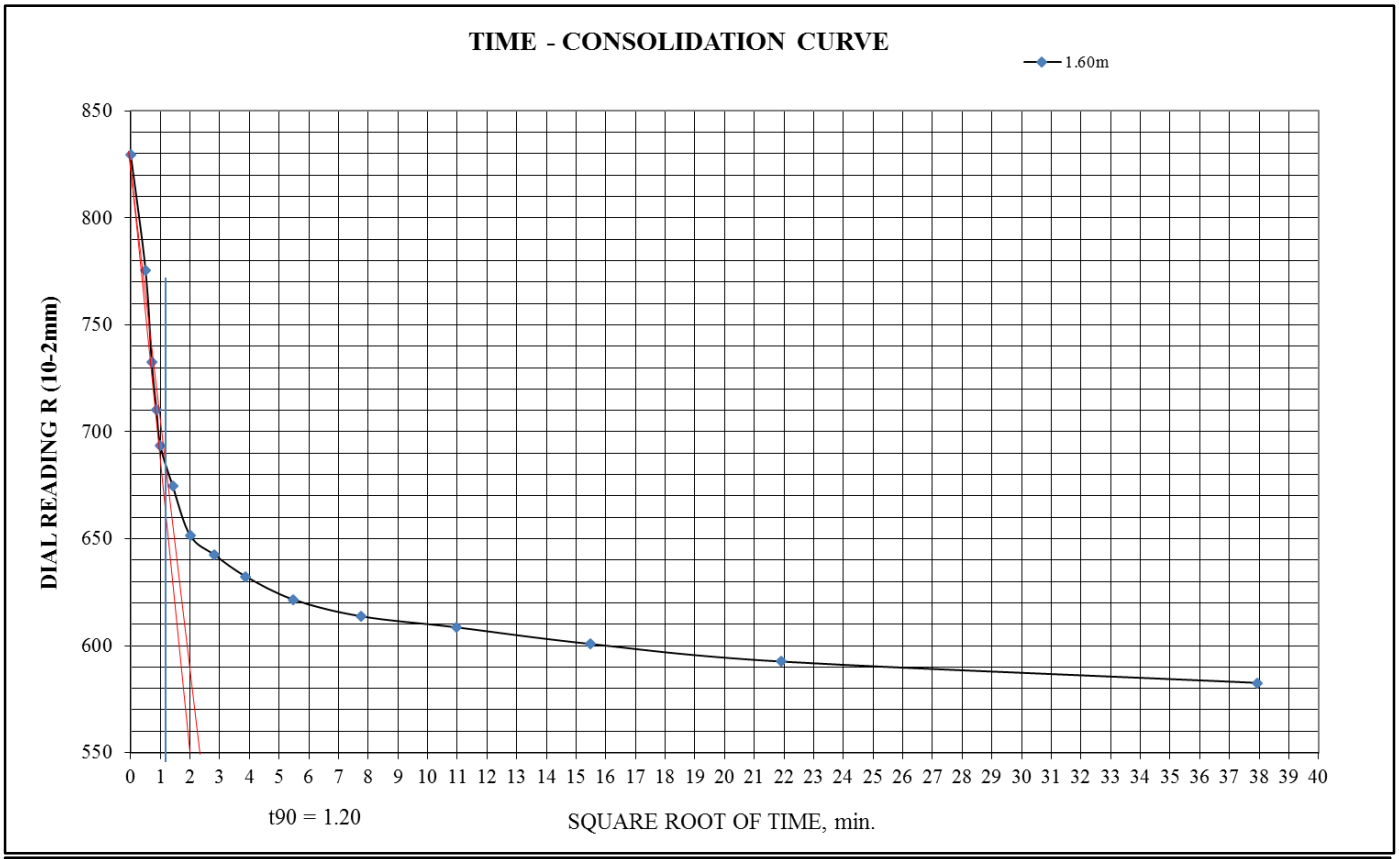
BH : - 23
Depth :- 3.00m
Dry Density : 1.422 gm/cc
Moiture Content :- 30.4 %

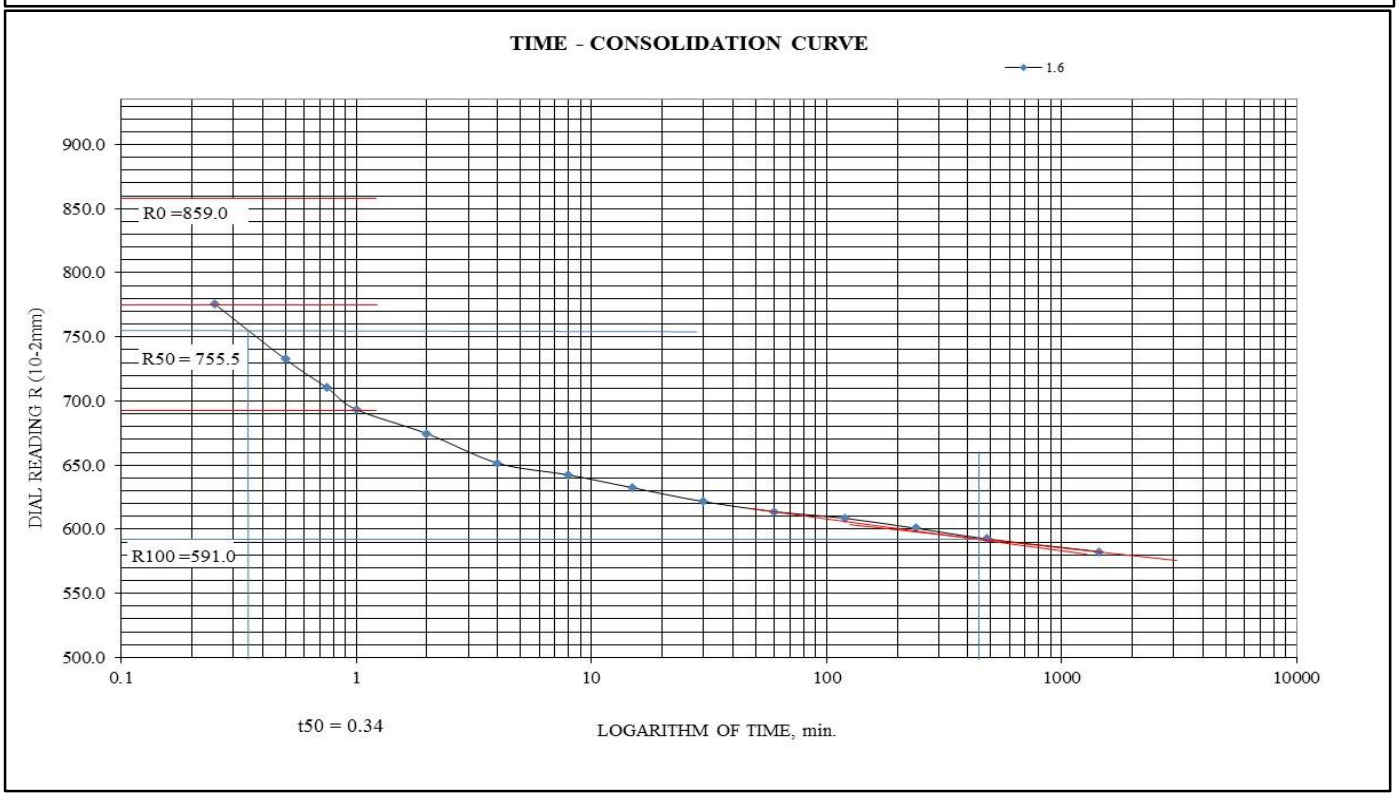
APPLIED PRESSURE kg/cm^2	VOID RATIO [e] (H - Hs) / Hs
0.10	0.593
0.20	0.585
0.40	0.575
0.80	0.551
1.60	0.512
3.20	0.473
6.40	0.440

Cc = 0.131

Pc = 0.42, kg/cm^2




TIME - CONSOLIDATION CURVE
1.60m
DIAL READING R (10-2mm)
850
800
750
700
650
600
550
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
t90 = 1.20
SQUARE ROOT OF TIME, min.

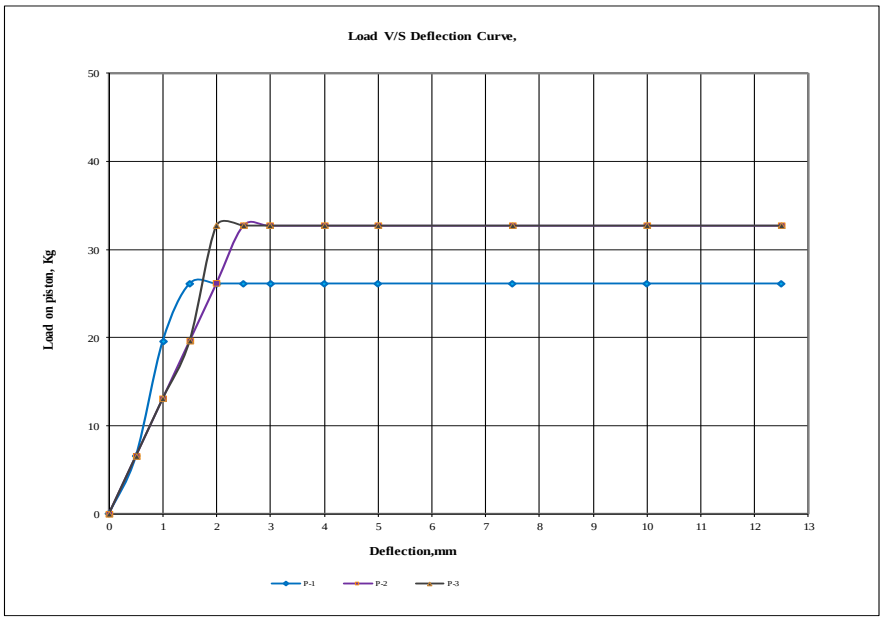

TIME - CONSOLIDATION CURVE
1.6
DIAL READING R (10-2mm)
900.0
850.0
800.0
750.0
700.0
650.0
600.0
550.0
500.0
R0 =859.0
R50 = 755.5
R100 =591.0
0.1
1
10
100
1000
10000
t50 = 0.34
LOGARITHM OF TIME, min.

ANNEXURE 4: FIELD TEST RESULTS

Location	:	CBR Point No.1	**Date:28-12-2020**
Co-ordinates	:	N 2659623.3080,E 558633.2562	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**1.91**	
Moisture Content, %	:	24.60	
Density, g/cc	:	1.419	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	26.1	1.91	32.7	2.38	1.0	2.38
Bearing Ratio at 5.0mm Penetration	2055.0	26.1	1.27	32.7	1.59	1.0	1.59

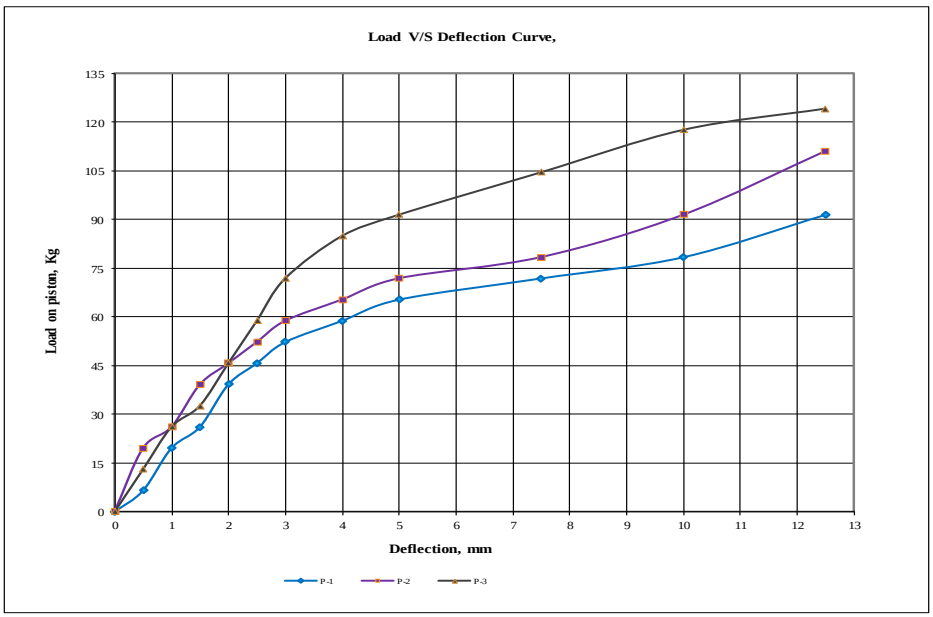
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	6.5	6.5	6.5
1900	1.0	19.6	13.1	13.1
1850	1.5	26.1	19.6	19.6
1800	2.0	26.1	26.1	32.7
1750	2.5	26.1	32.7	32.7
1700	3.0	26.1	32.7	32.7
1600	4.0	26.1	32.7	32.7
1500	5.0	26.1	32.7	32.7
1250	7.5	26.1	32.7	32.7
1000	10.0	26.1	32.7	32.7
750	12.5	26.1	32.7	32.7



Location	:	CBR Point No.2	**Date:28-12-2020**
Co-ordinates	:	N 2658812.9316,E 561969.7025	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**3.34**	
Moisture Content, %	:	23.80	
Density, g/cc	:	1.512	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	3.34	248.1	3.82	320.7	4.29
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	2.54	308.6	2.86	399.3	4.45

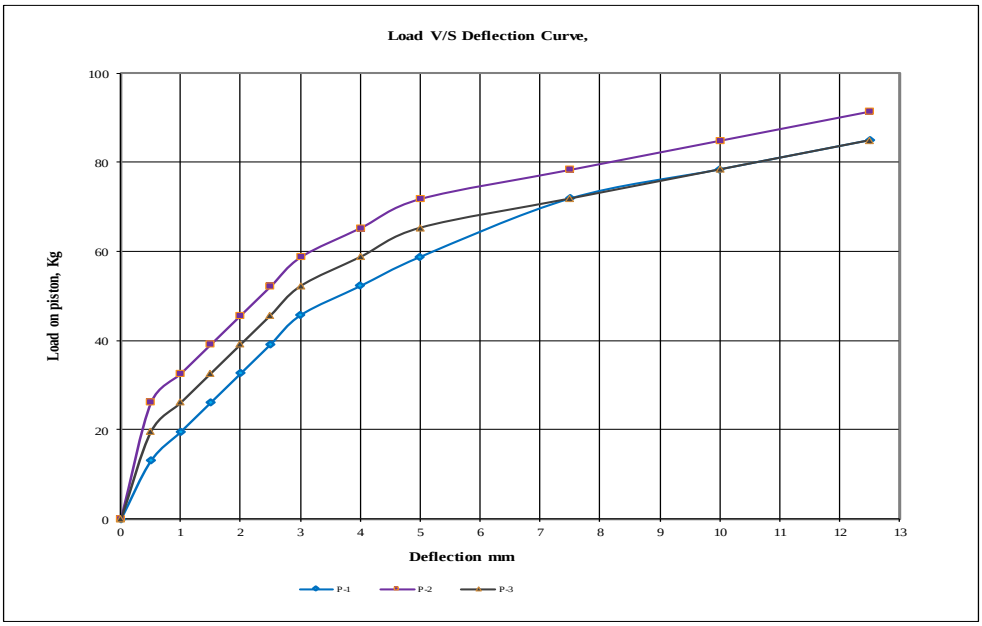
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	6.5	19.6	13.1
1900	1.0	19.6	26.1	26.1
1850	1.5	26.1	39.2	32.7
1800	2.0	39.2	45.7	45.7
1750	2.5	45.7	52.3	58.8
1700	3.0	52.3	58.8	71.9
1600	4.0	58.8	65.3	84.9
1500	5.0	65.3	71.9	91.5
1250	7.5	71.9	78.4	104.5
1000	10.0	78.4	91.5	117.6
750	12.5	91.5	111.1	124.1



Location	:	CBR Point No.3	**Date:28-12-2020**
Co-ordinates	:	N 2656902.2585,E 561188.5614	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**2.86**	
Moisture Content, %	:	24.80	
Density, g/cc	:	1.432	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),K**	**CBR Value,%**	**Test Load,(Pt),K**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	2.86	248.1	3.82	320.7	3.34
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	2.23	308.6	2.86	399.3	3.18

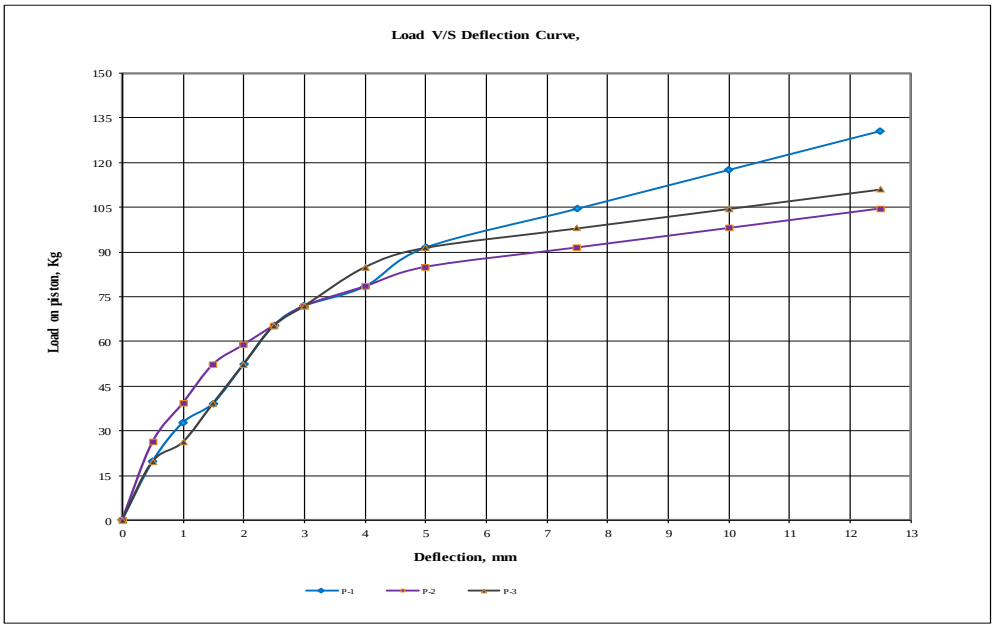
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	13.1	26.1	19.6
1900	1.0	19.6	32.7	26.1
1850	1.5	26.1	39.2	32.7
1800	2.0	32.7	45.7	39.2
1750	2.5	39.2	52.3	45.7
1700	3.0	45.7	58.8	52.3
1600	4.0	52.3	65.3	58.8
1500	5.0	58.8	71.9	65.3
1250	7.5	71.9	78.4	71.9
1000	10.0	78.4	84.9	78.4
750	12.5	84.9	91.5	84.9



Location	:	CBR Point No.4	**Date:28-12-2020**
Co-ordinates	:	N 2658391.1808,E 560232.0232	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**4.77**	
Moisture Content, %	:	24.90	
Density, g/cc	:	1.532	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	4.77	248.1	4.77	320.7	4.77
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	3.50	308.6	3.50	399.3	4.45

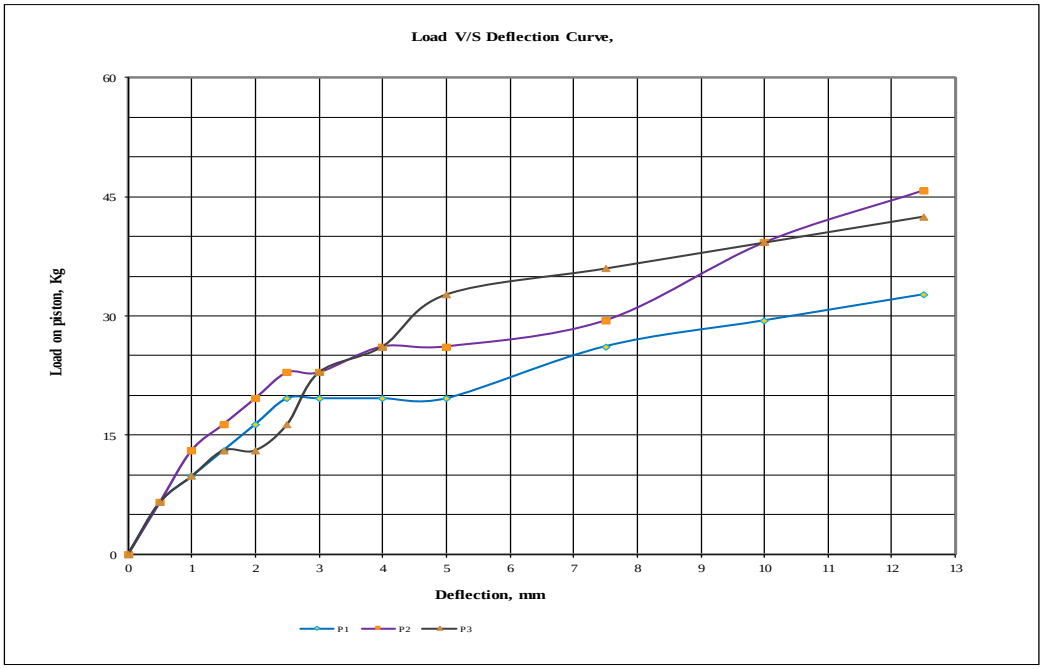
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	19.6	26.1	19.6
1900	1.0	32.7	39.2	26.1
1850	1.5	39.2	52.3	39.2
1800	2.0	52.3	58.8	52.3
1750	2.5	65.3	65.3	65.3
1700	3.0	71.9	71.9	71.9
1600	4.0	78.4	78.4	84.9
1500	5.0	91.5	84.9	91.5
1250	7.5	104.5	91.5	98.0
1000	10.0	117.6	98.0	104.5
750	12.5	130.7	104.5	111.1



Location	:	CBR Point No.5	**Date:28-12-2020**
Co-ordinates	:	N 2657549.9039,E 563210.4914	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**1.19**	
Moisture Content, %	:	26.10	
Density, g/cc	:	1.421	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	1.43	248.1	1.67	320.7	1.19
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	0.95	308.6	1.11	399.3	1.59

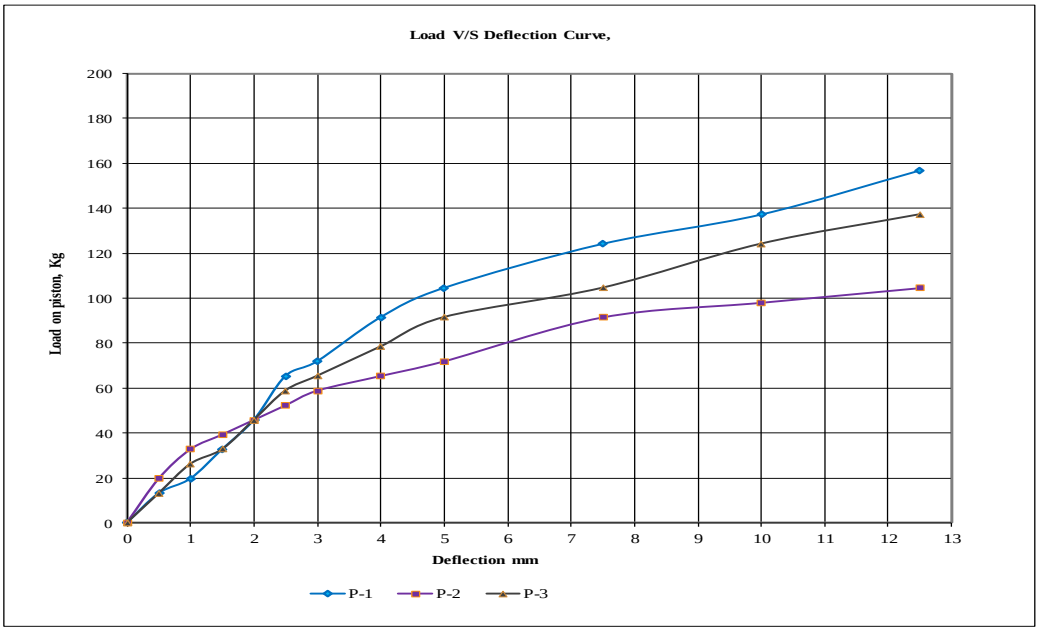
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	6.5	6.5	6.5
1900	1.0	9.8	13.1	9.8
1850	1.5	13.1	16.3	13.1
1800	2.0	16.3	19.6	13.1
1750	2.5	19.6	22.9	16.3
1700	3.0	19.6	22.9	22.9
1600	4.0	19.6	26.1	26.1
1500	5.0	19.6	26.1	32.7
1250	7.5	26.1	29.4	35.9
1000	10.0	29.4	39.2	39.2
750	12.5	32.7	45.7	42.5



Location	:	CBR Point No.6	**Date:-28-12-2020**
Co-ordinates	:	N 2661039.8338,E 560266.7423	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**3.82**	
Moisture Content, %	:	23.80	
Density, g/cc	:	1.539	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	4.77	248.1	3.82	320.7	4.29
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	3.50	308.6	2.86	399.3	4.45

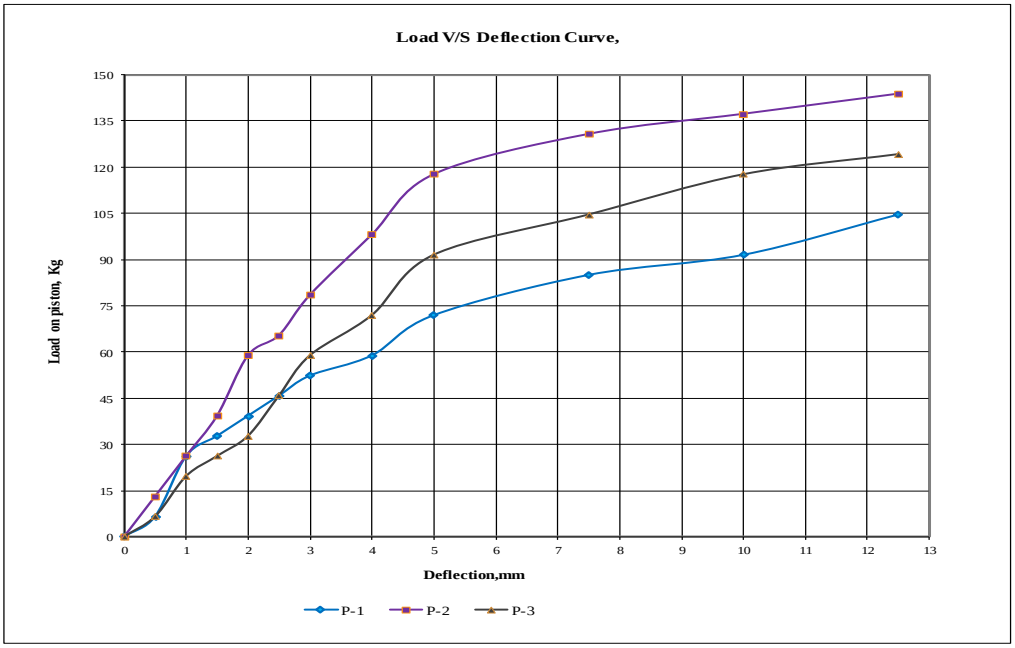
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	13.1	19.6	13.1
1900	1.0	19.6	32.7	26.1
1850	1.5	32.7	39.2	32.7
1800	2.0	45.7	45.7	45.7
1750	2.5	65.3	52.3	58.8
1700	3.0	71.9	58.8	65.3
1600	4.0	91.5	65.3	78.4
1500	5.0	104.5	71.9	91.5
1250	7.5	124.1	91.5	104.5
1000	10.0	137.2	98.0	124.1
750	12.5	156.8	104.5	137.2



Location	:	CBR Point No.7	**Date:28-12-2020**
Co-ordinates	:	N 2661187.7214,E 563195.3339	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**3.34**	
Moisture Content, %	:	24.40	
Density, g/cc	:	1.471	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	3.34	248.1	4.77	320.7	3.34
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	2.54	308.6	3.82	399.3	4.45

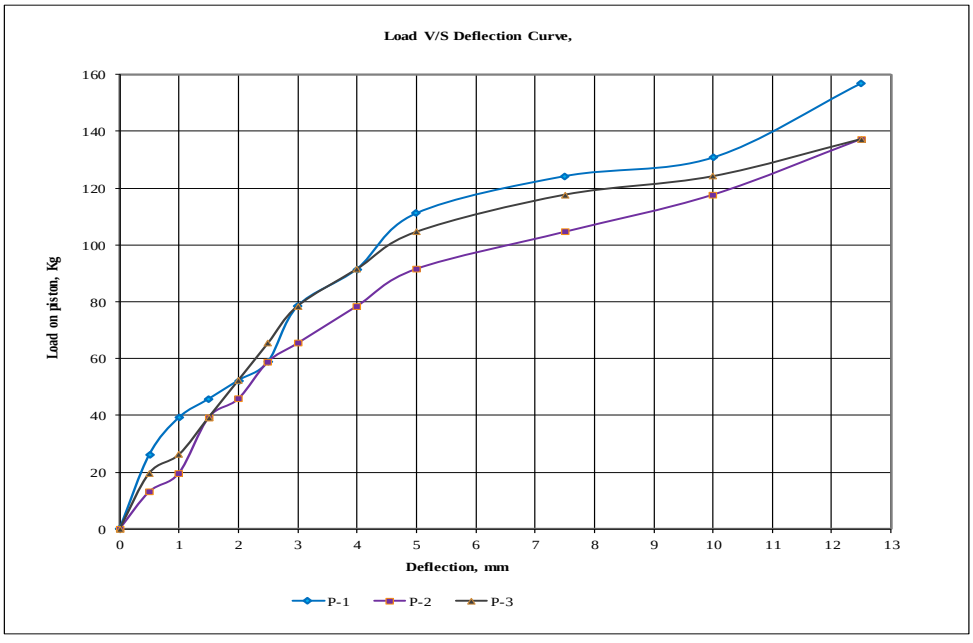
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	6.5	13.1	6.5
1900	1.0	26.1	26.1	19.6
1850	1.5	32.7	39.2	26.1
1800	2.0	39.2	58.8	32.7
1750	2.5	45.7	65.3	45.7
1700	3.0	52.3	78.4	58.8
1600	4.0	58.8	98.0	71.9
1500	5.0	71.9	117.6	91.5
1250	7.5	84.9	130.7	104.5
1000	10.0	91.5	137.2	117.6
750	12.5	104.5	143.7	124.1



Location	:	CBR Point No.8	**Date:28-12-2020**
Co-ordinates	:	N 2663200.7089,E 564112.0968	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**4.29**	
Moisture Content, %	:	26.00	
Density, g/cc	:	1.506	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	4.29	248.1	4.29	320.7	4.77
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	3.82	308.6	3.18	399.3	5.09

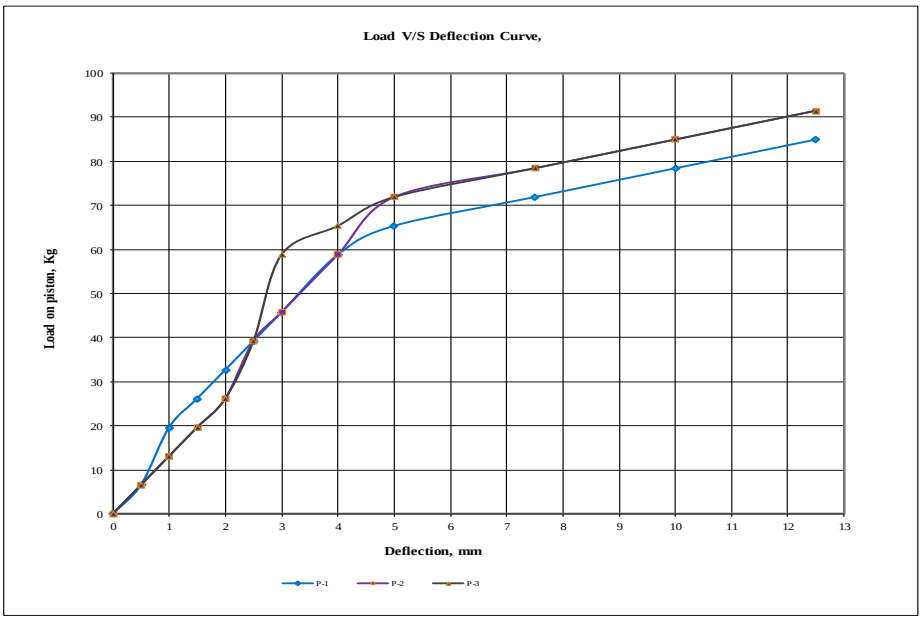
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	26.1	13.1	19.6
1900	1.0	39.2	19.6	26.1
1850	1.5	45.7	39.2	39.2
1800	2.0	52.3	45.7	52.3
1750	2.5	58.8	58.8	65.3
1700	3.0	78.4	65.3	78.4
1600	4.0	91.5	78.4	91.5
1500	5.0	111.1	91.5	104.5
1250	7.5	124.1	104.5	117.6
1000	10.0	130.7	117.6	124.1
750	12.5	156.8	137.2	137.2



Location	:	CBR Point No.9	**Date:28-12-2020**
Co-ordinates	:	N 2663360.0982,E 559776.7638	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**2.86**	
Moisture Content, %	:	29.60	
Density, g/cc	:	1.413	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	2.86	248.1	2.86	320.7	2.86
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	2.23	308.6	2.23	399.3	3.50

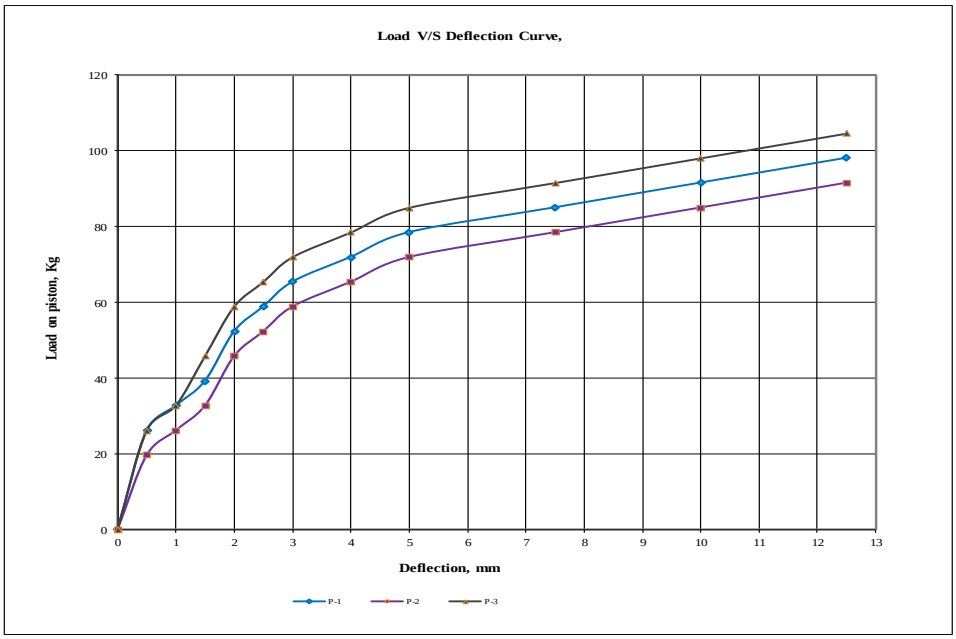
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	6.5	6.5	6.5
1900	1.0	19.6	13.1	13.1
1850	1.5	26.1	19.6	19.6
1800	2.0	32.7	26.1	26.1
1750	2.5	39.2	39.2	39.2
1700	3.0	45.7	45.7	58.8
1600	4.0	58.8	58.8	65.3
1500	5.0	65.3	71.9	71.9
1250	7.5	71.9	78.4	78.4
1000	10.0	78.4	84.9	84.9
750	12.5	84.9	91.5	91.5



Location	:	CBR Point No.10	**Date:28-12-2020**
Co-ordinates	:	N 2663040.9362,E 562363.8018	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**3.82**	
Moisture Content, %	:	24.50	
Density, g/cc	:	1.418	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	4.29	248.1	3.82	320.7	4.77
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	3.18	308.6	2.86	399.3	4.13

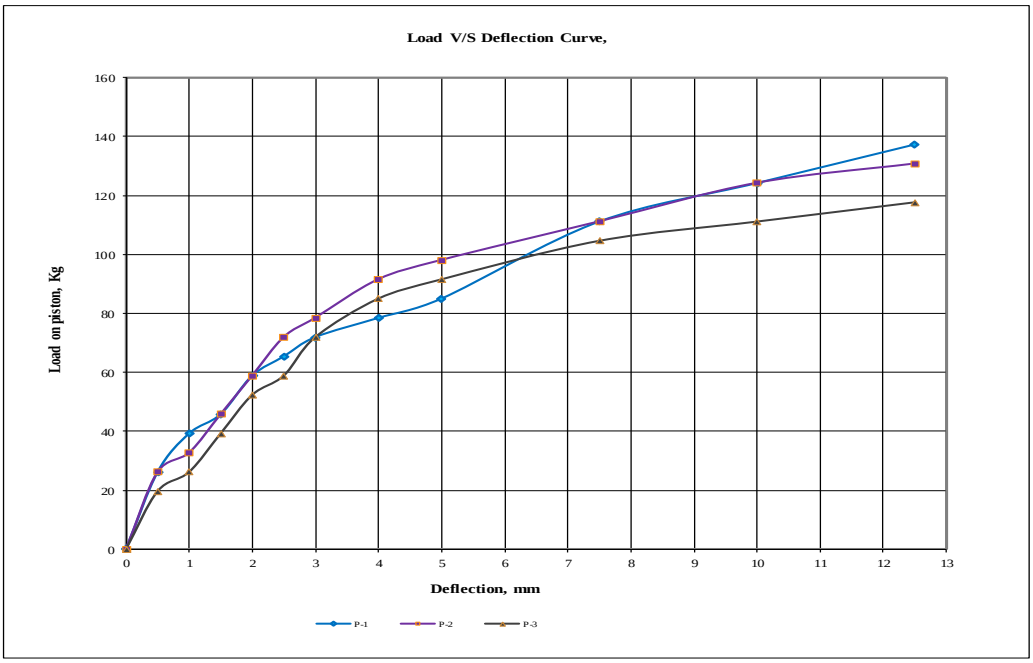
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	26.1	19.6	26.1
1900	1.0	32.7	26.1	32.7
1850	1.5	39.2	32.7	45.7
1800	2.0	52.3	45.7	58.8
1750	2.5	58.8	52.3	65.3
1700	3.0	65.3	58.8	71.9
1600	4.0	71.9	65.3	78.4
1500	5.0	78.4	71.9	84.9
1250	7.5	84.9	78.4	91.5
1000	10.0	91.5	84.9	98.0
750	12.5	98.0	91.5	104.5



Location	:	CBR Point No.11	**Date:27-12-2020**
Co-ordinates	:	N 2665485.2417,E 559567.1542	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**4.29**	
Moisture Content, %	:	22.90	
Density, g/cc	:	1.511	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	4.77	248.1	5.25	320.7	4.29
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	3.50	308.6	3.82	399.3	4.45

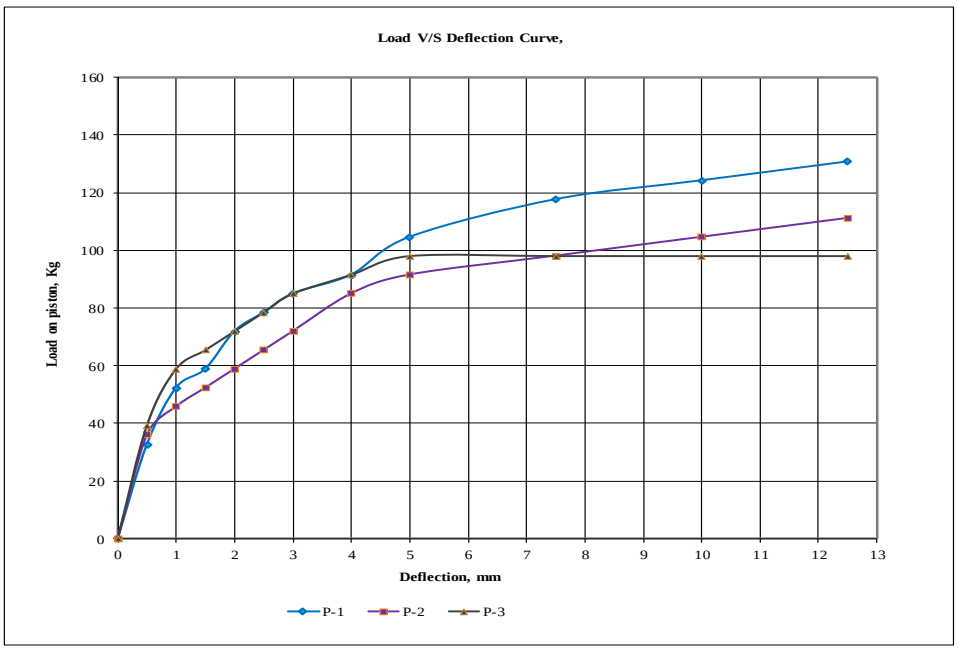
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	26.1	26.1	19.6
1900	1.0	39.2	32.7	26.1
1850	1.5	45.7	45.7	39.2
1800	2.0	58.8	58.8	52.3
1750	2.5	65.3	71.9	58.8
1700	3.0	71.9	78.4	71.9
1600	4.0	78.4	91.5	84.9
1500	5.0	84.9	98.0	91.5
1250	7.5	111.1	111.1	104.5
1000	10.0	124.1	124.1	111.1
750	12.5	137.2	130.7	117.6



Location	:	CBR Point No.12	**Date:27-12-2020**
Co-ordinates	:	N 2665605.1657,E 563367.5849	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**4.77**	
Moisture Content, %	:	23.40	
Density, g/cc	:	1.536	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),K**	**CBR Value,%**	**Test Load,(Pt),K**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	5.72	248.1	4.77	320.7	5.72
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	4.13	308.6	3.50	399.3	4.77

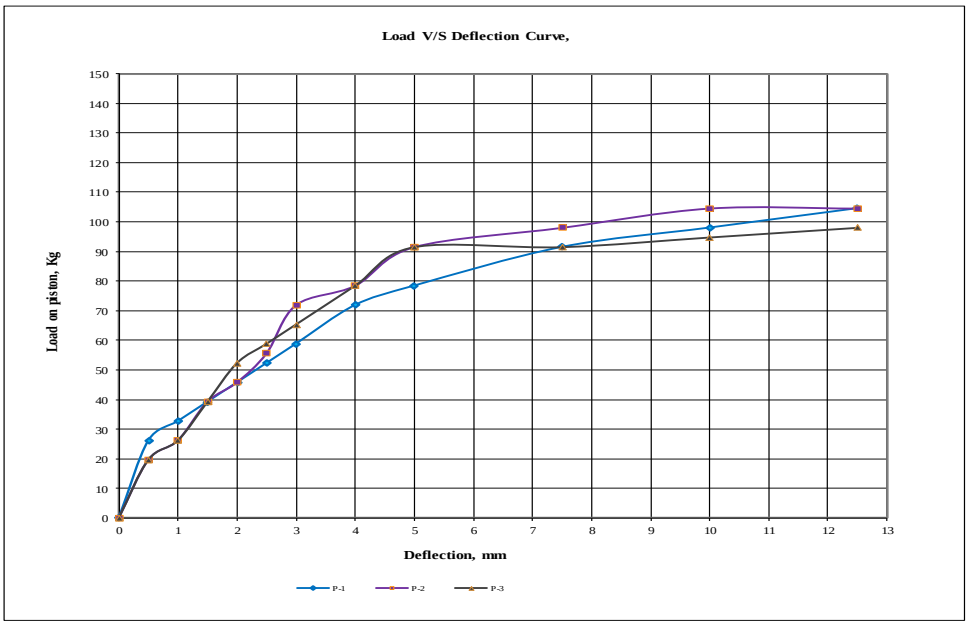
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	32.7	35.9	39.2
1900	1.0	52.3	45.7	58.8
1850	1.5	58.8	52.3	65.3
1800	2.0	71.9	58.8	71.9
1750	2.5	78.4	65.3	78.4
1700	3.0	84.9	71.9	84.9
1600	4.0	91.5	84.9	91.5
1500	5.0	104.5	91.5	98.0
1250	7.5	117.6	98.0	98.0
1000	10.0	124.1	104.5	98.0
750	12.5	130.7	111.1	98.0



Location	:	CBR Point No.13	**Date:27-12-2020**
Co-ordinates	:	N 2665074.6051,E 561691.7627	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**3.82**	
Moisture Content, %	:	21.80	
Density, g/cc	:	1.416	

Bearing Ratio	Standard Load (Ps),Kg	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	CBR Value,%	Test Load,(Pt),Kg	CBR Value,%	Test Load,(Pt),Kg	CBR Value,%
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	3.82	248.1	4.05	320.7	4.29
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	2.86	308.6	3.50	399.3	4.45

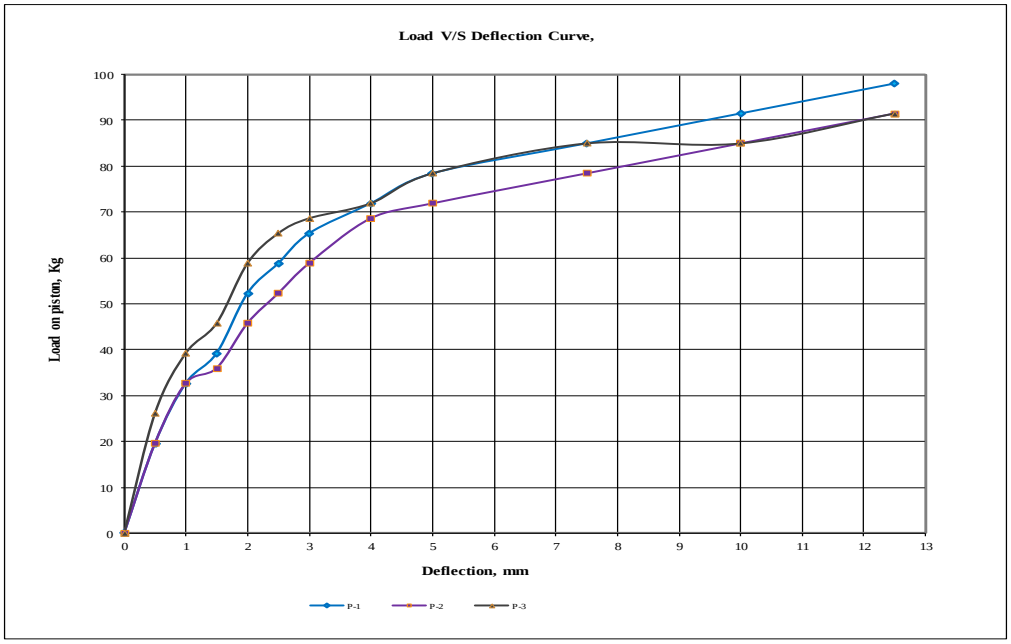
Dial Gauge Reading	Settlement, mm	P-1, Provig ring Reading in Kg	P-2, Provig ring Reading in Kg	P-3, Provig ring Reading in Kg
2000	0.0	0.0	0.0	0.0
1950	0.5	26.1	19.6	19.6
1900	1.0	32.7	26.1	26.1
1850	1.5	39.2	39.2	39.2
1800	2.0	45.7	45.7	52.3
1750	2.5	52.3	55.5	58.8
1700	3.0	58.8	71.9	65.3
1600	4.0	71.9	78.4	78.4
1500	5.0	78.4	91.5	91.5
1250	7.5	91.5	98.0	91.5
1000	10.0	98.0	104.5	94.7
750	12.5	104.5	104.5	98.0



Location	:	CBR Point No.14	**Date:27-12-2020**
Co-ordinates	:	N 2667601.4842,E 560113.3624	
Depth	:	200 mm below GL	
CBR Value (Natural Moisture Content), %	:	**3.82**	
Moisture Content, %	:	23.10	
Density, g/cc	:	1.421	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	4.29	248.1	3.82	320.7	4.77
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	3.18	308.6	2.86	399.3	3.82

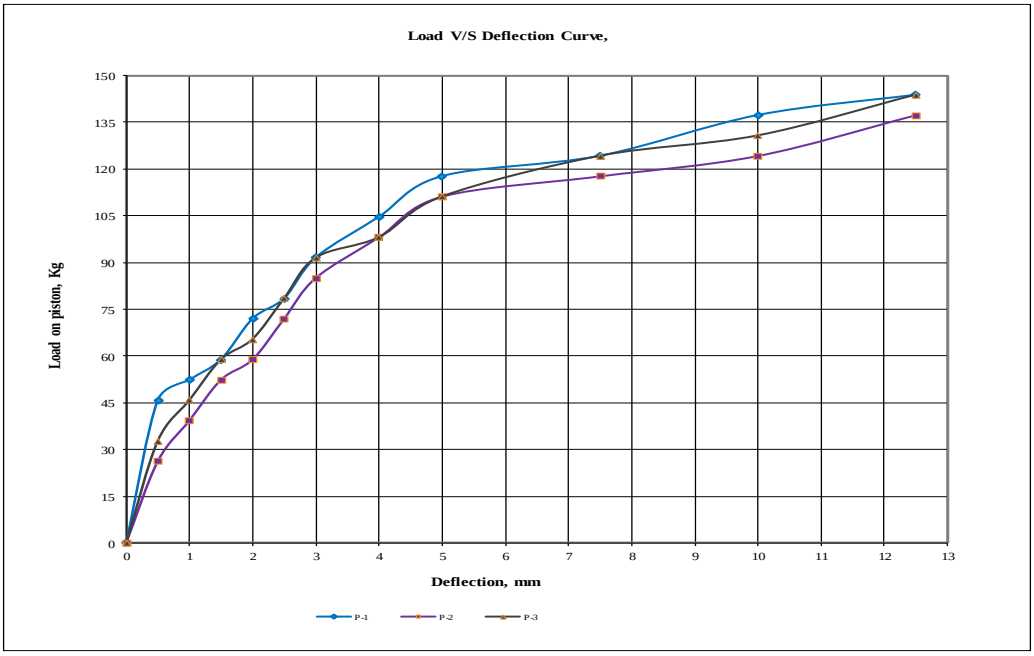
Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	19.6	19.6	26.1
1900	1.0	32.7	32.7	39.2
1850	1.5	39.2	35.9	45.7
1800	2.0	52.3	45.7	58.8
1750	2.5	58.8	52.3	65.3
1700	3.0	65.3	58.8	68.6
1600	4.0	71.9	68.6	71.9
1500	5.0	78.4	71.9	78.4
1250	7.5	84.9	78.4	84.9
1000	10.0	91.5	84.9	84.9
750	12.5	98.0	91.5	91.5



Location	:	CBR Point No.15	**Date:27-12-2020**
Co-ordinates	:	N 2667102.3899,E 562355.2594	
Depth	:	200 mm below GL	
CBR Value Unsoak), %	:	**5.25**	
Moisture Content, %	:	20.90	
Density, g/cc	:	1.541	

Bearing Ratio	**Standard Load (Ps),Kg**	Location-1, P-1		Location-1, P-2		Location-1, P-3	
		Test Load,(Pt),Kg	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**	**Test Load,(Pt),Kg**	**CBR Value,%**
Bearing Ratio at 2.5mm Penetration	1370.0	217.8	5.72	248.1	5.25	320.7	5.72
Bearing Ratio at 5.0mm Penetration	2055.0	296.5	4.45	308.6	4.13	399.3	5.41

Dial Gauge Reading	**Settlement, mm**	**P-1, Provig ring Reading in Kg**	**P-2, Provig ring Reading in Kg**	**P-3, Provig ring Reading in Kg**
2000	0.0	0.0	0.0	0.0
1950	0.5	45.7	26.1	32.7
1900	1.0	52.3	39.2	45.7
1850	1.5	58.8	52.3	58.8
1800	2.0	71.9	58.8	65.3
1750	2.5	78.4	71.9	78.4
1700	3.0	91.5	84.9	91.5
1600	4.0	104.5	98.0	98.0
1500	5.0	117.6	111.1	111.1
1250	7.5	124.1	117.6	124.1
1000	10.0	137.2	124.1	130.7
750	12.5	143.7	137.2	143.7



ANNEXURE 5: ERT

SOIL RESISTIVITY (ERT) AS PER IS-3043																				
Client Name:-			**Gujarat Industries Power Company Limited**																	
ERT No.	Co-ordinates	Date	Depth 'm'	RESISTANCE								RESISTIVITY								Average Ohm m	Average for No.
				1m	2m	3m	4m	5m	6m	8m	10m	1m	2m	3m	4m	5m	6m	8m	10m		
			Side	R = V / I (Ohm)								'r' = 2paR (Ohm-m)									
ERT 1	N 2659227, E 559579	24-12-2020	E	0.136	0.267	0.251	0.283	0.161	0.224	0.241	0.231	0.855	3.355	4.731	7.113	5.058	8.445	12.114	14.514	**7.02**	7.25
			W	0.155	0.342	0.342	0.341	0.122	0.213	0.284	0.308	0.974	4.298	6.447	8.570	3.833	8.030	14.275	19.352	**8.22**	
			S	0.238	0.302	0.239	0.342	0.214	0.155	0.204	0.240	1.495	3.795	4.505	8.595	6.723	5.843	10.254	15.080	**7.04**	
			N	0.210	0.168	0.245	0.311	0.234	0.151	0.127	0.295	1.319	2.111	4.618	7.816	7.351	5.693	6.384	18.535	**6.73**	
			SE	0.187	0.285	0.245	0.313	0.188	0.190	0.223	0.236	1.175	3.575	4.618	7.854	5.890	7.144	11.184	14.797	**7.03**	
			NW	0.183	0.255	0.294	0.326	0.178	0.182	0.206	0.302	1.147	3.204	5.532	8.193	5.592	6.861	10.330	18.944	**7.48**	
			SW	0.197	0.322	0.291	0.342	0.168	0.184	0.244	0.274	1.235	4.046	5.476	8.583	5.278	6.937	12.265	17.216	**7.63**	
			NE	0.173	0.218	0.248	0.297	0.198	0.188	0.184	0.263	1.087	2.733	4.675	7.464	6.205	7.069	9.249	16.525	**6.88**	
				0.185	0.270	0.269	0.319	0.183	0.186	0.214	0.269	1.161	3.390	5.075	8.024	5.741	7.003	10.757	16.870		
ERT 2	N 2658748, E 563008	24-12-2020	E	0.223	0.205	0.590	0.195	0.345	0.421	0.252	0.416	1.401	2.576	11.121	4.901	10.838	15.871	12.667	26.138	**10.69**	10.56
			W	0.243	0.298	0.452	0.178	0.311	0.329	0.341	0.324	1.527	3.745	8.520	4.474	9.770	12.403	17.141	20.358	**9.74**	
			S	0.215	0.230	0.459	0.324	0.349	0.316	0.342	0.345	1.351	2.890	8.652	8.143	10.967	11.913	17.191	21.677	**10.35**	
			N	0.340	0.366	0.623	0.315	0.372	0.485	0.177	0.422	2.136	4.599	11.743	7.917	11.687	18.284	8.897	26.515	**11.47**	
			SE	0.219	0.218	0.525	0.260	0.347	0.369	0.297	0.381	1.376	2.733	9.887	6.522	10.903	13.892	14.929	23.908	**10.52**	
			NW	0.292	0.332	0.538	0.247	0.342	0.407	0.259	0.373	1.832	4.172	10.132	6.195	10.729	15.344	13.019	23.436	**10.61**	
			SW	0.229	0.264	0.456	0.251	0.330	0.323	0.342	0.335	1.439	3.318	8.586	6.308	10.369	12.158	17.166	21.017	**10.05**	
			NE	0.282	0.286	0.607	0.255	0.359	0.453	0.215	0.419	1.769	3.588	11.432	6.409	11.263	17.078	10.782	26.327	**11.08**	
				0.255	0.275	0.531	0.253	0.344	0.388	0.278	0.377	1.604	3.453	10.009	6.359	10.816	14.618	13.974	23.672		
ERT 3	N 2657984, E 561584	24-12-2020	E	0.095	0.384	0.245	0.310	0.120	0.086	0.128	0.226	0.597	4.825	4.618	7.791	3.770	3.242	6.434	14.200	**5.68**	4.91
			W	0.065	0.262	0.131	0.382	0.134	0.083	0.084	0.125	0.408	3.292	2.469	9.601	4.210	3.129	4.222	7.854	**4.40**	
			S	0.094	0.245	0.240	0.338	0.125	0.090	0.125	0.135	0.591	3.079	4.524	8.495	3.927	3.393	6.283	8.482	**4.85**	
			N	0.121	0.341	0.201	0.198	0.184	0.090	0.075	0.173	0.760	4.285	3.789	4.976	5.781	3.393	3.770	10.870	**4.70**	
			SE	0.095	0.315	0.243	0.324	0.123	0.088	0.127	0.181	0.594	3.952	4.571	8.143	3.848	3.318	6.359	11.341	**5.27**	
			NW	0.093	0.302	0.166	0.290	0.159	0.087	0.080	0.149	0.584	3.789	3.129	7.288	4.995	3.261	3.996	9.362	**4.55**	
			SW	0.080	0.254	0.186	0.360	0.130	0.087	0.105	0.130	0.500	3.186	3.497	9.048	4.068	3.261	5.253	8.168	**4.62**	
			NE	0.108	0.363	0.223	0.254	0.152	0.088	0.102	0.200	0.679	4.555	4.203	6.384	4.775	3.318	5.102	12.535	**5.19**	
				0.094	0.308	0.204	0.307	0.141	0.087	0.103	0.165	0.589	3.870	3.850	7.716	4.422	3.289	5.177	10.352		
ERT 4	N 2657377, E 560536	24-12-2020	E	0.284	0.210	0.230	0.269	0.318	0.380	0.236	0.216	1.784	2.639	4.335	6.761	9.990	14.326	11.863	13.572	**8.16**	7.52
			W	0.252	0.193	0.117	0.213	0.277	0.484	0.282	0.210	1.583	2.425	2.205	5.353	8.702	18.246	14.175	13.195	**8.24**	
			S	0.220	0.142	0.136	0.201	0.168	0.310	0.240	0.236	1.382	1.784	2.564	5.052	5.278	11.687	12.064	14.828	**6.83**	
			N	0.151	0.132	0.210	0.321	0.268	0.345	0.173	0.162	0.949	1.659	3.958	8.068	8.419	13.006	8.696	10.179	**6.87**	
			SE	0.252	0.176	0.183	0.235	0.243	0.345	0.238	0.226	1.583	2.212	3.449	5.906	7.634	13.006	11.963	14.200	**7.49**	
			NW	0.202	0.163	0.164	0.267	0.273	0.415	0.228	0.186	1.266	2.042	3.082	6.710	8.561	15.626	11.435	11.687	**7.55**	
			SW	0.236	0.168	0.127	0.207	0.223	0.397	0.261	0.223	1.483	2.105	2.384	5.202	6.990	14.967	13.119	14.012	**7.53**	
			NE	0.218	0.171	0.220	0.295	0.293	0.363	0.205	0.189	1.367	2.149	4.147	7.414	9.205	13.666	10.279	11.875	**7.51**	
				0.227	0.169	0.173	0.251	0.258	0.380	0.233	0.206	1.425	2.127	3.266	6.308	8.097	14.316	11.699	12.943		
ERT 5	N 2656372, E 562303	24-12-2020	E	0.381	0.362	0.345	0.243	0.180	0.152	0.193	0.169	2.394	4.549	6.503	6.107	5.655	5.730	9.701	10.619	**6.41**	6.31
			W	0.223	0.210	0.193	0.145	0.126	0.173	0.163	0.238	1.401	2.639	3.638	3.644	3.958	6.522	8.193	14.954	**5.62**	
			S	0.278	0.221	0.205	0.168	0.125	0.296	0.141	0.268	1.747	2.777	3.864	4.222	3.927	11.159	7.087	16.839	**6.45**	
			N	0.380	0.310	0.280	0.185	0.170	0.213	0.117	0.296	2.388	3.896	5.278	4.650	5.341	8.030	5.881	18.598	**6.76**	
			SE	0.330	0.292	0.275	0.206	0.153	0.224	0.167	0.219	2.070	3.663	5.184	5.165	4.791	8.445	8.394	13.729	**6.43**	
			NW	0.302	0.260	0.237	0.165	0.148	0.193	0.140	0.267	1.894	3.267	4.458	4.147	4.650	7.276	7.037	16.776	**6.19**	
			SW	0.251	0.216	0.199	0.157	0.126	0.235	0.152	0.253	1.574	2.708	3.751	3.933	3.943	8.840	7.640	15.896	**6.04**	
			NE	0.381	0.336	0.313	0.214	0.175	0.183	0.155	0.233	2.391	4.222	5.890	5.378	5.498	6.880	7.791	14.608	**6.58**	
				0.316	0.276	0.256	0.185	0.150	0.209	0.154	0.243	1.982	3.465	4.821	4.656	4.720	7.860	7.716	15.252		

SOIL RESISTIVITY (ERT) AS PER 3043

Client Name:- **Gujarat Industries Power Company Limited**

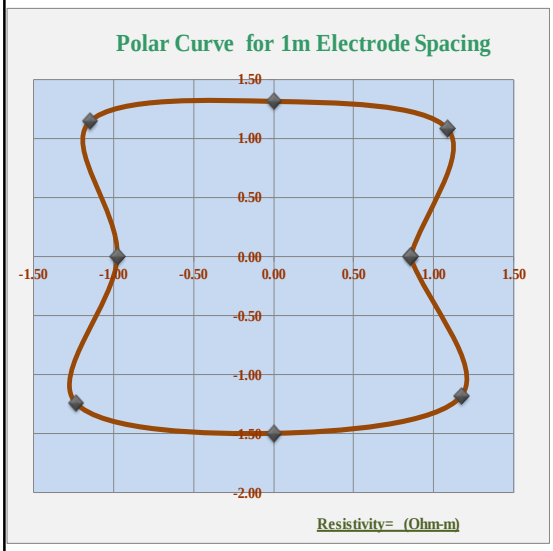
ERT No.	Co-ordinates	Date	Depth 'm'	RESISTANCE								RESISTIVITY								Average Ohm m	Average for No.
				1m	2m	3m	4m	5m	6m	8m	10m	1m	2m	3m	4m	5m	6m	8m	10m		
			Side	R = V / I (Ohm)								'r' = 2paR (Ohm-m)									
ERT 6	N 2661654, E 559603	25-12-2020	E	0.236	0.133	0.121	0.079	0.210	0.163	0.153	0.269	1.483	1.671	2.281	1.985	6.597	6.145	7.691	16.902	**5.59**	5.32
			W	0.153	0.123	0.110	0.093	0.236	0.196	0.131	0.291	0.961	1.546	2.073	2.337	7.414	7.389	6.585	18.284	**5.82**	
			S	0.224	0.169	0.106	0.091	0.163	0.116	0.185	0.263	1.407	2.124	1.998	2.287	5.121	4.373	9.299	16.525	**5.39**	
			N	0.160	0.185	0.123	0.106	0.153	0.123	0.098	0.210	1.005	2.325	2.318	2.664	4.807	4.637	4.926	13.195	**4.48**	
			SE	0.230	0.151	0.114	0.085	0.187	0.140	0.169	0.266	1.445	1.898	2.139	2.136	5.859	5.259	8.495	16.713	**5.49**	
			NW	0.157	0.154	0.117	0.100	0.195	0.160	0.115	0.251	0.983	1.935	2.196	2.501	6.110	6.013	5.755	15.739	**5.15**	
			SW	0.189	0.146	0.108	0.092	0.200	0.156	0.158	0.277	1.184	1.835	2.036	2.312	6.267	5.881	7.942	17.404	**5.61**	
			NE	0.198	0.159	0.122	0.093	0.182	0.143	0.126	0.240	1.244	1.998	2.300	2.325	5.702	5.391	6.308	15.048	**5.04**	
				0.193	0.153	0.115	0.092	0.191	0.150	0.142	0.258	1.214	1.916	2.168	2.318	5.985	5.636	7.125	16.226		
ERT 7	N 2661531, E 561820	25-12-2020	E	0.120	0.123	0.110	0.129	0.110	0.132	0.162	0.093	0.754	1.546	2.073	3.242	3.456	4.976	8.143	5.843	**3.75**	4.15
			W	0.110	0.169	0.153	0.143	0.136	0.120	0.155	0.130	0.691	2.124	2.884	3.594	4.273	4.524	7.791	8.168	**4.26**	
			S	0.103	0.150	0.125	0.134	0.114	0.115	0.130	0.145	0.647	1.885	2.356	3.368	3.581	4.335	6.535	9.111	**3.98**	
			N	0.163	0.220	0.175	0.110	0.086	0.106	0.167	0.190	1.024	2.765	3.299	2.765	2.702	3.996	8.394	11.938	**4.61**	
			SE	0.112	0.137	0.118	0.132	0.112	0.124	0.146	0.119	0.701	1.715	2.215	3.305	3.519	4.656	7.339	7.477	**3.87**	
			NW	0.137	0.195	0.164	0.127	0.111	0.113	0.161	0.160	0.858	2.444	3.091	3.179	3.487	4.260	8.093	10.053	**4.43**	
			SW	0.107	0.160	0.139	0.139	0.125	0.118	0.143	0.138	0.669	2.004	2.620	3.481	3.927	4.430	7.163	8.639	**4.12**	
			NE	0.142	0.172	0.143	0.120	0.098	0.119	0.165	0.142	0.889	2.155	2.686	3.003	3.079	4.486	8.269	8.891	**4.18**	
				0.124	0.166	0.141	0.129	0.112	0.118	0.154	0.140	0.779	2.080	2.653	3.242	3.503	4.458	7.716	8.765		
ERT 8	N 2661369, E 563535	27-12-2020	E	0.256	0.210	0.188	0.143	0.212	0.230	0.165	0.151	1.608	2.639	3.544	3.594	6.660	8.671	8.294	9.488	**5.56**	5.43
			W	0.283	0.290	0.195	0.120	0.238	0.231	0.122	0.169	1.778	3.644	3.676	3.016	7.477	8.708	6.132	10.619	**5.63**	
			S	0.330	0.186	0.114	0.169	0.285	0.243	0.130	0.119	2.073	2.337	2.149	4.247	8.954	9.161	6.535	7.477	**5.37**	
			N	0.295	0.239	0.147	0.121	0.195	0.183	0.147	0.163	1.854	3.003	2.771	3.041	6.126	6.899	7.389	10.242	**5.17**	
			SE	0.293	0.198	0.151	0.156	0.249	0.237	0.148	0.135	1.841	2.488	2.846	3.921	7.807	8.916	7.414	8.482	**5.46**	
			NW	0.289	0.265	0.171	0.121	0.217	0.207	0.135	0.166	1.816	3.324	3.223	3.028	6.802	7.804	6.761	10.430	**5.40**	
			SW	0.307	0.238	0.155	0.145	0.262	0.237	0.126	0.144	1.926	2.991	2.912	3.632	8.215	8.935	6.333	9.048	**5.50**	
			NE	0.276	0.225	0.168	0.132	0.204	0.207	0.156	0.157	1.731	2.821	3.157	3.318	6.393	7.785	7.841	9.865	**5.36**	
				0.291	0.231	0.161	0.138	0.233	0.222	0.141	0.151	1.828	2.906	3.035	3.475	7.304	8.360	7.087	9.456		
ERT 9	N 2663721, E 560157	25-12-2020	E	0.256	0.180	0.268	0.120	0.153	0.104	0.163	0.188	1.608	2.262	5.052	3.016	4.807	3.921	8.193	11.812	**5.08**	4.90
			W	0.192	0.125	0.165	0.086	0.142	0.183	0.210	0.204	1.206	1.571	3.110	2.161	4.461	6.899	10.556	12.818	**5.35**	
			S	0.236	0.160	0.245	0.109	0.106	0.175	0.112	0.135	1.483	2.011	4.618	2.739	3.330	6.597	5.630	8.482	**4.36**	
			N	0.155	0.098	0.186	0.140	0.168	0.163	0.174	0.143	0.974	1.232	3.506	3.519	5.278	6.145	8.746	8.985	**4.80**	
			SE	0.246	0.170	0.257	0.115	0.130	0.140	0.138	0.162	1.546	2.136	4.835	2.878	4.068	5.259	6.912	10.147	**4.72**	
			NW	0.174	0.112	0.176	0.113	0.155	0.173	0.192	0.174	1.090	1.401	3.308	2.840	4.869	6.522	9.651	10.901	**5.07**	
			SW	0.214	0.143	0.205	0.098	0.124	0.179	0.161	0.170	1.345	1.791	3.864	2.450	3.896	6.748	8.093	10.650	**4.85**	
			NE	0.206	0.139	0.227	0.130	0.161	0.134	0.169	0.166	1.291	1.747	4.279	3.267	5.042	5.033	8.470	10.399	**4.94**	
				0.210	0.141	0.216	0.114	0.142	0.156	0.165	0.168	1.318	1.769	4.072	2.859	4.469	5.890	8.281	10.524		
ERT 10	N 2663292, E 563220	27-12-2020	E	0.185	0.109	0.290	0.132	0.182	0.204	0.165	0.083	1.162	1.370	5.466	3.318	5.718	7.691	8.294	5.215	**4.78**	4.56
			W	0.174	0.185	0.295	0.190	0.156	0.159	0.136	0.072	1.093	2.325	5.561	4.775	4.901	5.994	6.836	4.524	**4.50**	
			S	0.249	0.210	0.193	0.157	0.120	0.136	0.185	0.056	1.565	2.639	3.638	3.946	3.770	5.127	9.299	3.519	**4.19**	
			N	0.268	0.169	0.201	0.184	0.163	0.184	0.159	0.093	1.684	2.124	3.789	4.624	5.121	6.937	7.992	5.843	**4.76**	
			SE	0.217	0.160	0.242	0.145	0.151	0.170	0.175	0.070	1.363	2.004	4.552	3.632	4.744	6.409	8.796	4.367	**4.48**	
			NW	0.221	0.177	0.248	0.187	0.160	0.172	0.148	0.083	1.389	2.224	4.675	4.700	5.011	6.465	7.414	5.184	**4.63**	
			SW	0.212	0.198	0.244	0.174	0.138	0.148	0.161	0.064	1.329	2.482	4.599	4.361	4.335	5.561	8.068	4.021	**4.34**	
			NE	0.227	0.139	0.246	0.158	0.173	0.194	0.162	0.088	1.423	1.747	4.628	3.971	5.419	7.314	8.143	5.529	**4.77**	
				0.219	0.168	0.245	0.166	0.155	0.171	0.161	0.076	1.376	2.114	4.613	4.166	4.877	6.437	8.105	4.775		

SOIL RESISTIVITY (ERT) AS PER IS-3043

Client Name:- **40MW Solar PV Project At Haripar, Gujarat**

ERT No.	Co-ordinates	Date	Depth 'm'	RESISTANCE								RESISTIVITY								Average Ohm m	Average for No.
				1m	2m	3m	4m	5m	6m	8m	10m	1m	2m	3m	4m	5m	6m	8m	10m		
			Side	R = V / I (Ohm)								'r' = 2paR (Ohm-m)									
ERT 11	N 2665085, E 563657	25-12-2020	E	0.084	0.163	0.173	0.197	0.125	0.115	0.102	0.117	0.528	2.048	3.261	4.951	3.927	4.335	5.127	7.351	**3.94**	
			W	0.076	0.112	0.183	0.156	0.117	0.108	0.119	0.152	0.478	1.407	3.449	3.921	3.676	4.072	5.982	9.550	**4.07**	
			S	0.143	0.174	0.341	0.249	0.153	0.112	0.203	0.190	0.898	2.187	6.428	6.258	4.807	4.222	10.204	11.938	**5.87**	
			N	0.123	0.142	0.218	0.210	0.140	0.132	0.155	0.183	0.773	1.784	4.109	5.278	4.398	4.976	7.791	11.498	**5.08**	
			SE	0.114	0.169	0.257	0.223	0.139	0.114	0.153	0.154	0.713	2.117	4.844	5.605	4.367	4.279	7.665	9.645	**4.90**	4.74
			NW	0.100	0.127	0.201	0.183	0.129	0.120	0.137	0.168	0.625	1.596	3.779	4.599	4.037	4.524	6.886	10.524	**4.57**	
			SW	0.110	0.143	0.262	0.203	0.135	0.110	0.161	0.171	0.688	1.797	4.939	5.089	4.241	4.147	8.093	10.744	**4.97**	
			NE	0.104	0.153	0.196	0.204	0.133	0.124	0.129	0.150	0.650	1.916	3.685	5.115	4.163	4.656	6.459	9.425	**4.51**	
				0.107	0.148	0.229	0.203	0.134	0.117	0.145	0.161	0.669	1.857	4.312	5.102	4.202	4.401	7.276	10.085		
ERT 12	N 2665476, E 560482	27-12-2020	E	0.201	0.153	0.121	0.090	0.155	0.149	0.096	0.193	1.263	1.923	2.281	2.262	4.869	5.617	4.825	12.127	**4.40**	
			W	0.338	0.240	0.139	0.162	0.155	0.152	0.132	0.139	2.124	3.016	2.620	4.072	4.869	5.730	6.635	8.734	**4.72**	
			S	0.193	0.245	0.120	0.143	0.183	0.102	0.145	0.125	1.213	3.079	2.262	3.594	5.749	3.845	7.288	7.854	**4.36**	
			N	0.295	0.218	0.145	0.138	0.187	0.109	0.100	0.143	1.854	2.739	2.733	3.468	5.875	4.109	5.027	8.985	**4.35**	
			SE	0.197	0.199	0.121	0.117	0.169	0.126	0.121	0.159	1.238	2.501	2.271	2.928	5.309	4.731	6.057	9.990	**4.38**	4.47
			NW	0.317	0.229	0.142	0.150	0.171	0.131	0.116	0.141	1.989	2.878	2.677	3.770	5.372	4.920	5.831	8.859	**4.54**	
			SW	0.266	0.243	0.130	0.153	0.169	0.127	0.139	0.132	1.668	3.047	3.255	3.833	5.309	4.788	6.962	8.294	**4.64**	
			NE	0.248	0.186	0.133	0.114	0.171	0.129	0.098	0.168	1.558	2.331	2.507	2.865	5.372	4.863	4.926	10.556	**4.37**	
				0.257	0.214	0.131	0.133	0.170	0.128	0.118	0.150	1.613	2.689	2.576	3.349	5.341	4.825	5.944	9.425		
ERT 13	N 2666960, E 559586	25-12-2020	E	0.320	0.306	0.276	0.220	0.169	0.224	0.241	0.231	2.011	3.845	5.202	5.529	5.309	8.445	12.114	14.514	**7.12**	
			W	0.256	0.226	0.210	0.296	0.266	0.213	0.284	0.246	1.608	2.840	3.958	7.439	8.357	8.030	14.275	15.457	**7.75**	
			S	0.526	0.432	0.389	0.329	0.256	0.155	0.226	0.240	3.305	5.429	7.332	8.269	8.042	5.843	11.360	15.080	**8.08**	
			N	0.432	0.356	0.298	0.273	0.234	0.151	0.127	0.295	2.714	4.474	5.617	6.861	7.351	5.693	6.384	18.535	**7.20**	
			SE	0.423	0.369	0.333	0.275	0.213	0.190	0.234	0.236	2.658	4.637	6.267	6.899	6.676	7.144	11.737	14.797	**7.60**	7.54
			NW	0.344	0.291	0.254	0.285	0.250	0.182	0.206	0.271	2.161	3.657	4.788	7.150	7.854	6.861	10.330	16.996	**7.47**	
			SW	0.391	0.329	0.300	0.313	0.261	0.184	0.255	0.243	2.457	4.134	5.645	7.854	8.200	6.937	12.818	15.268	**7.91**	
			NE	0.376	0.331	0.287	0.247	0.202	0.188	0.184	0.263	2.362	4.159	5.410	6.195	6.330	7.069	9.249	16.525	**7.16**	
				0.384	0.330	0.293	0.280	0.231	0.186	0.220	0.253	2.410	4.147	5.528	7.025	7.265	7.003	11.033	15.896		
ERT 14	N 2667794, E 561928	25-12-2020	E	0.159	0.174	0.132	0.202	0.084	0.056	0.088	0.120	0.999	2.187	2.488	5.077	2.639	2.111	4.423	7.540	**3.43**	
			W	0.210	0.243	0.210	0.285	0.118	0.084	0.062	0.162	1.319	3.054	3.958	7.163	3.707	3.167	3.116	10.179	**4.46**	
			S	0.173	0.120	0.245	0.383	0.155	0.098	0.073	0.121	1.087	1.508	4.618	9.626	4.869	3.695	3.669	7.603	**4.58**	
			N	0.265	0.180	0.179	0.211	0.158	0.108	0.085	0.120	1.665	2.262	3.374	5.303	4.964	4.072	4.273	7.540	**4.18**	
			SE	0.166	0.147	0.189	0.293	0.120	0.077	0.081	0.121	1.043	1.847	3.553	7.351	3.754	2.903	4.046	7.571	**4.01**	4.16
			NW	0.238	0.212	0.195	0.248	0.138	0.096	0.074	0.141	1.492	2.658	3.666	6.233	4.335	3.619	3.695	8.859	**4.32**	
			SW	0.192	0.182	0.228	0.334	0.137	0.091	0.068	0.142	1.203	2.281	4.288	8.394	4.288	3.431	3.393	8.891	**4.52**	
			NE	0.212	0.177	0.156	0.207	0.121	0.082	0.087	0.120	1.332	2.224	2.931	5.190	3.801	3.091	4.348	7.540	**3.81**	
				0.202	0.179	0.192	0.270	0.129	0.087	0.077	0.131	1.268	2.253	3.610	6.792	4.045	3.261	3.870	8.215		
ERT 15	N 2666315, E 562276	25-12-2020	E	0.168	0.312	0.222	0.105	0.089	0.263	0.169	0.220	1.056	3.921	4.185	2.639	2.796	9.915	8.495	13.823	**5.85**	
			W	0.242	0.224	0.210	0.123	0.108	0.216	0.203	0.165	1.521	2.815	3.958	3.091	3.393	8.143	10.204	10.367	**5.44**	
			S	0.183	0.231	0.204	0.182	0.113	0.286	0.211	0.290	1.150	2.903	3.845	4.574	3.550	10.782	10.606	18.221	**6.95**	
			N	0.220	0.260	0.173	0.138	0.106	0.228	0.125	0.186	1.382	3.267	3.261	3.468	3.330	8.595	6.283	11.687	**5.16**	
			SE	0.176	0.272	0.213	0.144	0.101	0.275	0.190	0.255	1.103	3.412	4.015	3.607	3.173	10.348	9.550	16.022	**6.40**	5.85
			NW	0.231	0.242	0.192	0.131	0.107	0.222	0.164	0.176	1.451	3.041	3.610	3.280	3.362	8.369	8.244	11.027	**5.30**	
			SW	0.213	0.228	0.207	0.153	0.111	0.251	0.207	0.228	1.335	2.859	3.902	3.833	3.471	9.462	10.405	14.294	**6.20**	
			NE	0.194	0.286	0.198	0.122	0.098	0.246	0.147	0.203	1.219	3.594	3.723	3.054	3.063	9.255	7.389	12.755	**5.51**	
				0.203	0.257	0.202	0.137	0.104	0.248	0.177	0.215	1.277	3.226	3.812	3.443	3.267	9.359	8.897	13.525		

ERT 1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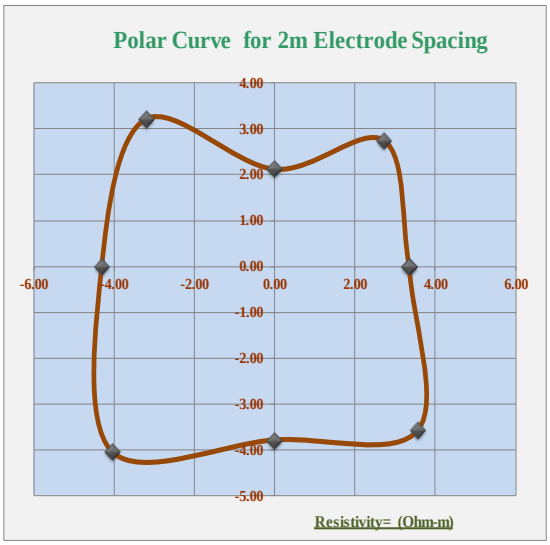
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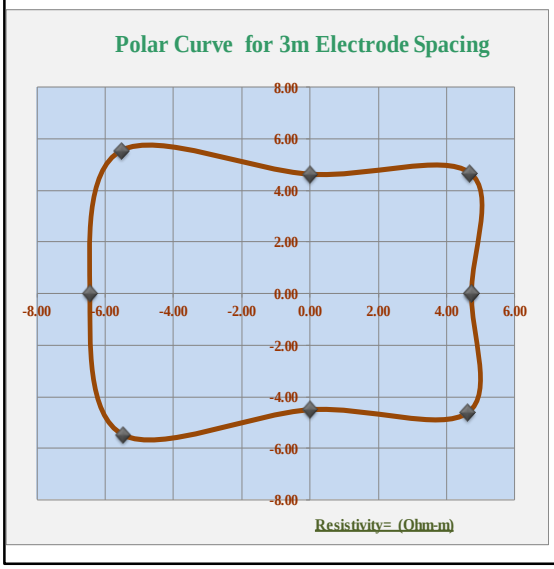
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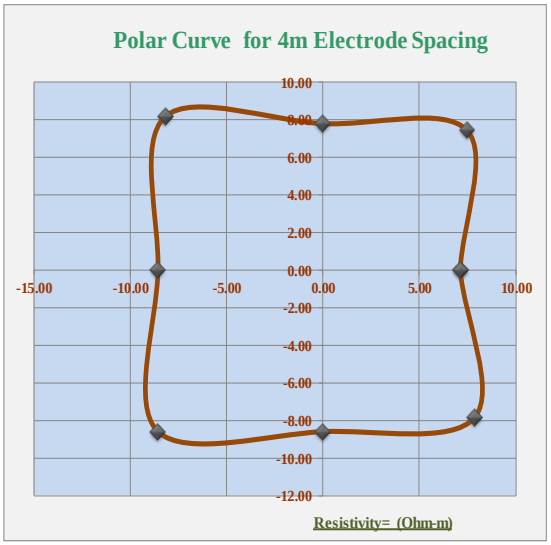
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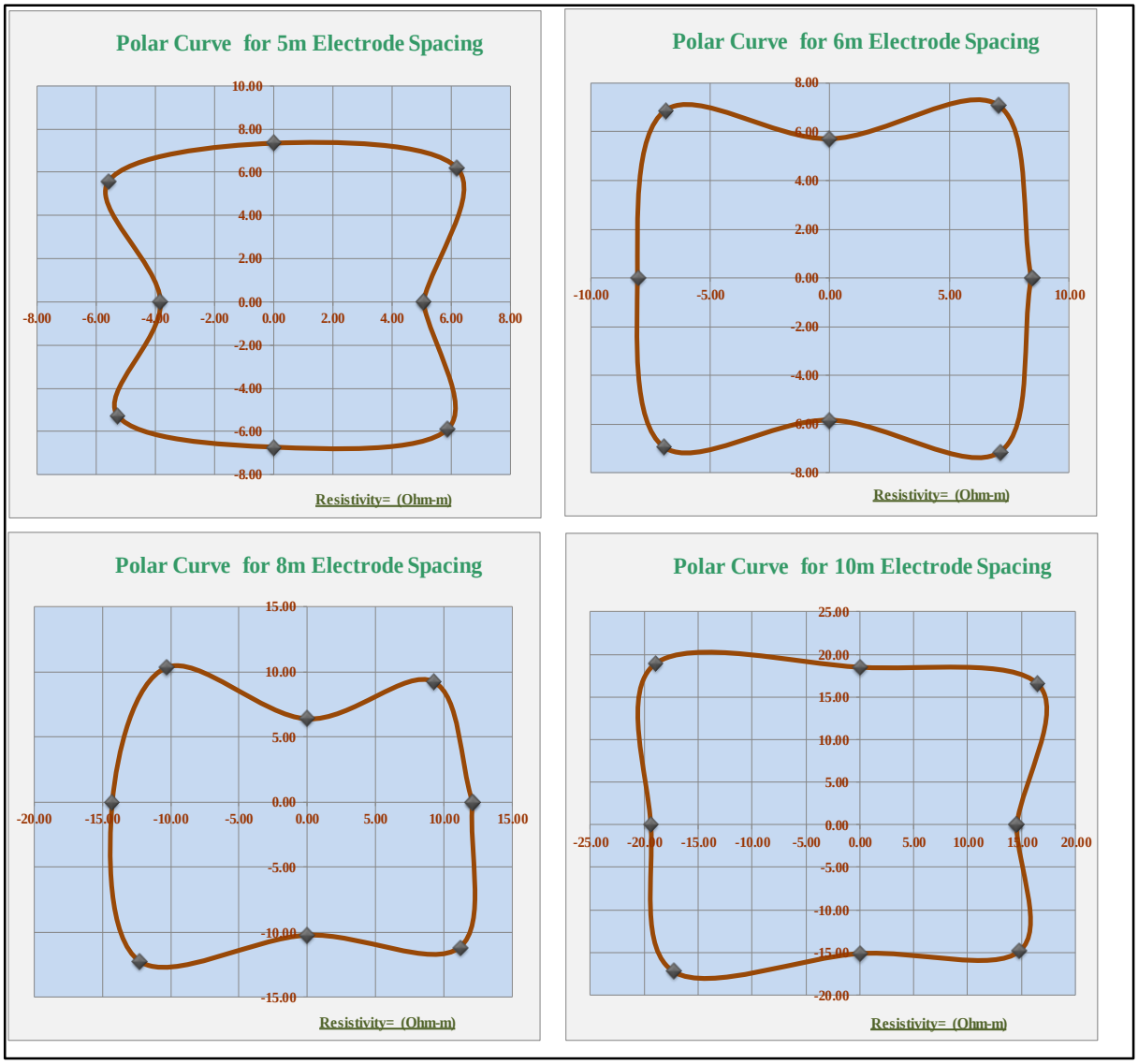
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Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
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10.00
5.00
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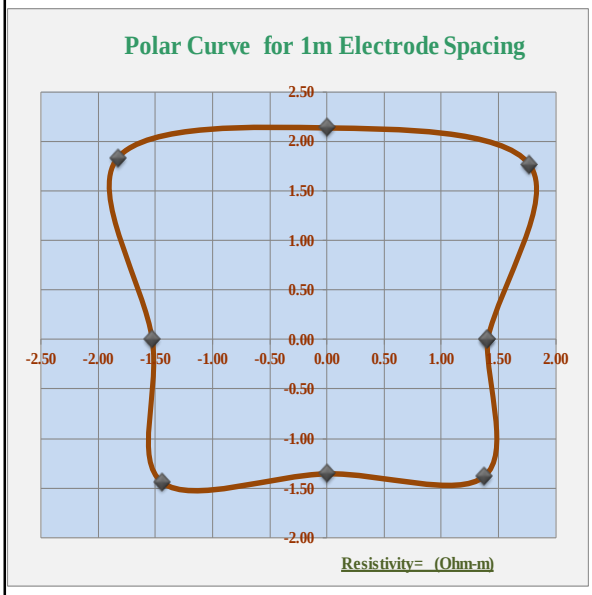
ERT-2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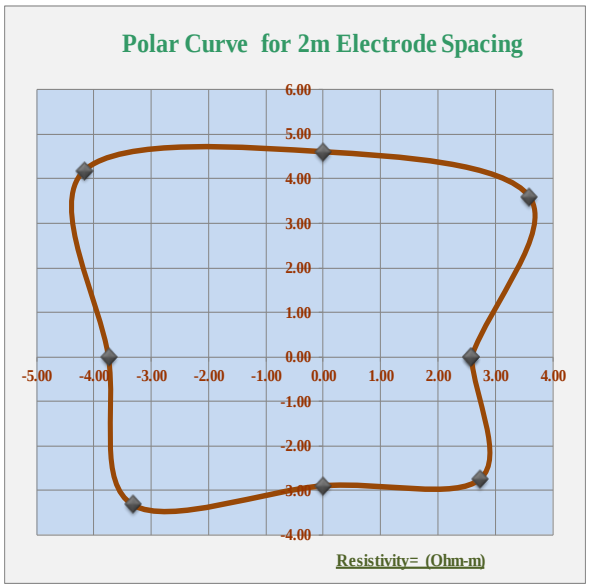
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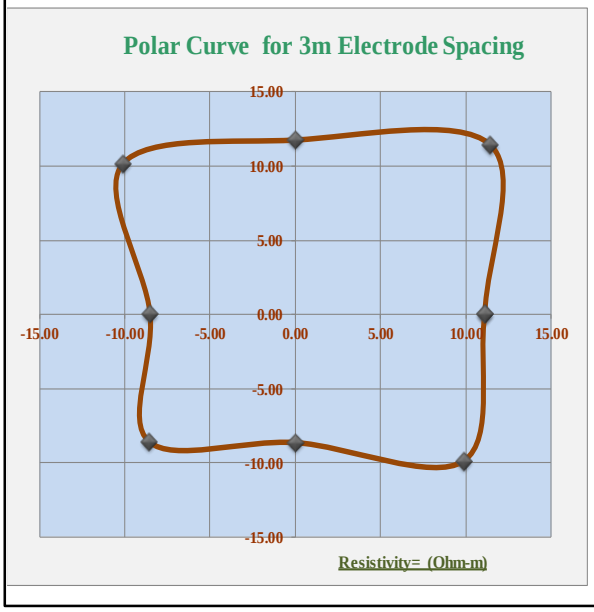
Resistivity= (Ohm-m)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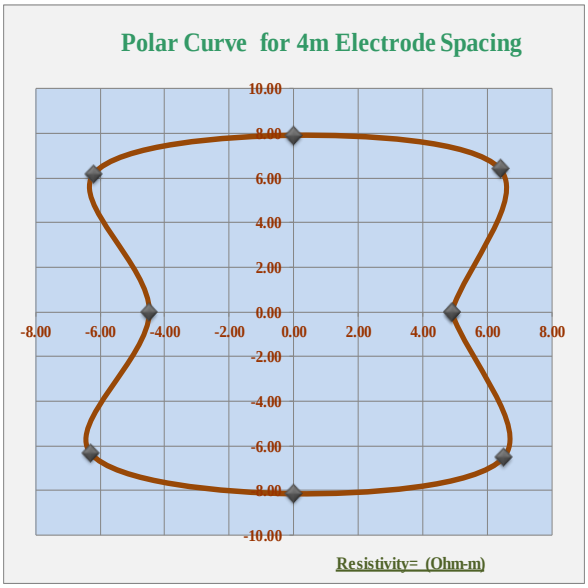
Resistivity= (Ohm-m)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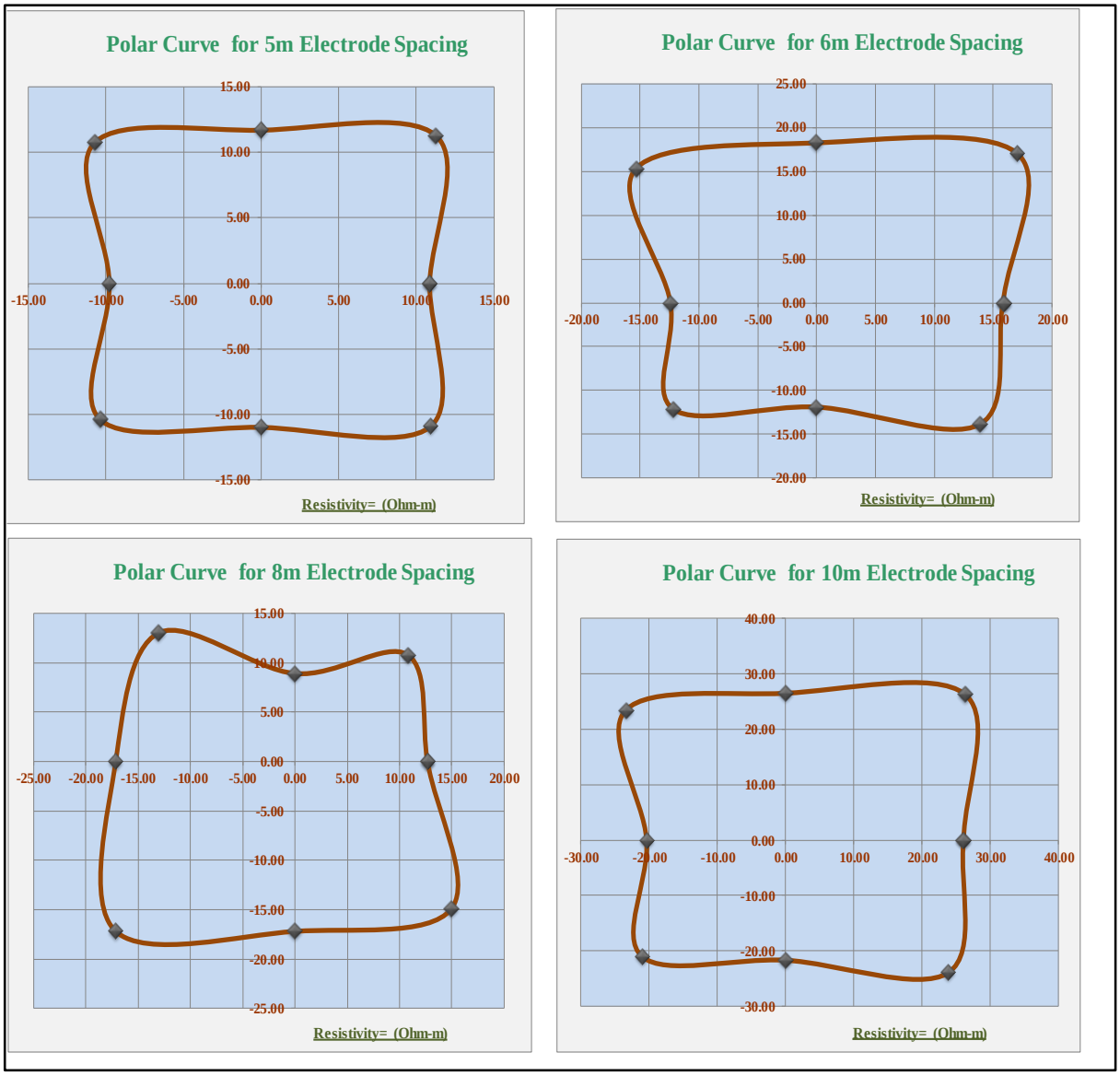
Resistivity= (Ohm-m)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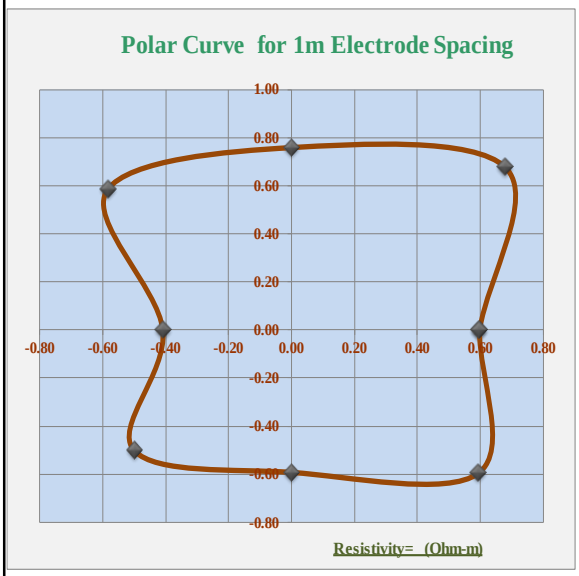
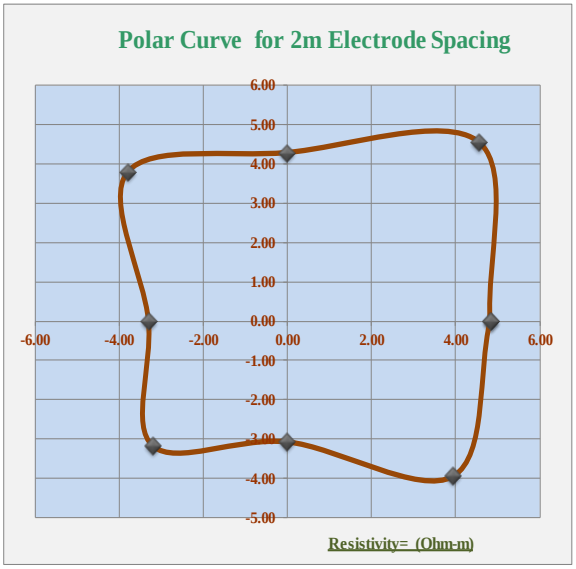
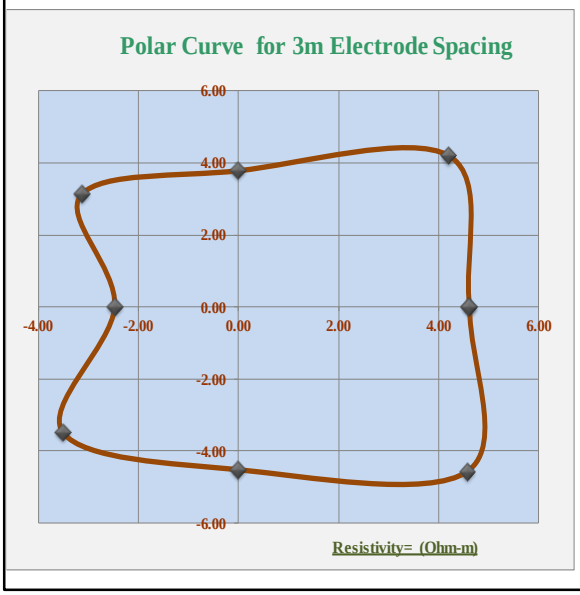
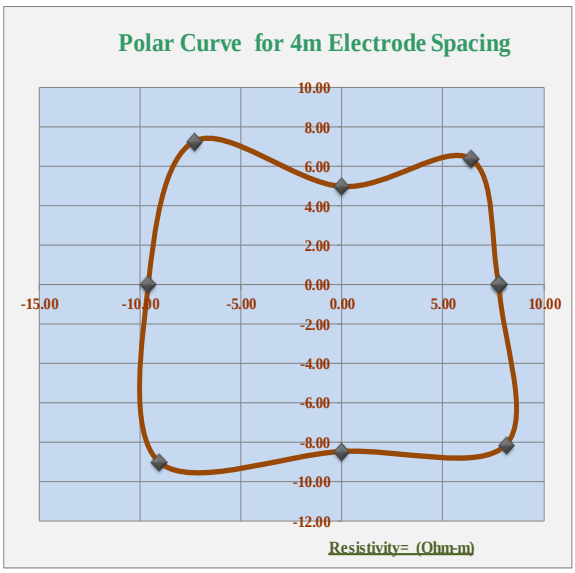
5.00
0.00
-5.00
-10.00
-15.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-20.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-25.00
-20.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
-30.00
-20.00
-10.00
0.00
10.00
20.00
30.00
40.00
Resistivity= (Ohm-m)

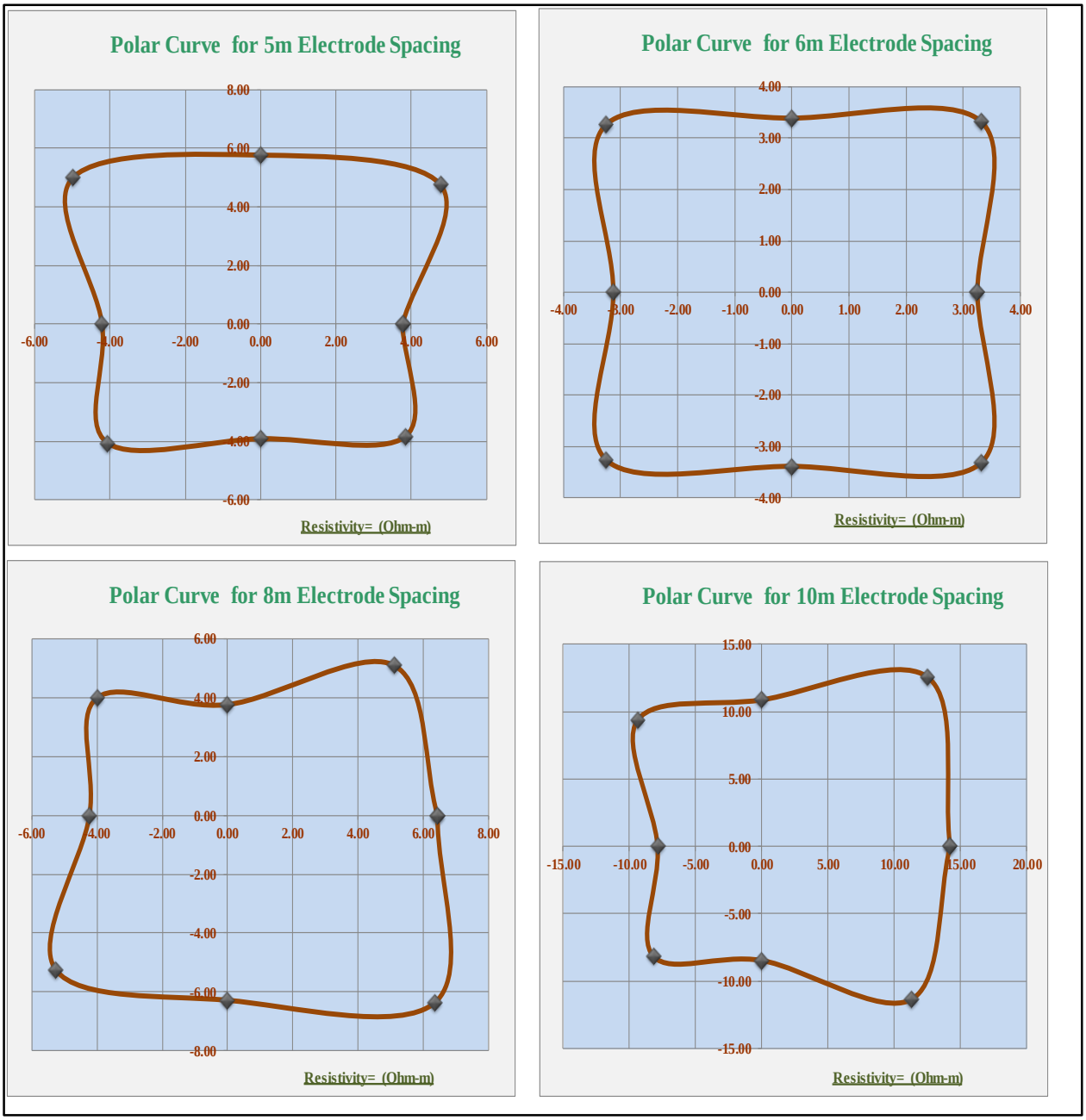
ERT-3


Polar Curve for 1m Electrode Spacing
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-0.80
-0.60
-0.40
-0.20
0.00
0.20
0.40
0.60
0.80
Resistivity= (Ohm-m)


Polar Curve for 2m Electrode Spacing
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Resistivity= (Ohm-m)


Polar Curve for 3m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Resistivity= (Ohm-m)


Polar Curve for 4m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
Resistivity= (Ohm-m)

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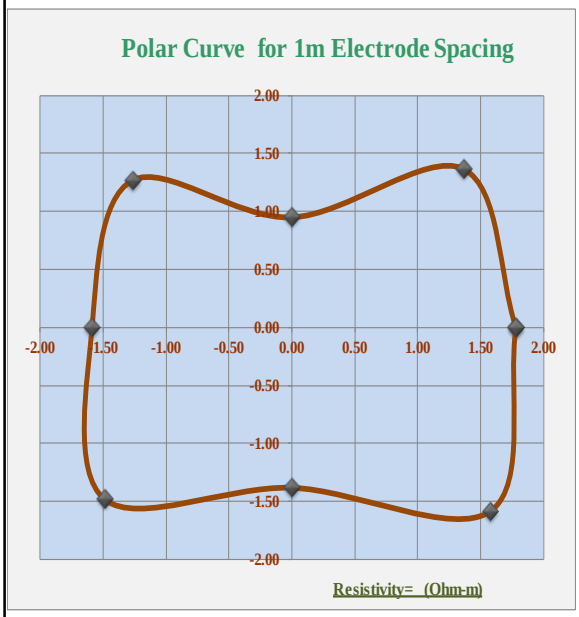
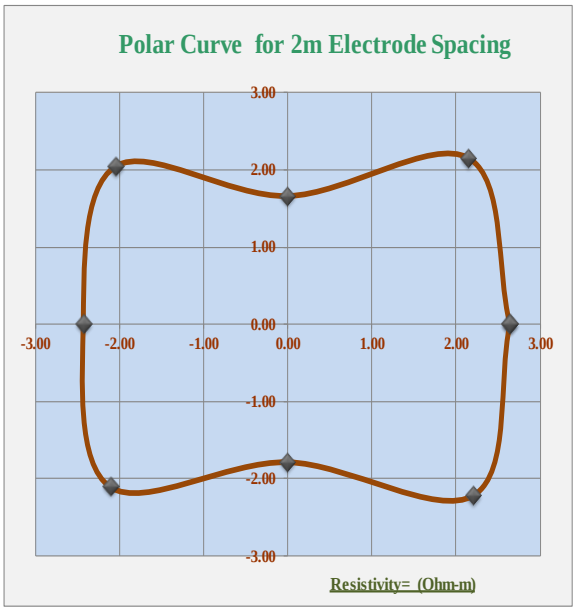
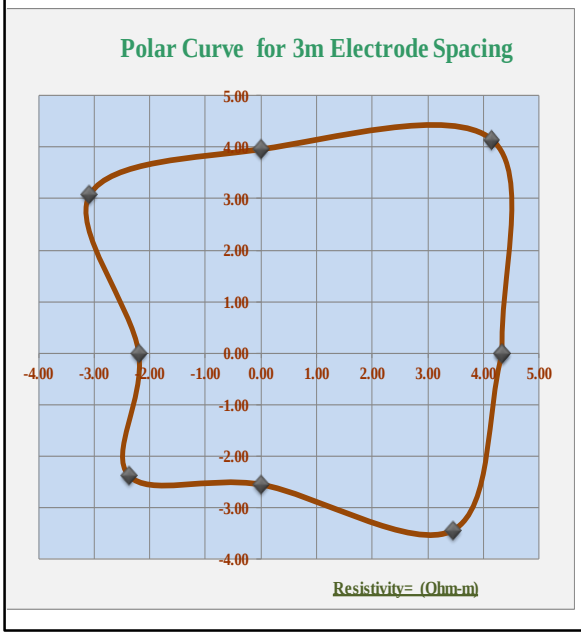
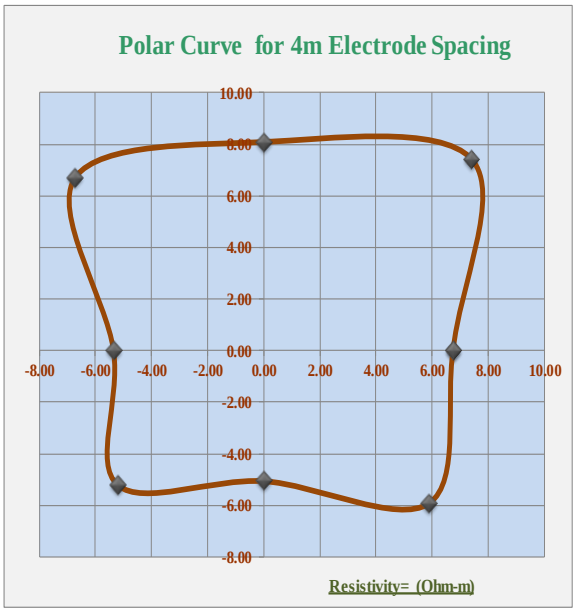
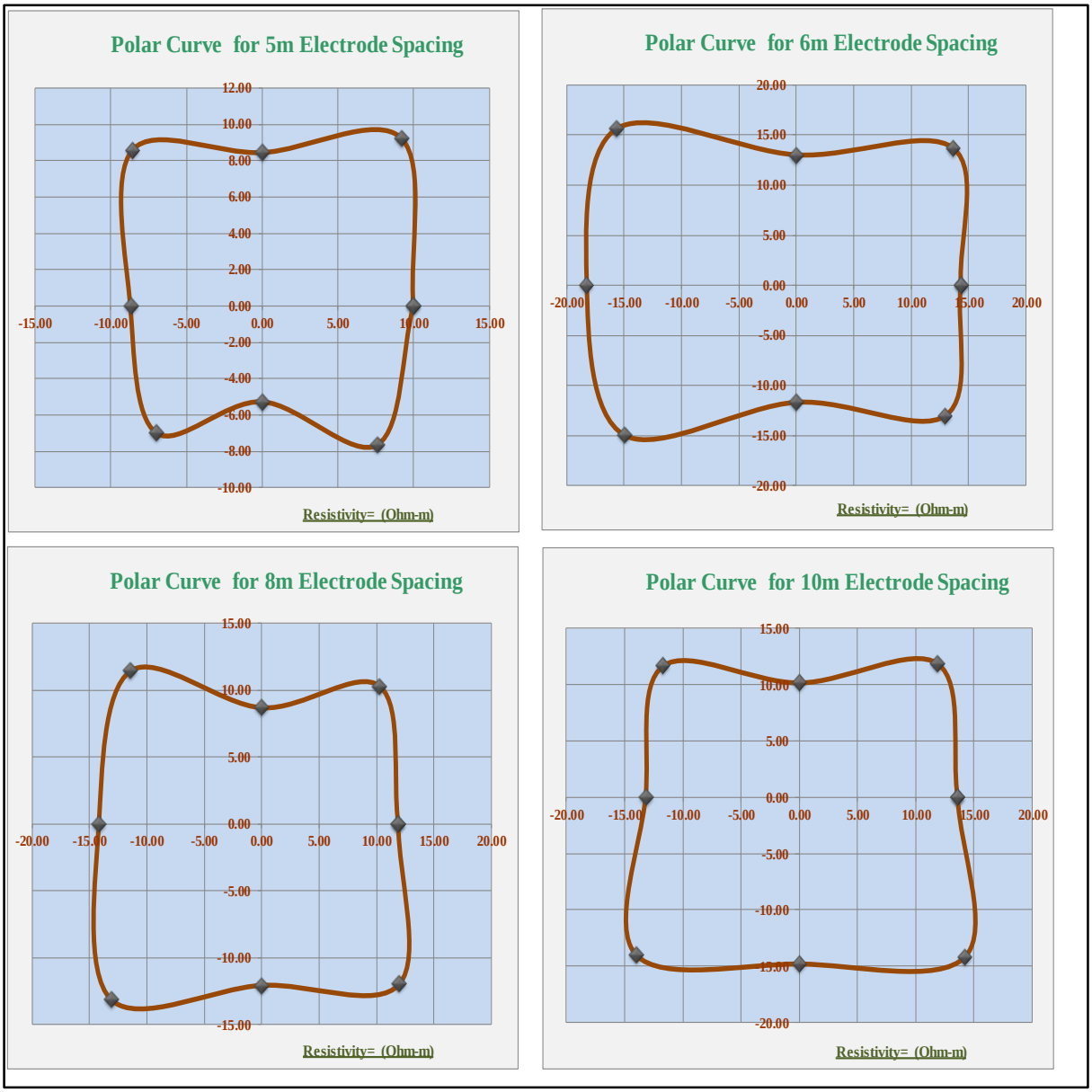

Polar Curve for 1m Electrode Spacing
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.00 -1.50 -1.00 -0.50 0.00 0.50 1.00 1.50 2.00
Resistivity= (Ohm-m)


Polar Curve for 2m Electrode Spacing
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)


Polar Curve for 3m Electrode Spacing
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00 5.00
Resistivity= (Ohm-m)


Polar Curve for 4m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00 10.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-20.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-20.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
Resistivity= (Ohm-m)

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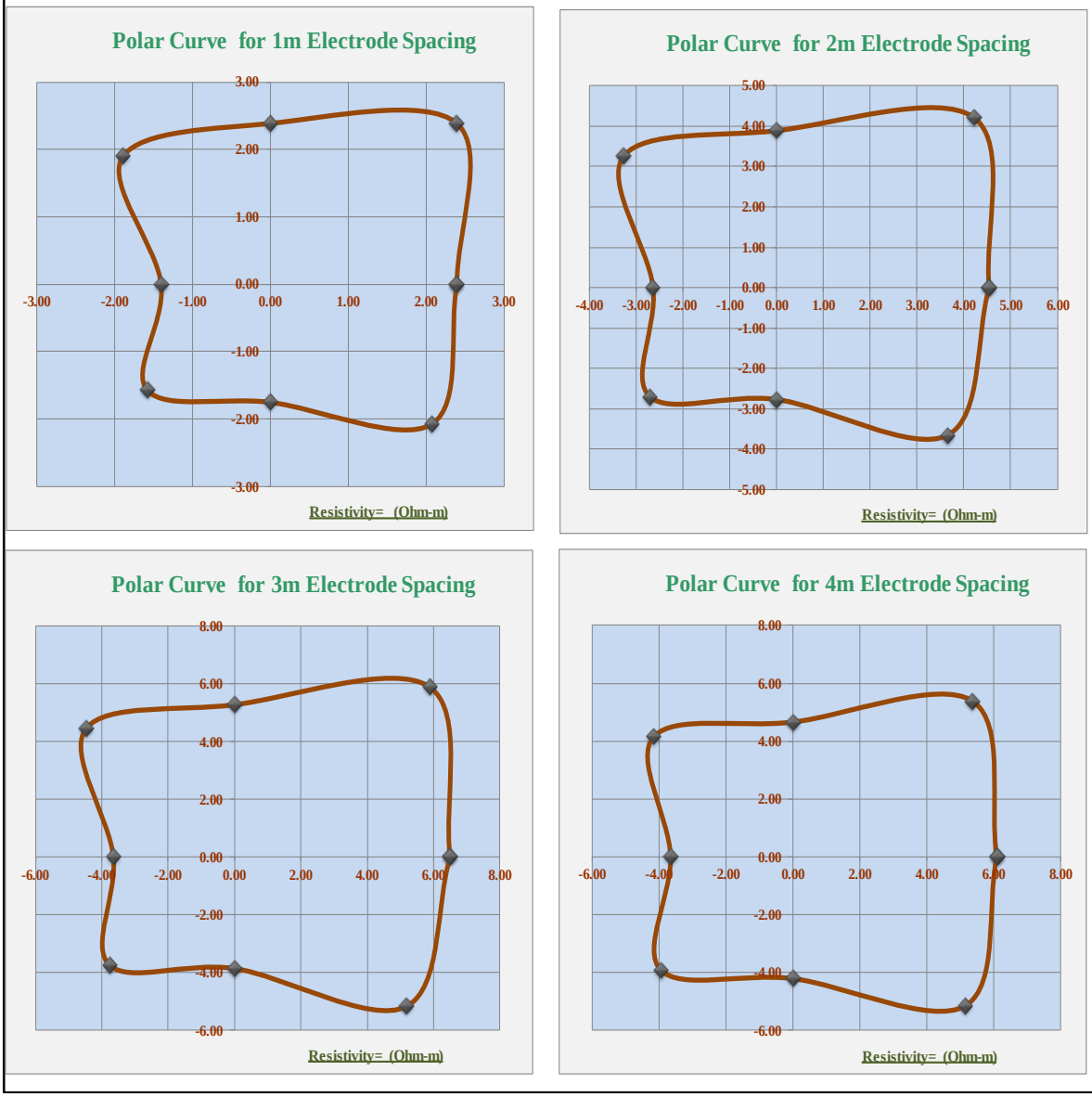
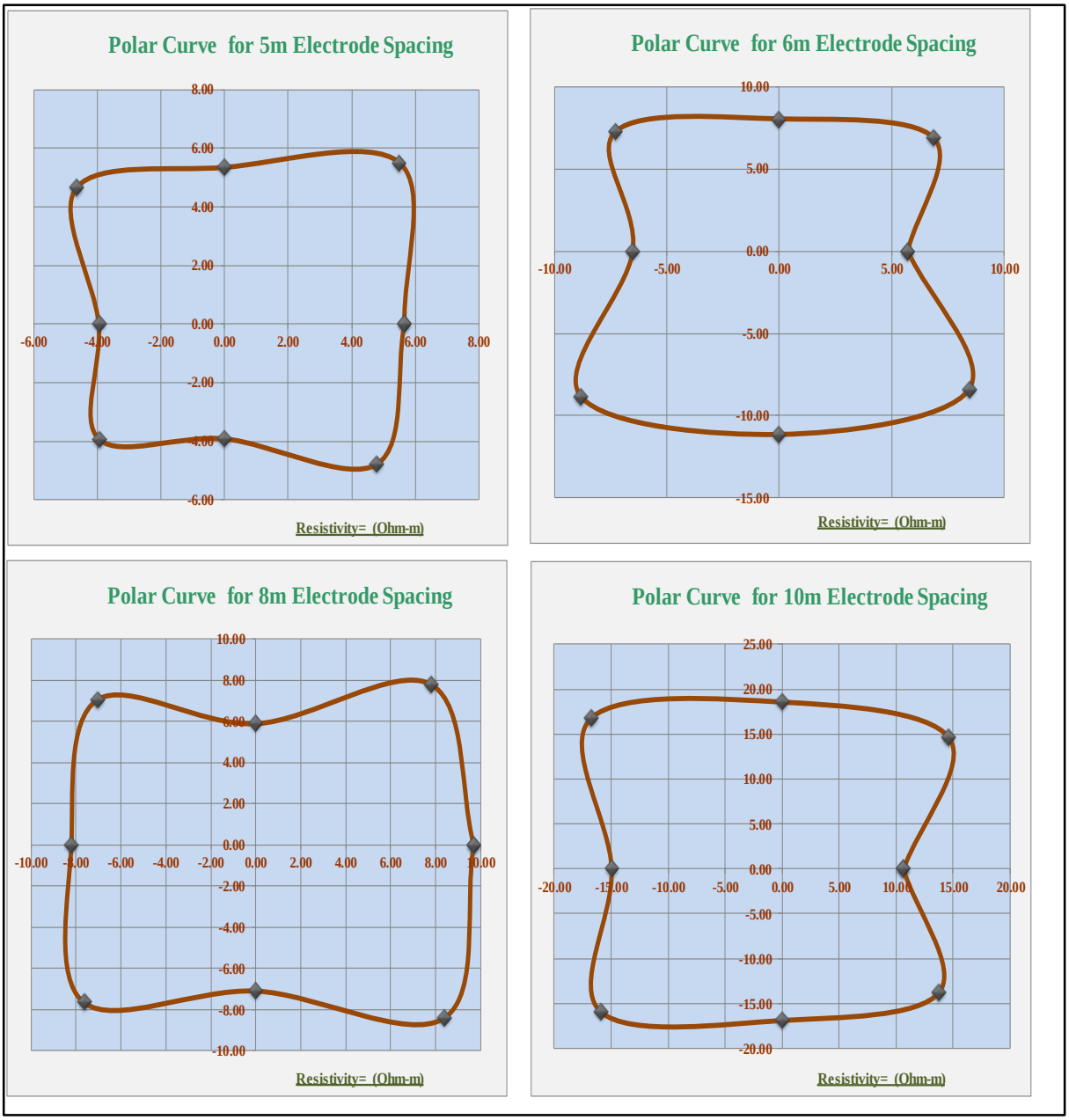

Polar Curve for 1m Electrode Spacing
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)
Polar Curve for 2m Electrode Spacing
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00 5.00 6.00
Resistivity= (Ohm-m)
Polar Curve for 3m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)
Polar Curve for 4m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
10.00
5.00
0.00
-5.00
-10.00
-15.00
-10.00 -5.00 0.00 5.00 10.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-10.00 -8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00 10.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-20.00 -15.00 -10.00 -5.00 0.00 5.00 10.00 15.00 20.00
Resistivity= (Ohm-m)

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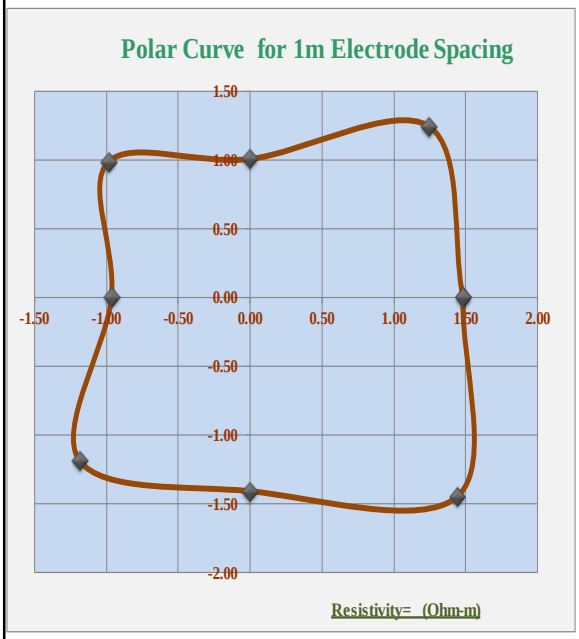
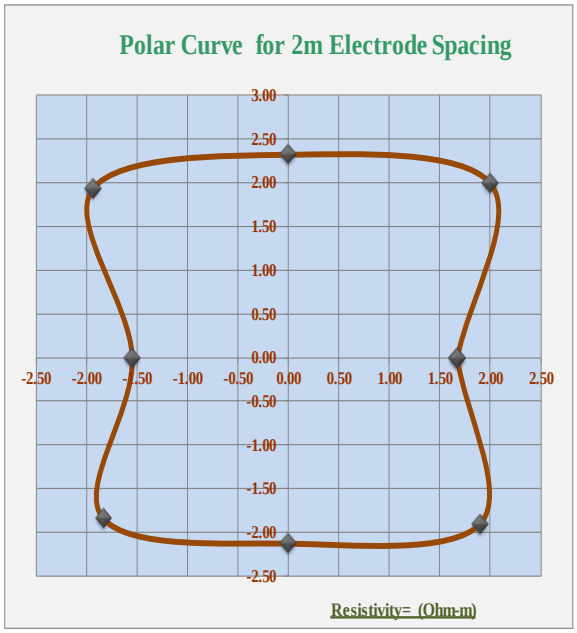
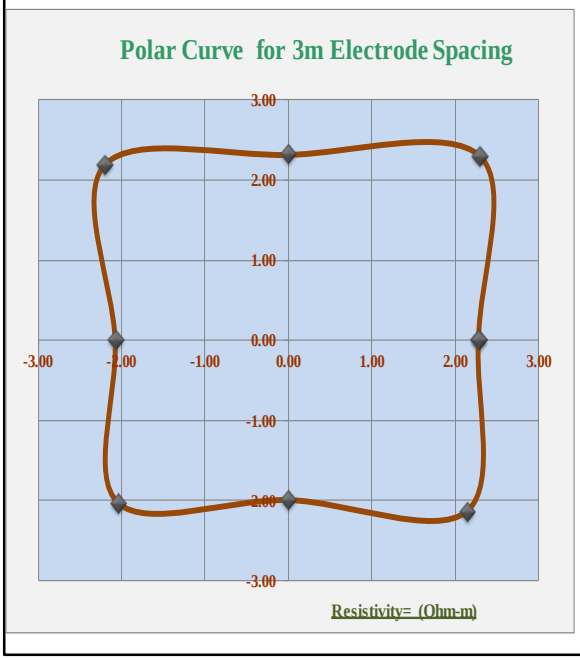
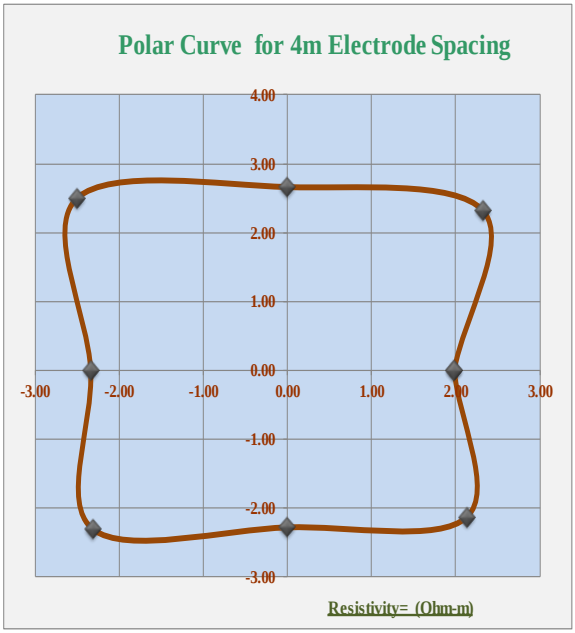
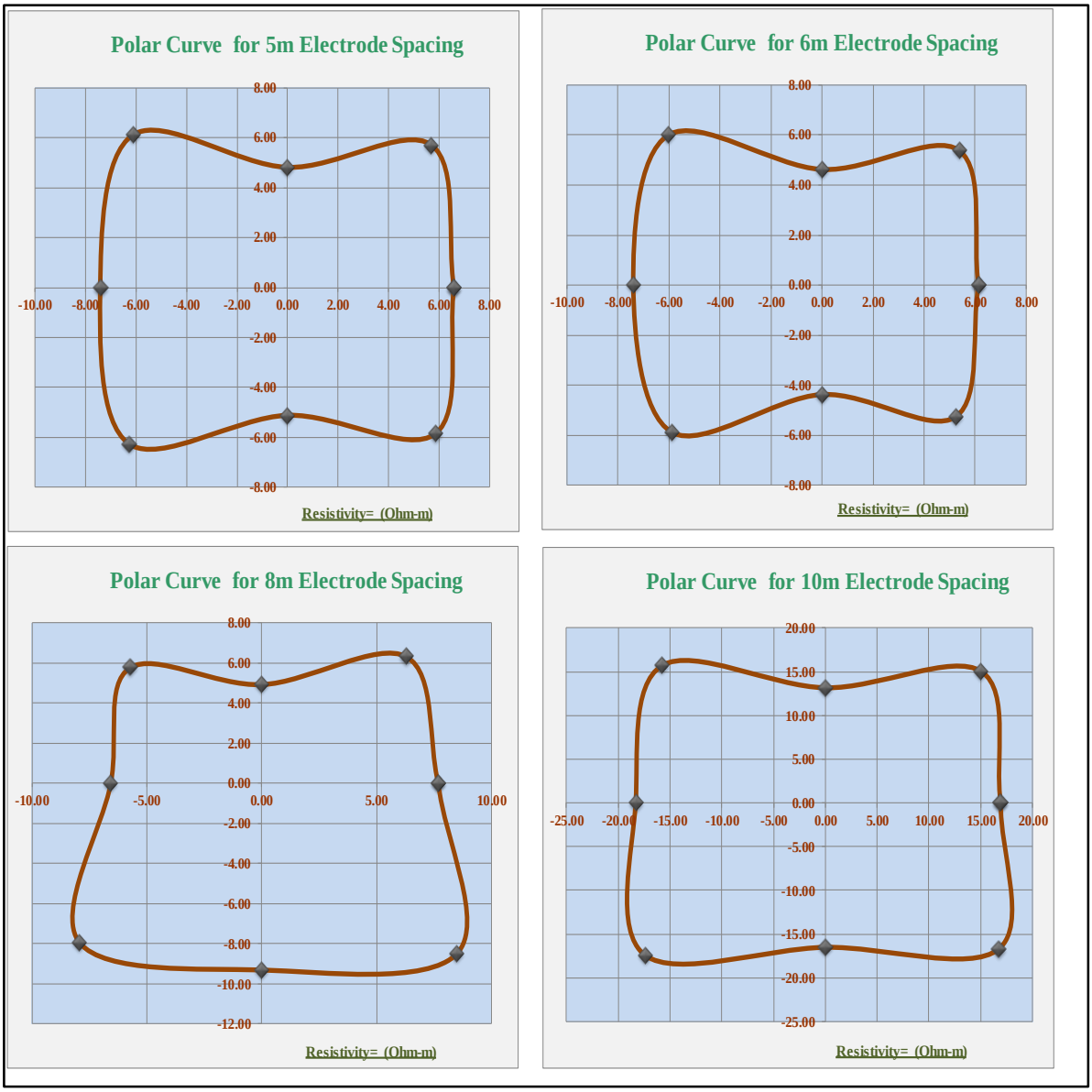

Polar Curve for 1m Electrode Spacing
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-1.50 -1.00 -0.50 0.00 0.50 1.00 1.50 2.00
Resistivity= (Ohm-m)


Polar Curve for 2m Electrode Spacing
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-2.50 -2.00 -1.50 -1.00 -0.50 0.00 0.50 1.00 1.50 2.00 2.50
Resistivity= (Ohm-m)


Polar Curve for 3m Electrode Spacing
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)


Polar Curve for 4m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00 -8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00 -8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-10.00 -5.00 0.00 5.00 10.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-25.00 -20.00 -15.00 -10.00 -5.00 0.00 5.00 10.00 15.00 20.00
Resistivity= (Ohm-m)

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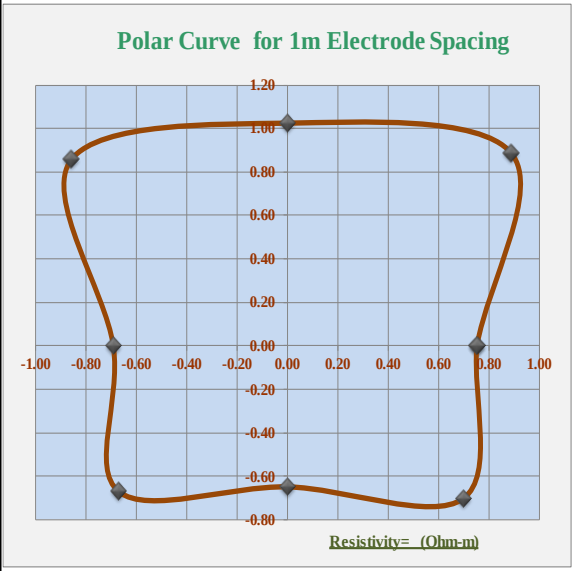
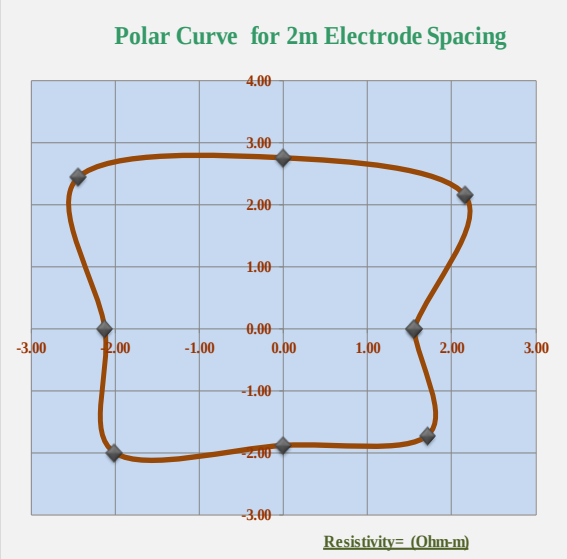
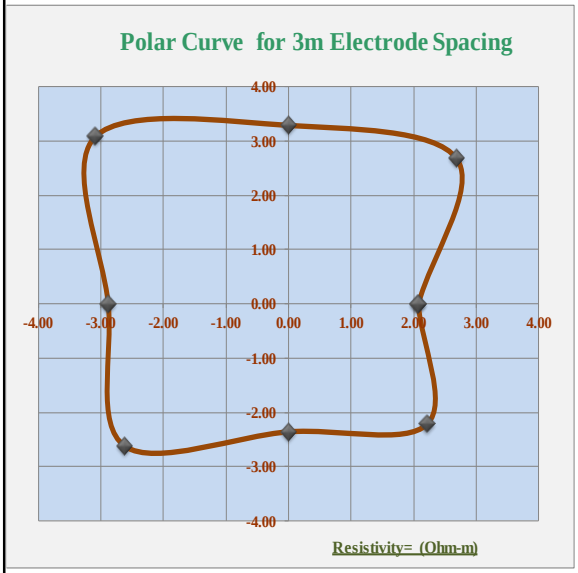
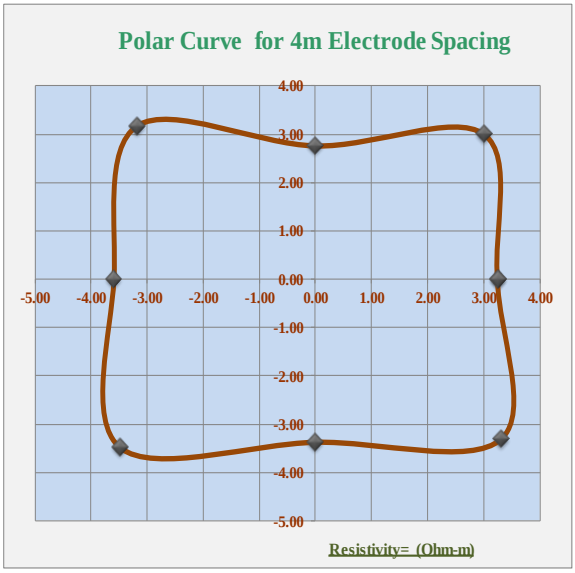
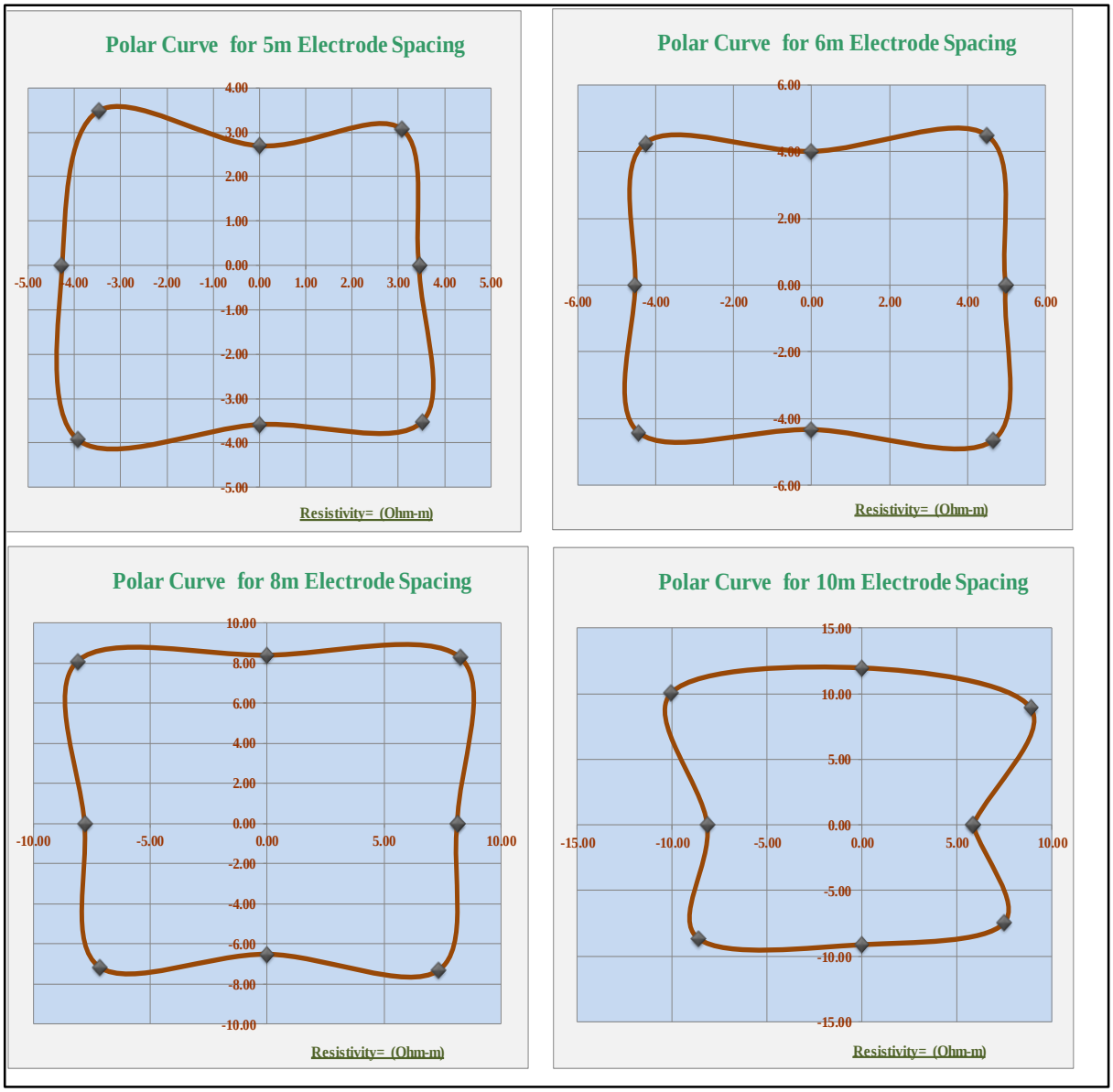

Polar Curve for 1m Electrode Spacing
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00 -0.80 -0.60 -0.40 -0.20 0.00 0.20 0.40 0.60 0.80 1.00
Resistivity= (Ohm-m)


Polar Curve for 2m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)


Polar Curve for 3m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00
Resistivity= (Ohm-m)


Polar Curve for 4m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00 5.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-10.00 -5.00 0.00 5.00 10.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-15.00 -10.00 -5.00 0.00 5.00 10.00
Resistivity= (Ohm-m)

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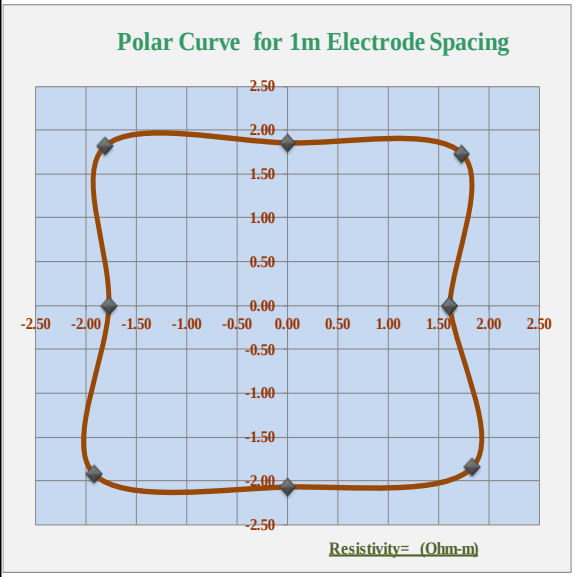
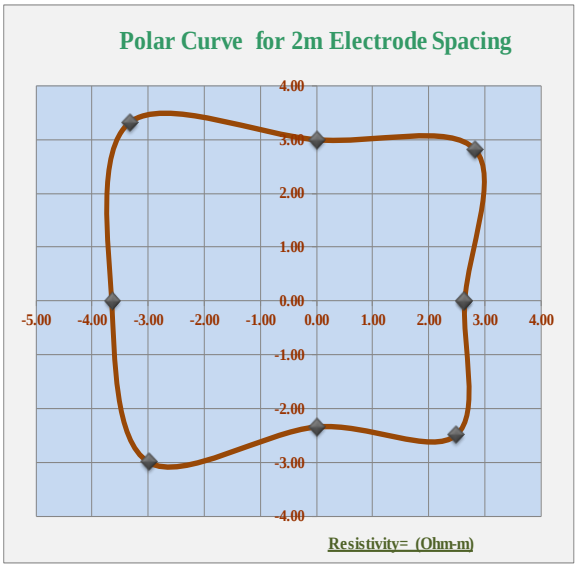
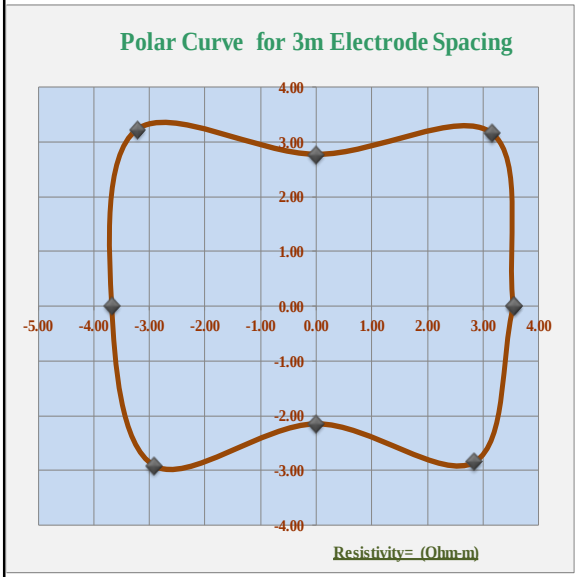
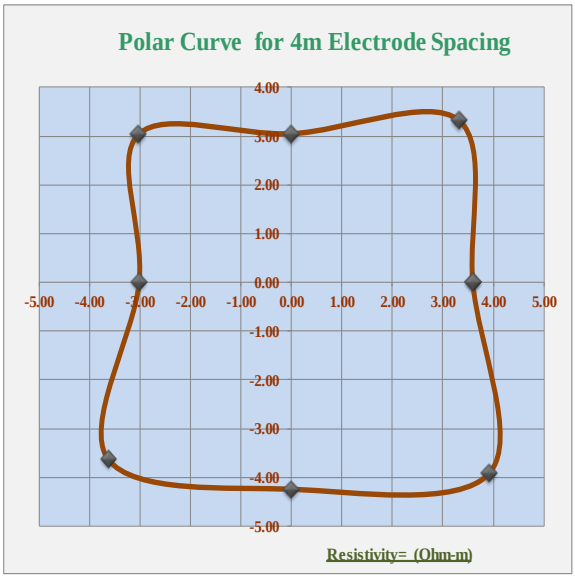
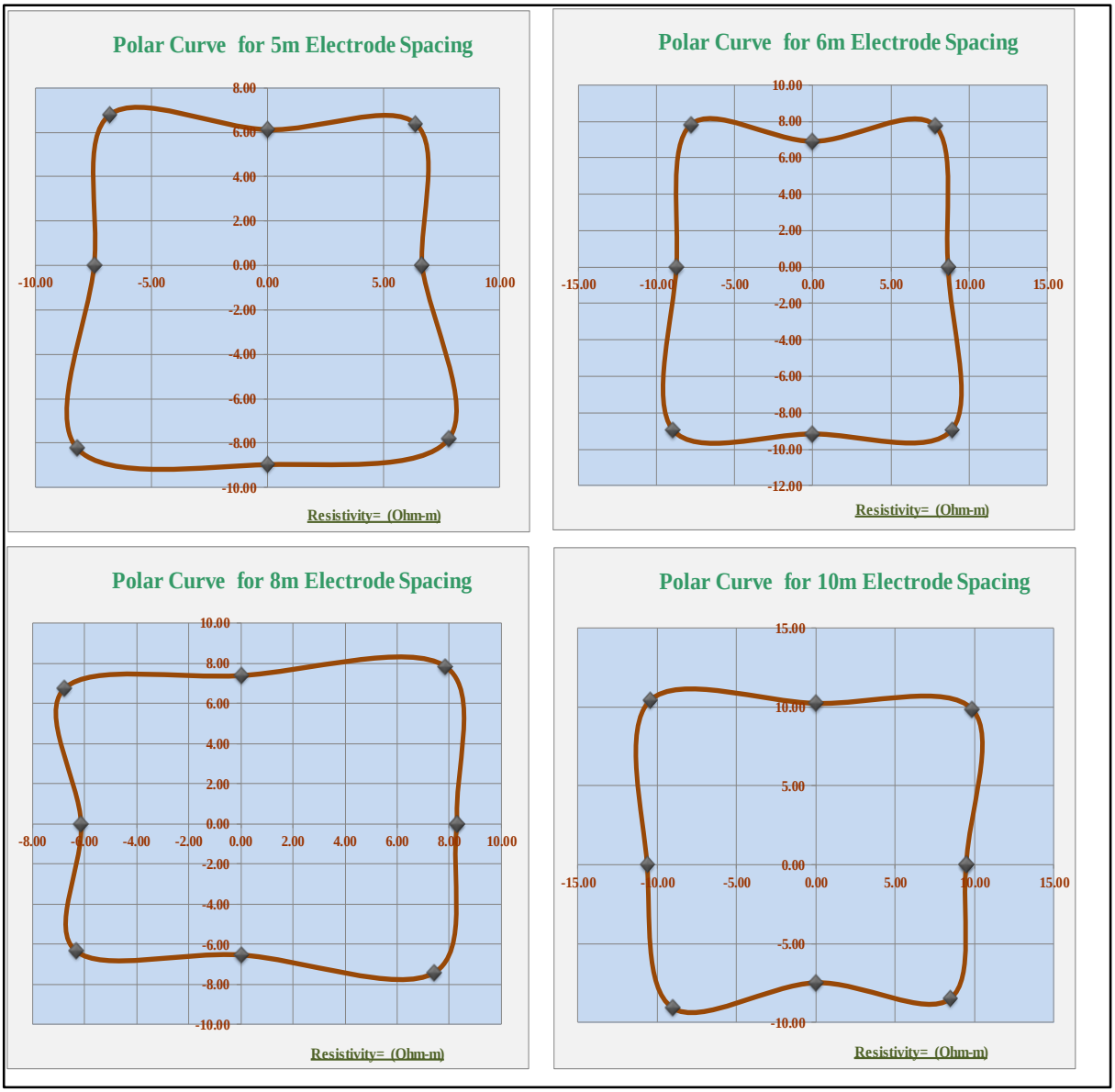

Polar Curve for 1m Electrode Spacing
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-2.50 -2.00 -1.50 -1.00 -0.50 0.00 0.50 1.00 1.50 2.00 2.50
Resistivity= (Ohm-m)


Polar Curve for 2m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00
Resistivity= (Ohm-m)


Polar Curve for 3m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00
Resistivity= (Ohm-m)


Polar Curve for 4m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00 5.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-10.00
-5.00
0.00
5.00
10.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
Resistivity= (Ohm-m)

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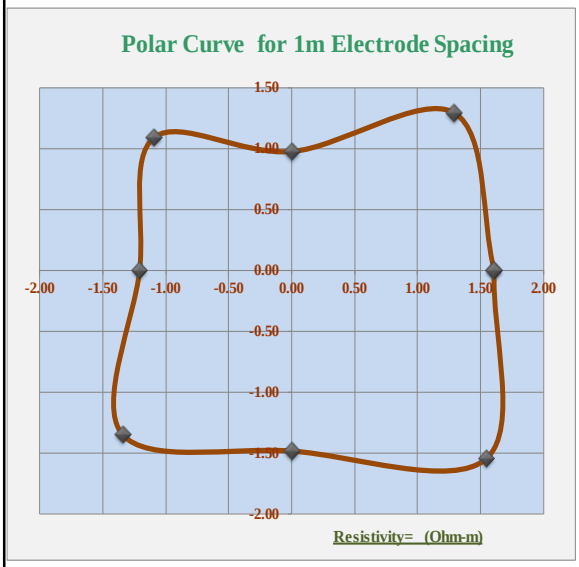
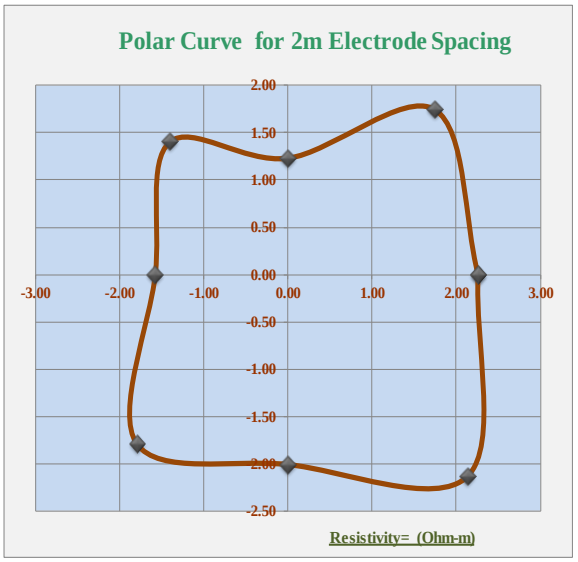
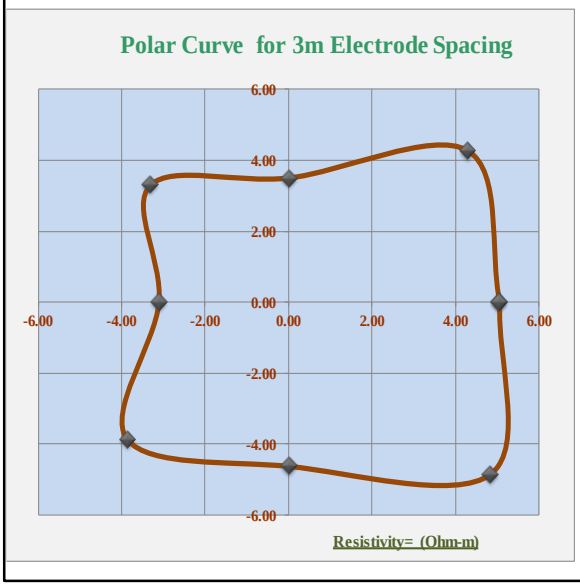
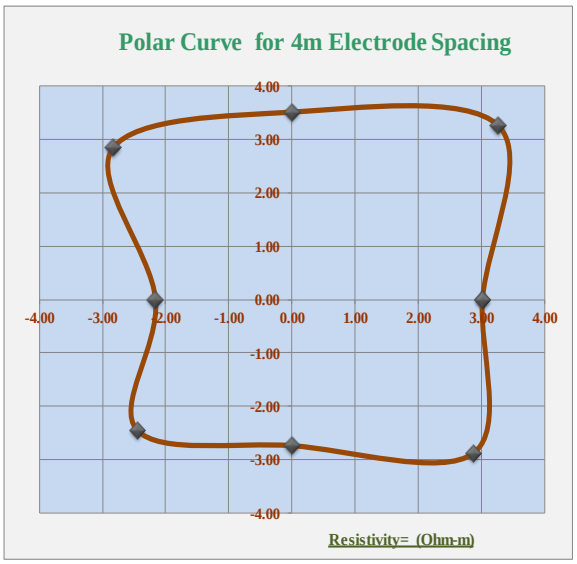
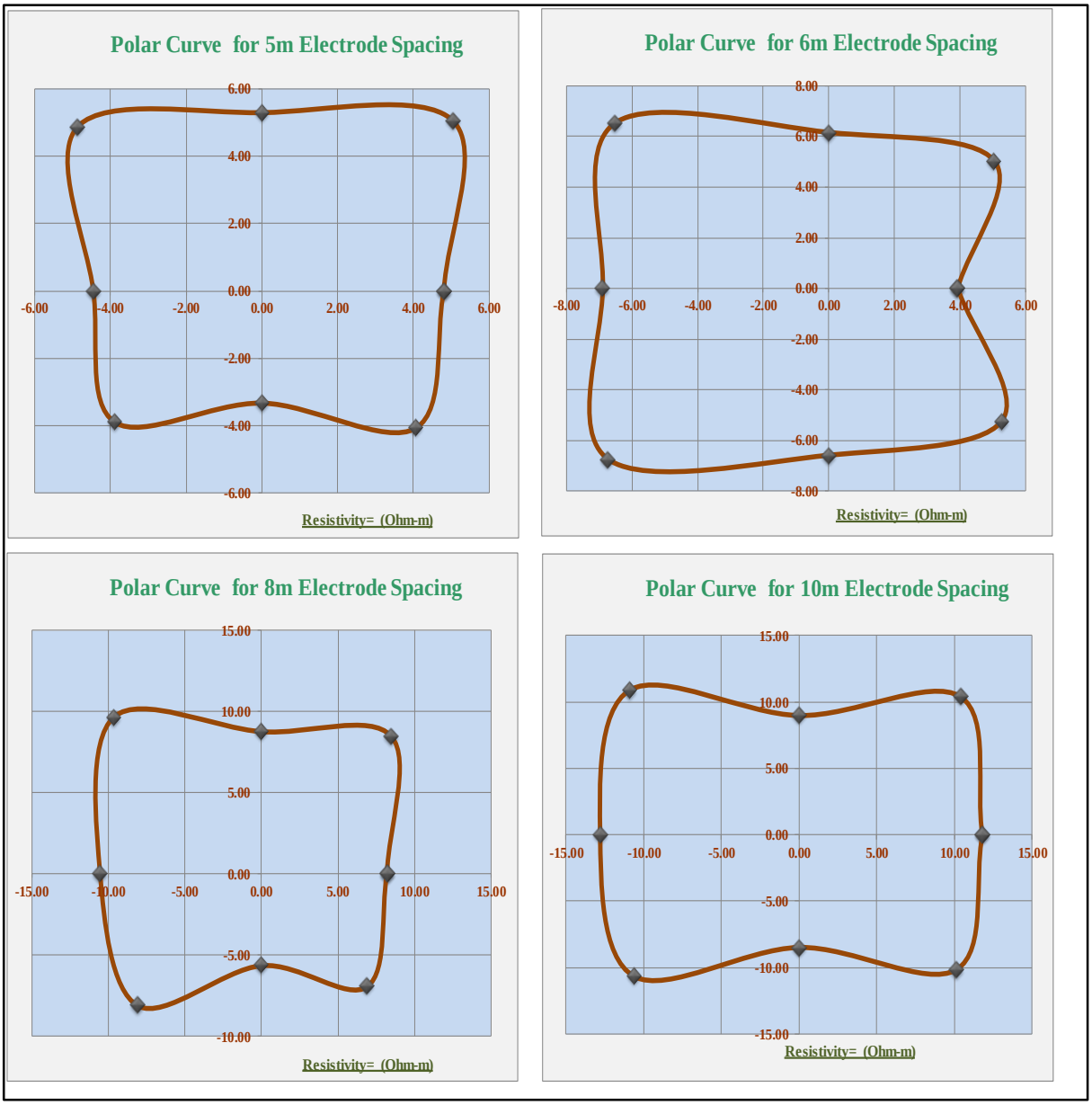

Polar Curve for 1m Electrode Spacing
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.00 -1.50 -1.00 -0.50 0.00 0.50 1.00 1.50 2.00
Resistivity= (Ohm-m)


Polar Curve for 2m Electrode Spacing
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)


Polar Curve for 3m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00
Resistivity= (Ohm-m)


Polar Curve for 4m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-8.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
Resistivity= (Ohm-m)

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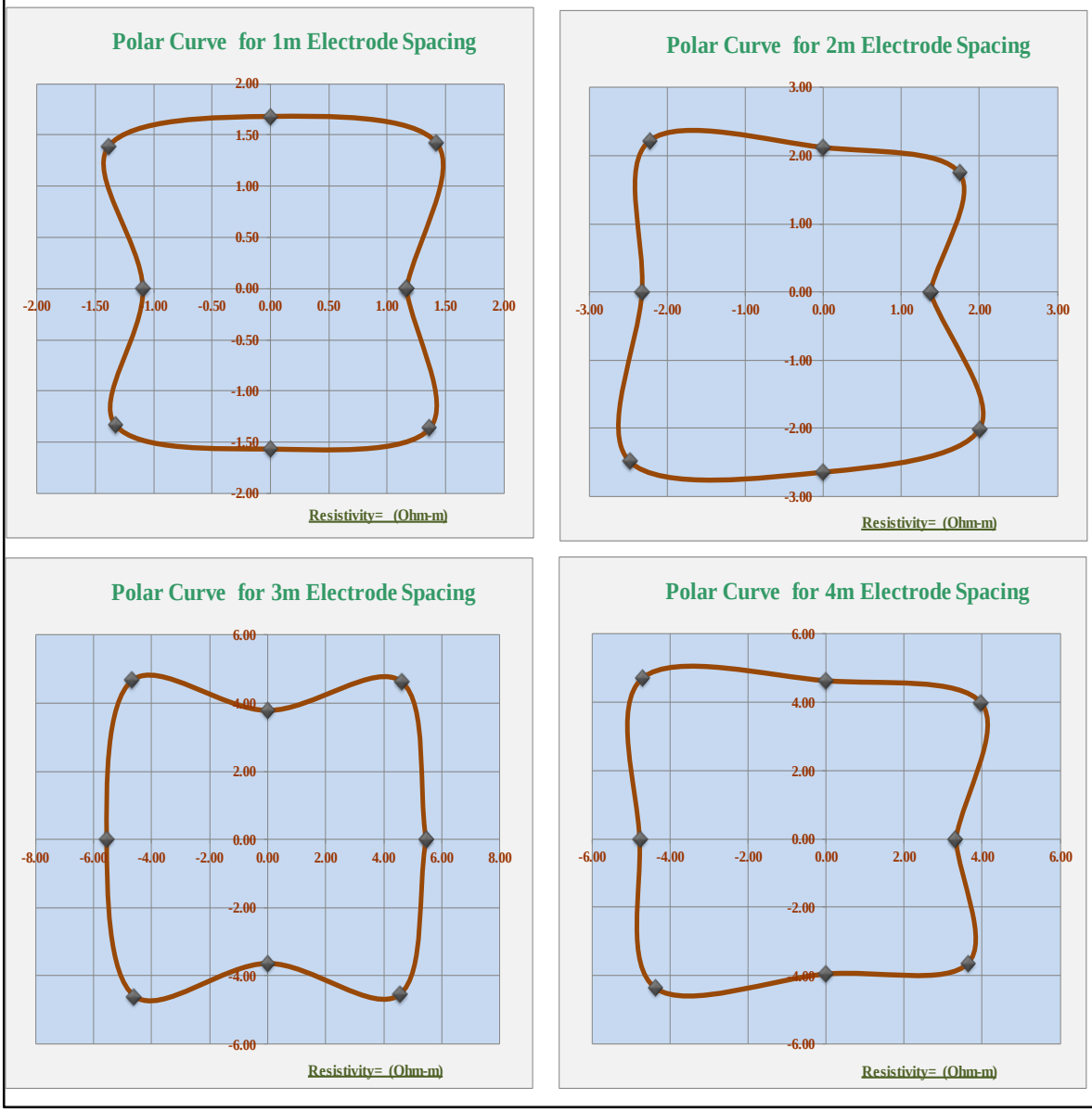
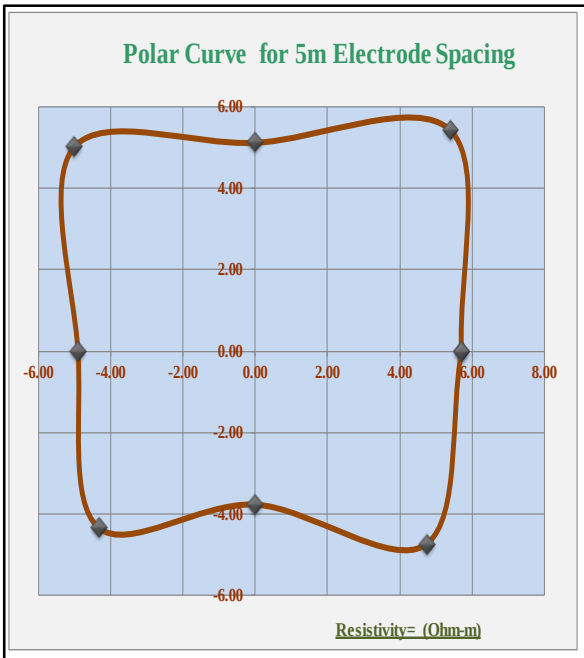
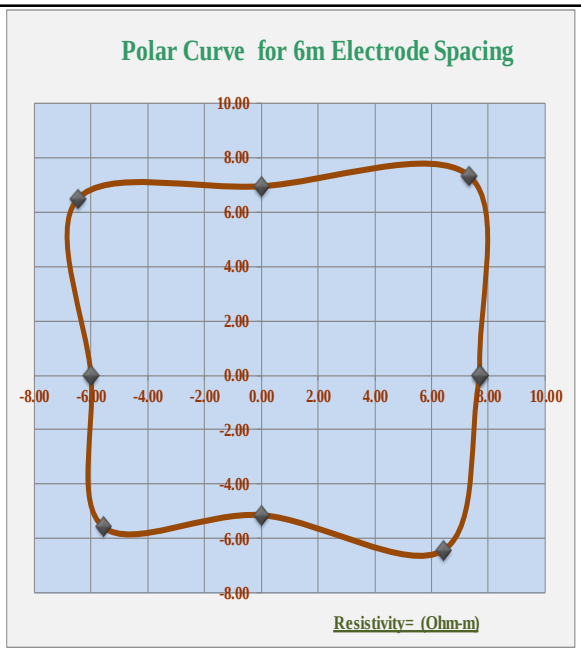
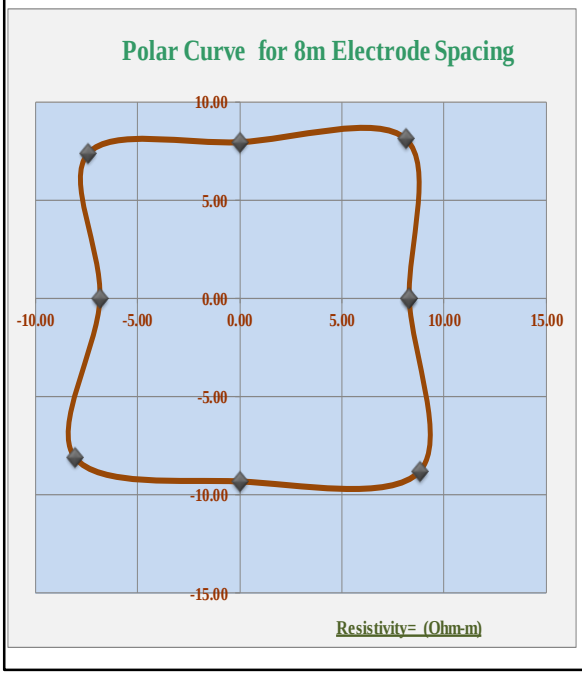
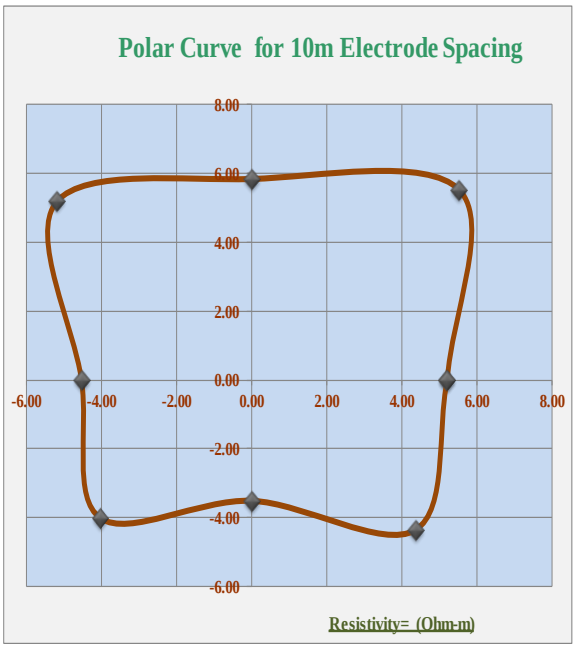

Polar Curve for 1m Electrode Spacing
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.00 -1.50 -1.00 -0.50 0.00 0.50 1.00 1.50 2.00
Resistivity= (Ohm-m)
Polar Curve for 2m Electrode Spacing
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)
Polar Curve for 3m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)
Polar Curve for 4m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00
Resistivity= (Ohm-m)


Polar Curve for 6m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-8.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
Resistivity= (Ohm-m)


Polar Curve for 8m Electrode Spacing
10.00
5.00
0.00
-5.00
-10.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
Resistivity= (Ohm-m)


Polar Curve for 10m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00
Resistivity= (Ohm-m)

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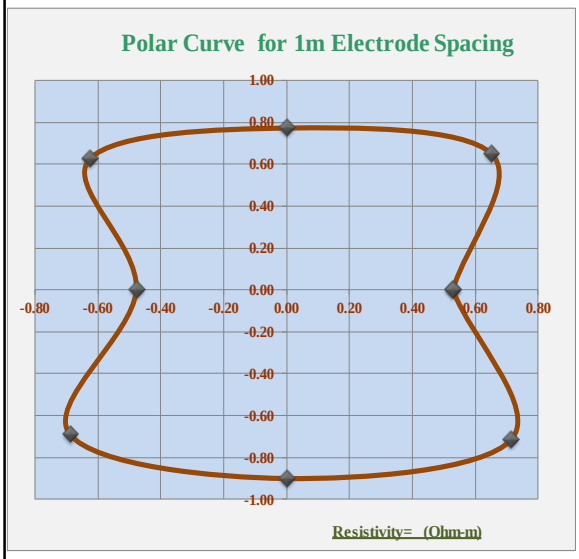
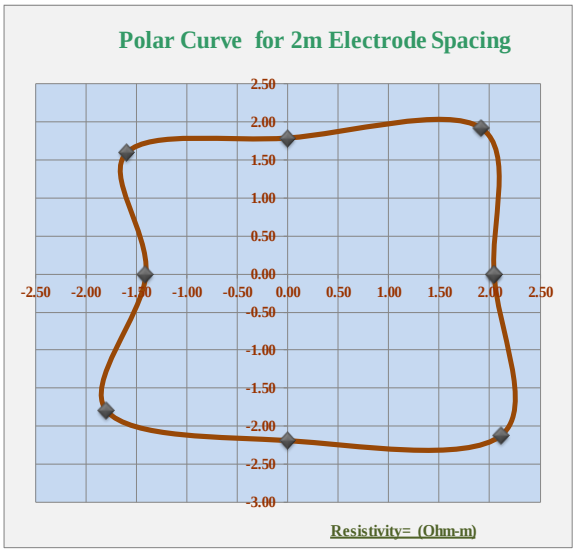
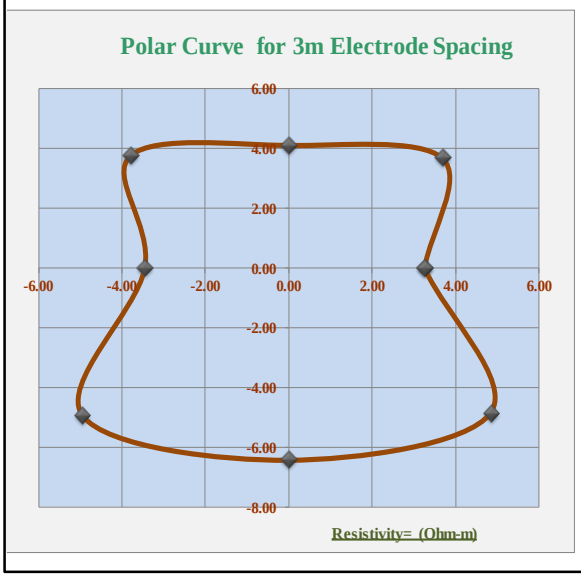
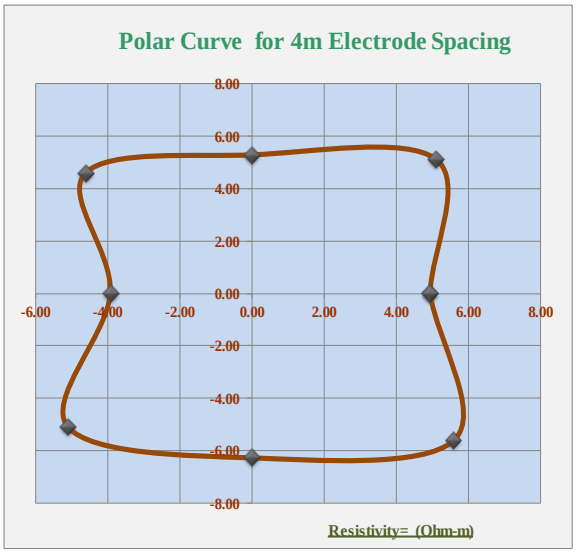
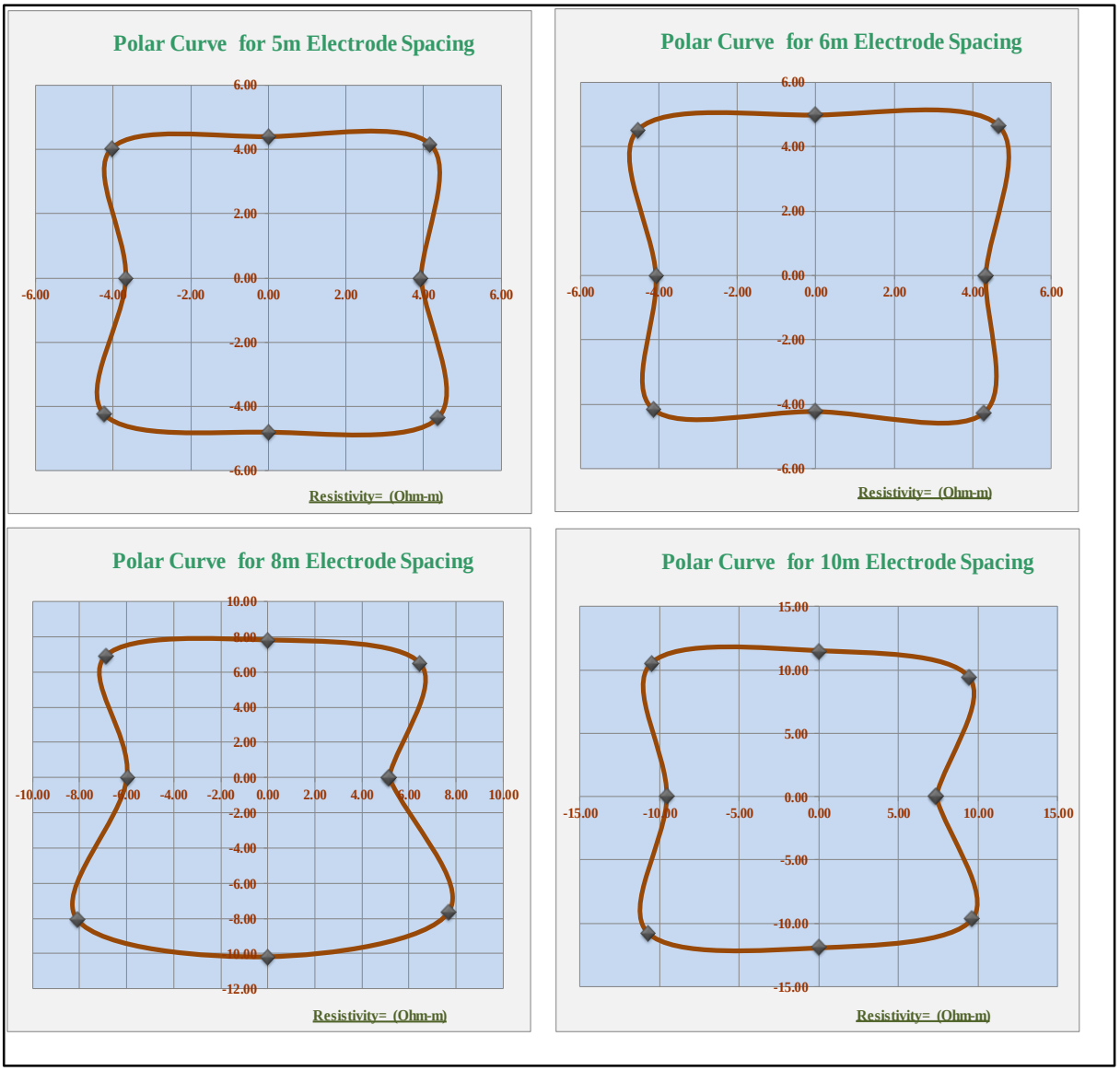

Polar Curve for 1m Electrode Spacing
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-0.80 -0.60 -0.40 -0.20 0.00 0.20 0.40 0.60 0.80
Resistivity= (Ohm-m)


Polar Curve for 2m Electrode Spacing
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-2.50 -2.00 -1.50 -1.00 -0.50 0.00 0.50 1.00 1.50 2.00 2.50
Resistivity= (Ohm-m)


Polar Curve for 3m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00
Resistivity= (Ohm-m)


Polar Curve for 4m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-15.00
-10.00
-5.00
0.00
5.00
10.00
15.00
Resistivity= (Ohm-m)

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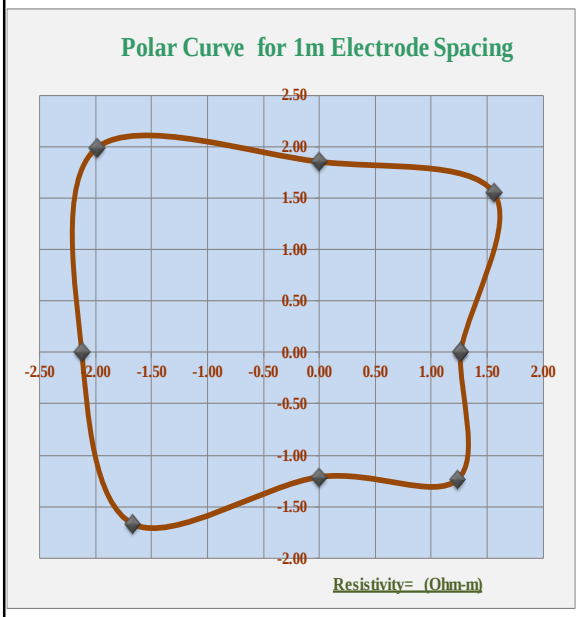
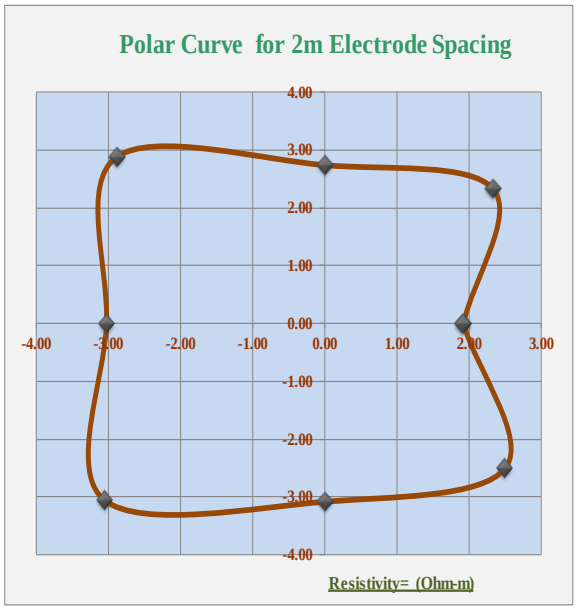
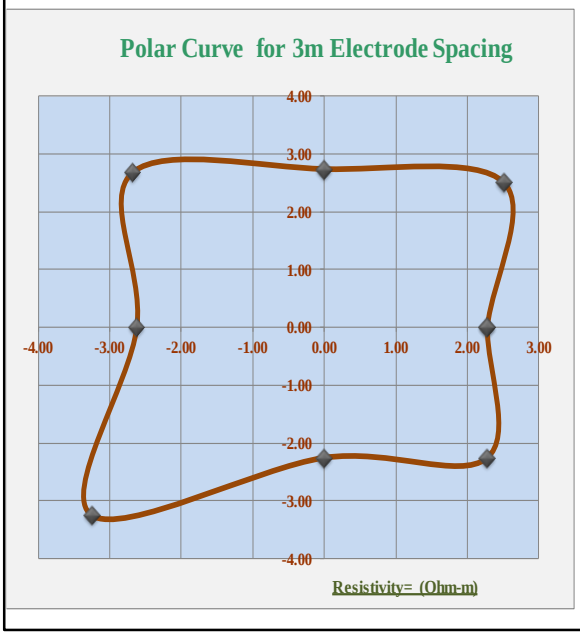
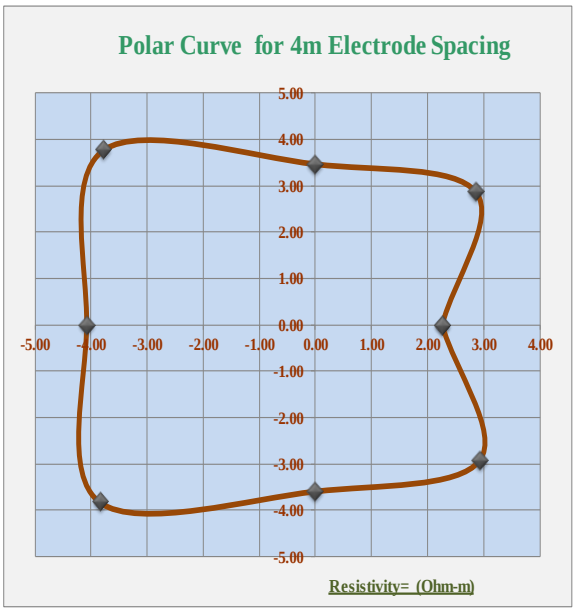
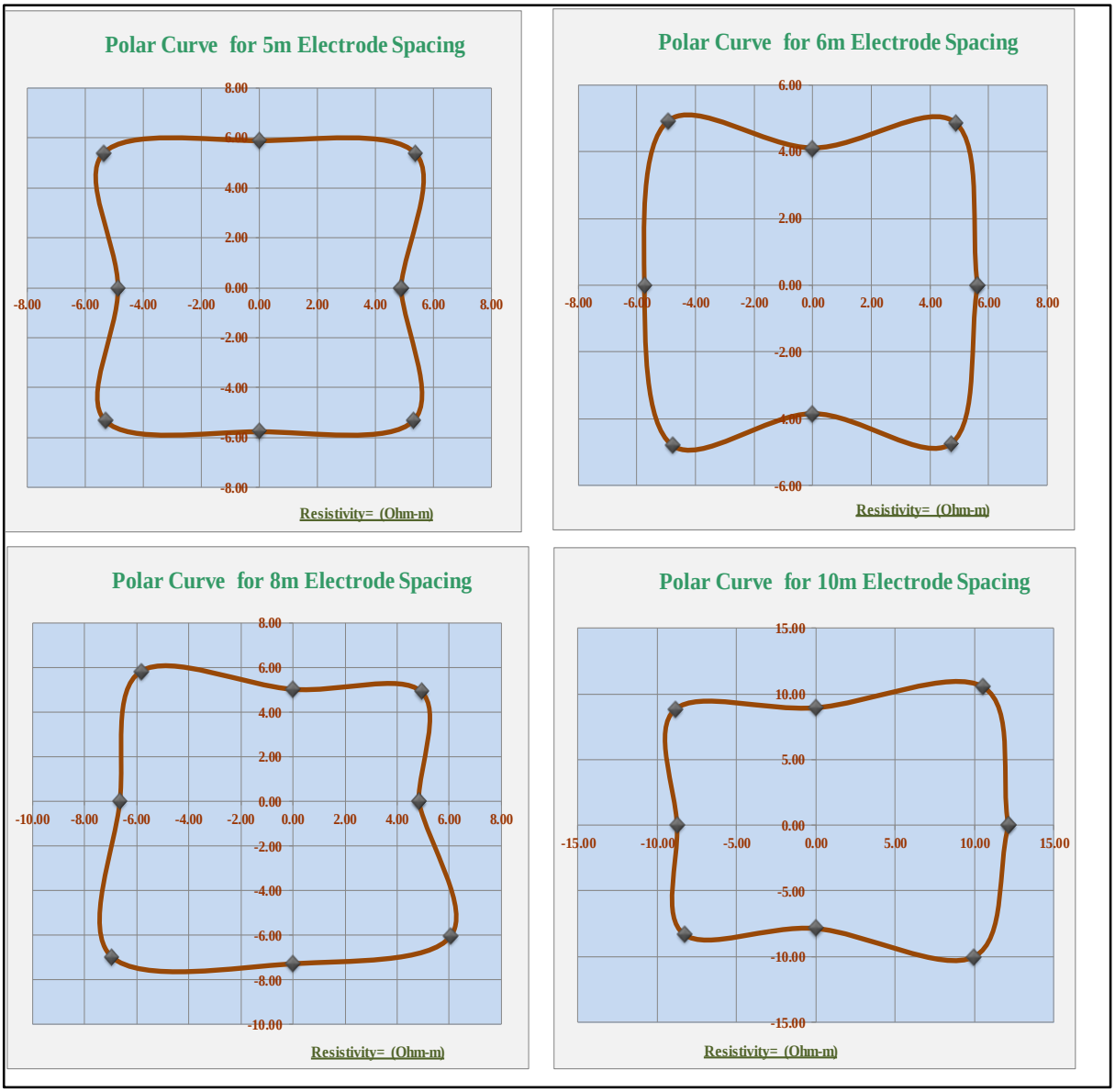

Polar Curve for 1m Electrode Spacing
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50 -2.00 -1.50 -1.00 -0.50 0.00 0.50 1.00 1.50 2.00
Resistivity= (Ohm-m)


Polar Curve for 2m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)


Polar Curve for 3m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)


Polar Curve for 4m Electrode Spacing
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-10.00 -8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-15.00 -10.00 -5.00 0.00 5.00 10.00 15.00
Resistivity= (Ohm-m)

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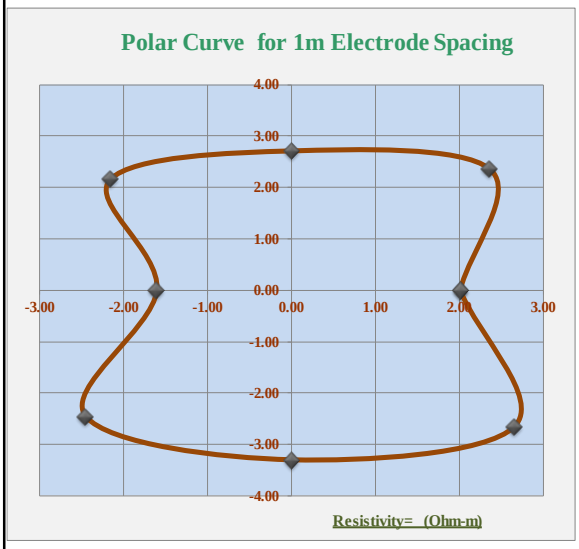
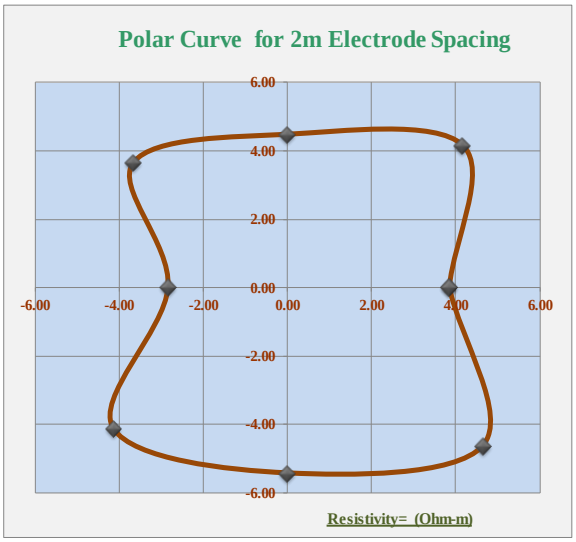
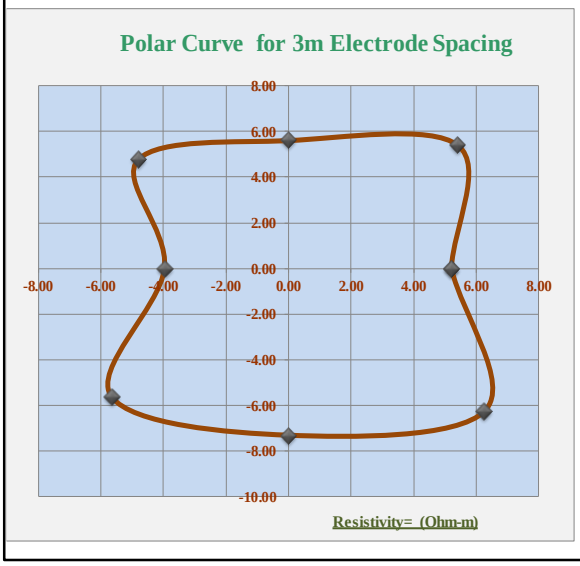
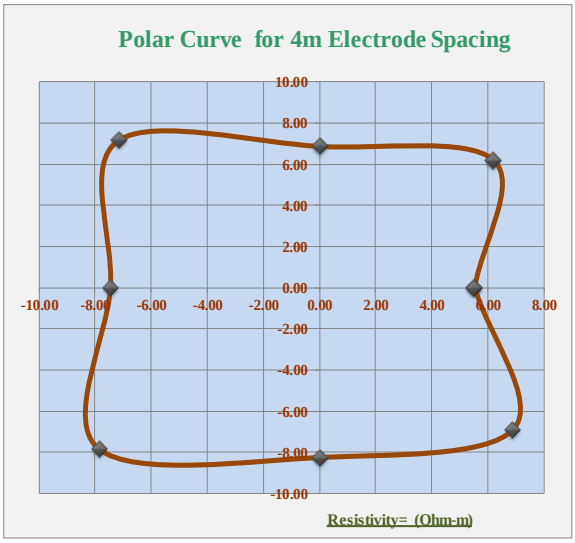
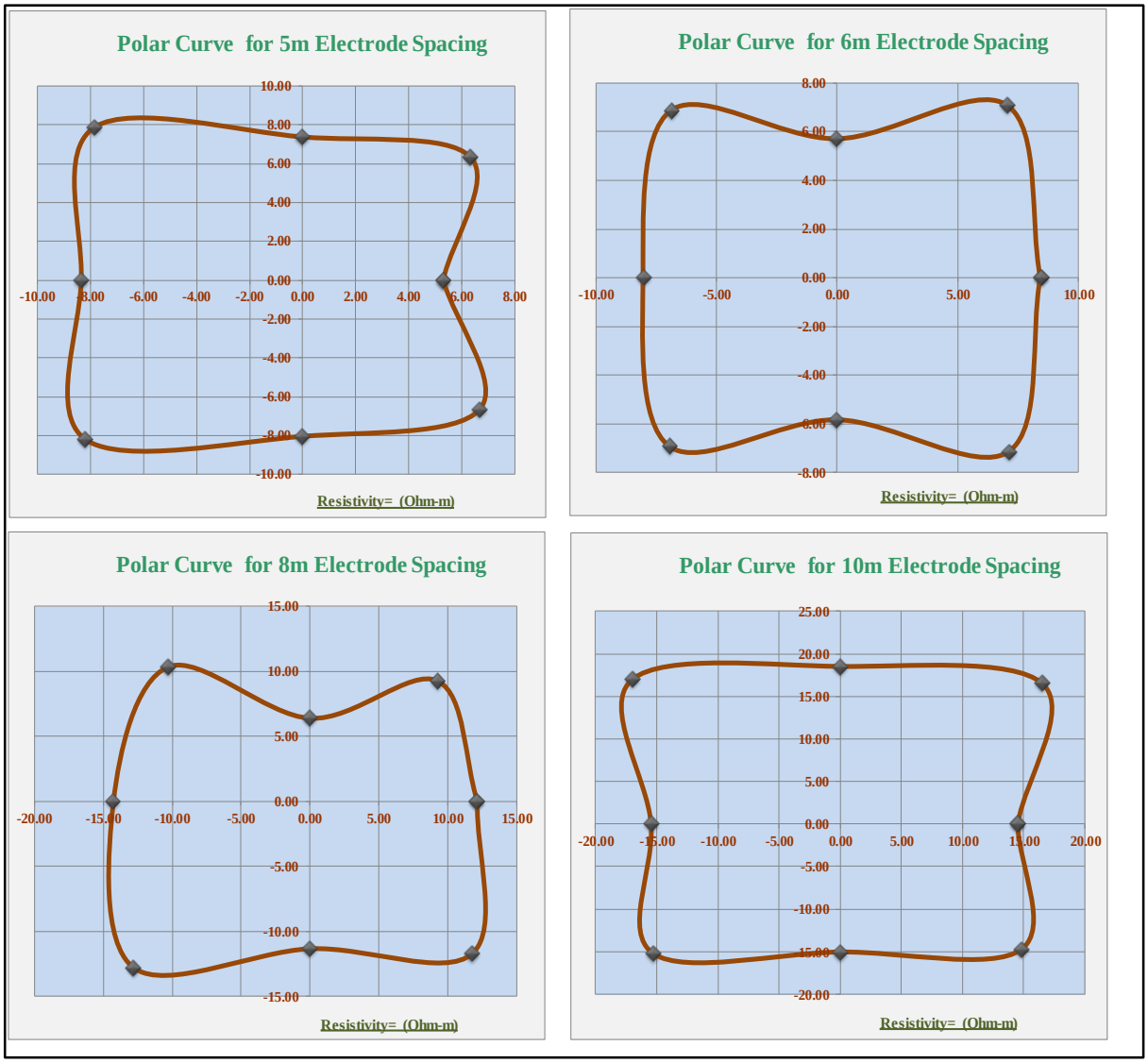

Polar Curve for 1m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
Resistivity= (Ohm-m)

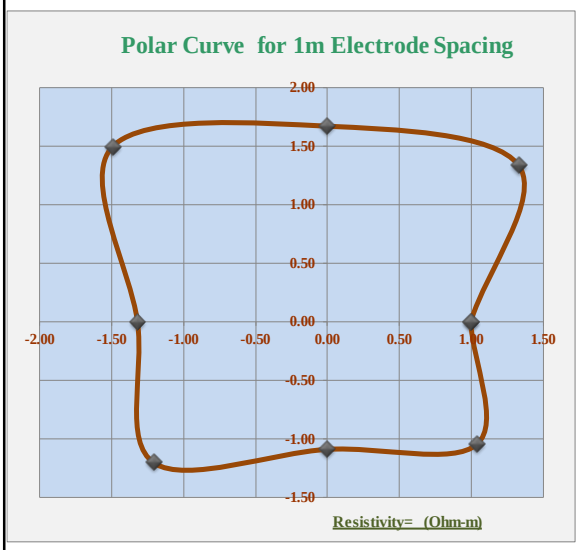

Polar Curve for 2m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Resistivity= (Ohm-m)

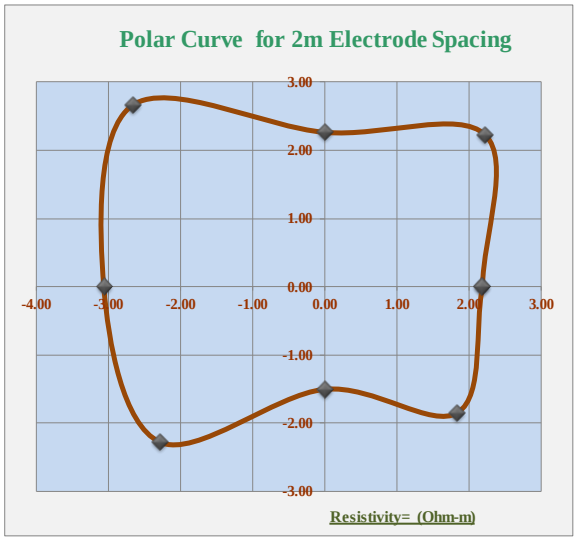

Polar Curve for 3m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00
Resistivity= (Ohm-m)

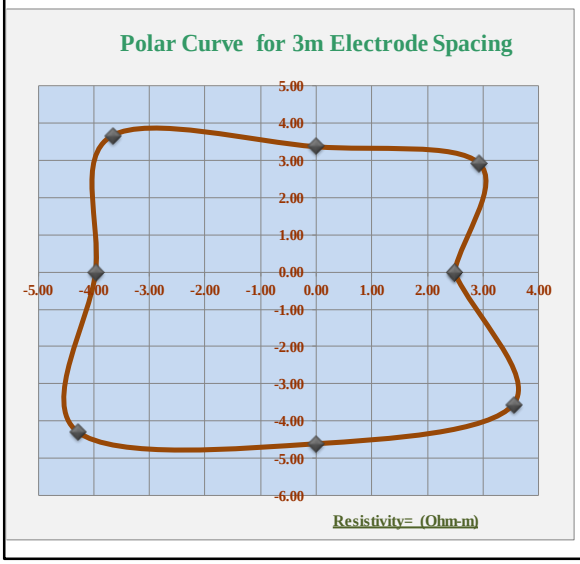

Polar Curve for 4m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00
Resistivity= (Ohm-m)

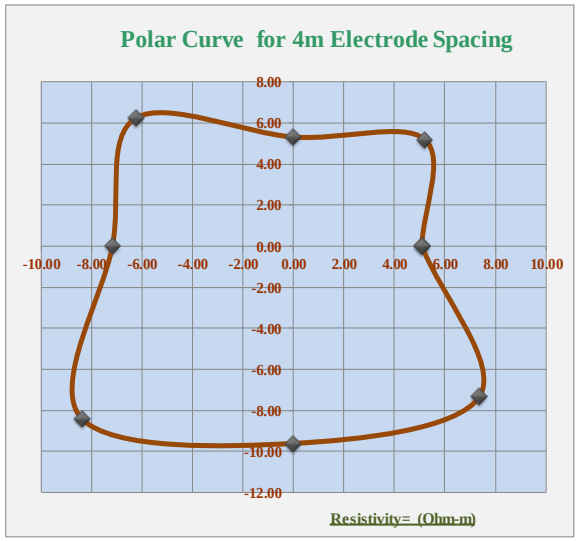

Polar Curve for 5m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-10.00 -8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00 -5.00 0.00 5.00 10.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00 -15.00 -10.00 -5.00 0.00 5.00 10.00 15.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-20.00 -15.00 -10.00 -5.00 0.00 5.00 10.00 15.00 20.00
Resistivity= (Ohm-m)

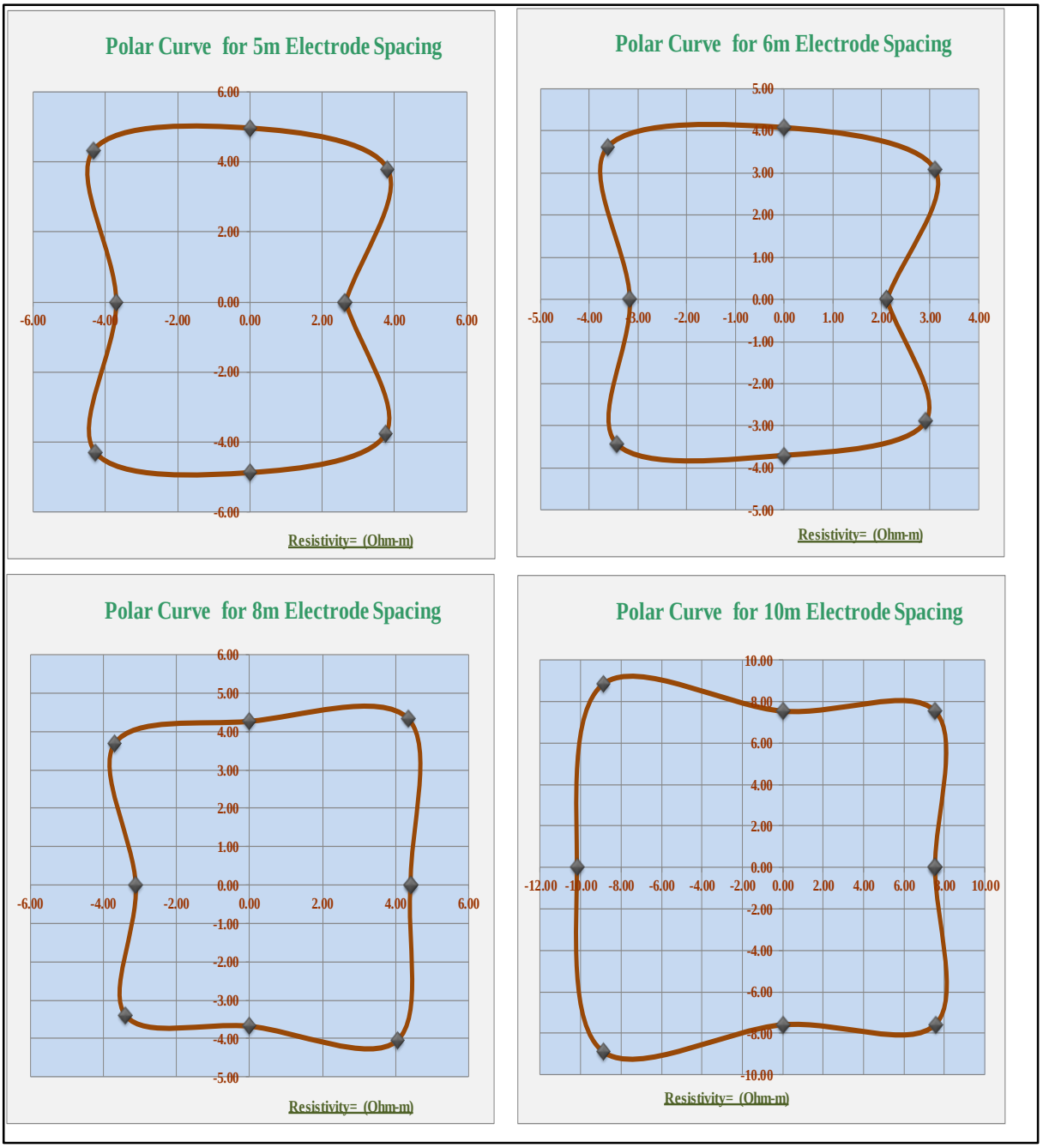
ERT-14


Polar Curve for 1m Electrode Spacing
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00 -1.50 -1.00 -0.50 0.00 0.50 1.00 1.50
Resistivity= (Ohm-m)

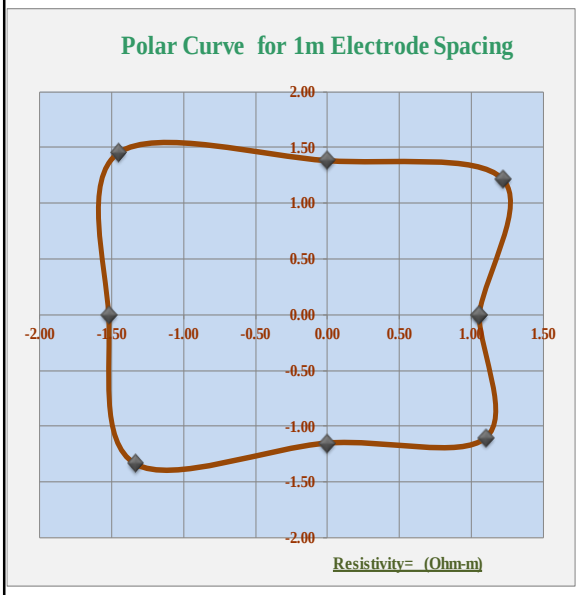

Polar Curve for 2m Electrode Spacing
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00
Resistivity= (Ohm-m)

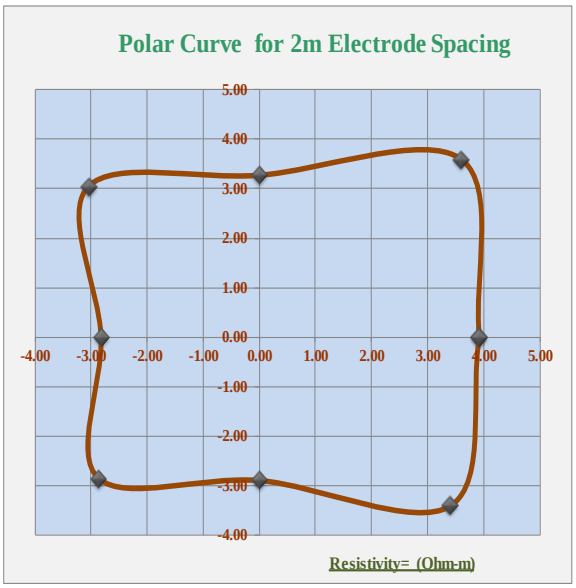

Polar Curve for 3m Electrode Spacing
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00
Resistivity= (Ohm-m)

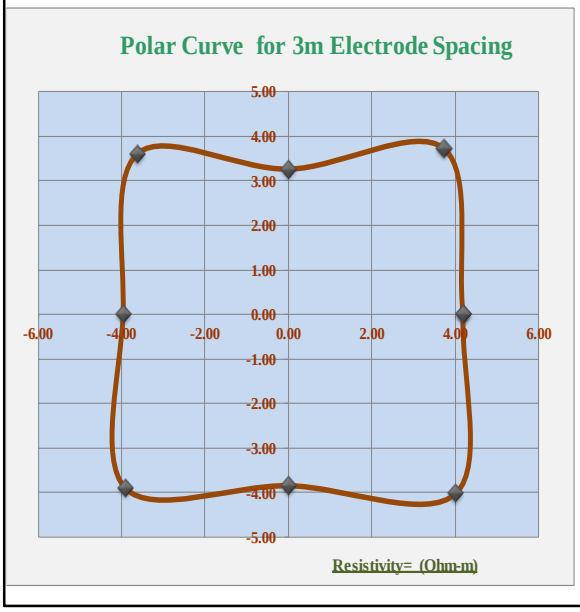

Polar Curve for 4m Electrode Spacing
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-10.00 -8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00 10.00
Resistivity= (Ohm-m)

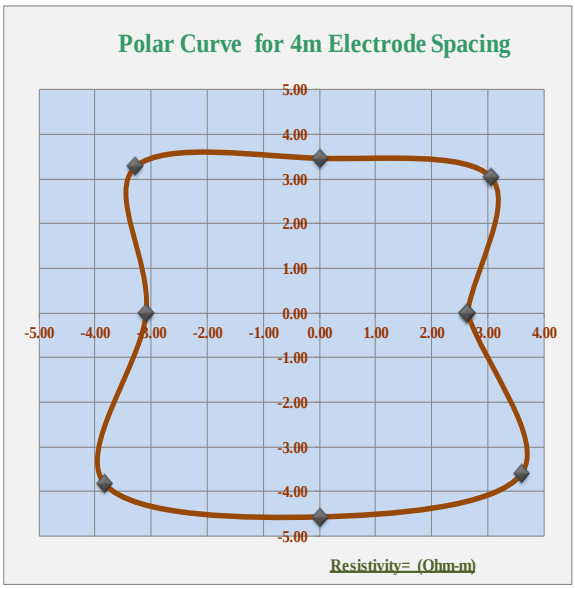

Polar Curve for 5m Electrode Spacing
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00 -4.00 -2.00 0.00 2.00 4.00 6.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00 -10.00 -8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00 10.00
Resistivity= (Ohm-m)

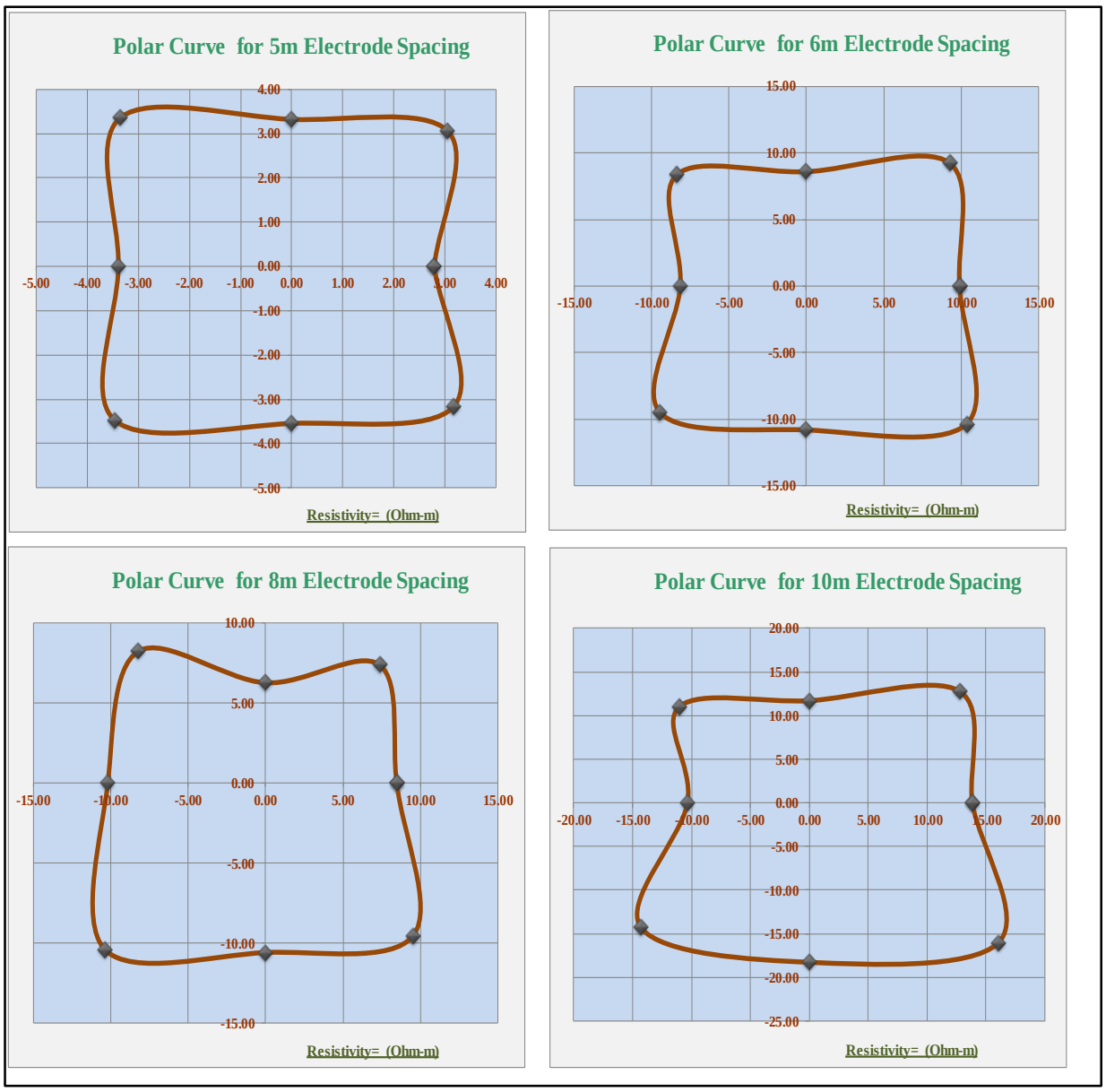
ERT-15


Polar Curve for 1m Electrode Spacing
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.00
-1.50
-1.00
-0.50
0.00
0.50
1.00
1.50
Resistivity= (Ohm-m)


Polar Curve for 2m Electrode Spacing
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
Resistivity= (Ohm-m)


Polar Curve for 3m Electrode Spacing
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
Resistivity= (Ohm-m)


Polar Curve for 4m Electrode Spacing
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-5.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
Resistivity= (Ohm-m)


Polar Curve for 5m Electrode Spacing
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-5.00 -4.00 -3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00
Resistivity= (Ohm-m)
Polar Curve for 6m Electrode Spacing
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-15.00 -10.00 -5.00 0.00 5.00 10.00 15.00
Resistivity= (Ohm-m)
Polar Curve for 8m Electrode Spacing
10.00
5.00
0.00
-5.00
-10.00
-15.00
-15.00 -10.00 -5.00 0.00 5.00 10.00 15.00
Resistivity= (Ohm-m)
Polar Curve for 10m Electrode Spacing
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-20.00 -15.00 -10.00 -5.00 0.00 5.00 10.00 15.00 20.00
Resistivity= (Ohm-m)

ANNEXURE 6: SAMPLE CALCULATION SHEETS

A) PILE DESIGN - Bored Cast *in-situ* Piles - (IS 2911 Part I / Sec2)

Sample Calculation for 4.5m LONG PILE with 0.3m DIAMETER for BH-1

DESIGN PARAMAETRS					
1	Diameter	D	m	0.30	
2	Length	L	m	4.50	Without considering CUTOFF below EGL
3	Angle of Internal Friction at Toe	ϕ	degree	15.0	
4	Cohesion at Toe	c	kN/m2	0.0	
5	L/D Ratio	=		15.00	
6	Critical Depth	Dc	m	4.50	
7	Water Table below EGL	w	m	0.00	
8	Cross Sectional Area of Pile tip	Ap	m^2	0.071	
9	Factor of Safety for Uplift Capacity	Fsu		3.0	IS 2911 Part 1 Sec 2 Cl: 6.3.2
10	Factor of Safety for Vertical Capacity	Fsv		2.5	IS 2911 Part 1 Sec 2 Cl: 6.8.2

Layer below Ground	Depth, m	Type of soil	Bulk Density	Effective Unit Weight of soil at pile tip	Average Cohesion at pile tip	Angle of Internal Friction	Shear Strength	Angle of Wall Friction between Pile and Soil	Bearing Capacity Factor			Adhesion Factor	Coefficient of Earth Pressure
	L		γ_b	γ	Ci	ϕ	Cu	δi	Nc	Nq	Nγ	αi	Ki
	m		kN/m^3	kN/m^3	kN/m^2	degree	kN/m^2	degree	--	--	--	--	--
1	0.00	Cl	17.40	7.40	0	0.0	0.0	0.0	9.0	1.00	0.00	0.00	1.00
2	1.50	Cl	17.40	7.40	21	0.0	21.0	0.0	9.0	1.00	0.00	1.00	1.00
3	4.50	ML	17.71	7.71	0	15.0	9.2	15.0	9.0	3.95	2.65	0.00	1.00

Effective Overburden Pressure at Tip	Effective Overburden Pressure at CG	Surface Area of Pile Shaft	Skin Friction, Psu			End Bearing, Ppu				Self Weight of pile	Ultimate Vertical Capacity	Safe Vertical Capacity	Uplift Capacity
			αi.ci.Asi	Ki.Pdi.Tanδi.Asi	Psu	Nc.Cp	q. N_q	0.5 D γ Nγ	Ppu				
q	Pd	A_{si}									Qu = Ppu + Psu	Qus	Qp
kN/m^2	kN/m^2	m^2	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.10	5.55	1.42	29.82	0.00	29.82	189.00	11.10	0.00	14.21	2.55	44.03	17.61	12.49
34.23	22.67	2.83	0.00	17.19	47.01	0.00	135.21	3.06	9.82	5.52	56.82	22.73	21.19

Sample Calculation for 4.5m LONG PILE with 0.3m DIAMETER for BH-1

DESIGN PARAMETERS

Diameter of Pile	D	=	0.30	m	
Length of Pile	L	=	4.50	m	Without considering CUTOFF below EGL
Angle of Internal Friction at Toe	Ø	=	15	degree	
Cohesion at Toe	c	=	0	kN/m2	
L/D Ratio	L/D	=	15.00		
Critical Depth	Dc	=	4.50	m	
Water Table below EGL	w	=	0.00	m	
Cross Sectional Area of Pile-tip	Ap	=	0.071	m^2	
Factor of Safety (Uplift Capacity)	Fsu	=	3.00		(Ref.: IS 2911 Part 1 Sec 2 CL.: 6.3.2)
Factor of Safety (Vertical Capacity)	Fsv	=	2.50		(Ref.: IS 2911 Part 1 Sec 2 CL.: 6.8.2)

Vertical Capacity, Qu = End Bearing - 'Ppu' + Skin Friction - 'Psu'

Ppu = Ap x ((0.5 x D x γ x Nγ + q x Nq) + (Nc x Cp))

= 0.071 x ((0.5 x 0.3 x 7.71 x 2.65) + (34.23 x 3.95) + (0 x 9))

= 9.82 kN

Psu = ((K x Pd x tan(di) x Asi) + (ai x ci x Asi)) + Skin Friction upto 4.5m Depth

= ((1 x 22.665 x tan15 x 2.83) + (0 x 0 x 2.83)) + 29.82

= 47.01 kN

Vertical Capacity, Qu = Ppu + Psu

= 9.82 + 47.01

Qu = 56.83 kN

Safe Vertical Capacity, Qus = Qu / Fsv

= 56.83 / 2.5

Qus = 22.732 kN

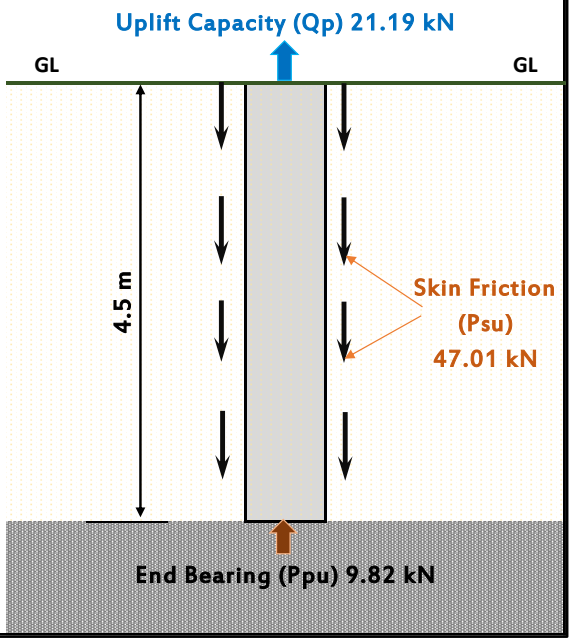
Qus = 2.28 MT

Uplift Capacity, Qp = (Psu / FoS) + Self Weight of Pile

= (47.01 / 3) + 5.52

Qp = 21.19 kN

Qp = 2.12 MT



SAMPLE CALCULATION

A) PILE DESIGN - Bored Cast *in-situ* Piles - (IS 2911 Part I/Sec2)

1	**Diameter (D), cm**	**=**	**30**	**35**
LATERAL CAPACITY OF PILE FOR SAND & NORMALY LOADED CLAYS				
1	Permissible Deflection of top, Y, mm		5	
2	Grade of Concrete	**M**	**35**	
3	Young's Modulus of Concrete, E, kN/m^2		29580399	
4	Moment Inertia of Pile, I, m^4		0.000398	0.000737
5	Free Length, e		0	
FIXED HEAD CONSIDERATION				
6	**Modulus of Subgrade reaction, ηh, kN/m^3**		1544	**(For N - 11 from IS 2911 Part 1 Sec 2)**
7	Stiffness Factor T, m		1.5	1.7
8	Ratio Lf / T		2.2	
9	**Cantilever Length, zf, m (Depth of Fixity)**		**3.3**	**3.7**
10	**Lateral Capacity, kN**		**19.6**	**25.1**
11	Reduction Factor, m		0.830	
12	Maximum Moment in Pile, kN-m		**26.9**	**38.9**
FREE HEAD CONSIDERATION				
13	Ratio Lf / R		1.9	
14	**Cantilever Length, Lf, m (Depth of Fixity)**		**2.9**	**3.2**
15	**Lateral Capacity, KN**		**7.6**	**9.7**
16	Reduction Factor, m		0.400	
17	Maximum Moment in Pile, kN-m		**8.68**	**12.56**

A) PILE DESIGN - Bored Cast *in-situ* Piles - (IS 2911 Part I / Sec2)

Sample Calculation for 25m LONG PILE with 0.75m DIAMETER for BH-1

DESIGN PARAMAETRS					
1	Diameter	D	m	0.75	
2	Length	L	m	25.00	Without considering CUTOFF below EGL
3	Angle of Internal Friction at Toe	ϕ	degree	13.0	
4	Cohesion at Toe	c	kN/m2	20.0	
5	L/D Ratio	=		15.00	
6	Critical Depth	Dc	m	11.25	
7	Water Table below EGL	w	m	0.00	
8	Cross Sectional Area of Pile tip	Ap	m^2	0.442	
9	Factor of Safety for Uplift Capacity	Fsu		3.0	IS 2911 Part 1 Sec 2 Cl: 6.3.2
10	Factor of Safety for Vertical Capacity	Fsv		2.5	IS 2911 Part 1 Sec 2 Cl: 6.8.2

Layer below Ground	Depth, m	Type of soil	Bulk Density	Effective Unit Weight of soil at pile tip	Average Cohesion at pile tip	Angle of Internal Friction	Shear Strength	Angle of Wall Friction between Pile and Soil	Bearing Capacity Factor			Adhesion Factor	Coefficient of Earth Pressure
	L		γ_b	γ	Ci	ϕ	Cu	δi	Nc	Nq	Nγ	αi	Ki
	m		kN/m^3	kN/m^3	kN/m^2	degree	kN/m^2	degree	--	--	--	--	--
1	0.00	Cl	17.40	7.40	0	0.0	0.0	0.0	9.0	1.00	0.00	0.00	1.00
2	1.50	Cl	17.40	7.40	21	0.0	21.0	0.0	9.0	1.00	0.00	1.00	1.00
3	4.00	ML	17.71	7.71	0	15.0	8.1	15.0	9.0	3.95	2.65	0.00	1.00
4	8.00	ML	18.93	8.93	0	15.0	17.7	15.0	9.0	3.95	2.65	0.00	1.00
5	9.50	CL	18.13	8.13	5	14.0	24.5	14.0	9.0	3.59	2.29	1.00	1.00
6	12.50	ML	18.19	8.19	0	18.0	30.1	18.0	9.0	5.26	4.07	0.00	1.00
7	18.50	ML	19.19	9.19	0	22.0	37.4	22.0	9.0	7.83	7.13	0.00	1.00
8	25.00	Cl	18.62	8.62	20	13.0	41.4	13.0	9.0	3.27	1.97	0.99	1.00
9	30.00	Cl	18.31	8.31	51	10.0	67.3	10.0	9.0	2.48	1.23	0.68	1.00

Effective Overburden Pressure at Tip	Effective Overburden Pressure at CG	Surface Area of Pile Shaft	Skin Friction, Psu			End Bearing, Ppu				Self Weight of pile	Ultimate Vertical Capacity	Safe Vertical Capacity	Uplift Capacity
			αi.ci.Asi	Ki.Pdi.Tanδi.Asi	Psu	Nc.Cp	q. N_q	0.5 D γ Nγ	Ppu				
q	Pd	A_{si}									Qu = Ppu + Psu	Qus	Qp
kN/m^2	kN/m^2	m^2	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.10	5.55	3.54	74.34	0.00	74.34	189.00	11.10	0.00	88.44	15.91	162.78	65.11	40.69
30.38	20.74	5.90	0.00	32.78	107.12	0.00	119.98	7.66	56.42	31.38	163.54	65.42	67.09
66.10	48.24	9.43	0.00	121.88	229.00	0.00	261.08	8.87	119.32	56.13	348.32	139.33	132.46
78.29	72.19	3.54	17.70	63.72	310.42	45.00	281.06	6.98	147.20	65.41	457.63	183.05	168.88
92.52	85.40	7.07	0.00	196.19	506.61	0.00	486.64	12.50	220.62	83.97	727.23	290.89	252.84
92.52	92.52	14.14	0.00	528.55	1035.16	0.00	724.41	24.57	331.05	121.09	1366.21	546.48	466.14
92.52	92.52	15.32	303.34	327.23	1665.72	180.00	302.53	6.37	216.09	161.30	1881.81	752.72	716.54
92.52	92.52	11.79	408.88	192.33	2266.93	459.00	229.44	3.83	305.99	192.23	2572.91	1029.17	947.87

Sample Calculation for 25m LONG PILE with 0.75m DIAMETER for BH-1

DESIGN PARAMETERS

Diameter of Pile	D	=	0.75	m	
Length of Pile	L	=	25.00	m	Without considering CUTOFF below EGL
Angle of Internal Friction at Toe	Ø	=	13	degree	
Cohesion at Toe	c	=	20	kN/m2	
L/D Ratio	L/D	=	15.00		
Critical Depth	Dc	=	11.25	m	
Water Table below EGL	w	=	0.00	m	
Cross Sectional Area of Pile-tip	Ap	=	0.442	m^2	
Factor of Safety (Uplift Capacity)	Fsu	=	3.00		(Ref.: IS 2911 Part 1 Sec 2 CL.: 6.3.2)
Factor of Safety (Vertical Capacity)	Fsv	=	2.50		(Ref.: IS 2911 Part 1 Sec 2 CL.: 6.8.2)

Vertical Capacity, Qu = End Bearing - 'Ppu' + Skin Friction - 'Psu'

Ppu = Ap x ((0.5 x D x γ x Nγ + q x Nq) + (Nc x Cp))

= 0.442 x ((0.5 x 0.75 x 8.62 x 1.97) + (92.52 x 3.27) + (20 x 9))

= 216.1 kN

Psu = ((K x Pd x tan(di) x Asi) + (ai x ci x Asi)) + Skin Friction upto 25m Depth

= ((1 x 92.5175 x tan13 x 15.32) + (0.99 x 20 x 15.32)) + 1035.157

= 1665.72 kN

Vertical Capacity, Qu = Ppu + Psu

= 216.1 + 1665.72

Qu = 1881.82 kN

Safe Vertical Capacity, Qus = Qu / Fsv

= 1881.82 / 2.5

Qus = 752.728 kN

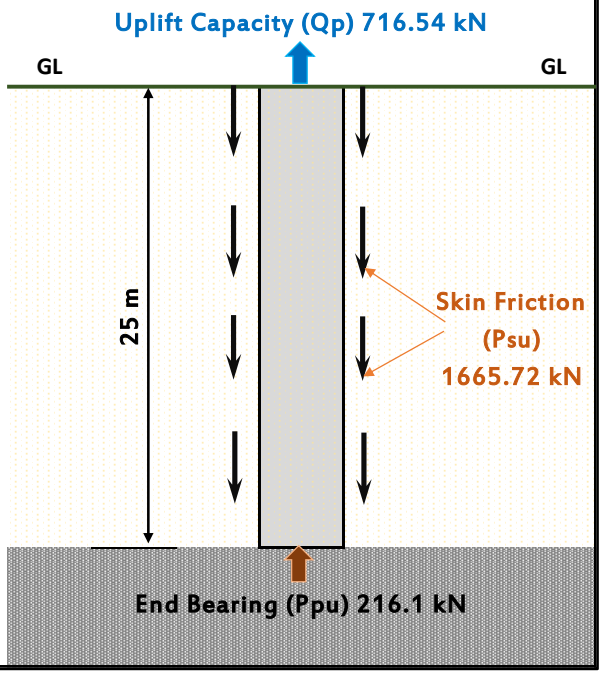
Qus = 75.28 MT

Uplift Capacity, Qp = (Psu / FoS) + Self Weight of Pile

= (1665.72 / 3) + 161.3

Qp = 716.54 kN

Qp = 71.65 MT



SAMPLE CALCULATION

A) PILE DESIGN - Bored Cast *in-situ* Piles - (IS 2911 Part I/Sec2)

1	**Diameter (D), cm**	**=**	**75**	**90**	**100**
LATERAL CAPACITY OF PILE FOR SAND & NORMALY LOADED CLAYS					
1	Permissible Deflection of top, Y, mm		5		
2	Grade of Concrete	**M**	**35**		
3	Young's Modulus of Concrete, E, kN/m^2		29580399		
4	Moment Inertia of Pile, I, m^4		0.015532	0.032206	0.049087
5	Free Length, e		0		
FIXED HEAD CONSIDERATION					
6	**Modulus of Subgrade reaction, ηh, kN/m^3 (For N - 11 from IS 2911 Part 1 Sec 2)**		1544		
7	Stiffness Factor T, m		3.1	3.6	3.9
8	Ratio Lf / T		2.2		
9	**Cantilever Length, zf, m (Depth of Fixity)**		**6.9**	**8.0**	**8.7**
	Lateral Capacity, kN		**84.9**	**113.7**	**134.5**
11	Reduction Factor, m		0.830		
12	Maximum Moment in Pile, kN-m		**242.2**	**375.1**	**483.1**
FREE HEAD CONSIDERATION					
13	Ratio Lf / R		1.9		
14	**Cantilever Length, Lf, m (Depth of Fixity)**		**5.9**	**6.9**	**7.5**
15	**Lateral Capacity, kN**		**33.0**	**44.1**	**52.2**
16	Reduction Factor, m		0.400		
17	Maximum Moment in Pile, kN-m		**78.24**	**121.19**	**156.06**

ANNEXURE 7: LIQUEFACTION CALCULATION SHEET

Sample Calculation - Liquefaction		
BH - 5 , Depth - 0.5 m		
Sr.No.	Parameter	Values
1	Height of fall of Hammer, m	0.76
2	Weight of fall of Hammer, kg	63.5
3	Earthquake Magnitude, Mw	7.5
4	Depth below EGL, m	0.5
5	Type of Strata	MI
6	Observed SPT Value , N	6
7	Saturated density (t/m^3), σ_{v0}	1.71
8	Submerged Density (t/m^3), σ'_{v0}	0.71
9	Fine Content (%)	97
10	Stress reduction coefficient (rd)	1.00
	rd = 1 - (0.007652 x Z), If depth ≤ 9.15m	
	rd = 1.174 - (0.0267 x Z), If depth 9.15 < Z ≤ 23m	
	Where Z = Depth	
11	Zone Factor for Zone - V (BHUJ)	0.36
12	Total overburden pressure (σ_0), t/m^2	0.85
13	Effective overburden (σ_o), t/m^2	0.35
14	Cyclic Stress ratio (CSR)	0.56
15	CSR = 0.65 x (a_{max} /g)x (σ_{v0}/σ'_{v0}) x rd	
	Design ground acceleration a_{max}/g = 0.18	
	SPT corrected (N1)60	
16	C_N (Max Value 1.7)	1.70
	$C_N = \sqrt{10.2/\sigma_0}$	
	5.38	
	Effective overburden (σ_o), t/m^2	
17	C_{HW} = Energy Ratio for Rope and Pully System = HEIGHT x WEIGHT /48387	0.997
	C_{HT} = Correction for hammer energy ratio	0.75
	ER = Rope & Pully System (80 %)	
18	C_{BD} = Bore hole Diameter Correction	1.05
	Up to 150mm = 1.05	
19	C_{RL} = Rod length correction	0.75
	Length < 3m - 0.75	
	Length 3 - 4 m - 0.80	
	Length 4 -6m - 0.85	
	Length 6 - 10m - 0.95	
	Length 10 - 30m - 1.0	
20	C_{SS} = Correction for Standard Sampler	1.10

Continue…

Sample Calculation - Liquefaction		
BH - 5 , Depth - 0.5 m		
Sr.No.	Parameter	Values
21	SPT corrected $(N1)_{60}$	6.61
	$N \times C_N \times C_{HW} \times C_{HT} \times C_{BD} \times C_{RL} \times C_{SS}$	
22	α	0.5
	If Fine Content < 5 , $\alpha = 0$	
	If Fine Content >35 , $\alpha = 0.5$	
	α = Exp.(1.7 x (190/Fone Content ^{2})	
23	β	1.20
	If Fine Content ≤ 5 , $\beta = 1$	
	If Fine Content ≥35 , $\beta = 1.2$	
	$\beta = (0.99 + (\text{Fine Content})^{1.5}/1000)$	
24	$(N1)_{60cs}$	
	$(N1)_{60cs} = \alpha + \beta \times (N_1)60$	8.43
25	$CRR_{M = 7.5}$	0.10
	If $(N1)_{60cs} > 30$, NA	
	$CRR_{M = 7.5} = (1 / 34 - (N1)_{60}) + ((N1)_{60} / 135) + (50 / (10 \times (N1)_{60} + 45)^2) - (1/200)$	
26	Magnitude Scaling Factor (MSF)	1.00
	$MSF = 10^{2.24}/Mw^{2.56}$	
27	CRR	0.10
	If $(N1)_{60cs} > 30$, NA	
	$CRR = CRR_{7.5} \times Ks \times Ka$	
	km = 1	
	kx=1	
28	FOS = CRR / CSR	0.18
29	Conclusion	Liquefiable
	If FOS < 1, Liquefiable	
	If FOS > 1, Non Liquefiable	

LIQUEFACTION POTENTIAL - BOREHOLE v/s DEPTH

Depth Below EGL, m	BH-1	BH-2	BH-4	BH-5	BH-6	BH-7	BH-9	BH-10	BH-11	BH-12	BH-13	BH-14	BH-15	BH-16	BH-17	BH-18	BH-19	BH-20	BH-21	BH-22	BH-23	BH-24	BH-25	BH-26	BH-27	BH-28	BH-29	BH-30
EGL - 0.00 m	EGL - 0.00 m																											EGL - 0.00 m
1.50	NL	NL	NL	L	L	NL	NL	NL	L	NL	NL	L	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	L	NL	NL	L	L
3.00	L	NL	NL	L	L	NL	NL	NL	L	NL	NL	L	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	L	NL	NL	NL	L
4.50	L	NL	L	L	L	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL	L	NL	NL	L	NL	NL	NL	NL	L	NL	L
6.00	NL	NL	NL	L	L	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	L	L	L
7.50	L	NL	NL	L	L	L	NL	NL	NL	L	NL	NL	L	NL	L	NL	NL	L	L	NL	L	NL	NL	NL	NL	L	NL	L
9.00	NL	L	NL	NL	L	L	NL	NL	NL	L	NL	NL	L	L	L	NL	NL	L	L	NL	L	NL	NL	NL	NL	L	NL	L
10.50	L	L	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	L	NL	NL	NL	NL	L	NL	L
12.00	L	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL	NL	L	NL	NL	L	NL	NL	NL	NL	L
13.50	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	L	NL	NL	NL	NL	NL	NL	L	NL	NL	L	NL	NL	NL	NL	L
15.00	NL	NL	NL	L	NL	NL	NL	NL	L	NL	L	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	L
16.50	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL
18.00	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
19.50	NL	L	NL	NL	L	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	L	NL	NL	NL	NL	NL	L	L	NL	NL	NL	NL
21.00	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	L	NL	NL	NL	NL	NL	L	L	NL	NL	NL	NL
22.50	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL
24.00	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
25.50	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
27.00	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	L	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
28.50	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
30.00	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 1

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 2.20 m **Zone Factor :** 0.36

Borehole No.: 1 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m^3)	Submerged Density (t/m^3)	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt (Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} X N$	$(N1)_{60} = C_N X N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24} /(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) Kσ Kα	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
3.00	CI	11	1.74	0.74	99.00	20.00	41.00	35.60	0.98	5.22	2.22	0.54	1.70	0.75	0.997	1.05	0.80	1.10	7.60	12.93	0.50	1.20	16.01	0.17	1.000	0.17	0.32	Non-Liquefiable	
4.50	ML	16	1.89	0.89	93.00				0.97	8.06	3.56	0.51	1.69	0.75	0.997	1.05	0.85	1.10	11.75	19.89	0.50	1.20	24.37	0.28	1.000	0.28	0.55		Liquefiable
7.50	ML	22	1.89	0.89	96.00				0.94	13.74	6.24	0.49	1.28	0.75	0.997	1.05	0.95	1.10	18.06	23.09	0.50	1.20	28.21	0.38	1.000	0.38	0.78		Liquefiable
9.50	CL	23	1.81	0.81	94.00	25.10	34.00	30.80	0.92	17.36	7.86	0.48	1.14	0.75	0.997	1.05	0.95	1.10	18.88	21.50	0.50	1.20	26.30	0.32	1.000	0.32	0.67	Non-Liquefiable	
10.50	ML	25	1.82	0.82	88.00				0.89	19.18	8.68	0.46	1.08	0.75	0.997	1.05	1	1.10	21.60	23.41	0.50	1.20	28.59	0.39	1.000	0.39	0.85		Liquefiable
13.50	ML	39	1.82	0.82	79.00	19.40	44.00	40.10	0.81	24.64	11.14	0.42	0.96	0.75	0.997	1.05	1	1.10	33.70	32.24	0.50	1.20	39.19	NA	1.000	NA	>1		Non Liquefiable
15.00	ML	35	1.92	0.92	82.00				0.77	27.52	12.52	0.40	0.90	0.75	0.997	1.05	1	1.10	30.24	27.30	0.50	1.20	33.25	NA	1.000	NA	>1		Non Liquefiable
16.50	ML	41	1.92	0.92	78.00	21.60	44.00	40.40	0.73	30.40	13.90	0.38	0.86	0.75	0.997	1.05	1	1.10	35.42	30.35	0.50	1.20	36.92	NA	1.000	NA	>1		Non Liquefiable
20.00	ML	56	1.92	0.92	71.00				0.64	37.11	17.11	0.32	0.77	0.75	0.997	1.05	1	1.10	48.38	37.35	0.50	1.20	45.32	NA	1.000	NA	>1		Non Liquefiable
24.50	CI	29	1.86	0.86	99.00	22.60	15.00	37.60	0.52	45.49	20.99	0.26	0.70	0.75	0.997	1.05	1	1.10	25.06	17.46	0.50	1.20	21.46	0.23	1.000	0.23	0.89	Non-Liquefiable	
30.50	CI	23	1.83	0.83	99.00	23.80	15.00	46.90	0.36	56.48	25.98	0.18	0.63	0.75	0.997	1.05	1	1.10	19.87	12.45	0.50	1.20	15.44	0.16	1.000	0.16	0.90	Non-Liquefiable	

1) The project site falls in Zone - V. A maximum earthquake intensity of 7.5 has been considered in the analysis.

2) C_{HT} & C_{HW}= Correction for hammer energy ratio, C_{HT} = 0.76, Energy Ratio for Rope and Pully System = 80 %, C_{HW} = Height x Weight / 48387

3) Borehole diameter = 150 mm , Hence C_{BD} = 1.05

4) C_{SS} = Correction for Standard sampler = 1.0

5) $C_{60} = C_{HT}C_{HW}C_{BD}C_{RL}C_{SS}$

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 2

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 2.20 m **Zone Factor :** 0.36

Borehole No.: 2 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m^3)	Submerged Density (t/m^3)	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\,(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}/(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) $K\sigma$ $K\alpha$	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	CL	4	1.77	0.77	97.00	26.80	35.00	34.40	1.00	0.88	0.38	0.54	1.70	0.75	0.997	1.05	0.75	1.10	2.59	4.41	0.50	1.20	5.79	0.08	1.000	0.08	0.15	Non-Liquefiable	
1.50	CL	6	1.77	0.77	98.00	26.80	43.00	34.70	0.99	2.65	1.15	0.53	1.70	0.75	0.997	1.05	0.75	1.10	3.89	6.61	0.50	1.20	8.43	0.10	1.000	0.10	0.19	Non-Liquefiable	
4.50	CL	8	1.77	0.77	93.00	26.80		31.60	0.97	7.96	3.46	0.52	1.70	0.75	0.100	1.05	0.85	1.10	0.59	1.00	0.50	1.20	1.70	0.05	1.000	0.05	0.10	Non-Liquefiable	
7.50	ML	16	1.85	0.85	89.00				0.94	13.50	6.00	0.50	1.30	0.75	0.100	1.05	0.95	1.10	1.31	1.71	0.50	1.20	2.55	0.06	1.000	0.06	0.11		Liquefiable
9.00	ML	21	1.85	0.85	91.00				0.93	16.28	7.28	0.49	1.18	0.75	0.100	1.05	0.95	1.10	1.72	2.04	0.50	1.20	2.95	0.06	1.000	0.06	0.12		Liquefiable
10.50	ML	32	1.85	0.85	92.00				0.89	19.05	8.55	0.47	1.09	0.75	0.100	1.05	1	1.10	2.76	3.02	0.50	1.20	4.12	0.07	1.000	0.07	0.14		Liquefiable
12.50	CL	30	1.84	0.84	95.00	22.60	37.00	34.50	0.84	22.72	10.22	0.44	1.00	0.75	0.100	1.05	1	1.10	2.59	2.59	0.50	1.20	3.61	0.06	1.000	0.06	0.14	Non-Liquefiable	
16.50	CL	49	1.84	0.84	97.00	22.60	35.00	32.80	0.73	30.07	13.57	0.38	0.87	0.75	0.100	1.05	1	1.10	4.23	3.67	0.50	1.20	4.90	0.07	1.000	0.07	0.19	Non-Liquefiable	
18.50	CI	30	1.88	0.88	98.00	24.30	42.00	41.40	0.68	33.83	15.33	0.35	0.82	0.75	0.100	1.05	1	1.10	2.59	2.11	0.50	1.20	3.04	0.06	1.000	0.06	0.17	Non-Liquefiable	
19.50	ML	27	1.88	0.88	58.00				0.65	35.70	16.20	0.34	0.79	0.75	0.100	1.05	1	1.10	2.33	1.85	0.50	1.20	2.72	0.06	1.000	0.06	0.17		Liquefiable
24.00	CI	30	1.89	0.89	83.00	23.80		42.30	0.53	44.19	20.19	0.27	0.71	0.75	0.100	1.05	1	1.10	2.59	1.84	0.50	1.20	2.71	0.06	1.000	0.06	0.21	Non-Liquefiable	
30.00	CI	20	1.94	0.94	99.00	24.90	47.00	46.00	0.37	55.81	25.81	0.19	0.63	0.75	0.100	1.05	1	1.10	1.73	1.09	0.50	1.20	1.80	0.05	1.000	0.05	0.28	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 4

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 2.20 m **Zone Factor :** 0.36

Borehole No.: 4 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60}$ = C_{60} X N	$(N1)_{60}$ = C_N X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	CL	6	1.74	0.74	99.00	25.00	46.00	38.20	1.00	0.87	0.37	0.55	1.70	0.75	0.997	1.05	0.75	1.10	3.89	6.61	0.50	1.20	8.43	0.10	1.000	0.10	0.18	Non-Liquefiable	
1.50	CL	8	1.74	0.74	99.00	25.00	42.00	36.10	0.99	2.61	1.11	0.54	1.70	0.75	0.997	1.05	0.75	1.10	5.18	8.81	0.50	1.20	11.08	0.12	1.000	0.12	0.23	Non-Liquefiable	
4.50	ML	14	1.82	0.82	96.00				0.97	8.06	3.56	0.51	1.69	0.75	0.997	1.05	0.85	1.10	10.28	17.39	0.50	1.20	21.37	0.23	1.000	0.23	0.46		Liquefiable
6.00	CI	11	1.91	0.91	98.00	23.60		37.20	0.95	10.93	4.93	0.50	1.44	0.75	0.997	1.05	0.95	1.10	9.03	12.99	0.50	1.20	16.09	0.17	1.000	0.17	0.35	Non-Liquefiable	
7.50	CI	36	1.91	0.91	98.00	23.60	39.00	36.50	0.94	13.79	6.29	0.48	1.27	0.75	0.997	1.05	0.95	1.10	29.55	37.63	0.50	1.20	45.66	NA	1.000	NA	>1	Non-Liquefiable	
10.50	CI	25	1.91	0.91	94.00	23.60		37.10	0.89	19.51	9.01	0.45	1.06	0.75	0.997	1.05	1	1.10	21.60	22.98	0.50	1.20	28.07	0.37	1.000	0.37	0.82	Non-Liquefiable	
13.50	ML	46	1.83	0.83	74.00				0.81	24.99	11.49	0.41	0.94	0.75	0.997	1.05	1	1.10	39.74	37.45	0.50	1.20	45.44	NA	1.000	NA	>1		Non Liquefiable
15.00	ML	70	1.83	0.83	50.00				0.77	27.72	12.72	0.39	0.90	0.75	0.997	1.05	1	1.10	60.48	54.15	0.50	1.20	65.48	NA	1.000	NA	>1		Non Liquefiable
18.50	CI	30	1.88	0.88	98.00	24.30	42.00	41.40	0.68	34.30	15.80	0.35	0.80	0.75	0.997	1.05	1	1.10	25.92	20.83	0.50	1.20	25.49	0.30	1.000	0.30	0.87	Non-Liquefiable	
19.50	ML	27	1.88	0.88	58.00				0.65	36.18	16.68	0.33	0.78	0.75	0.997	1.05	1	1.10	23.33	18.24	0.50	1.20	22.39	0.25	1.000	0.25	0.75		Liquefiable
24.00	CI	30	1.89	0.89	83.00	23.80		42.30	0.53	44.66	20.66	0.27	0.70	0.75	0.997	1.05	1	1.10	25.92	18.21	0.50	1.20	22.36	0.25	1.000	0.25	0.92	Non-Liquefiable	
30.00	CI	20	1.94	0.94	99.00	24.90	47.00	46.00	0.37	56.28	26.28	0.19	0.62	0.75	0.997	1.05	1	1.10	17.28	10.77	0.50	1.20	13.42	0.14	1.000	0.14	0.77	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 5

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 2.00 m **Zone Factor :** 0.36

Water Table Considered : 0.00 m **Location :** BHUJ

Borehole No.: 5

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{EQ}	C_{RL}	C_{SS}	$(N)_{60}$ = C_{60} X N	$(N1)_{60}$ = C_N X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	MI	6	1.71	0.71	97.00				1.00	0.85	0.35	0.56	1.70	0.75	0.997	1.05	0.75	1.10	3.89	6.61	0.50	1.20	8.43	0.10	1.000	0.10	0.18		Liquefiable
1.50	ML	15	1.72	0.72	98.00				0.99	2.57	1.07	0.56	1.70	0.75	0.997	1.05	0.75	1.10	9.72	16.52	0.50	1.20	20.33	0.22	1.000	0.22	0.40		Liquefiable
3.00	ML	11	1.72	0.72	96.00				0.98	5.15	2.15	0.55	1.70	0.75	0.997	1.05	0.80	1.10	7.60	12.93	0.50	1.20	16.01	0.17	1.000	0.17	0.31		Liquefiable
4.50	ML	11	1.72	0.72	99.00				0.97	7.73	3.23	0.54	1.70	0.75	0.997	1.05	0.85	1.10	8.08	13.73	0.50	1.20	16.98	0.18	1.000	0.18	0.33		Liquefiable
7.50	ML	14	1.85	0.85	69.00				0.94	13.28	5.78	0.51	1.33	0.75	0.997	1.05	0.95	1.10	11.49	15.27	0.50	1.20	18.82	0.20	1.000	0.20	0.40		Liquefiable
12.50	CI	23	1.72	0.72	93.00	19.40	44.00	40.10	0.84	21.89	9.39	0.46	1.04	0.75	0.997	1.05	1	1.10	19.87	20.71	0.50	1.20	25.35	0.30	1.000	0.30	0.65	Non-Liquefiable	
13.50	ML	45	1.81	0.81	79.00				0.81	23.70	10.20	0.44	1.00	0.75	0.997	1.05	1	1.10	38.88	38.88	0.50	1.20	47.16	NA	1.000	NA	>1		Non Liquefiable
15.00	ML	27	1.81	0.81	80.00				0.77	26.41	11.41	0.42	0.95	0.75	0.997	1.05	1	1.10	23.33	22.05	0.50	1.20	26.97	0.34	1.000	0.34	0.81		Liquefiable
17.00	ML	41	1.81	0.81	84.00				0.72	30.03	13.03	0.39	0.88	0.75	0.997	1.05	1	1.10	35.42	31.34	0.50	1.20	38.11	NA	1.000	NA	>1		Non Liquefiable
24.50	CI	26	1.94	0.94	98.00	21.60	44.00	40.30	0.52	44.59	20.09	0.27	0.71	0.75	0.997	1.05	1	1.10	22.46	16.01	0.50	1.20	19.71	0.21	1.000	0.21	0.78	Non-Liquefiable	
30.00	CI	25	1.96	0.96	99.00	22.30		48.30	0.37	55.36	25.36	0.19	0.63	0.75	0.997	1.05	1	1.10	21.60	13.70	0.50	1.20	16.94	0.18	1.000	0.18	0.95	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 6

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.20 m **Zone Factor :** 0.36

Water Table Considered : 0.00 m **Location :** BHUJ

Borehole No.: 6 **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Hammer Fall: 0.76 m

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60}$ X N	$(N1)_{60} = C_N$ X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
2.00	MI	6	1.75	0.75	90.00				0.98	3.50	1.50	0.54	1.70	0.75	0.997	1.05	0.75	1.10	3.89	6.61	0.50	1.20	8.43	0.10	1.000	0.10	0.19		Liquefiable
3.00	MI	12	1.75	0.75	92.00				0.98	5.25	2.25	0.53	1.70	0.75	0.997	1.05	0.80	1.10	8.29	14.10	0.50	1.20	17.42	0.19	1.000	0.19	0.35		Liquefiable
7.50	ML	24	1.94	0.94	72.00				0.94	13.98	6.48	0.48	1.25	0.75	0.997	1.05	0.95	1.10	19.70	24.71	0.50	1.20	30.16	NA	1.000	NA	>1		Non Liquefiable
10.50	ML	36	1.91	0.91	77.00				0.89	19.70	9.20	0.45	1.05	0.75	0.997	1.05	1	1.10	31.10	32.76	0.50	1.20	39.81	NA	1.000	NA	>1		Non Liquefiable
12.50	ML	30	1.91	0.91	52.00				0.84	23.51	11.01	0.42	0.96	0.75	0.997	1.05	1	1.10	25.92	24.95	0.50	1.20	30.44	NA	1.000	NA	>1		Non Liquefiable
15.00	ML	46	1.95	0.95	82.00				0.77	28.38	13.38	0.38	0.87	0.75	0.997	1.05	1	1.10	39.74	34.70	0.50	1.20	42.14	NA	1.000	NA	>1		Non Liquefiable
19.50	ML	33	1.95	0.95	87.00				0.65	37.16	17.66	0.32	0.76	0.75	0.997	1.05	1	1.10	28.51	21.67	0.50	1.20	26.51	0.33	1.000	0.33	1.01		Non Liquefiable
21.00	ML	35	1.95	0.95	84.00				0.61	40.08	19.08	0.30	0.73	0.75	0.997	1.05	1	1.10	30.24	22.11	0.50	1.20	27.03	0.34	1.000	0.34	1.12		Non Liquefiable
24.00	CI	32	1.97	0.97	99.00	19.20	47.00	46.60	0.53	45.99	21.99	0.26	0.68	0.75	0.997	1.05	1	1.10	27.65	18.83	0.50	1.20	23.10	0.26	1.000	0.26	0.99	Non-Liquefiable	
30.00	CI	29	2.04	1.04	99.00	20.00	44.00	48.90	0.37	58.21	28.21	0.18	0.60	0.75	0.997	1.05	1	1.10	25.06	15.07	0.50	1.20	18.58	0.20	1.000	0.20	1.10	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 7

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 2.20 m **Zone Factor :** 0.36

Borehole No.: 7 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_w) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60}$ X N	$(N1)_{60} = C_N$ X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
1.00	CL	6	1.78	0.78	98.00	21.60	36.00	38.60	0.99	1.78	0.78	0.53	1.70	0.75	0.997	1.05	0.75	1.10	3.89	6.61	0.50	1.20	8.43	0.10	1.000	0.10	0.19	Non-Liquefiable	
3.00	CL	5	1.78	0.78	99.00	21.60	36.00	38.60	0.98	5.33	2.33	0.52	1.70	0.75	0.997	1.05	0.80	1.10	3.46	5.88	0.50	1.20	7.55	0.09	1.000	0.09	0.18	Non-Liquefiable	
7.50	ML	21	1.86	0.86	88.00				0.94	13.70	6.20	0.49	1.28	0.75	0.997	1.05	0.95	1.10	17.24	22.11	0.50	1.20	27.03	0.34	1.000	0.34	0.70		Liquefiable
10.50	ML	34	1.90	0.90	79.00				0.89	19.41	8.91	0.46	1.07	0.75	0.997	1.05	1	1.10	29.38	31.44	0.50	1.20	38.22	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	39	2.01	1.01	85.00				0.81	25.43	11.93	0.41	0.92	0.75	0.997	1.05	1	1.10	33.70	31.16	0.50	1.20	37.90	NA	1.000	NA	>1		Non Liquefiable
15.00	ML	46	2.01	1.01	81.00				0.77	28.43	13.43	0.38	0.87	0.75	0.997	1.05	1	1.10	39.74	34.63	0.50	1.20	42.06	NA	1.000	NA	>1		Non Liquefiable
19.50	ML	48	2.01	1.01	84.00				0.65	37.46	17.96	0.32	0.75	0.75	0.997	1.05	1	1.10	41.47	31.25	0.50	1.20	38.00	NA	1.000	NA	>1		Non Liquefiable
21.00	ML	35	2.01	1.01	82.00				0.61	40.47	19.47	0.30	0.72	0.75	0.997	1.05	1	1.10	30.24	21.89	0.50	1.20	26.76	0.33	1.000	0.33	1.11		Non Liquefiable
24.00	CI	30	1.87	0.87	94.00	21.60	36.00	38.60	0.53	46.09	22.09	0.26	0.68	0.75	0.997	1.05	1	1.10	25.92	17.61	0.50	1.20	21.64	0.24	1.000	0.24	0.91	Non-Liquefiable	
30.00	CI	24	2.05	1.05	99.00	31.80	44.00	45.70	0.37	58.41	28.41	0.18	0.60	0.75	0.997	1.05	1	1.10	20.74	12.43	0.50	1.20	15.41	0.16	1.000	0.16	0.91	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 9

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.50 m **Zone Factor :** 0.36

Borehole No.: 9 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_w) :** 7.5

Depth below EGL, m		Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, $MSF = (10)^{2.24}/(MW)^{2.56}$	$CRR = CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
3.00	CL	7	1.76	0.76	95.00	28.70		32.40	0.98	5.28	2.28	0.53	1.70	0.75	0.997	1.05	0.80	1.10	4.84	8.23	0.50	1.20	10.37	0.12	1.000	0.12	0.22	Non-Liquefiable	
6.00	CL	8	1.70	0.70	99.00	20.80	40.00	35.00	0.95	10.39	4.39	0.53	1.52	0.75	0.997	1.05	0.95	1.10	6.57	10.01	0.50	1.20	12.51	0.14	1.000	0.14	0.26	Non-Liquefiable	
10.50	ML	41	1.83	0.83	87.00				0.89	18.63	8.13	0.48	1.12	0.75	0.997	1.05	1	1.10	35.42	39.67	0.50	1.20	48.10	NA	1.000	NA	>1		Non Liquefiable
13.50	SM	65	1.89	0.89	38.00				0.81	24.29	10.79	0.43	0.97	0.75	0.997	1.05	1	1.10	56.16	54.60	0.50	1.20	66.02	NA	1.000	NA	>1		Non Liquefiable
16.50	ML	58	1.86	0.86	52.00				0.73	29.86	13.36	0.38	0.87	0.75	0.997	1.05	1	1.10	50.11	43.78	0.50	1.20	53.04	NA	1.000	NA	>1		Non Liquefiable
19.50	ML	100	1.95	0.95	82.00				0.65	35.70	16.20	0.34	0.79	0.75	0.997	1.05	1	1.10	86.40	68.56	0.50	1.20	82.77	NA	1.000	NA	>1		Non Liquefiable
22.50	ML	40	1.92	0.92	87.00				0.57	41.45	18.95	0.29	0.73	0.75	0.997	1.05	1	1.10	34.56	25.35	0.50	1.20	30.92	NA	1.000	NA	>1		Non Liquefiable
27.00	CI	35	1.92	0.92	84.00	25.60	36.00	42.50	0.45	50.09	23.09	0.23	0.66	0.75	0.997	1.05	1	1.10	30.24	20.10	0.50	1.20	24.62	0.28	1.000	0.28	1.24	Non-Liquefiable	
30.00	CI	32	1.92	0.92	99.00	25.10		48.60	0.37	55.85	25.85	0.19	0.63	0.75	0.997	1.05	1	1.10	27.65	17.37	0.50	1.20	21.34	0.23	1.000	0.23	1.23	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 10

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.00 m **Zone Factor :** 0.36

Borehole No.: 10 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m		Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, $MSF = (10)^{2.24}/(MW)^{2.56}$	$CRR = CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
1.50		CI	8	1.76	0.76	98.00	20.50	37.00	42.60	0.99	2.63	1.13	0.54	1.70	0.75	0.997	1.05	0.75	1.10	5.18	8.81	0.50	1.20	11.08	0.12	1.000	0.12	0.23	Non-Liquefiable	
6.00		CI	15	1.76	0.76	98.00	24.30	38.00	36.20	0.95	10.53	4.53	0.52	1.50	0.75	0.997	1.05	0.95	1.10	12.31	18.47	0.50	1.20	22.67	0.25	1.000	0.25	0.49	Non-Liquefiable	
9.00		CL	20	1.78	0.78	99.00	21.90		33.40	0.93	15.87	6.87	0.50	1.22	0.75	0.997	1.05	0.95	1.10	16.42	20.01	0.50	1.20	24.51	0.28	1.000	0.28	0.56	Non-Liquefiable	
12.00		CI	19	1.74	0.74	97.00	22.40	44.00	40.80	0.85	21.08	9.08	0.46	1.06	0.75	0.997	1.05	1	1.10	16.42	17.40	0.50	1.20	21.38	0.23	1.000	0.23	0.50	Non-Liquefiable	
16.50		ML	55	1.98	0.98	52.00				0.73	29.98	13.48	0.38	0.87	0.75	0.997	1.05	1	1.10	47.52	41.33	0.50	1.20	50.10	NA	1.000	NA	>1		Non Liquefiable
19.50		ML	58	1.94	0.94	65.00				0.65	35.80	16.30	0.34	0.79	0.75	0.997	1.05	1	1.10	50.11	39.64	0.50	1.20	48.06	NA	1.000	NA	>1		Non Liquefiable
24.00		CI	30	1.88	0.88	96.00	22.40	47.00	43.90	0.53	44.24	20.24	0.27	0.71	0.75	0.997	1.05	1	1.10	25.92	18.40	0.50	1.20	22.58	0.25	1.000	0.25	0.92	Non-Liquefiable	
27.00		CI	30	1.95	0.95	96.00	23.20		46.50	0.45	50.09	23.09	0.23	0.66	0.75	0.997	1.05	1	1.10	25.92	17.23	0.50	1.20	21.17	0.23	1.000	0.23	1.00	Non-Liquefiable	
30.00		CI	30	1.95	0.95	77.00	22.70	24.00	40.30	0.37	55.94	25.94	0.19	0.63	0.75	0.997	1.05	1	1.10	25.92	16.25	0.50	1.20	20.01	0.22	1.000	0.22	1.14	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 11

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.20 m **Zone Factor :** 0.36

Borehole No.: 11 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}/(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	CL	6	1.75	0.75	89.00	25.00	47.00	34.20	1.00	0.87	0.37	0.55	1.70	0.75	0.997	1.05	0.75	1.10	3.89	6.61	0.50	1.20	8.43	0.10	1.000	0.10	0.18	Non-Liquefiable	
1.50	MI	10	1.77	0.77	95.00				0.99	2.64	1.14	0.54	1.70	0.75	0.997	1.05	0.75	1.10	6.48	11.02	0.50	1.20	13.72	0.15	1.000	0.15	0.28		Liquefiable
4.50	ML	22	1.77	0.77	80.00				0.97	7.95	3.45	0.52	1.70	0.75	0.997	1.05	0.85	1.10	16.16	27.47	0.50	1.20	33.46	NA	1.000	NA	>1		Non Liquefiable
7.50	ML	25	1.88	0.88	85.00				0.94	13.60	6.10	0.49	1.29	0.75	0.997	1.05	0.95	1.10	20.52	26.54	0.50	1.20	32.35	NA	1.000	NA	>1		Non Liquefiable
10.50	ML	30	1.84	0.84	75.00				0.89	19.12	8.62	0.46	1.09	0.75	0.997	1.05	1	1.10	25.92	28.20	0.50	1.20	34.34	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	25	1.84	0.84	94.00				0.81	24.64	11.14	0.42	0.96	0.75	0.997	1.05	1	1.10	21.60	20.67	0.50	1.20	25.31	0.30	1.000	0.30	0.71		Liquefiable
15.00	ML	29	1.84	0.84	91.00				0.77	27.40	12.40	0.40	0.91	0.75	0.997	1.05	1	1.10	25.06	22.73	0.50	1.20	27.77	0.36	1.000	0.36	0.90		Liquefiable
18.00	CL	31	1.92	0.92	97.00	20.90	45.00	31.90	0.69	33.15	15.15	0.36	0.82	0.75	0.997	1.05	1	1.10	26.78	21.98	0.50	1.20	26.87	0.33	1.000	0.33	0.94	Non-Liquefiable	
24.00	CI	20	1.92	0.92	98.00	22.20	47.00	44.50	0.53	44.68	20.68	0.27	0.70	0.75	0.997	1.05	1	1.10	17.28	12.13	0.50	1.20	15.06	0.16	1.000	0.16	0.60	Non-Liquefiable	
30.00	CI	16	1.93	0.93	99.00	22.80		48.20	0.37	56.25	26.25	0.19	0.62	0.75	0.997	1.05	1	1.10	13.82	8.62	0.50	1.20	10.84	0.12	1.000	0.12	0.64	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 12

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.50 m **Zone Factor :** 0.36

Borehole No.: 12 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_w) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cycilic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60}$ X N	$(N1)_{60} = C_N$ X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	CRR$_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = CRR$_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	CH	3	1.71	0.71	88.00	20.00	62.00	53.40	1.00	0.85	0.35	0.56	1.70	0.75	0.997	1.05	0.75	1.10	1.94	3.30	0.50	1.20	4.47	0.07	1.000	0.07	0.12	Non-Liquefiable	
6.00	CL	6	1.71	0.71	96.00	22.60		34.30	0.95	10.25	4.25	0.54	1.55	0.75	0.997	1.05	0.95	1.10	4.92	7.63	0.50	1.20	9.65	0.11	1.000	0.11	0.20	Non-Liquefiable	
7.50	ML	9	1.82	0.82	98.00				0.94	12.99	5.49	0.52	1.36	0.75	0.997	1.05	0.95	1.10	7.39	10.07	0.50	1.20	12.59	0.14	1.000	0.14	0.26		Liquefiable
10.50	ML	21	1.77	0.77	94.00				0.89	18.29	7.79	0.49	1.14	0.75	0.997	1.05	1	1.10	18.14	20.76	0.50	1.20	25.41	0.30	1.000	0.30	0.61		Liquefiable
13.50	ML	28	1.77	0.77	94.00				0.81	23.61	10.11	0.44	1.00	0.75	0.997	1.05	1	1.10	24.19	24.30	0.50	1.20	29.66	0.45	1.000	0.45	1.00		Non Liquefiable
16.50	ML	50	1.85	0.85	63.00				0.73	29.15	12.65	0.40	0.90	0.75	0.997	1.05	1	1.10	43.20	38.80	0.50	1.20	47.06	NA	1.000	NA	>1		Non Liquefiable
19.50	ML	72	1.85	0.85	50.00				0.65	34.69	15.19	0.35	0.82	0.75	0.997	1.05	1	1.10	62.21	50.98	0.50	1.20	61.68	NA	1.000	NA	>1		Non Liquefiable
24.00	CI	35	1.88	0.88	90.00	22.60	47.00	44.80	0.53	43.16	19.16	0.28	0.73	0.75	0.997	1.05	1	1.10	30.24	22.06	0.50	1.20	26.98	0.34	1.000	0.34	1.20	Non-Liquefiable	
30.00	CI	32	1.85	0.85	98.00	20.30		42.20	0.37	54.27	24.27	0.20	0.65	0.75	0.997	1.05	1	1.10	27.65	17.92	0.50	1.20	22.01	0.24	1.000	0.24	1.24	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 13

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 3.90 m **Zone Factor :** 0.36

Borehole No.: 13 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_w) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}/(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
3.00	CL	12	1.73	0.73	98.00	26.00		33.70	0.98	5.19	2.19	0.54	1.70	0.75	0.997	1.05	0.80	1.10	8.29	14.10	0.50	1.20	17.42	0.19	1.000	0.19	0.34	Non-Liquefiable	
6.00	CL	15	1.76	0.76	99.00	24.00		33.10	0.95	10.48	4.48	0.52	1.51	0.75	0.997	1.05	0.95	1.10	12.31	18.57	0.50	1.20	22.79	0.25	1.000	0.25	0.49	Non-Liquefiable	
7.50	ML	32	1.79	0.79	61.00				0.94	13.17	5.67	0.51	1.34	0.75	0.997	1.05	0.95	1.10	26.26	35.23	0.50	1.20	42.77	NA	1.000	NA	>1		Non Liquefiable
10.50	SM	29	1.84	0.84	44.00				0.89	18.69	8.19	0.48	1.12	0.75	0.997	1.05	1	1.10	25.06	27.97	0.50	1.20	34.06	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	35	1.80	0.80	54.00				0.81	24.09	10.59	0.43	0.98	0.75	0.997	1.05	1	1.10	30.24	29.68	0.50	1.20	36.12	NA	1.000	NA	>1		Non Liquefiable
15.00	ML	29	1.80	0.80	60.00				0.77	26.79	11.79	0.41	0.93	0.75	0.997	1.05	1	1.10	25.06	23.31	0.50	1.20	28.47	0.39	1.000	0.39	0.94		Liquefiable
16.50	ML	35	1.80	0.80	84.00				0.73	29.49	12.99	0.39	0.89	0.75	0.997	1.05	1	1.10	30.24	26.80	0.50	1.20	32.66	NA	1.000	NA	>1		Non Liquefiable
18.00	CL	29	1.85	0.85	89.00	18.40	40.00	33.90	0.69	32.26	14.26	0.37	0.85	0.75	0.997	1.05	1	1.10	25.06	21.19	0.50	1.20	25.93	0.31	1.000	0.31	0.85	Non-Liquefiable	
24.00	CL	35	1.89	0.89	99.00	20.10	46.00	34.10	0.53	43.59	19.59	0.28	0.72	0.75	0.997	1.05	1	1.10	30.24	21.82	0.50	1.20	26.69	0.33	1.000	0.33	1.19	Non-Liquefiable	
30.00	CI	18	1.71	0.71	99.00	33.70		46.10	0.37	53.85	23.85	0.20	0.65	0.75	0.997	1.05	1	1.10	15.55	10.17	0.50	1.20	12.71	0.14	1.000	0.14	0.70	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 14

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.40 m **Zone Factor :** 0.36

Borehole No.: 14 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_w) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60}$ X N	$(N1)_{60} = C_N$ X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	ML	7	1.70	0.70	88.00				1.00	0.85	0.35	0.56	1.70	0.75	0.997	1.05	0.75	1.10	4.54	7.71	0.50	1.20	9.75	0.11	1.000	0.11	0.20		Liquefiable
1.50	ML	12	1.70	0.70	70.00				0.99	2.56	1.06	0.56	1.70	0.75	0.997	1.05	0.75	1.10	7.78	13.22	0.50	1.20	16.36	0.17	1.000	0.17	0.31		Liquefiable
4.50	ML	16	1.71	0.71	67.00				0.97	7.69	3.19	0.54	1.70	0.75	0.997	1.05	0.85	1.10	11.75	19.98	0.50	1.20	24.47	0.28	1.000	0.28	0.52		Liquefiable
9.00	ML	33	1.82	0.82	72.00				0.93	15.86	6.86	0.50	1.22	0.75	0.997	1.05	0.95	1.10	27.09	33.04	0.50	1.20	40.14	NA	1.000	NA	>1		Non Liquefiable
12.00	ML	32	1.82	0.82	69.00				0.85	21.30	9.30	0.46	1.05	0.75	0.997	1.05	1	1.10	27.65	28.95	0.50	1.20	35.24	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	33	1.82	0.82	66.00				0.81	24.02	10.52	0.43	0.98	0.75	0.997	1.05	1	1.10	28.51	28.07	0.50	1.20	34.18	NA	1.000	NA	>1		Non Liquefiable
16.50	ML	64	1.82	0.82	59.00				0.73	29.47	12.97	0.39	0.89	0.75	0.997	1.05	1	1.10	55.29	49.04	0.50	1.20	59.35	NA	1.000	NA	>1		Non Liquefiable
18.00	CI	70	1.82	0.82	72.00	20.90	41.00	40.30	0.69	32.19	14.19	0.37	0.85	0.75	0.997	1.05	1	1.10	60.48	51.27	0.50	1.20	62.02	NA	1.000	NA	>1	Non-Liquefiable	
21.00	CI	50	1.72	0.72	96.00	18.70	41.00	37.60	0.61	37.35	16.35	0.33	0.79	0.75	0.997	1.05	1	1.10	43.20	34.12	0.50	1.20	41.45	NA	1.000	NA	>1	Non-Liquefiable	
24.00	CI	30	1.80	0.80	98.00	22.10	42.00	45.20	0.53	42.74	18.74	0.28	0.74	0.75	0.997	1.05	1	1.10	25.92	19.12	0.50	1.20	23.44	0.26	1.000	0.26	0.93	Non-Liquefiable	
27.00	CI	28	1.85	0.85	98.00	23.40		49.10	0.45	48.28	21.28	0.24	0.69	0.75	0.997	1.05	1	1.10	24.19	16.75	0.50	1.20	20.60	0.22	1.000	0.22	0.93	Non-Liquefiable	
30.00	CI	27	1.88	0.88	98.00	24.20	46.00	48.70	0.37	53.91	23.91	0.20	0.65	0.75	0.997	1.05	1	1.10	23.33	15.24	0.50	1.20	18.78	0.20	1.000	0.20	1.02	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 15

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.30 m **Zone Factor :** 0.36

Borehole No.: 15 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60}$ X N	$(N1)_{60} = C_N$ X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	CL	8	1.74	0.74	87.00	25.00		33.50	1.00	0.87	0.37	0.55	1.70	0.75	0.997	1.05	0.75	1.10	5.18	8.81	0.50	1.20	11.08	0.12	1.000	0.12	0.22	Non-Liquefiable	
3.00	CI	8	1.74	0.74	97.00	27.10	45.00	38.00	0.98	5.21	2.21	0.54	1.70	0.75	0.997	1.05	0.80	1.10	5.53	9.40	0.50	1.20	11.78	0.13	1.000	0.13	0.24	Non-Liquefiable	
6.00	CI	10	1.83	0.83	95.00	25.80	43.00	38.50	0.95	10.70	4.70	0.51	1.47	0.75	0.997	1.05	0.95	1.10	8.21	12.10	0.50	1.20	15.02	0.16	1.000	0.16	0.31	Non-Liquefiable	
7.50	ML	15	1.83	0.83	95.00				0.94	13.44	5.94	0.50	1.31	0.75	0.997	1.05	0.95	1.10	12.31	16.13	0.50	1.20	19.86	0.21	1.000	0.21	0.43		Liquefiable
10.50	ML	31	1.83	0.83	77.00				0.89	18.93	8.43	0.47	1.10	0.75	0.997	1.05	1	1.10	26.78	29.46	0.50	1.20	35.85	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	28	1.94	0.94	80.00				0.81	24.74	11.24	0.42	0.95	0.75	0.997	1.05	1	1.10	24.19	23.04	0.50	1.20	28.15	0.38	1.000	0.37	0.89		Liquefiable
18.00	CL	30	1.86	0.86	96.00	23.60	41.00	31.90	0.69	33.10	15.10	0.36	0.82	0.75	0.997	1.05	1	1.10	25.92	21.30	0.50	1.20	26.06	0.31	1.000	0.31	0.88	Non-Liquefiable	
27.00	CI	19	1.83	0.83	87.00	22.30		47.40	0.45	49.53	22.53	0.23	0.67	0.75	0.997	1.05	1	1.10	16.42	11.05	0.50	1.20	13.76	0.15	1.000	0.15	0.63	Non-Liquefiable	
30.00	CI	19	1.86	0.86	99.00	23.80	48.00	48.00	0.37	55.10	25.10	0.19	0.64	0.75	0.997	1.05	1	1.10	16.42	10.46	0.50	1.20	13.06	0.14	1.000	0.14	0.74	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 16

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.30 m **Zone Factor :** 0.36

Borehole No.: 16 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m^3)	Submerged Density (t/m^3)	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/ σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60}$ = C_{60} X N	$(N1)_{60}$ = C_N X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) Kσ Kα	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	CL	5	1.71	0.71	100.00	20.00		31.60	1.00	0.85	0.35	0.56	1.70	0.75	0.997	1.05	0.75	1.10	3.24	5.51	0.50	1.20	7.11	0.09	1.000	0.09	0.16	Non-Liquefiable	
3.00	CI	5	1.71	0.71	98.00	23.90		42.50	0.98	5.12	2.12	0.55	1.70	0.75	0.997	1.05	0.80	1.10	3.46	5.88	0.50	1.20	7.55	0.09	1.000	0.09	0.17	Non-Liquefiable	
7.50	ML	18	1.81	0.81	96.00	25.80	43.00	38.50	0.94	13.26	5.76	0.51	1.33	0.75	0.997	1.05	0.95	1.10	14.77	19.66	0.50	1.20	24.09	0.27	1.000	0.27	0.54		Liquefiable
10.50	ML	35	1.92	0.92	92.00				0.89	19.02	8.52	0.47	1.09	0.75	0.997	1.05	1	1.10	30.24	33.08	0.50	1.20	40.20	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	45	1.92	0.92	96.00				0.81	24.78	11.28	0.42	0.95	0.75	0.997	1.05	1	1.10	38.88	36.97	0.50	1.20	44.86	NA	1.000	NA	>1		Non Liquefiable
15.00	CI	28	1.91	0.91	98.00	24.30		37.90	0.77	27.65	12.65	0.40	0.90	0.75	0.997	1.05	1	1.10	24.19	21.72	0.50	1.20	26.57	0.33	1.000	0.33	0.83	Non-Liquefiable	
18.00	CI	25	1.93	0.93	96.00	24.90		41.30	0.69	33.45	15.45	0.35	0.81	0.75	0.997	1.05	1	1.10	21.60	17.55	0.50	1.20	21.56	0.24	1.000	0.24	0.67	Non-Liquefiable	
19.50	ML	29	1.83	0.83	100.00				0.65	36.18	16.68	0.33	0.78	0.75	0.997	1.05	1	1.10	25.06	19.59	0.50	1.20	24.01	0.27	1.000	0.27	0.82		Liquefiable
24.00	CI	30	1.88	0.88	97.00	20.30	42.00	45.50	0.53	44.66	20.66	0.27	0.70	0.75	0.997	1.05	1	1.10	25.92	18.21	0.50	1.20	22.36	0.25	1.000	0.25	0.92	Non-Liquefiable	
25.50	ML	26	2.01	1.01	98.00				0.49	47.67	22.17	0.25	0.68	0.75	0.997	1.05	1	1.10	22.46	15.24	0.50	1.20	18.79	0.20	1.000	0.20	0.81		Liquefiable
27.00	ML	24	2.01	1.01	99.00				0.45	50.67	23.67	0.23	0.66	0.75	0.997	1.05	1	1.10	20.74	13.61	0.50	1.20	16.83	0.18	1.000	0.18	0.79		Liquefiable
36.00	CI	25	1.96	0.96	98.00	23.10		47.60	0.21	68.30	32.30	0.11	0.56	0.75	0.997	1.05	1	1.10	21.60	12.14	0.50	1.20	15.06	0.16	1.000	0.16	1.53	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 17

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 3.00 m **Zone Factor :** 0.36

Borehole No.: 17 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}/(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
1.50	CL	5	1.75	0.75	92.00	25.00	56.00	51.60	0.99	2.63	1.13	0.54	1.70	0.75	0.997	1.05	0.75	1.10	3.24	5.51	0.50	1.20	7.11	0.09	1.000	0.09	0.16	Non-Liquefiable	
3.00	CI	10	1.77	0.77	100.00	29.70	41.00	39.90	0.98	5.28	2.28	0.53	1.70	0.75	0.997	1.05	0.80	1.10	6.91	11.75	0.50	1.20	14.60	0.16	1.000	0.16	0.29	Non-Liquefiable	
7.50	ML	16	1.79	0.79	77.00				0.94	13.33	5.83	0.50	1.32	0.75	0.997	1.05	0.95	1.10	13.13	17.37	0.50	1.20	21.35	0.23	1.000	0.23	0.46		Liquefiable
10.50	ML	36	1.79	0.79	84.00				0.89	18.70	8.20	0.48	1.12	0.75	0.997	1.05	1	1.10	31.10	34.70	0.50	1.20	42.14	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	39	1.85	0.85	87.00				0.81	24.26	10.76	0.43	0.97	0.75	0.997	1.05	1	1.10	33.70	32.81	0.50	1.20	39.87	NA	1.000	NA	>1		Non Liquefiable
19.50	ML	49	1.85	0.85	95.00				0.65	35.38	15.88	0.34	0.80	0.75	0.997	1.05	1	1.10	42.33	33.93	0.50	1.20	41.21	NA	1.000	NA	>1		Non Liquefiable
24.00	CI	17	1.73	0.73	98.00	19.20	41.00	38.30	0.53	43.18	19.18	0.28	0.73	0.75	0.997	1.05	1	1.10	14.69	10.71	0.50	1.20	13.35	0.14	1.000	0.14	0.51	Non-Liquefiable	
30.00	CI	22	1.86	0.86	100.00	23.60		46.50	0.37	54.32	24.32	0.19	0.65	0.75	0.997	1.05	1	1.10	19.01	12.31	0.50	1.20	15.27	0.16	1.000	0.16	0.83	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 18

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 2.50 m **Zone Factor :** 0.36

Borehole No.: 18 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, $MSF = (10)^{2.24}/(MW)^{2.56}$	$CRR = CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
3.00	CI	9	1.65	0.65	100.00	25.60	42.00	36.00	0.98	4.94	1.94	0.58	1.70	0.75	0.997	1.05	0.80	1.10	6.22	10.58	0.50	1.20	13.19	0.14	1.000	0.14	0.24	Non-Liquefiable	
7.50	ML	38	1.68	0.68	68.00				0.94	12.49	4.99	0.55	1.43	0.75	0.997	1.05	0.95	1.10	31.19	44.59	0.50	1.20	54.01	NA	1.000	NA	>1		Non Liquefiable
10.50	ML	71	1.84	0.84	94.00				0.89	18.02	7.52	0.50	1.16	0.75	0.997	1.05	1	1.10	61.34	71.44	0.50	1.20	86.23	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	62	1.99	0.99	77.00				0.81	24.00	10.50	0.44	0.99	0.75	0.997	1.05	1	1.10	53.57	52.79	0.50	1.20	63.85	NA	1.000	NA	>1		Non Liquefiable
24.00	CL	30	1.82	0.82	93.00	21.50	42.00	32.70	0.53	43.12	19.12	0.28	0.73	0.75	0.997	1.05	1	1.10	25.92	18.93	0.50	1.20	23.22	0.26	1.000	0.26	0.92	Non-Liquefiable	
30.00	CI	25	1.94	0.94	100.00	32.10	48.00	49.80	0.37	54.73	24.73	0.19	0.64	0.75	0.997	1.05	1	1.10	21.60	13.87	0.50	1.20	17.15	0.18	1.000	0.18	0.94	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 19

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.30 m **Zone Factor :** 0.36

Borehole No.: 19 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60}$ = C_{60} X N	$(N1)_{60}$ = C_N X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
3.00	CI	10	1.73	0.73	99.00	25.10	42.00	37.20	0.98	5.20	2.20	0.54	1.70	0.75	0.997	1.05	0.80	1.10	6.91	11.75	0.50	1.20	14.60	0.16	1.000	0.16	0.29	Non-Liquefiable	
7.50	ML	34	2.00	1.00	74.00				0.94	14.18	6.68	0.47	1.24	0.75	0.997	1.05	0.95	1.10	27.91	34.49	0.50	1.20	41.89	NA	1.000	NA	>1		Non Liquefiable
12.00	CL	20	1.87	0.87	98.00	23.20	44.00	30.00	0.85	22.61	10.61	0.43	0.98	0.75	0.997	1.05	1	1.10	17.28	16.94	0.50	1.20	20.83	0.23	1.000	0.23	0.53	Non-Liquefiable	
16.50	ML	30	1.78	0.78	99.00				0.73	30.61	14.11	0.37	0.85	0.75	0.997	1.05	1	1.10	25.92	22.04	0.50	1.20	26.94	0.34	1.000	0.34	0.90		Liquefiable
19.50	ML	20	1.87	0.87	95.00				0.65	36.22	16.72	0.33	0.78	0.75	0.997	1.05	1	1.10	17.28	13.50	0.50	1.20	16.70	0.18	1.000	0.18	0.54		Liquefiable
24.00	CI	25	1.85	0.85	99.00	19.20		45.00	0.53	44.55	20.55	0.27	0.70	0.75	0.997	1.05	1	1.10	21.60	15.22	0.50	1.20	18.76	0.20	1.000	0.20	0.74	Non-Liquefiable	
30.00	CI	23	1.89	0.89	98.00	23.60		48.60	0.37	55.87	25.87	0.19	0.63	0.75	0.997	1.05	1	1.10	19.87	12.48	0.50	1.20	15.47	0.16	1.000	0.16	0.87	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 20

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.40 m **Zone Factor :** 0.36

Borehole No.: 20 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_w) :** 7.5

Depth below EGL, m		Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60}$ X N	$(N1)_{60} = C_N$ X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
1.50	CL	3	1.78	0.78	99.00	25.00	47.00	31.10	0.99	2.67	1.17	0.53	1.70	0.75	0.997	1.05	0.75	1.10	1.94	3.30	0.50	1.20	4.47	0.07	1.000	0.07	0.13	Non-Liquefiable	
4.50	ML	4	1.78	0.78	94.00				0.97	8.00	3.50	0.52	1.70	0.75	0.997	1.05	0.85	1.10	2.94	4.99	0.50	1.20	6.49	0.08	1.000	0.08	0.16		Liquefiable
6.00	CH	10	1.78	0.78	99.00	29.40	75.00	59.70	0.95	10.66	4.66	0.51	1.48	0.75	0.997	1.05	0.95	1.10	8.21	12.14	0.50	1.20	15.07	0.16	1.000	0.16	0.31	Non-Liquefiable	
7.50	ML	15	1.87	0.87	95.00				0.94	13.47	5.97	0.50	1.31	0.75	0.997	1.05	0.95	1.10	12.31	16.09	0.50	1.20	19.81	0.21	1.000	0.21	0.43		Liquefiable
10.50	ML	27	1.91	0.91	84.00				0.89	19.19	8.69	0.46	1.08	0.75	0.997	1.05	1	1.10	23.33	25.27	0.50	1.20	30.82	NA	1.000	NA	>1		Non Liquefiable
15.00	ML	33	1.83	0.83	89.00				0.77	27.42	12.42	0.40	0.91	0.75	0.997	1.05	1	1.10	28.51	25.84	0.50	1.20	31.51	NA	1.000	NA	>1		Non Liquefiable
21.00	CL	57	2.06	1.06	98.00	36.40	42.00	32.50	0.61	39.80	18.80	0.30	0.74	0.75	0.997	1.05	1	1.10	49.25	36.28	0.50	1.20	44.03	NA	1.000	NA	>1	Non-Liquefiable	
24.00	CI	40	1.89	0.89	97.00	31.10	46.00	44.80	0.53	45.45	21.45	0.26	0.69	0.75	0.997	1.05	1	1.10	34.56	23.83	0.50	1.20	29.09	0.41	1.000	0.41	1.57	Non-Liquefiable	
27.00	CI	35	1.91	0.91	96.00	25.80	48.00	43.40	0.45	51.19	24.19	0.22	0.65	0.75	0.997	1.05	1	1.10	30.24	19.63	0.50	1.20	24.06	0.27	1.000	0.27	1.22	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 21

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.50 m **Zone Factor :** 0.36

Borehole No.: 21 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_w) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60}$ X N	$(N1)_{60} = C_N$ X N_{60}	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
3.00	CL	9	1.71	0.71	82.00	24.20	34.00	29.10	0.98	5.13	2.13	0.55	1.70	0.75	0.997	1.05	0.80	1.10	6.22	10.58	0.50	1.20	13.19	0.14	1.000	0.14	0.26	Non-Liquefiable	
6.00	CI	10	1.79	0.79	98.00	27.40	46.00	40.70	0.95	10.49	4.49	0.52	1.51	0.75	0.997	1.05	0.95	1.10	8.21	12.37	0.50	1.20	15.34	0.16	1.000	0.16	0.31	Non-Liquefiable	
7.50	ML	18	1.78	0.78	90.00				0.94	13.17	5.67	0.51	1.34	0.75	0.997	1.05	0.95	1.10	14.77	19.82	0.50	1.20	24.28	0.28	1.000	0.28	0.54		Liquefiable
10.50	ML	31	1.78	0.78	96.00				0.89	18.51	8.01	0.48	1.13	0.75	0.997	1.05	1	1.10	26.78	30.23	0.50	1.20	36.77	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	30	1.88	0.88	96.00				0.81	24.13	10.63	0.43	0.98	0.75	0.997	1.05	1	1.10	25.92	25.39	0.50	1.20	30.96	NA	1.000	NA	>1		Non Liquefiable
21.00	ML	39	1.88	0.88	87.00				0.61	38.20	17.20	0.32	0.77	0.75	0.997	1.05	1	1.10	33.70	25.95	0.50	1.20	31.64	NA	1.000	NA	>1		Non Liquefiable
24.00	CI	28	1.79	0.79	98.00	18.90	44.00	37.00	0.53	43.58	19.58	0.28	0.72	0.75	0.997	1.05	1	1.10	24.19	17.46	0.50	1.20	21.45	0.23	1.000	0.23	0.84	Non-Liquefiable	
30.00	CI	19	1.80	0.80	94.00	17.60	42.00	35.40	0.37	54.39	24.39	0.19	0.65	0.75	0.997	1.05	1	1.10	16.42	10.62	0.50	1.20	13.24	0.14	1.000	0.14	0.73	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 22

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.40 m **Zone Factor :** 0.36

Borehole No.: 22 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60}$ = C_{60} X N	$(N1)_{60}$ = C_N X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
1.50	CL	5	1.71	0.71	98.00	25.00	38.00	33.80	0.99	2.57	1.07	0.56	1.70	0.75	0.997	1.05	0.75	1.10	3.24	5.51	0.50	1.20	7.11	0.09	1.000	0.09	0.16	Non-Liquefiable	
3.00	CI	6	1.75	0.75	92.00	27.70	43.00	36.20	0.98	5.19	2.19	0.54	1.70	0.75	0.997	1.05	0.80	1.10	4.15	7.05	0.50	1.20	8.96	0.10	1.000	0.10	0.19	Non-Liquefiable	
6.00	CI	10	1.72	0.72	98.00	22.60	41.00	35.80	0.95	10.36	4.36	0.53	1.53	0.75	0.997	1.05	0.95	1.10	8.21	12.56	0.50	1.20	15.57	0.17	1.000	0.17	0.31	Non-Liquefiable	
10.50	ML	24	1.93	0.93	89.00				0.89	19.05	8.55	0.47	1.09	0.75	0.997	1.05	1	1.10	20.74	22.65	0.50	1.20	27.68	0.36	1.000	0.36	0.77		Liquefiable
13.50	ML	27	1.94	0.94	91.00				0.81	24.85	11.35	0.42	0.95	0.75	0.997	1.05	1	1.10	23.33	22.11	0.50	1.20	27.04	0.34	1.000	0.34	0.81		Liquefiable
22.50	ML	45	1.85	0.85	88.00				0.57	41.50	19.00	0.29	0.73	0.75	0.997	1.05	1	1.10	38.88	28.49	0.50	1.20	34.68	NA	1.000	NA	>1		Non Liquefiable
24.00	CI	35	1.90	0.90	95.00	18.30		38.30	0.53	44.34	20.34	0.27	0.71	0.75	0.997	1.05	1	1.10	30.24	21.41	0.50	1.20	26.19	0.32	1.000	0.32	1.17	Non-Liquefiable	
27.00	CI	20	1.91	0.91	99.00	17.20		39.80	0.45	50.08	23.08	0.23	0.66	0.75	0.997	1.05	1	1.10	17.28	11.49	0.50	1.20	14.28	0.15	1.000	0.15	0.66	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 23

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.30 m **Zone Factor :** 0.36

Borehole No.: 23 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_w) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}/(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	CH	7	1.85	0.85	100.00	25.00	58.00	51.00	1.00	0.93	0.43	0.51	1.70	0.75	0.997	1.05	0.75	1.10	4.54	7.71	0.50	1.20	9.75	0.11	1.000	0.11	0.22	Non-Liquefiable	
3.00	CI	12	1.85	0.85	97.00	30.40	45.00	40.60	0.98	5.56	2.56	0.50	1.70	0.75	0.997	1.05	0.80	1.10	8.29	14.10	0.50	1.20	17.42	0.19	1.000	0.19	0.37	Non-Liquefiable	
4.50	ML	13	1.90	0.90	96.00				0.97	8.42	3.92	0.49	1.61	0.75	0.997	1.05	0.85	1.10	9.55	15.40	0.50	1.20	18.98	0.20	1.000	0.20	0.42		Liquefiable
7.50	ML	30	1.98	0.98	96.00				0.94	14.37	6.87	0.46	1.22	0.75	0.997	1.05	0.95	1.10	24.62	30.01	0.50	1.20	36.51	NA	1.000	NA	>1		Non Liquefiable
10.50	ML	16	1.98	0.98	95.00				0.89	20.32	9.82	0.43	1.02	0.75	0.997	1.05	1	1.10	13.82	14.09	0.50	1.20	17.41	0.19	1.000	0.19	0.43		Liquefiable
12.00	CL	15	1.83	0.83	96.00	18.00	35.00	30.30	0.85	23.06	11.06	0.42	0.96	0.75	0.997	1.05	1	1.10	12.96	12.45	0.50	1.20	15.44	0.16	1.000	0.16	0.39	Non-Liquefiable	
21.00	ML	45	1.99	0.99	92.00				0.61	40.94	19.94	0.29	0.72	0.75	0.997	1.05	1	1.10	38.88	27.81	0.50	1.20	33.87	NA	1.000	NA	>1		Non Liquefiable
24.00	CI	15	2.00	1.00	98.00	23.50	43.00	47.00	0.53	46.95	22.95	0.26	0.67	0.75	0.997	1.05	1	1.10	12.96	8.64	0.50	1.20	10.87	0.12	1.000	0.12	0.47	Non-Liquefiable	
27.00	CI	18	2.00	1.00	94.00	21.40	43.00	46.20	0.45	52.96	25.96	0.22	0.63	0.75	0.997	1.05	1	1.10	15.55	9.75	0.50	1.20	12.20	0.13	1.000	0.13	0.61	Non-Liquefiable	
30.00	CI	23	2.03	1.03	94.00	22.20	45.00	41.70	0.37	59.03	29.03	0.18	0.59	0.75	0.997	1.05	1	1.10	19.87	11.78	0.50	1.20	14.63	0.16	1.000	0.16	0.88	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 24

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.40 m **Zone Factor :** 0.36

Borehole No.: 24 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m^3)	Submerged Density (t/m^3)	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/ σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60}$ X N	$(N1)_{60} = C_N$ X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) Kσ Kα	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
1.50	CL	5	1.71	0.71	98.00	24.00	39.00	34.50	0.99	2.56	1.06	0.56	1.70	0.75	0.997	1.05	0.75	1.10	3.24	5.51	0.50	1.20	7.11	0.09	1.000	0.09	0.16	Non-Liquefiable	
4.50	CL	9	1.78	0.78	99.00	25.00	36.00	33.40	0.97	7.89	3.39	0.53	1.70	0.75	0.997	1.05	0.85	1.10	6.61	11.24	0.50	1.20	13.98	0.15	1.000	0.15	0.29	Non-Liquefiable	
7.50	ML	29	1.78	0.78	94.00				0.94	13.23	5.73	0.51	1.33	0.75	0.997	1.05	0.95	1.10	23.80	31.76	0.50	1.20	38.62	NA	1.000	NA	>1		Non Liquefiable
10.50	ML	28	1.85	0.85	85.00				0.89	18.78	8.28	0.47	1.11	0.75	0.997	1.05	1	1.10	24.19	26.85	0.50	1.20	32.71	NA	1.000	NA	>1		Non Liquefiable
13.50	ML	33	1.90	0.90	90.00				0.81	24.49	10.99	0.42	0.96	0.75	0.997	1.05	1	1.10	28.51	27.47	0.50	1.20	33.47	NA	1.000	NA	>1		Non Liquefiable
18.00	CI	41	1.78	0.78	98.00	22.90	42.00	38.50	0.69	32.48	14.48	0.36	0.84	0.75	0.997	1.05	1	1.10	35.42	29.73	0.50	1.20	36.17	NA	1.000	NA	>1	Non-Liquefiable	
19.50	ML	34	1.76	0.76	90.00				0.65	35.13	15.63	0.34	0.81	0.75	0.997	1.05	1	1.10	29.38	23.73	0.50	1.20	28.98	0.41	1.000	0.41	1.19		Non Liquefiable
24.00	CI	35	1.80	0.80	98.31	20.60		45.80	0.53	43.25	19.25	0.28	0.73	0.75	0.997	1.05	1	1.10	30.24	22.01	0.50	1.20	26.92	0.34	1.000	0.34	1.20	Non-Liquefiable	
27.00	CI	32	1.92	0.92	92.96	22.10	45.00	38.50	0.45	48.99	21.99	0.24	0.68	0.75	0.997	1.05	1	1.10	27.65	18.83	0.50	1.20	23.09	0.26	1.000	0.26	1.09	Non-Liquefiable	
30.00	CI	35	1.99	0.99	98.28	23.40		39.60	0.37	54.98	24.98	0.19	0.64	0.75	0.997	1.05	1	1.10	30.24	19.32	0.50	1.20	23.69	0.27	1.000	0.27	1.39	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 25

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.40 m **Zone Factor :** 0.36

Borehole No.: 25 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m^3)	Submerged Density (t/m^3)	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/ σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60}$ X N	$(N1)_{60} = C_N$ X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) Kσ Kα	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
1.50	MI	13	1.72	0.72	95.00				0.99	2.58	1.08	0.55	1.70	0.75	0.997	1.05	0.75	1.10	8.42	14.32	0.50	1.20	17.68	0.19	1.000	0.19	0.34		Liquefiable
6.00	CL	11	1.74	0.74	98.00	23.20	37.00	33.80	0.95	10.39	4.39	0.53	1.52	0.75	0.997	1.05	0.95	1.10	9.03	13.77	0.50	1.20	17.02	0.18	1.000	0.18	0.34	Non-Liquefiable	
7.50	ML	12	1.79	0.79	97.00				0.94	13.08	5.58	0.52	1.35	0.75	0.997	1.05	0.95	1.10	9.85	13.32	0.50	1.20	16.48	0.18	1.000	0.18	0.34		Liquefiable
10.50	ML	22	1.81	0.81	93.00				0.89	18.50	8.00	0.48	1.13	0.75	0.997	1.05	1	1.10	19.01	21.46	0.50	1.20	26.25	0.32	1.000	0.32	0.66		Liquefiable
13.50	ML	24	1.81	0.81	99.00				0.81	23.93	10.43	0.44	0.99	0.75	0.997	1.05	1	1.10	20.74	20.51	0.50	1.20	25.11	0.29	1.000	0.29	0.67		Liquefiable
16.50	ML	24	1.81	0.81	97.00				0.73	29.35	12.85	0.39	0.89	0.75	0.997	1.05	1	1.10	20.74	18.47	0.50	1.20	22.67	0.25	1.000	0.25	0.64		Liquefiable
18.00	CL	30	1.81	0.81	91.00	26.10	39.00	32.50	0.69	32.07	14.07	0.37	0.85	0.75	0.997	1.05	1	1.10	25.92	22.07	0.50	1.20	26.98	0.34	1.000	0.34	0.91	Non-Liquefiable	
21.00	ML	22	1.80	0.80	89.00				0.61	37.47	16.47	0.33	0.79	0.75	0.997	1.05	1	1.10	19.01	14.96	0.50	1.20	18.45	0.20	1.000	0.20	0.60		Liquefiable
24.00	CI	17	1.80	0.80	99.00	22.30	44.00	47.20	0.53	42.88	18.88	0.28	0.74	0.75	0.997	1.05	1	1.10	14.69	10.80	0.50	1.20	13.46	0.14	1.000	0.14	0.51	Non-Liquefiable	
30.00	CI	18	1.86	0.86	96.00	19.50		35.90	0.37	54.04	24.04	0.20	0.65	0.75	0.997	1.05	1	1.10	15.55	10.13	0.50	1.20	12.66	0.14	1.000	0.14	0.70	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 26

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.00 m **Zone Factor :** 0.36

Borehole No.: 26

Water Table Considered : 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg

Earthquake Magnitude (M_W) : 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m^3)	Submerged Density (t/m^3)	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}/(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) $K\sigma$ $K\alpha$	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	MI	4	1.70	0.70	98.00				1.00	0.85	0.35	0.57	1.70	0.75	0.997	1.05	0.75	1.10	2.59	4.41	0.50	1.20	5.79	0.08	1.000	0.08	0.14		Liquefiable
1.50	MI	16	1.70	0.70	99.00				0.99	2.55	1.05	0.56	1.70	0.75	0.997	1.05	0.75	1.10	10.37	17.63	0.50	1.20	21.65	0.24	1.000	0.24	0.42		Liquefiable
4.50	MI	35	1.70	0.70	96.00				0.97	7.66	3.16	0.55	1.70	0.75	0.997	1.05	0.85	1.10	25.70	43.70	0.50	1.20	52.93	NA	1.000	NA	>1		Non Liquefiable
7.50	SM	38	2.00	1.00	49.00				0.94	13.66	6.16	0.49	1.29	0.75	0.997	1.05	0.95	1.10	31.19	40.14	0.50	1.20	48.67	NA	1.000	NA	>1		Non Liquefiable
10.50	ML	50	1.82	0.82	65.00				0.89	19.12	8.62	0.46	1.09	0.75	0.997	1.05	1	1.10	43.20	47.00	0.50	1.20	56.90	NA	1.000	NA	>1		Non Liquefiable
19.50	ML	30	1.84	0.84	84.59				0.65	35.72	16.22	0.34	0.79	0.75	0.997	1.05	1	1.10	25.92	20.55	0.50	1.20	25.16	0.30	1.000	0.30	0.88		Liquefiable
22.50	ML	26	1.85	0.85	92.00				0.57	41.26	18.76	0.30	0.74	0.75	0.997	1.05	1	1.10	22.46	16.57	0.50	1.20	20.38	0.22	1.000	0.22	0.75		Liquefiable
24.00	CI	25	1.86	0.86	95.00	21.90	42.00	41.40	0.53	44.05	20.05	0.27	0.71	0.75	0.997	1.05	1	1.10	21.60	15.41	0.50	1.20	18.99	0.20	1.000	0.20	0.74	Non-Liquefiable	
36.00	CI	30	1.96	0.96	98.00	22.20		44.00	0.21	67.53	31.53	0.11	0.57	0.75	0.997	1.05	1	1.10	25.92	14.74	0.50	1.20	18.19	0.19	1.000	0.19	1.82	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 27

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.30 m **Zone Factor :** 0.36

Borehole No.: 27 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60}$ = C_{60} X N	$(N1)_{60}$ = C_N X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
3.00	CI	10	1.80	0.80	97.00	25.10		35.90	0.98	5.40	2.40	0.51	1.70	0.75	0.997	1.05	0.80	1.10	6.91	11.75	0.50	1.20	14.60	0.16	1.000	0.16	0.30	Non-Liquefiable	
7.50	ML	31	1.81	0.81	79.00				0.94	13.56	6.06	0.49	1.30	0.75	0.997	1.05	0.95	1.10	25.44	33.01	0.50	1.20	40.11	NA	1.000	NA	>1		Non Liquefiable
10.50	ML	35	1.81	0.81	82.00				0.89	19.00	8.50	0.47	1.10	0.75	0.997	1.05	1	1.10	30.24	33.12	0.50	1.20	40.25	NA	1.000	NA	>1		Non Liquefiable
16.50	ML	57	1.88	0.88	70.00				0.73	30.26	13.76	0.38	0.86	0.75	0.997	1.05	1	1.10	49.25	42.40	0.50	1.20	51.38	NA	1.000	NA	>1		Non Liquefiable
19.50	ML	51	1.88	0.88	82.00				0.65	35.89	16.39	0.33	0.79	0.75	0.997	1.05	1	1.10	44.06	34.76	0.50	1.20	42.22	NA	1.000	NA	>1		Non Liquefiable
24.00	CI	30	1.87	0.87	94.00	22.50		39.00	0.53	44.31	20.31	0.27	0.71	0.75	0.997	1.05	1	1.10	25.92	18.37	0.50	1.20	22.54	0.25	1.000	0.25	0.92	Non-Liquefiable	
30.00	CH	22	1.93	0.93	89.00	23.50		51.20	0.37	55.89	25.89	0.19	0.63	0.75	0.997	1.05	1	1.10	19.01	11.93	0.50	1.20	14.82	0.16	1.000	0.16	0.84	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 28

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 3.30 m **Zone Factor :** 0.36

Borehole No.: 28 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m		Type of soil	Observed SPT Value (N)	Saturated Density (t/m ³)	Submerged Density (t/m ³)	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m²	Effective overburden (σ'_o), t/m²	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, $MSF = (10)^{2.24}/(MW)^{2.56}$	$CRR = CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
3.00	CI	7	1.73	0.73	99.00	22.60		35.30	0.98	2.19	5.19	0.54	1.70	0.75	0.997	1.05	0.80	1.10	4.84	8.23	0.50	1.20	10.37	0.12	1.000	0.12	0.21	Non-Liquefiable	
7.50	ML	14	1.87	0.87	96.00				0.94	6.09	13.59	0.49	1.29	0.75	0.997	1.05	0.95	1.10	11.49	14.87	0.50	1.20	18.35	0.20	1.000	0.20	0.40		Liquefiable
10.50	ML	18	1.87	0.87	98.00				0.89	8.69	19.19	0.46	1.08	0.75	0.997	1.05	1	1.10	15.55	16.85	0.50	1.20	20.72	0.22	1.000	0.22	0.49		Liquefiable
12.00	CL	13	1.82	0.82	95.86	22.60	44.00	32.20	0.85	9.92	21.92	0.44	1.01	0.75	0.997	1.05	1	1.10	11.23	11.39	0.50	1.20	14.17	0.15	1.000	0.15	0.34	Non-Liquefiable	
18.00	CL	40	1.87	0.87	89.85	21.50		32.60	0.69	15.12	33.12	0.36	0.82	0.75	0.997	1.05	1	1.10	34.56	28.38	0.50	1.20	34.56	NA	1.000	NA	>1	Non-Liquefiable	
24.00	CL	44	1.81	0.81	50.72	14.50	26.00	30.10	0.53	20.01	44.01	0.27	0.71	0.75	0.997	1.05	1	1.10	38.01	27.14	0.50	1.20	33.07	NA	1.000	NA	>1	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 29

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.00 m **Zone Factor :** 0.36

Borehole No.: 29 **Water Table Considered :** 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_w) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60}$ = C_{60} X N	$(N1)_{60}$ = C_N X N_{60}	α	β	$(N_1)_{60CS}$ = α + β $(N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}$ /$(MW)^{2.56}$	CRR = $CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
3.00	CI	11	1.82	0.82	95.00	23.50	42.00	35.30	0.98	5.46	2.46	0.51	1.70	0.75	0.997	1.05	0.80	1.10	7.60	12.93	0.50	1.20	16.01	0.17	1.000	0.17	0.34	Non-Liquefiable	
4.50	ML	13	1.84	0.84	64.00				0.97	8.21	3.71	0.50	1.66	0.75	0.997	1.05	0.85	1.10	9.55	15.82	0.50	1.20	19.49	0.21	1.000	0.21	0.42		Liquefiable
10.50	ML	29	1.87	0.87	65.00				0.89	19.45	8.95	0.45	1.07	0.75	0.997	1.05	1	1.10	25.06	26.75	0.50	1.20	32.60	NA	1.000	NA	>1		Non Liquefiable
12.00	ML	31	1.87	0.87	67.00				0.85	22.26	10.26	0.43	1.00	0.75	0.997	1.05	1	1.10	26.78	26.70	0.50	1.20	32.55	NA	1.000	NA	>1		Non Liquefiable
18.00	CL	40	1.81	0.81	70.00	18.60		29.30	0.69	33.11	15.11	0.36	0.82	0.75	0.997	1.05	1	1.10	34.56	28.39	0.50	1.20	34.57	NA	1.000	NA	>1	Non-Liquefiable	
25.50	ML	38	1.81	0.81	81.00				0.49	46.67	21.17	0.25	0.69	0.75	0.997	1.05	1	1.10	32.83	22.79	0.50	1.20	27.84	0.36	1.000	0.36	1.43		Non Liquefiable
30.00	CI	33	1.92	0.92	99.00	20.80		49.90	0.37	55.29	25.29	0.19	0.64	0.75	0.997	1.05	1	1.10	28.51	18.11	0.50	1.20	22.23	0.25	1.000	0.25	1.29	Non-Liquefiable	

Evaluation of Liquefaction Potential (IS 1893 - Part 1 : 2016) for BH - 30

Project Name: Geotechnical Investigation and Topographical survey of proposed Solar/ Wind/ Hybrid Park at Great Rann of Kutch area, Gujarat

Actual Water Table Depth : 4.30 m **Zone Factor :** 0.36

Water Table Considered : 0.00 m **Location :** BHUJ

Hammer Fall: 0.76 m **Hammer Weight:** 63.5 kg **Earthquake Magnitude (M_W) :** 7.5

Depth below EGL, m	Type of soil	Observed SPT Value (N)	Saturated Density (t/m ^{3})	Submerged Density (t/m ^{3})	Fine Content (%)	Field Moisture Content, FMC (%)	Particles less than 5 micron size (%)	Liquid Limit, LL (%)	Stress Reduction Coefficient (r_d)	Total overburden pressure (σ_o), t/m^2	Effective overburden (σ'_o), t/m^2	Cyclic Stress ratio (CSR)	C_N = sqrt(Pa/σ'_o)	C_{HT}	C_{HW}	C_{BD}	C_{RL}	C_{SS}	$(N)_{60} = C_{60} \times N$	$(N1)_{60} = C_N \times N_{60}$	α	β	$(N_1)_{60CS} = \alpha + \beta\ (N1)_{60}$	$CRR_{7.5}$	Magnitude Scaling Factor, MSF = $(10)^{2.24}/(MW)^{2.56}$	$CRR = CRR_{7.5}$ (MSF) K_σ K_α	FOS = CRR / CSR	Conclusion for Cohesive Soils	Conclusion for Cohesionless Soils
0.50	ML	5	1.76	0.76	84.00				1.00	0.88	0.38	0.54	1.70	0.75	0.997	1.05	0.75	1.10	3.24	5.51	0.50	1.20	7.11	0.09	1.000	0.09	0.16		Liquefiable
4.50	ML	11	1.76	0.76	95.00				0.97	7.91	3.41	0.52	1.70	0.75	0.997	1.05	0.85	1.10	8.08	13.73	0.50	1.20	16.98	0.18	1.000	0.18	0.34		Liquefiable
7.50	ML	10	1.87	0.87	93.00				0.94	13.51	6.01	0.50	1.30	0.75	0.997	1.05	0.95	1.10	8.21	10.70	0.50	1.20	13.34	0.14	1.000	0.14	0.29		Liquefiable
10.50	ML	16	1.80	0.80	96.00				0.89	18.91	8.41	0.47	1.10	0.75	0.997	1.05	1	1.10	13.82	15.23	0.50	1.20	18.77	0.20	1.000	0.20	0.43		Liquefiable
15.00	ML	26	1.80	0.80	93.00				0.77	27.01	12.01	0.41	0.92	0.75	0.997	1.05	1	1.10	22.46	20.71	0.50	1.20	25.35	0.30	1.000	0.30	0.73		Liquefiable
16.50	ML	33	1.80	0.80	94.00				0.73	29.71	13.21	0.39	0.88	0.75	0.997	1.05	1	1.10	28.51	25.06	0.50	1.20	30.57	NA	1.000	NA	>1		Non Liquefiable
18.00	CL	35	1.84	0.84	95.84	21.20		30.10	0.69	32.47	14.47	0.36	0.84	0.75	0.997	1.05	1	1.10	30.24	25.39	0.50	1.20	30.96	NA	1.000	NA	>1	Non-Liquefiable	
21.00	CL	40	1.89	0.89	90.15	20.10	40.00	33.60	0.61	38.15	17.15	0.32	0.77	0.75	0.997	1.05	1	1.10	34.56	26.65	0.50	1.20	32.48	NA	1.000	NA	>1	Non-Liquefiable	
24.00	CL	50	1.94	0.94	89.25	24.20	37.00	32.30	0.53	43.97	19.97	0.27	0.71	0.75	0.997	1.05	1	1.10	43.20	30.87	0.50	1.20	37.55	NA	1.000	NA	>1	Non-Liquefiable	
30.00	CI	30	1.90	0.90	92.00	23.40	43.00	46.70	0.37	55.36	25.36	0.19	0.63	0.75	0.997	1.05	1	1.10	25.92	16.44	0.50	1.20	20.22	0.22	1.000	0.22	1.14	Non-Liquefiable	

ANNEXURE 8 : SBC SAMPLE CALCULATION SHEET

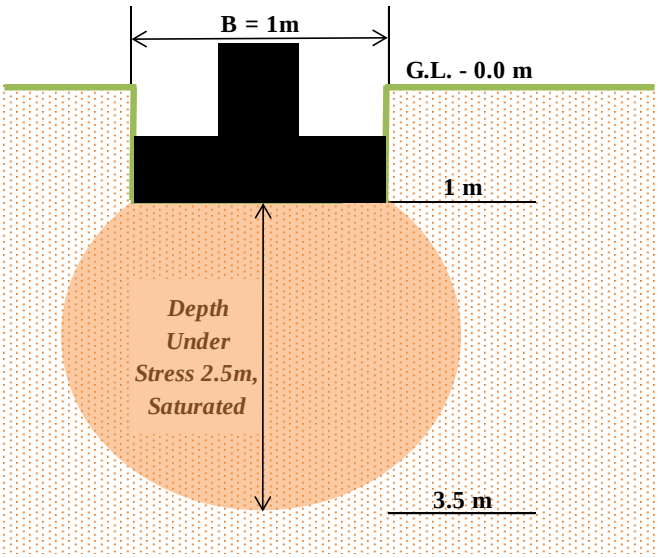
SAFE BEARING CAPACITY OF SOIL - IS 6403:1981

Sample Calculations for 1 m X 1 m X 1 m deep footing for BH-7

DESIGN PARAMETERS

Shape of footing	Square	
Depth of footing (D)	1.000	m
Width of footing (B)	1.000	m
Length of footing (L)	1.000	m

Depth of Water Table	0.00	m
Dry Density (γ_d)	1.396	T/m^3
Moisture Content (w)	27.20	%
Cohesion (c)	2.70	T/m^2
Angle of Int.Friction (Ø)	0.00	degree
Specific Gravity (G)	2.594	m
Effective Surcharge over EGL	0.00	m
Ratio (D/B)	0.000	
Water Table Factor (W')	0.500	
Bulk Density (γ_b)	1.776	T/m^3
Sat. Density (γ_{sat})	1.858	T/m^3
Sub. Density (γ')	0.776	T/m^3



Overburden Pressure (q) = (1.776*(1-(1-0))+(0.776*(1-0))

q = 0.776 T/m²

Inclination Angle (α)	0
Factor of Safety (F)	2.5
Surcharge Density Assumed, gm/cc	1.000

Void Ratio (e_0) = $\left[\frac{G \times \gamma_w}{\gamma_d}\right] - 1$

e_0 = 0.858

Cohesion (c), T/m^2 = 2.70

Ø',° = tan-1(0.67 tan Ø) = 0.00

Mode of Failure = *Local Shear Failure*

Bearing Capacity Factors		
Nc'	=	5.140
Nq'	=	1.000
Nγ'	=	0.000

d, s, i	Depth factor	Shape factor	Inclination factor
dc, sc, ic	1.200	1.300	1.000
dq, sq, iq	1.000	1.200	1.000
d_γ, s_γ, i_γ	1.000	0.800	1.000

Sample Calculation for Local Shear Failure (Void Ratio > 0.75)

q_u = 0.67 c N'c Sc dc ic + q (N'q - 1) Sq dq iq + 0.5 B γ' N'γ Sγ dγ iγ W'

= (0.67 x 2.7 x 5.14 x 1.3 x 1.2 x 1) + (0.776 x (1 - 1) x 1.2 x 1 x 1) + (0.5 x 1 x 0.776 x 0 x 0.8 x 1 x 1 x 0.5)

= 14.51 q_s = 5.80 T/m²

Abbreviations :

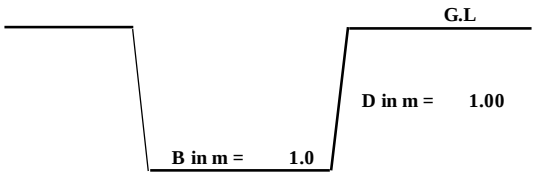
Nγ' Nc' Nq' = Bearing Capacity Factors

q_u = Ultimate Bearing Capacity

q_s = Safe Bearing Capacity

SETTLEMENT ANALYSIS OF SOIL - Based on I.S. 8009 Part 1

SAMPLE CALCULATION



Depth under Stress = 3.0 m
Depth of Groundwater, Dw = 0 m
Length of Footing, L = 1.0 m

Depth of each layer below EGL	Depth of Center of each layer below Foundation	Thickness of each layer	Compression Index, Cc	Compression Index, Cc Considered	Modulus of Elasticity, kg/cm²	Specific Gravity	Bulk Density, g/cc	Dry Density, g/cc	Saturated Density, g/cc	Submerged Density, g/cc	Void Ration,
d1	z1	H	Cc	Cc	E	G	γb	γd		γ'	e0
1.50	0.25	0.50	0.173	0.173	24	2.594	1.776	1.396	1.858	0.858	0.858
3.00	1.25	1.50	0.173	0.173	24	2.594	1.776	1.396	1.858	0.858	0.858

IMMEDIATE SETTLEMENT

I = 0.95 — Ref.: Table 2, IS 8009 Part 1- 1976
Modulus of Elasticity, E = 24 kg/cm² — Average within Influence Zone
Poisson's Ration, μ = 0.3 — Ref.: Table 2-7, J E Bowle's Foundation Analysis and Design
Assume Pressure P = 3.06 T/m²
0.306 kg/cm²

$$\text{Immediate Settlement, } \rho i = \frac{P \times B (1 - \mu^2) \times I}{E} = \frac{0.306 \times (1 \times 100) \times (1 - 0.3 \times 0.3) \times 0.95}{24} = 1.102 \text{ cm}$$

CONSOLIDATION SETTLEMENT

Zi in m	B / 2Z m	L / 2Z n	I_B (Fig 18, IS 8009 Part 1)	= 4 x I_B	Po = Yb x d kg/cm²	Δ P = P x I_B kg/cm²	Cc / 1 + eo	log (Po+ΔP) / (Po)	ρc = (7) x Cc x (8) cm
(1)					(5)	7	(7)	(8)	(10)
0.25	2.000	2.000	0.232	0.930	0.107	0.285	0.09	0.563	2.620
1.25	0.400	0.400	0.060	0.241	0.193	0.074	0.09	0.141	1.962
								Σρc =	4.5817

Consolidation Settlement, ρc = Σρc x Soil Factor
4.5817 x 0.7
3.2071 cm

Soil factor	0.700
Rigidity factor	0.800
Depth factor	0.726

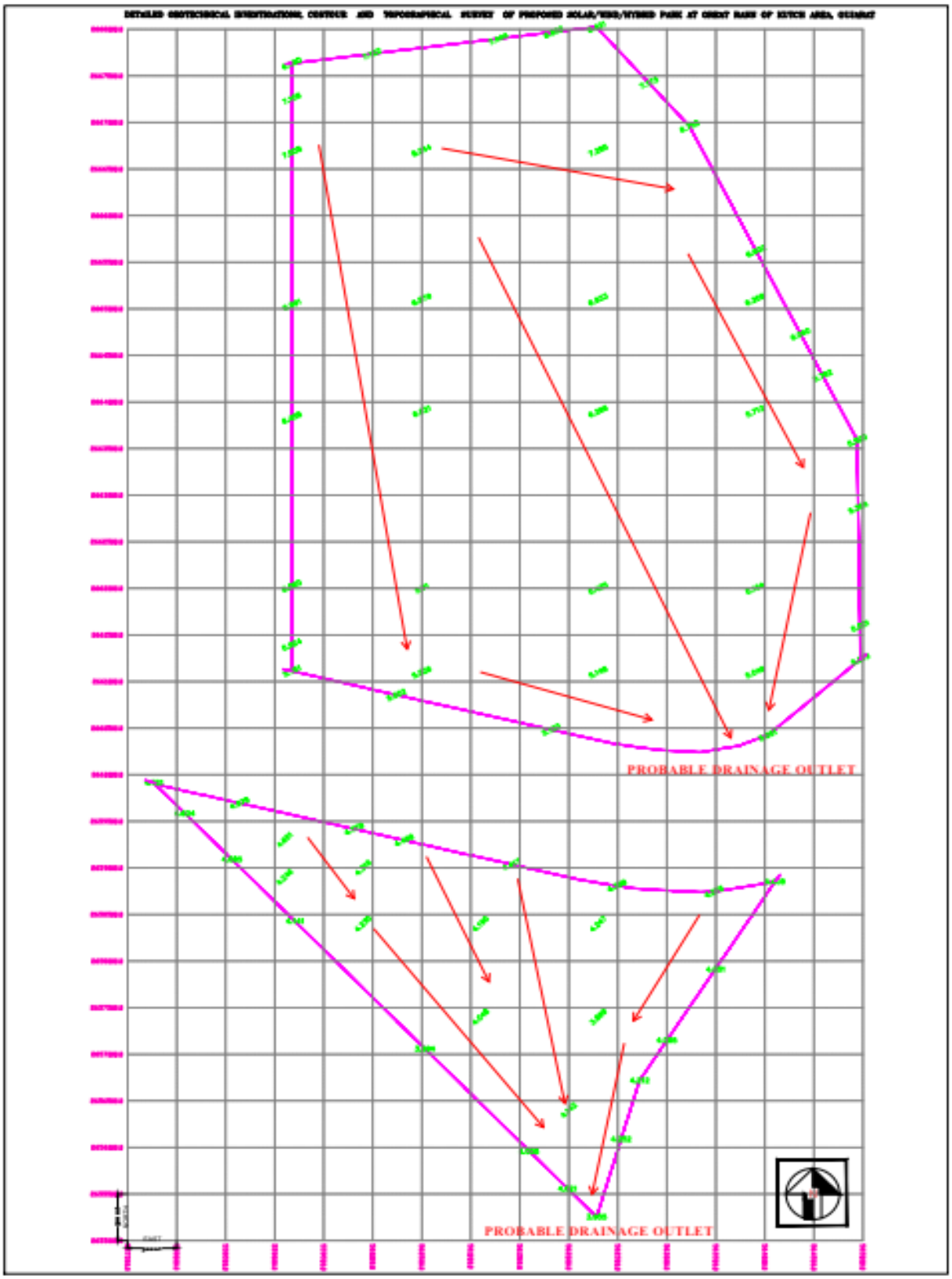
Total Settlement, ρt = (ρi + ρc) x Depth Factor x Rigidity Factor
= (1.102 + 3.2071) x 0.726 x 0.8
= 2.503 cm
= 25.03 mm

Hence the Safe Bearing Pressure = 3.06T/Sq.m

D/√LB *1.00*
Note- √LB/D *1.00*

I_B - Influence Factor from Fig 18, IS 8009 P 1- 1976
Cc Value is taken from the Laboratory test Result
G Value is taken from the Laboratory test Result
γb Value is taken from the Laboratory test Result
γd Value is taken from the Laboratory test Result
e0 = (G. γω) / γd - 1

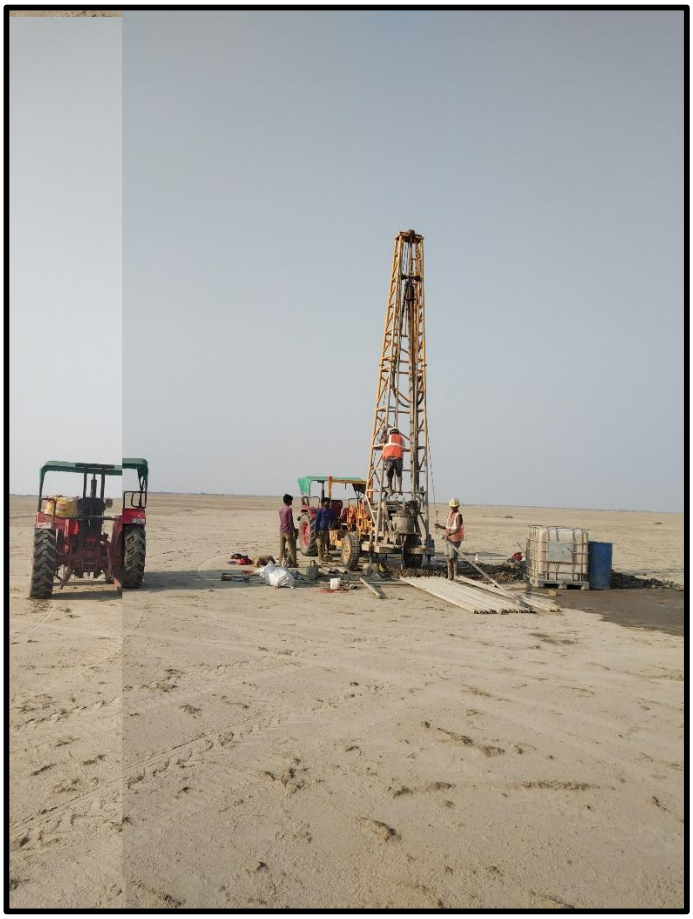
ANNEXURE 9: PROBABLE DRAINAGE OUTLET



Note: **Kindly refer the detailed contour plan, submitted separately, for RL.**

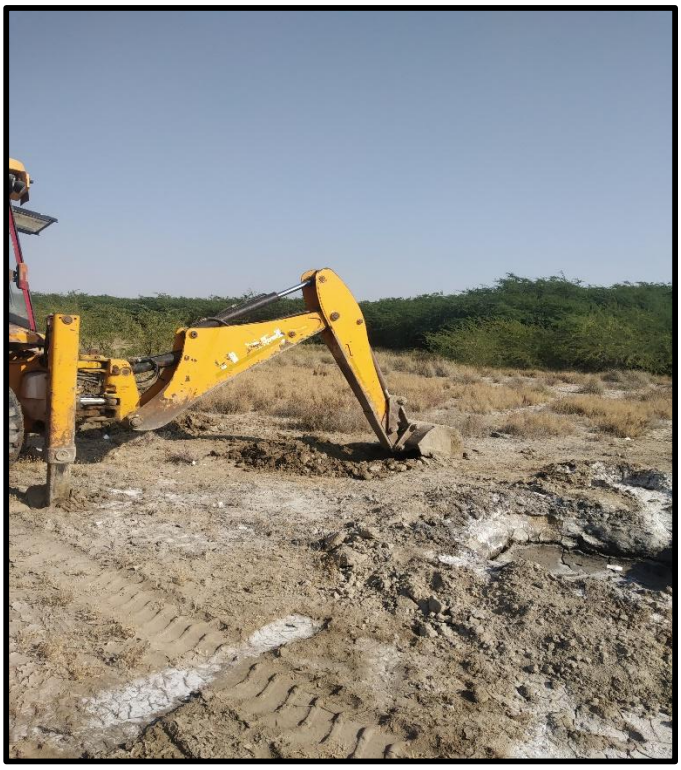
ANNEXURE 10: SITE PHOTOGRAPHS

SITE CONDITION



SOIL EXPLORATION

WATER TABLE MEASUREMENT



TRIAL PIT WORK

FIELD CBR TEST

ERT

FIELD VANE SHEAR TEST

ABBREVIATIONS

G	Gravel
S	Sand
M	Silt
C	Clay
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NP	Non-Plastic
FDD	Field Dry Density
FMC	Field Moisture Content
C	Unit Cohesion
Ø	Angle of Internal Friction
Cc	Compression Index
Pc	Pre-Consolidation Pressure
UCS	Unconfined Compressive Strength
CH	Clay of High Plasticity
CI	Clay of Intermediate Plasticity
CL	Clay of Low Plasticity
MH	Silt of High Plasticity
MI	Silt of Intermediate Plasticity
ML	Silt of Low Plasticity
SP	Poorly Graded Sand
SM	Silty Sand
DS	Disturbed Sample
UDS	Undisturbed Sample
EGL	Existing Ground Level

APPENDIX

Table 4 Requirements for Concrete Exposed to Sulphate Attack

(Clauses 8.2.2.4 and 9.1.2)

Sl No.	Class	Concentration of Sulphates, Expressed as SO_3			Type of Cement	Dense, Fully Compacted Concrete, Made with 20 mm Nominal Maximum Size Aggregates Complying with IS 383	
		In Soil					
		Total SO_3	SO_3 in 2:1 Water: Soil Extract	In Ground Water		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio
		Percent	g/l	g/l			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1	Traces (< 0.2)	Less than 1.0	Less than 0.3	Ordinary Portland cement or Portland slag cement or Portland pozzolana cement	280	0.55
ii)	2	0.2 to 0.5	1.0 to 1.9	0.3 to 1.2	Ordinary Portland cement or Portland slag cement or Portland pozzolana cement	330	0.50
					Supersulphated cement or sulphate resisting Portland cement	310	0.50
iii)	3	0.5 to 1.0	1.9 to 3.1	1.2 to 2.5	Supersulphated cement or sulphate resisting Portland cement	330	0.50
					Portland pozzolana cement or Portland slag cement	350	0.45
iv)	4	1.0 to 2.0	3.1 to 5.0	2.5 to 5.0	Supersulphated or sulphate resisting Portland cement	370	0.45
v)	5	More than 2.0	More than 5.0	More than 5.0	Sulphate resisting Portland cement or supersulphated cement with protective coatings	400	0.40

NOTES

1 Cement content given in this table is irrespective of grades of cement.

2 Use of supersulphated cement is generally restricted where the prevailing temperature is above 40 °C.

3 Supersulphated cement gives an acceptable life provided that the concrete is dense and prepared with a water-cement ratio of 0.4 or less, in mineral acids, down to *p*H 3.5.

4 The cement contents given in col 6 of this table are the minimum recommended. For SO_3 contents near the upper limit of any class, cement contents above these minimum are advised.

5 For severe conditions, such as thin sections under hydrostatic pressure on one side only and sections partly immersed, considerations should be given to a further reduction of water-cement ratio.

6 Portland slag cement conforming to IS 455 with slag content more than 50 percent exhibits better sulphate resisting properties.

7 Where chloride is encountered along with sulphates in soil or ground water, ordinary Portland cement with C_3A content from 5 to 8 percent shall be desirable to be used in concrete, instead of sulphate resisting cement. Alternatively, Portland slag cement conforming to IS 455 having more than 50 percent slag or a blend of ordinary Portland cement and slag may be used provided sufficient information is available on performance of such blended cements in these conditions.

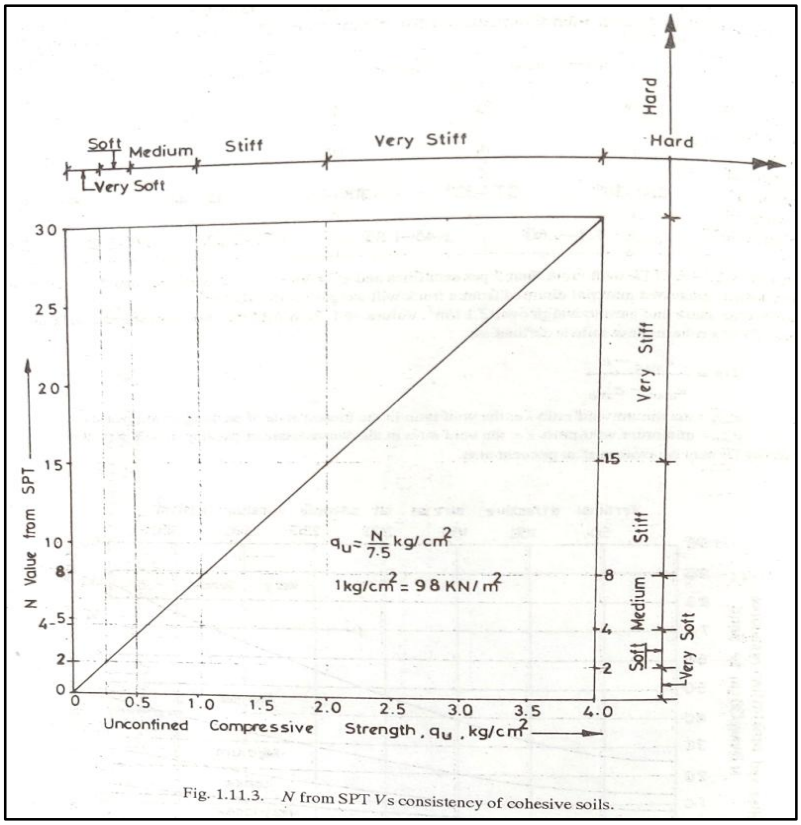
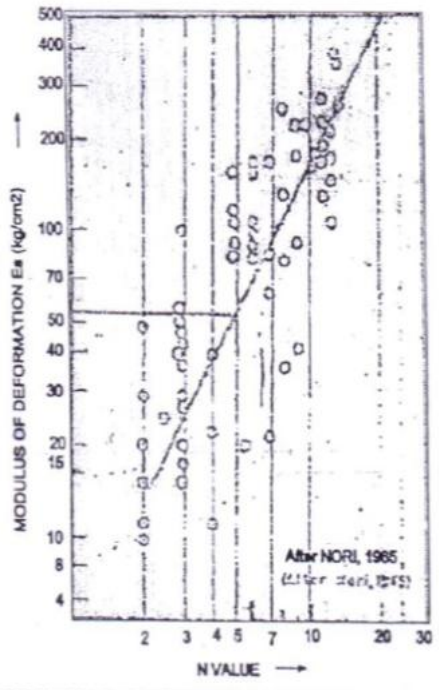
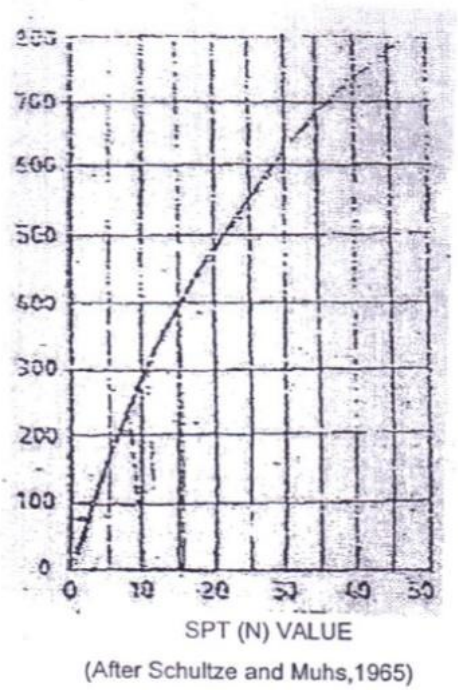


Fig. 1.11.3. *N* from SPT *V*s consistency of cohesive soils.



RELATIONSHIP BETWEEN SPT(N) AND COMPRESSIBILITY MODULUS FOR COHESIVE SOILS



(After Schultze and Muhs,1965)

RELATIONSHIP BETWEEN SPT (N) AND COMPRESSIBILITY MODULUS, Es FOR SAND

REFERENCES

INDIAN STANDARD CODES

IS Code	Description
IS 1498:1970	*Classification and Identification of Soils for General Engineering Purposes*
IS 1892:1979	*Code of Practice for Subsurface Investigation for Foundation*
IS 1904-1986	*Code of Practice for Design and Construction of Foundations in Soils: General Requirements*
IS 2131-1981	*Method for Standard Penetration Test for Soils*
IS 2132-1986	*Code of Practice for Thin-Walled Tube Sampling of Soils*
IS 2911(P1-S1)-2010	*Design and Construction of Pile Foundations - Code of Practice Concrete Piles: Driven Cast In-situ Concrete Piles*
IS 2911(P1-S2)-2010	*Design and Construction of Pile Foundations - Code of Practice Concrete Piles: Bored Cast In-situ Concrete Piles*
IS 4464-1985	*Code of Practice for Presentation of Drilling Information and Core Description in Foundation Investigation*
IS 2720	Various parts. Methods for testing of soils

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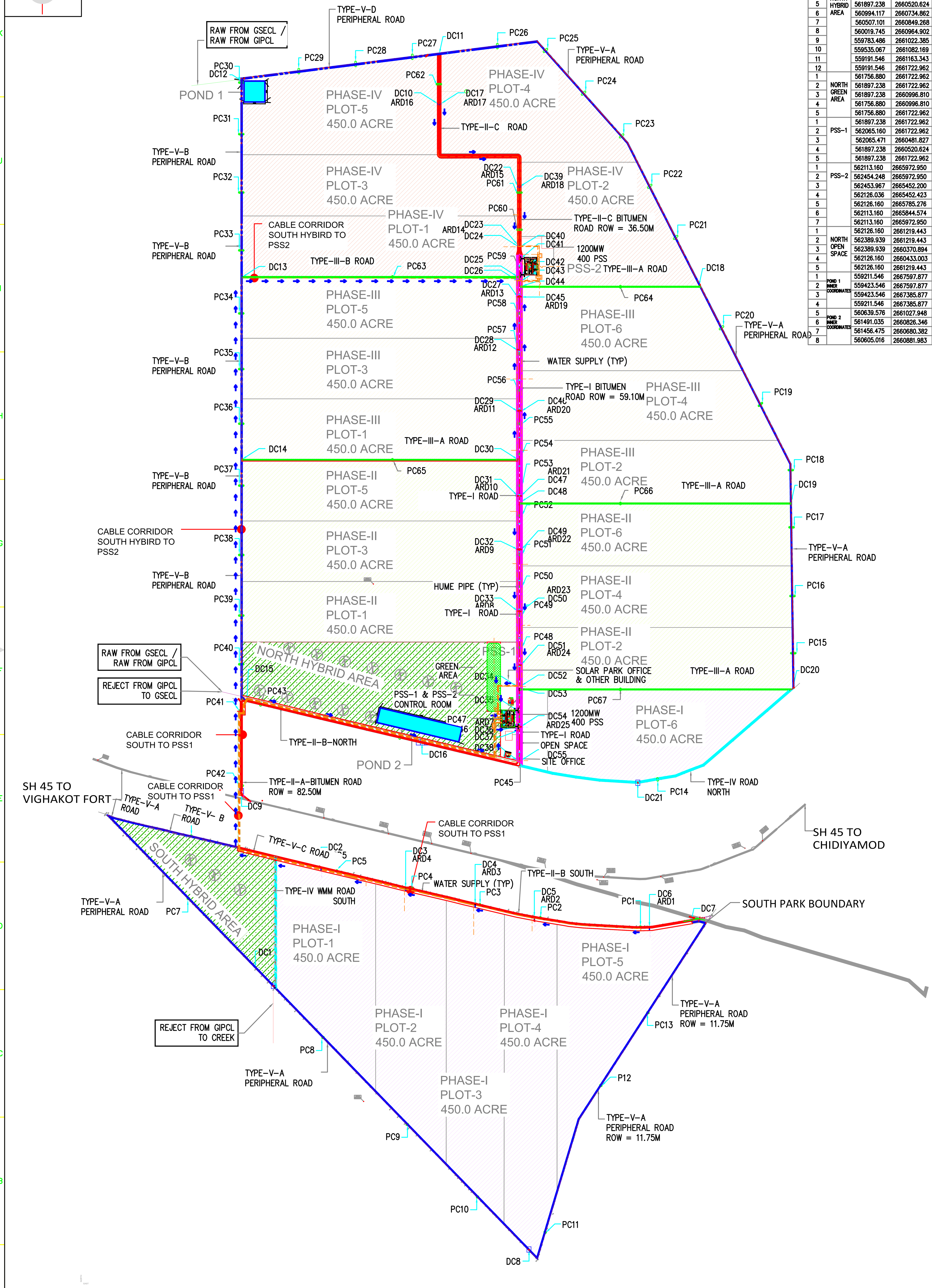
Punamia, B. C.	*Soil Mechanics & Foundations*
Terzaghi, Peck & Mesri	*Soil Mechanics in Engineering Practice*

TECHNICAL PAPER

Author Name	Title
Sancio R.B, Bray J.D., Reimer M.F., Durgunoglu T.	*"An assessment of the liquefaction susceptibility of Adapazari silt",* 2003 Pacific Conference on Earthquake Engineering, pp:172-179

TRUE NORTH
PLANT NORTH

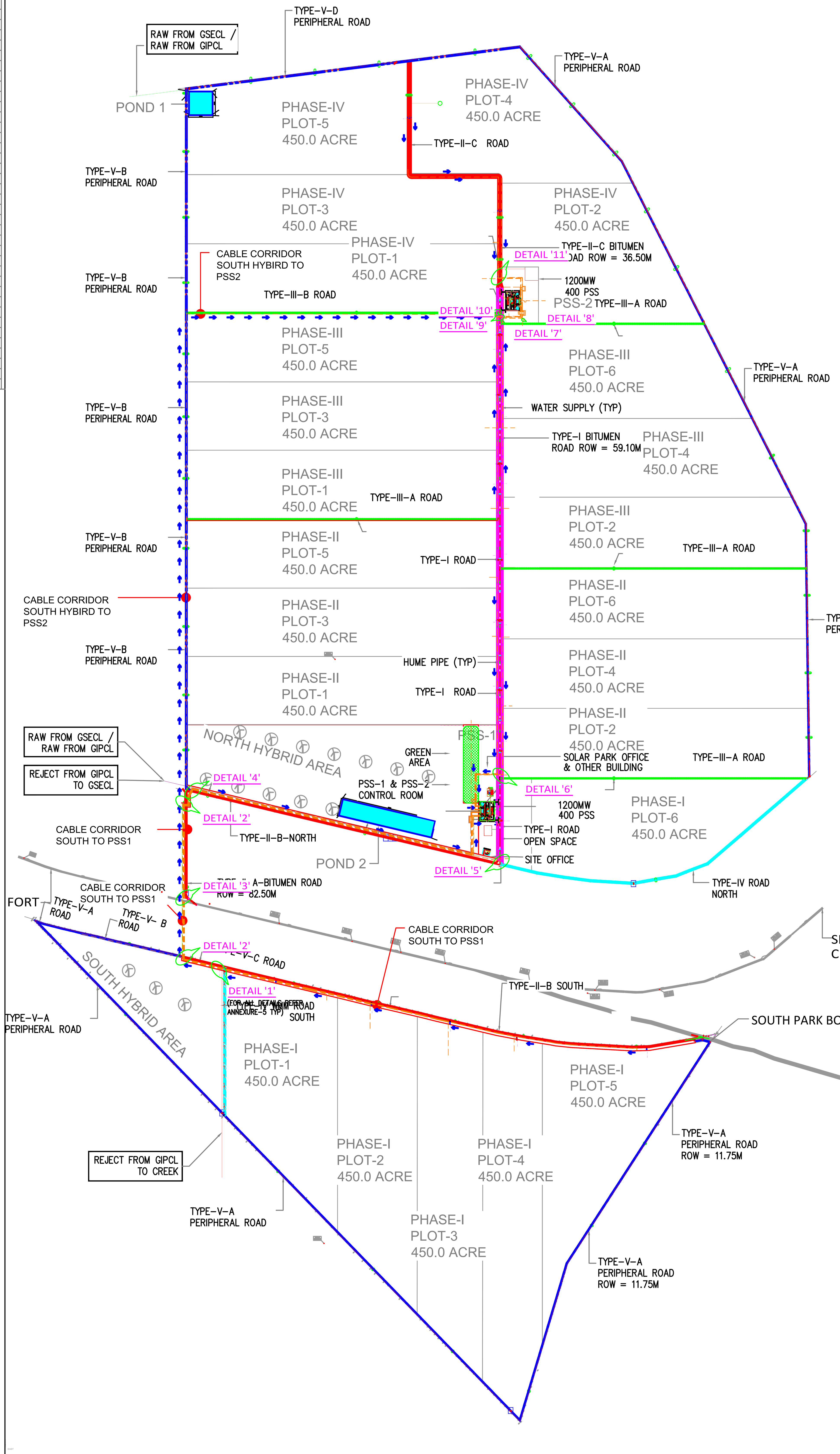
Attachment-2



MASTER PLAN
SCALE 1:1800

TENTATIVEPLOT CO–ORDINATES

S.NO	PLOT		
1	NORTH HYBRID AREA	559191.546	2661722.962
2		561756.880	2661722.962
3		561756.880	2660996.810
4		561897.238	2660996.810
5		561897.238	2660520.624
6		560994.117	2660734.862
7		560507.101	2660849.268
8		560019.745	2660964.902
9		559783.486	2661022.385
10		559535.067	2661082.169
11		559191.546	2661163.343
12		559191.546	2661722.962
1	NORTH GREEN AREA	561756.880	2661722.962
2		561897.238	2661722.962
3		561897.238	2660996.810
4		561756.880	2660996.810
5		561756.880	2661722.962
1	PSS–1	561897.238	2661722.962
2		562065.160	2661722.962
3		562065.471	2660481.827
4		561897.238	2660520.624
5		561897.238	2661722.962
1	PSS–2	562113.160	2665972.950
2		562454.248	2665972.950
3		562453.967	2665452.200
4		562126.036	2665452.423
5		562126.160	2665785.276
6		562113.160	2665844.574
7		562113.160	2665972.950
1	NORTH OPEN SPACE	562126.160	2661219.443
2		562389.939	2661219.443
3		562389.939	2660370.894
4		562126.160	2660433.003
5		562126.160	2661219.443
1	POND 1 INNER COORDINATES	559211.546	2667597.877
2		559423.546	2667597.877
3		559423.546	2667385.877
4		559211.546	2667385.877
5	POND 2 INNER COORDINATES	560639.576	2661027.948
6		561491.035	2660826.346
7		561456.475	2660680.382
8		560605.016	2660881.983



CABLE ROUTING SCHEMATIC
SCALE 1:1800

NOTES :

1. ALL DIMENSIONS AREA IN METERS UNLESS OTHERWISE SPECIFIED.
2. FOR ROAD LAYOUT AND CROSSING TYPES REFER ROAD ANNEXURE–2&3 DRAWINGS.
3. FOR DRAINS, CULVERTS AND HUME PIPE DETAILS REFER DRAIN ANNEXURE – 4&5 DRAWINGS.

LEGEND :

- TYPE–I ROAD
- TYPE–II ROAD
- TYPE–III ROAD
- TYPE–IV ROAD
- TYPE–V ROAD
- CABLE
- WATER SUPPLY LINE
- HUME PIPE (PC1)
- DRAIN CULVERT (DC1)

TENTATIVE PLOT CO–ORDINATES

S.NO	PLOT	EASTING	NORTHING
1	SOUTH HYBRID AREA	557789.627	2659899.295
2		557815.015	2659882.764
3		557852.052	2659873.357
4		558017.577	2659827.175
5		558205.038	2659783.032
6		558204.107	2659778.573
7		558353.142	2659747.434
8		558503.676	2659709.606
9		559141.262	2659562.040
10		559140.010	2659533.374
11		559530.424	2659439.513
12		559530.424	2658113.320
13		558864.242	2658800.486
14		558516.213	2659159.479
15		557851.053	2659843.436
16		557789.627	2659899.295
1	PHASE–I–PLOT–1	559550.207	2659433.971
2		559633.043	2659413.983
3		560119.638	2659298.539
4		560362.907	2659240.829
5		560587.745	2659188.364
6		560587.745	2657022.694
7		560256.360	2657364.517
8		559908.331	2657723.509
9		559549.398	2658093.935
10		559550.207	2659433.971
1	PHASE–I–PLOT–2	560587.745	2659188.364
2		561093.190	2659069.029
3		561329.126	2659013.602
4		561327.347	2656259.685
5		560587.745	2657022.694
6		560587.745	2659188.364
1	PHASE–I–PLOT–3	561329.126	2659013.602
2		561510.079	2658968.644
3		561579.582	2658953.199
4		561938.395	2658868.102
5		561933.703	2655634.664
6		561648.478	2655928.547
7		561327.347	2656259.685
8		561329.126	2659013.602
1	PHASE–I–PLOT–4	561938.395	2658868.102
2		562067.875	2658837.665
3		562298.331	2658794.271
4		562490.059	2658763.437
5		562490.059	2655987.722
6		562277.875	2655279.324
7		561933.703	2655634.664
8		561938.395	2658868.102
1	PHASE–I–PLOT–5	562490.059	2658763.437
2		562560.728	2658752.072
3		562612.302	2658741.950
4		562757.722	2658726.860
5		563063.814	2658709.569
6		563324.445	2658695.107
7		563486.342	2658699.823
8		563986.273	2658784.382
9		564033.492	2658768.085
10		563822.311	2658441.887
11		563550.586	2658022.167
12		563278.860	2657602.447
13		563007.134	2657182.727
14		562710.969	2656725.256
15		562580.248	2656288.827
16		562490.059	2655987.722
17		562490.059	2658763.437
1	PHASE–I–PLOT–6	562389.939	2661219.443
2		564921.037	2661219.443
3		564710.629	2661037.020
4		564494.324	2660851.181
5		564324.063	2660703.881
6		564178.623	2660579.193
7		564019.045	2660442.386
8		563819.260	2660366.161
9		563728.420	2660329.608
10		563579.667	2660304.504
11		563335.653	2660261.772
12		562940.688	2660285.153
13		562689.726	2660318.245
14		562470.130	2660352.748
15		562444.579	2660358.028
16		562389.939	2660370.894
17		562389.939	2661219.443
1	PHASE II–PLOT–1	559191.5460	2661722.9620
2		559191.5460	2662357.1670
3		562065.1600	2662357.1670
4		562065.1600	2661722.9620
1	PHASE II–PLOT–2	562126.2750	2661231.9430
2		562126.2750	2661875.2610
3		564953.3450	2661875.2610
4		564961.9280	2661241.9240
5		564950.4150	2661231.9430
1	PHASE II–PLOT–3	559191.5460	2662357.1670
2		559191.5460	2662991.3730
3		562065.1600	2662991.3730
4		562065.1600	2662357.1670

S.NO	PLOT	EASTING	NORTHING
1	PHASE II–PLOT–4	562126.2750	2661875.2610
2		562126.2750	2662520.4650
3		564944.3190	2662520.4650
4		564953.3450	2661875.2610
1	PHASE II–PLOT–5	559191.5460	2662991.3730
2		559191.5460	2663625.5790
3		562065.1600	2663625.5790
4		562065.1600	2662991.3730
1	PHASE II–PLOT–6	562126.2750	2662520.4650
2		562126.2750	2663167.9240
3		564935.7850	2663167.9240
4		564944.3190	2662520.4650
1	PHASE III–PLOT–1	559191.546	2664271.724
2		562065.160	2664271.724
3		562065.160	2663638.079
4		559191.546	2663638.079
5		559191.546	2664271.724
1	PHASE III–PLOT–2	562126.160	2663180.420
2		562126.160	2663835.216
3		564803.383	2663835.216
4		564930.061	2663585.689
5		564935.615	2663180.420
6		562126.160	2663180.420
1	PHASE III–PLOT–3	559191.546	2664905.835
2		562065.160	2664905.835
3		562065.160	2664271.724
4		559191.546	2664271.724
5		559191.546	2664905.835
1	PHASE III–PLOT–4	562126.160	2663835.216
2		562126.160	2664565.970
3		564432.426	2664565.970
4		564803.383	2663835.216
5		562126.160	2663835.216
1	PHASE III–PLOT–5	559191.546	2665551.946
2		562065.160	2665551.946
3		562065.160	2664917.835
4		559191.546	2664917.835
5		559191.546	2665551.946
1	PHASE III–PLOT–6	562126.160	2665439.700
2		563988.825	2665439.700
3		564126.419	2665168.672
4		564352.759	2664722.835
5		564432.426	2664565.970
6		562126.160	2664565.970
7		562126.160	2665439.700
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2		562075.160	2666188.046
3		562075.160	2665818.890
4		562065.160	2665773.276
5		562065.091	2665555.746
6		559191.546	2665555.445
7		559191.546	2666188.046
1	PHASE IV–PLOT–2	562113.160	2666751.188
2		563323.014	2666751.188
3		563447.398	2666506.181
4		563673.739	2666060.345
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9		562113.160	2665972.950
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3		561274.584	2666791.047
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6		559191.546	2666188.046
7		559191.546	2666830.229
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3		562280.699	2668006.890
4		562599.030	2667649.570
5		562931.629	2667276.236
6		563221.836	2666950.484
7		563323.014	2666751.188
8		562113.160	2666751.188
9		562113.160	2666804.797
10		562076.910	2666841.047
11		561274.584	2666841.047
12		561273.334	2667880.033
1	PHASE IV–PLOT–5	559191.546	2667617.877
2		560787.217	2667818.817
3		561235.334	2667875.248
4		561235.334	2666830.229
5		559191.546	2666830.229
6		559191.546	2667617.877
1	NORTH OPEN SPACE	562126.160	2661219.443
2		562389.939	2661219.443
3		562389.939	2660370.894
4		562126.160	2660433.003
5		562126.160	2661219.443

R5

TENDER PURPOSES ONLY

REV.	DATE	DESCRIPTION	DRN.	STR.	MECH.	ELEC.	INST.
R5	20.06.2023	ISSUED FOR TENDER PURPOSE	GCY	ENN			
R4	06.03.2023	ISSUED FOR TENDER PURPOSE	GCY	ENN			
R3	19.12.2022	ISSUED FOR TENDER PURPOSE	GCY	ENN			
R2	27.09.2022	ISSUED FOR TENDER PURPOSE	GCY	ENN			
R1	05.08.2022	ISSUED FOR TENDER PURPOSE	GCY	ENN			
R0	06.05.2022	ISSUED FOR TENDER PURPOSE	GCY	ENN			

APPROVED BY

FICHTNER
Consulting Engineers
(India) Private Limited
Chennai, Bangaluru

GUJARAT INDUSTRIES POWER CO. LTD
2375 MW CAPACITY SOLAR/WIND/HYBRID
RENEWABLE ENERGY PARK AT GREAT RANN OF KUTCH AREA, GUJARAT

	SIGNATURE	DATE
DRAWN	GCY	12.04.2022
DESIGNED	PPR	08.04.2022
CHECKED	ENN	13.04.2022
DEPT.HEAD	MSP	13.04.2022
PROJ.MGR.	ENN	13.04.2022

MASTER PLAN

RELEASED FOR: PRELIMINARY / TENDER ✓ / ENGINEERING / CONSTRUCTION

DEPT. IWE | JOB NO. 1721125 A | SCALE: AS SHOWN | REV. R5

DWG.NO. ANNEXURE–1

SIZE–A0

Attachment-3

Hydrology & Hydrogeological Study

For Proposed RE-Hybrid Park at Khavda, District Kutch, Gujarat

Submitted To:

GUJARAT INDUSTRIES POWER COMPANY LIMITED
P.O. Ranoli,
Vadodara 391 350,
Gujarat- INDIA

Consultant:

NATIONAL INSTITUTE OF HYDROLOGY,
Jal Vigyan Bhawan,
Roorkee-247 667, Uttarakhand,
INDIA

January, 2022

Hydrology & Hydrogeological Study

For Proposed RE-Hybrid Park at Khavda, District Kutch, Gujarat

Director: **Dr. J.V. Tyagi**

STUDY GROUP

Dr. Sudhir Kumar, Scientist-G and Head

Dr. Santosh M. Pingale, Scientist-C

Submitted by

National Institute of Hydrology, Roorkee

ACKNOWLEDGMENTS

The Principal Investigator is thankful to M/s Gujarat Industries Power Company Ltd. (GIPCL) for sponsoring the consultancy on "***Hydrology & Hydrogeological Study for Proposed RE-Hybrid Park at Khavda, District Kutch, Gujarat"*** to National Institute of Hydrology, Roorkee. Thanks are due to **A K Vaishnav GM (RE Projects & IT), K R Ghataliya, Manager (RE Projects), and Sh. Ravinder Kapri (Deputy Manager)** and all other members of GIPCL, Vadodra for extending all the help and support in completion of this report. We also acknowledge the GIPCL, Vadodra for providing different data and information related with proposed RE-hybrid park site at Khavda village in District Kutch, Gujarat.

We are thankful to ***Dr. JV Tyagi, Director,*** *National Institute of Hydrology, Roorkee* for providing all administrative and financial support for the successful completion of the project.

We also acknowledge the USGS Earth Resources Observation and ALOS PALSAR data provided by the Japan Aerospace Exploration Agency portal.

The meteorological data from the Indian Meteorological Department (IMD), Pune is thankfully acknowledged.

The principal investigator is thankful to all the scientists and staff of NIH, who directly or indirectly have helped the investigators in completing the project.

(Sudhir Kumar)
Scientist G and PI

LIST OF ABBREVIATIONS

AOI	Area of Interest
ALOS PALSAR	Advanced Land Observing Satellite-1 Phased Array type L-band Synthetic Aperture Radar
amsl	above mean sea level
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
IMD	Indian Meteorological Department
IDF	Intensity-Duration-Frequency Curves
CPHEEO	Central Public Health & Environmental Engineering Organisation
CN	Curve Number
CGWB	Central Groundwater Board
DEM	Digital Elevation Model
GIPCL	Gujarat Industries Power Company Limited
LULC	Land Use/Land Cover
NRCS	Natural Resources Conservation Service
RE	Renewable Energy
RWH	Rainwater Harvesting
RUSLE	Revised Universal Soil Loss Equation
SCS	Soil Conservation Service
SDR	Sediment Delivery Ratio
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WGS	World Geodetic System

SUMMARY

The hybrid renewable energy park having capacity to generate around 30,000 megawatt (MW) solar and wind power combined have been proposed at Khavda village in Kutch district of Gujarat. The assessment of hydrogeological study is required to ascertain the safety of the park in the future extreme events of climate as well as various natural hazards. The sustainable stormwater management and flood risk management measures are needed within a catchment. Therefore, the hydrology and hydrogeological investigations have been carried out in the proposed RE-Hybrid Park at Khavda (District Kutch, Gujarat). Primary and secondary data have been used from different sources to study the project site. The rational method has been used for peak runoff potential estimations and computed design stormwater drain capacity. The volume of surface runoff and soil loss from the GIPCL project block have been estimated using SCS-CN method and RUSLE, respectively. The total sediment yield received from the project area is also estimated using the sediment delivery ratio method. The detail investigations have been carried out to assess the groundwater potential (quantity and quality), surface water availability and estimated water requirement for different uses in the proposed project site. In addition, flooding and runoff zones have been identified and their estimates were computed from project site. It is clear that site is constructed as independent zone and not having any catchment from the upstream directions, which can contribute to flooding in the park site. Rainwater harvesting and water management strategies have been devised based on the field conditions. Finally, it is recommended that proper provision of regular operation and maintenance of the stormwater drainage system in the park.

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1 INTRODUCTION

1.1 Background

A hybrid renewable energy park, having electricity generation capacity of around 30,000 megawatt (MW) from solar and wind energy, is coming up near village Khavda in Kutch district of Gujarat. The project will avoid emission of five crore tonnes of carbon dioxide annually. The salient features of the project are given in ***Table 1***:

Table 1: Salient features of the 30-GW renewable energy park

Largest of its kind in the world: The 30-GW renewable energy park at Kutch, Gujarat is billed as the largest of its kind in the world.
GOI vision: The project is in line with the Government of India's vision to install 175 GW of renewable energy capacity by the year 2022 and is of national importance.
The park will have two zones: Spread over 72, 600 ha of land, the first will be a 49,600-hectare hybrid park zone, accommodating wind and solar power plants of 24,800 MW capacity; and second will be an exclusive wind power zone spread over 23,000 hectares.
Location of the project: The project site is located close to the Indo-Pak border between Khavda village and Vighakot.
Hybrid Park: It will be located 6 km from the International border.
Exclusive Wind Park: It will be located 1-6 km from the International border.
Distance from Indo-Pak border: The project will come up around 25 km away from Khavda (the last point accessible by the civilians in the area).
Allocation of the Project:
Hybrid Park Zone:
(a) Adani Green Energy Ltd (19,000 Ha; 9,500 MW)
(b) Sarjan Realities Ltd (Suzlon, 9,500 Ha; 4,750 MW)
(c) NTPC Ltd (9,500 Ha; 4,750 MW)
(d) Gujarat Industries Power Company Ltd (4,750 Ha; 2,375 MW)
(e) Gujarat State Electricity Corporation (6,650 Ha; 3,325 MW).
Exclusive Wind Park Zone: The entire 23,000 Ha of land has been allotted to Solar Energy Corporation of India (SECI).
Time: The estimated time for the completion of the project is five years.

Gujarat Industries Power Company Limited (GIPCL) commissioned National Institute of Hydrology (NIH) Roorkee to conduct a hydrology and hydrogeological study for the proposed Renewable Energy (RE)-hybrid park site in Khavda at District Kutch, Gujarat. This study requires the hydrology and hydrogeological estimates based on the base line analysis, catchment characteristics, identification of water bodies, meteorological analysis, extreme events of rainfall, peak runoff and extreme flood risk, earthquake and tsunami risk, area drainage study, stormwater drains/culverts design, impact of Land Use/Land Cover (LULC) change, soil erosion and sediment yield, water availability (surface, groundwater and imported source) rainwater harvesting and water management study in the site and plan the RE-hybrid park for solar and wind plant design suitably to account for this consideration.

1.2 Objectives

The general objective of this study is to investigate the hydrology & hydrogeology of the proposed RE-Hybrid Park at Khavda (District Kutch, Gujarat).

Specific Objectives of the study are:

i) To assess the rainfall variability and estimate the design rainfall of the different return periods using IDF curves for the proposed RE-Hybrid park site.
ii) To assess the natural hazards and risks due to earthquake, tsunami, cyclone, volcanic and flood risk in the study region.
iii) To compute the runoff potential and soil erosion from of the project site.
iv) To assess the water availability and water requirement in the project area.
v) To suggest the stormwater management and rainwater harvesting system in the park site.

1.3 Significance of the study

The study investigates the RE-Hybrid Park feasibility and identify the natural hazards and risks associated with in the park site based on hydrology and

hydrogeological investigations. Further, the study aims to contribute to the feasibility and improved performance of the stormwater management and rainwater harvesting plan through the implementation of appropriate water management strategies in the catchment area of the park site. The catchment response in terms of stormwater and peak rate of runoff are required for efficient and sustainable stormwater management during extreme events of climatic conditions in the study area.

2 STUDY AREA

2.1 Location

The site lies in the seasonal salt marsh area in the Great Rann of Kutch of Kutch District, Gujarat, India (***Figure 1***). The site is located in the North Western part (Un-surveyed land near village Khavda, Tehsil: Bhuj) of Kutch District in the Great Rann of Kutch, Gujarat.

Kutch district is fairly well connected by rail and road. The National High Way (NH 8A) connects Kandla with Ahmedabad. Nearest airport is at Bhuj, which is connected with Ahmedabad airport.

The study area is located between geographic coordinates 69°34'5.329" to 69°38'20.829" East Longitudes and 24°00'29.002" to 24°07' 24.235" North Latitudes. In the UTM coordinate system the area lies in Zone 42N, and lies between 557764.97m to 564975.22m Easting and 2655253.88m to 2668024.76m Northing. The GIPCL site is divided into two parts by Khavda – Vighakot Road, *Block-1* lies in the north of road and has an area of 3,693ha and *Block-2* lies south of the road and has an area of 1,057ha.

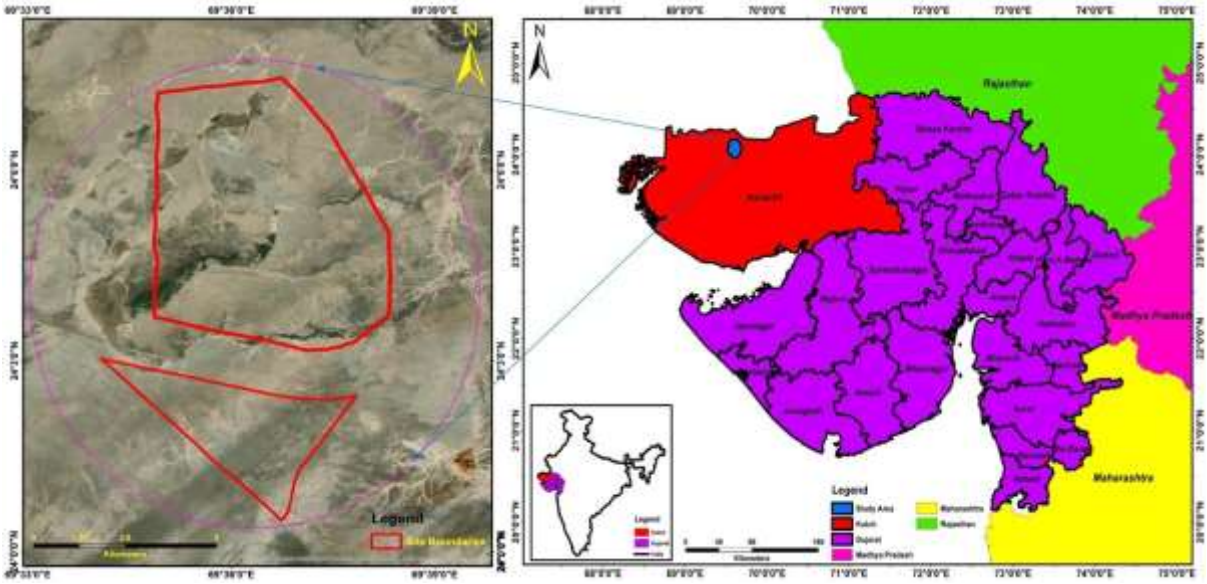


Figure 1: Location of the proposed RE Park of GIPCL

Project site is located around 12 to 15 km in south / southwest direction of International border with Pakistan. The area is heavily patrolled by Border

Security Forces (BSF) and the Indian Army conducts exercises here to acclimatize its troops to this harsh terrain.

Project site area lies in Survey of India toposheet 40E/12 (G4V12). The location and 5 km buffer zone around the project site is shown in ***Figure 2***.

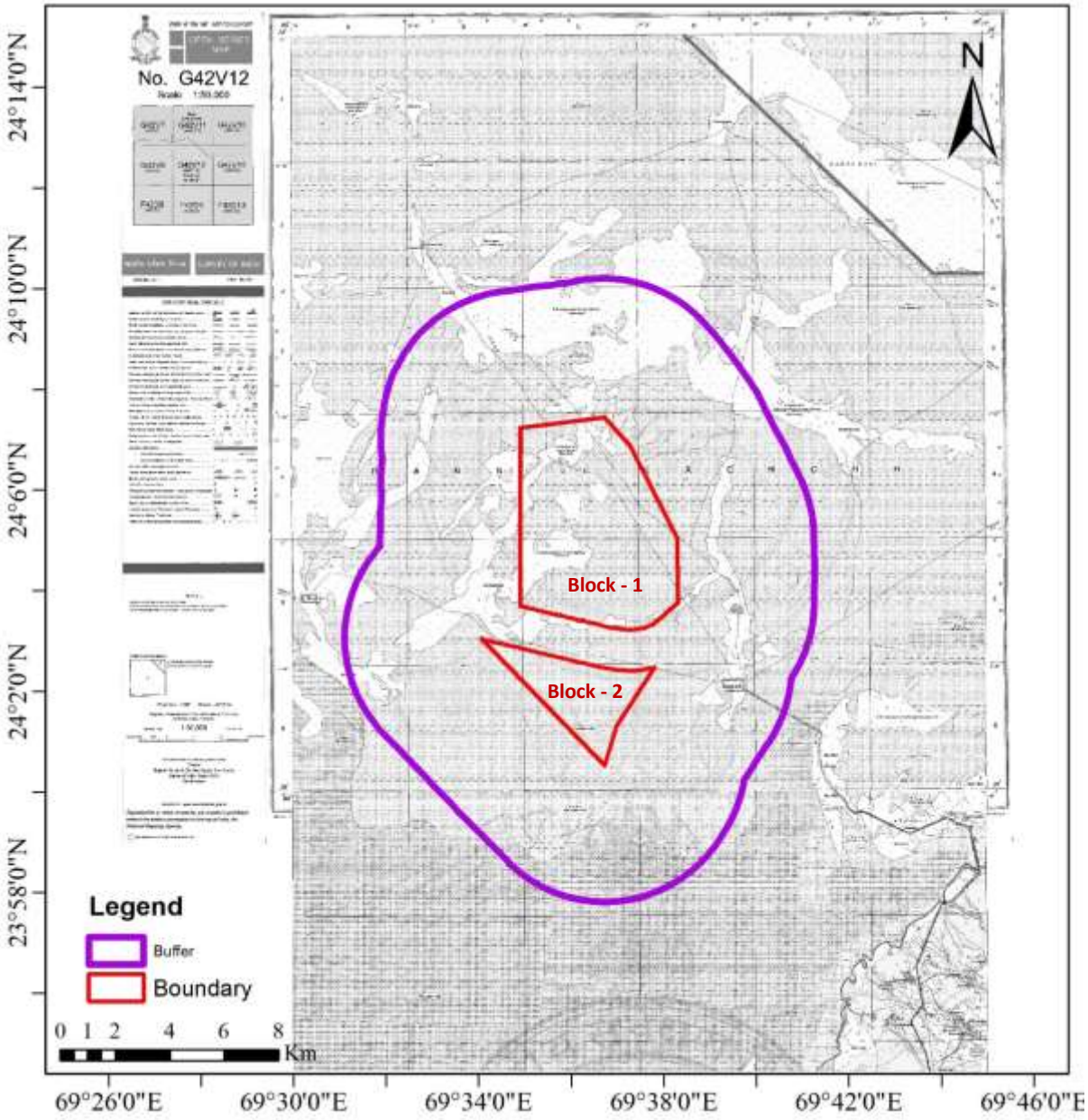


Figure 2: GIPCL Project site on SoI toposheet

The location and 5 km buffer zone around the project site on Landsat 8 imagery is shown in ***Figure 3***.

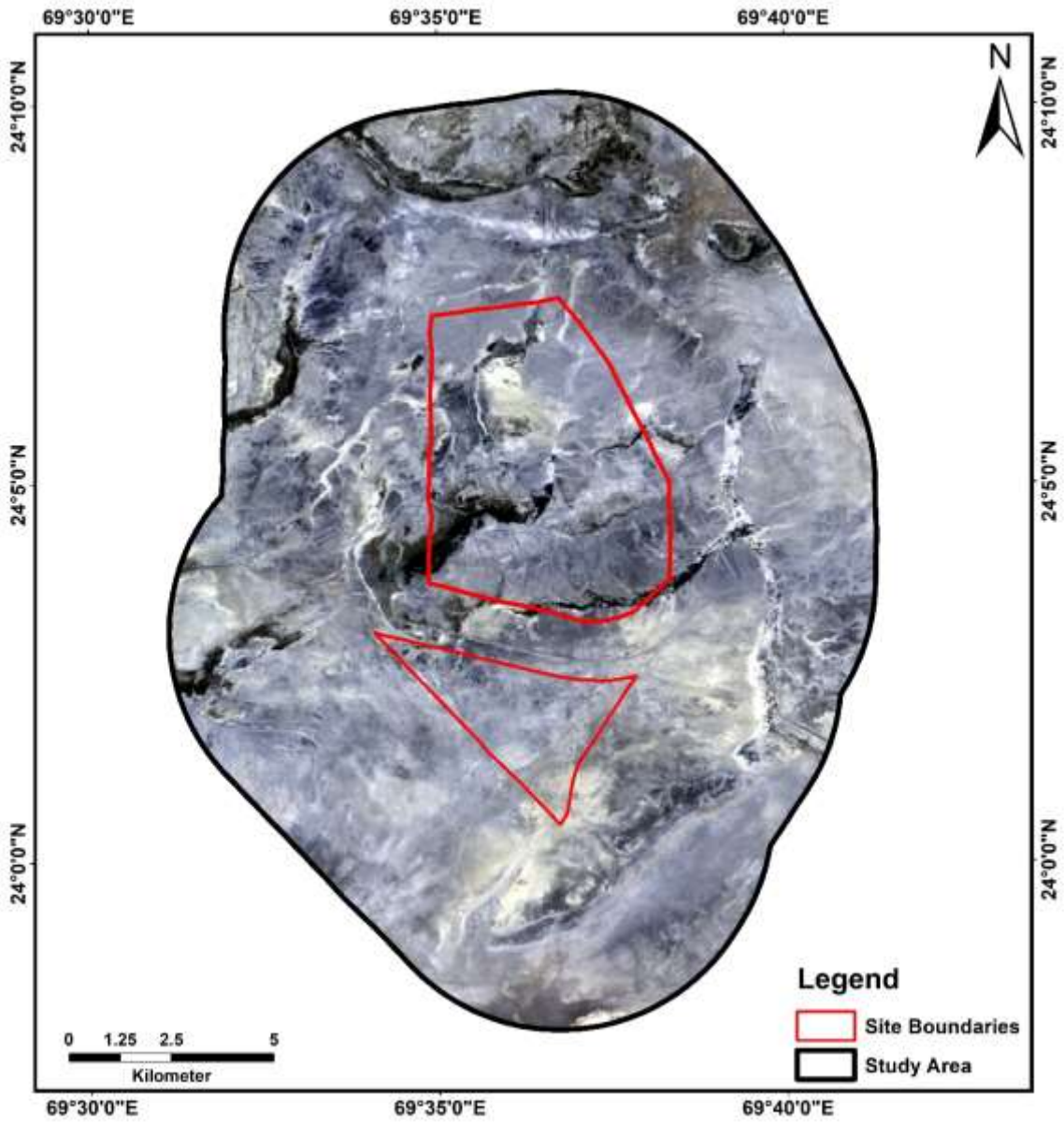


Figure 3: GIPCL Project site on Landsat-8 imagery

2.2 Topography

The topography of Kutch area comprises an array of hills and depressions (***Figure 4***). Elevated lands are occupied by Mesozoic and Tertiary rocks, whereas the residual depressions or low-lying regions consist of Quaternary sediment successions marked alluvial river terraces in the rocky mainland and the mud-flats and salt pans in the Great and Little Rann's and Banni Plains

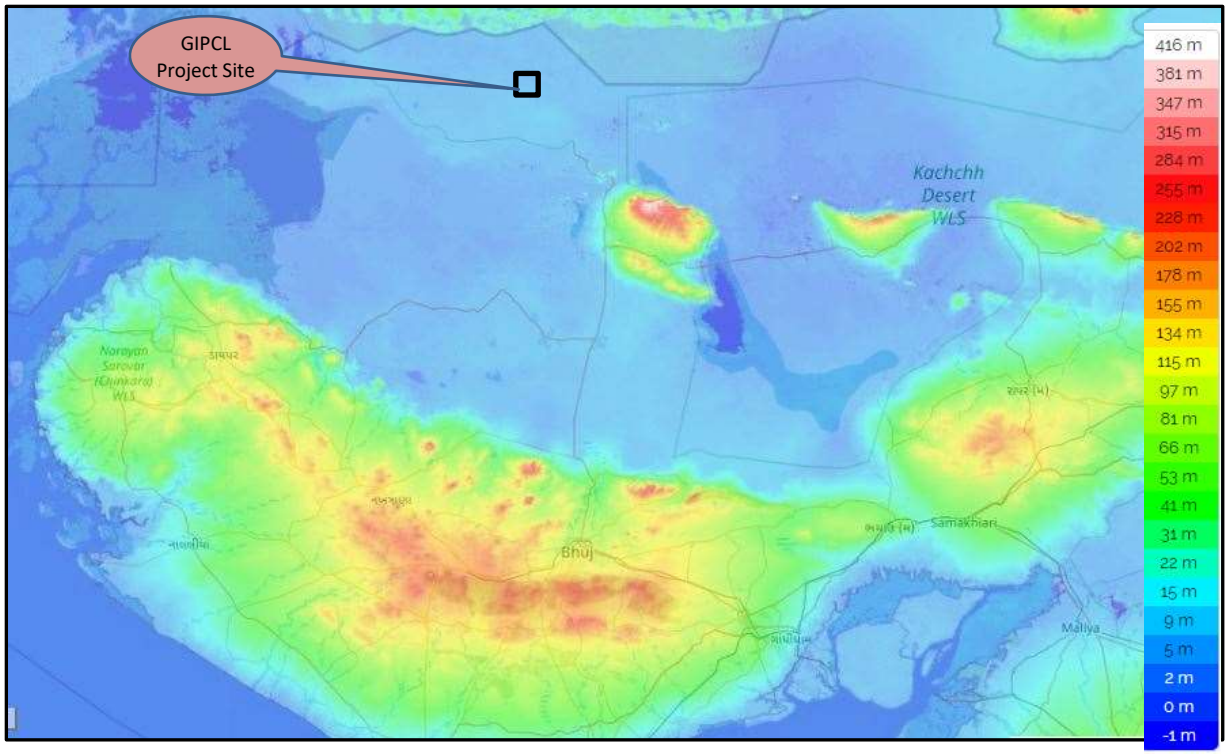


Figure 4: General topography of the Kutch area

In the project site area, the surface is generally flat and very close to sea level with elevation <10m. There are areas of higher ground, known as ***Bets*** or ***Medaks***, which lie two to three meters or more above the general ground level. Trees and shrubs grow on the bets, and they provide refuges for wildlife during the annual floods.

2.3 Climate

The study area experiences extreme climatic conditions characterized by its aridity, low rainfall and extreme temperatures. Mean maximum temperature ranges between 26.7°C during January to about 39.5°C during May and the mean minimum temperatures vary between 9°C during January and 27°C during June. The relative humidity in Kutch varies between 43.5% during March and 77% during August. The wind velocity in the district varies from about 124 km/d during November and 375 km/d during June. The potential Evapo-transpiration, calculated using Penman's method varies between 3.4 mm/d during December and 9.2 mm/d during May (CGWB, 2013). Long-term average annual rainfall for Bhuj IMD station is 378.2 mm. Climate data of Bhuj district is shown in ***Figure 5***.

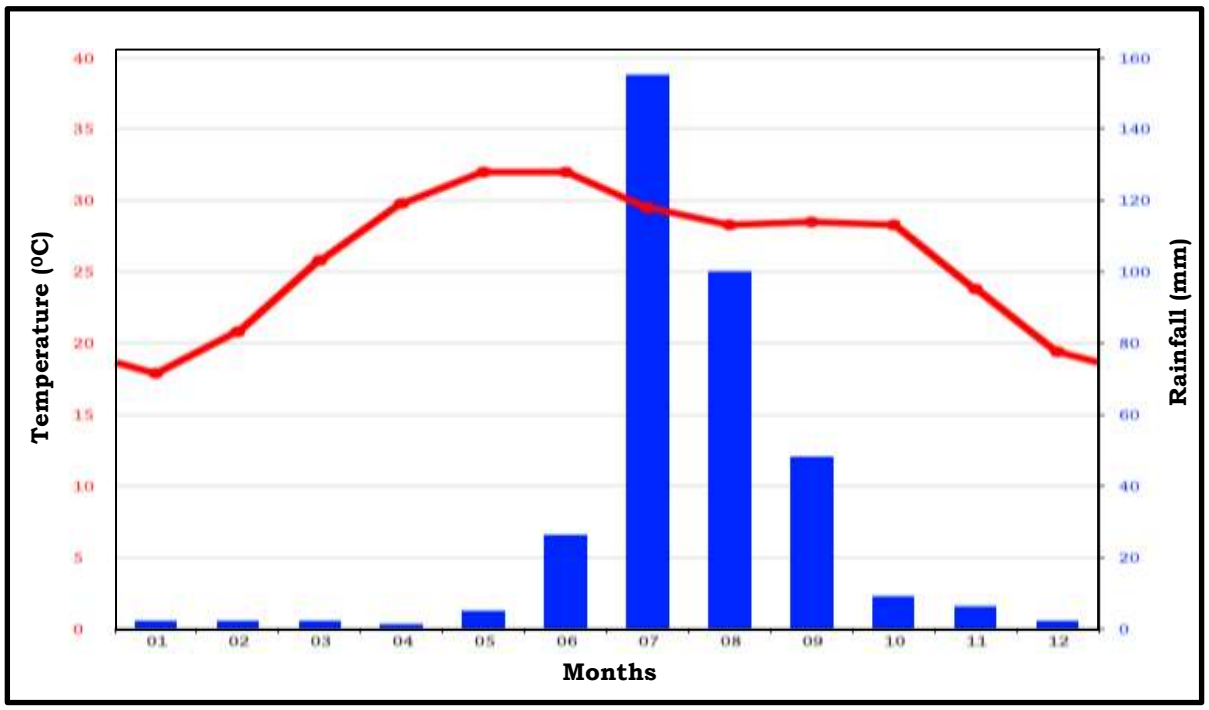


Figure 5: Climatic chart of Bhuj District

Most of the rainfall (about 345 mm) is received during south-west monsoon between June and September. The number of rainy days varies between 20 and 30 or even less and coefficient of variation of rainfall is normally between 30 and 70%. The climatological data for IMD station Bhuj is given in ***Table 2***.

Table 2: Climatological data of IMD Station, Bhuj

Month	Max. Temp	Min. Temp	RH	Wind Speed	Sunshine	Solar Radiation	ET_0	Rainfall
	(°C)	(°C)	(%)	(Km/d)	(Hrs)	($MJ/m^2/d$)	(mm/d)	(mm)
Jan	26.7	9.0	47.0	138.2	8.9	16.7	3.6	2.0
Feb	29.8	12.0	45.5	149.0	9.5	19.5	4.5	1.1
Mar	34.9	17.6	43.5	177.7	10.1	22.8	6.2	2.9
Apr	38.7	22.1	44.5	217.2	10.8	25.6	7.9	0.7
May	39.5	25.2	53.5	330.3	11.4	27.1	9.2	1.7
Jun	37.1	27.0	65.0	375.2	8.7	23.1	7.7	33.9
Jul	33.6	26.2	75.0	346.5	5.3	17.9	5.4	136.3
Aug	32.5	25.2	77.0	307.0	5.4	17.6	4.9	120.7
Sep	33.7	23.8	70.5	229.8	7.9	20.2	5.4	54.2
Oct	35.9	20.6	52.5	141.8	9.6	20.4	5.3	15.4
Nov	32.4	15.5	48.0	123.9	9.3	17.6	4.1	7.7
Dec	28.1	10.5	49.0	131.0	8.9	15.9	3.4	1.6
Total	-	-	-	-	-	-	-	378.2
Average	*33.6*	*19.6*	*55.9*	*222.3*	*8.8*	*20.4*	*5.6*	-

2.4 Drainage

Many rivers originating in Rajasthan and Gujarat flow into the Rann of Kutch, including the Luni, Bhuki, Bharud, Nara, Kharod, Banas, Saraswati, Rupen, Bambhan and Machchhu. Kori Creek and Sir Creek, tidal creeks which are part of the Indus River Delta, are located at the western end of the Great Rann of Kutch (***Figure 6***) (*After* Chamyal et al. 2003).

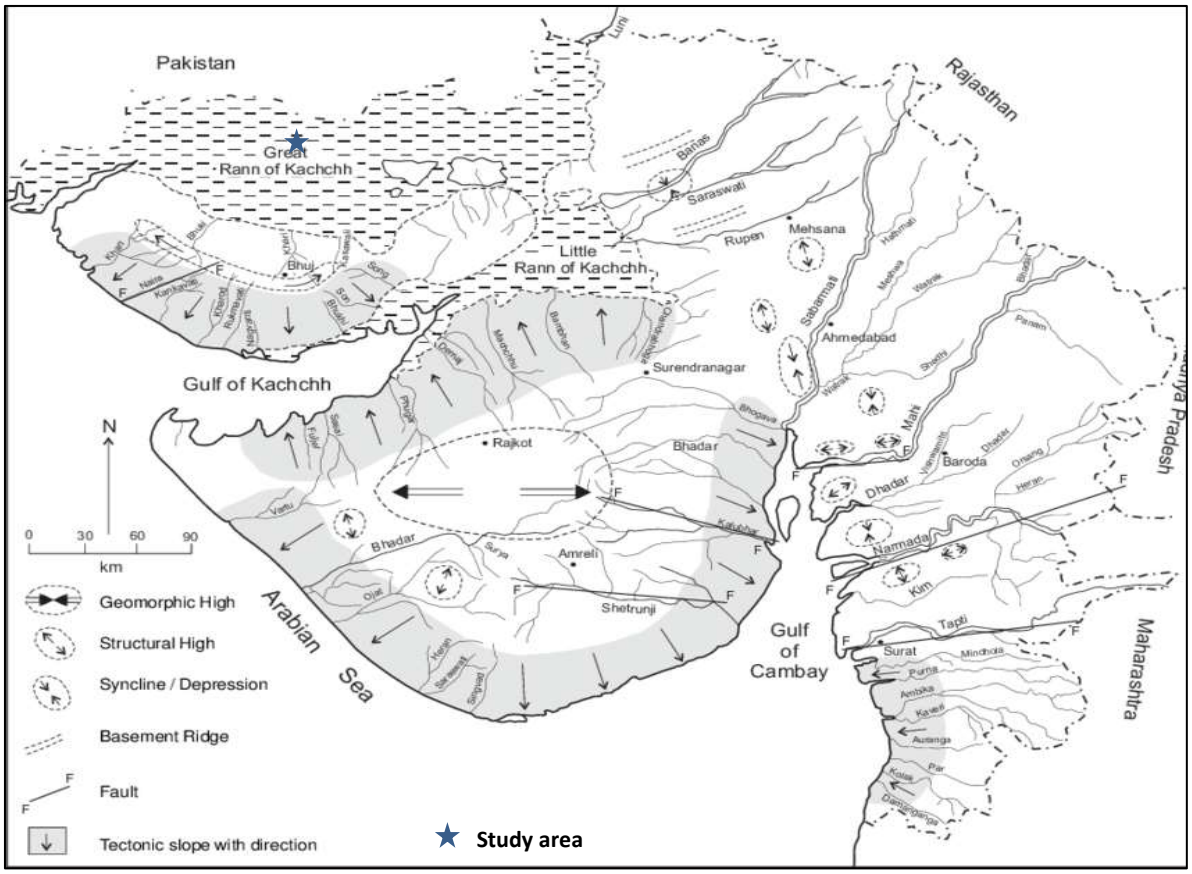


Figure 6: Drainage map of Gujarat

In the project site area, there is no major river. There are numerous Gullies and temporary streams which passes through the study area. These gullies are temporary and flows only during the monsoon season. There are some bigger non-perennial streams which appears to have existed for at least few decades.

2.5 Soils

The project site of GIPCL comes under Rann physiographic zone and comprises marshy land and salt/mud flats. The soils of the Kutch district are

broadly grouped into four types, i.e., shallow black soils, residual sandy soils, coastal alluvial soils and desert soils. The study area is mainly comprises of desert soils and has salinity problem. These soils are fairly deep and light grey in colour. The texture is sandy to sandy loam with silty clay loam in some areas. The salt content is very high with the sodium chloride as the dominant salt (CGWB, 2013). The soil belongs to 'Group A' type soil based on U.S. Soil Conservation Service (SCS) classification.

The two Ranns of Kutch have the soils which are formed as a result of the geological processes of Pleistocene age. The alluvial deposits due to the river system flowing through the area have subsequently been overlain by the aeolian deposits. These soils are fairly deep, light grey in colour. The texture is sandy to sandy loam with silty clay loam in some areas. The salt content is very high with the sodium chloride as the dominant salt. The profile study reveals the presence of sufficient amount of gypsum throughout the profile.

2.6 Geology and Hydrogeology

Sedimentary rocks of marine and non-marine origin formed under different environmental conditions during middle Jurassic to Recent period occur in the Kutch district besides volcanic and intrusive rocks (Deccan Trap) of middle Cretaceous to lower Eocene (***Figure 7***) (*after* Biswas, 1963).

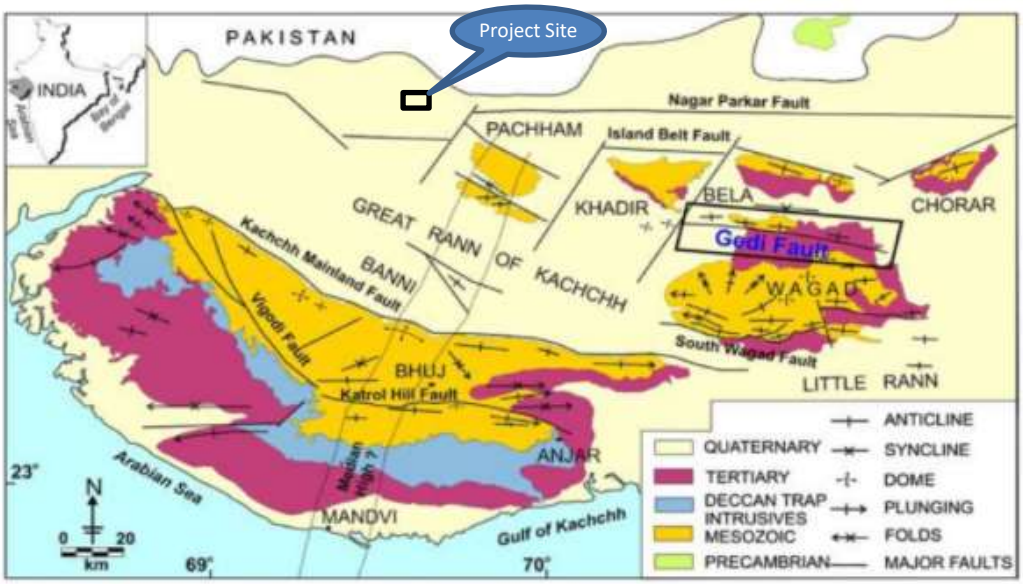


Figure 7: Geological map of the Kutch District

The geological formations in Kutch district can be grouped as:

a) Mesozoic formations

b) Deccan trap (Hard rock) as aquifer

c) Tertiary formations

d) Quaternary sediments

In the study area, the alluvium (Quaternary sediments) comprising of brown loam, kankars, silt, clay, sand and gravel. Groundwater table lies at a depth of 2-5 m below the ground surface.

2.7 Landuse / Land Cover (LULC)

Rann of Kutch, Gujarat, which is a large area of salt marshes near the border between India and Pakistan. The predominant land use of this site is barren land with scanty vegetation of arid grassland ecosystem (***Figure 8***).

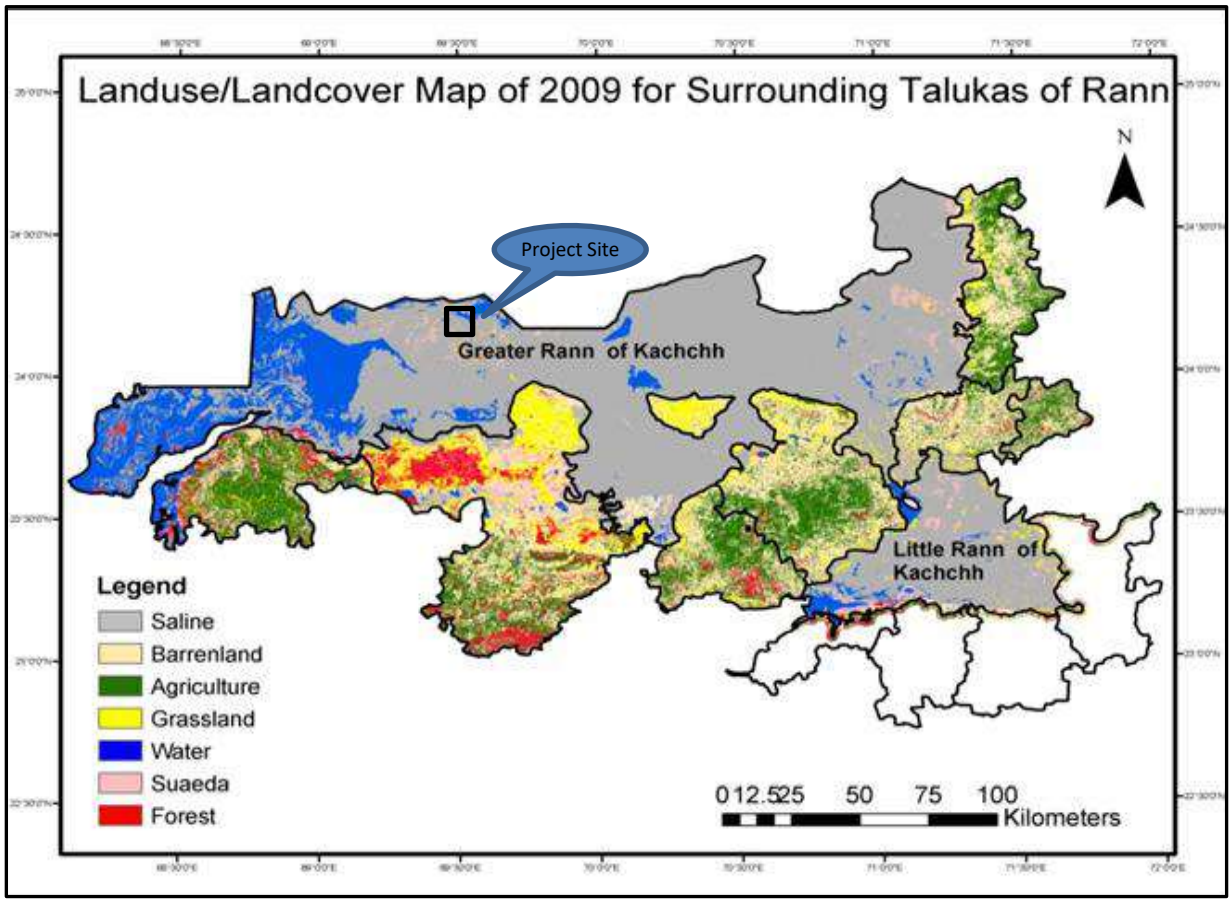


Figure 8: LULC map of the Great Rann of Kutch

The shrubs are present almost everywhere within the study area. The total area covered by the scrubs is approximately 12% of the total study area which covers dried drainage, Bet and remaining Rann area. Road network is not present within the Rann however there is a single major road and very few minor roads present in Bet areas which covers approximately 0.03% of total study area.

There is no settlement/habitat within the study area however there are few built-up spaces primarily meant for security purposes. Salt pan activities along with its supporting water channels and Bunds are seen in the southern part of the study area which covers around 0.81%. Remaining areas is mostly mud/tidal flats.

2.8 Flora and Fauna

In the Rann of Kutch area, trees are rare except on the bets which rise above the flood zone. The predominant vegetation in the Rann of Kutch are grassland and thorny scrubs. Common grass species include: *Apluda aristate*, *Cymbopogon spp., Eragrostis spp., and Elionurus spp., Cenchrus spp., Pennisetum spp*. The non-native tree *Prosopis juliflora* has now established on the bets, and its seed pods provide year-round food for the wild asses.

The Rann of Kutch is home to about 50 species of mammals. They include several large herbivores, including Indian wild ass (*Equus hemionus khur*), chinkara (*Gazella bennettii*), nilgai (*Boselaphus tragocamelus*), and blackbuck (*Antilope cervicapra*), and the large predators wolf (*Canis lupus*), striped hyena (*Hyaena hyaena*), desert wildcat (*Felis lybica*), and caracal (*Felis caracal*). The Indian wild ass once had a wider distribution but is now limited to the Rann of Kutch. The nilgai and blackbuck are threatened species.

There are over 200 bird species in the Rann of Kutch, including the threatened species lesser florican (*Sypheotides indicus*) and houbara bustard (*Chlamydotis undulata*). The seasonal wetlands provide habitat for many water birds, including the demoiselle crane (*Grus virg*o) and lesser flamingo (*Phoeniconaias minor*).

Vultures temporary resting place lies 2 km North-East of project site. The Griffon Vulture (*Gyps fulvus*), also known as the *Eurasian Griffon*, a bird of prey family *Accipitridae*, is found in the area. This vulture establishes nesting colonies in areas that are undisturbed by humans and is a scavenger and feeds mostly on carcasses of dead animals.

2.9 Eco sensitive areas

Kutch is a unique kind of ecological zone demarcated as Kutch desert biotic province under desert bio geographic zone of the country (Rodgers & Panwar, 1988). It represents a distinct biological diversity and gene pool of Indian arid region (Chawla, 2004). The Rann is unique in a sense that it has the characteristics of both desert and wetland and therefore supports unique assemblages of flora and fauna. The eco region of Rann of Kutch represents the saline and marshy habitat dominated by scrub vegetation and flooded grasslands with swampy land providing shelter to diverse wildlife. The environment of Rann is cyclic in nature, where during some part of the year land remains under water and rest of period remains dry making the Rann suitable for aquatic as well as terrestrial biota.

Rann harbors rich floral and faunal diversity besides providing habitat for some important threatened wildlife including Asiatic wild Ass, Indian gazelle, blue bull, wild boar, desert cat, striped hyena, Indian wolf and caracal. The large and open wetlands of Rann are also a unique wintering and breeding ground for diverse avifauna such as Greater & Lesser Flamingo, Cranes, Falcons, Wild ducks, Ibis, Spoonbill, Pelicans, etc. Due to the presence of large number of rare and endangered fauna and flora in Rann, in year 2008 it was declared as a Kutch Biosphere Reserve (KBR) under protected area network of India (MoEF, 2010).

The present study area located in the Great Rann of Kutch (GRK). The part of GRK is an important wetland of Gujarat and flamingo city is also located in the GRK. Hence, the care should be taken to avoid adverse impact of disposal on wetland. The Great Rann of Kutch having total area of 16,780 km^2 (GUIDE, 1997). It includes Kutch Desert Wildlife Sanctuary (7505.22 km^2) and forms

part of Kutch Biosphere Reserve (12,454 km^2). It is important to note that Kutch Biosphere Reserve (KBR) includes both Great Rann and Little Rann of Kutch) (***Figure 9***).

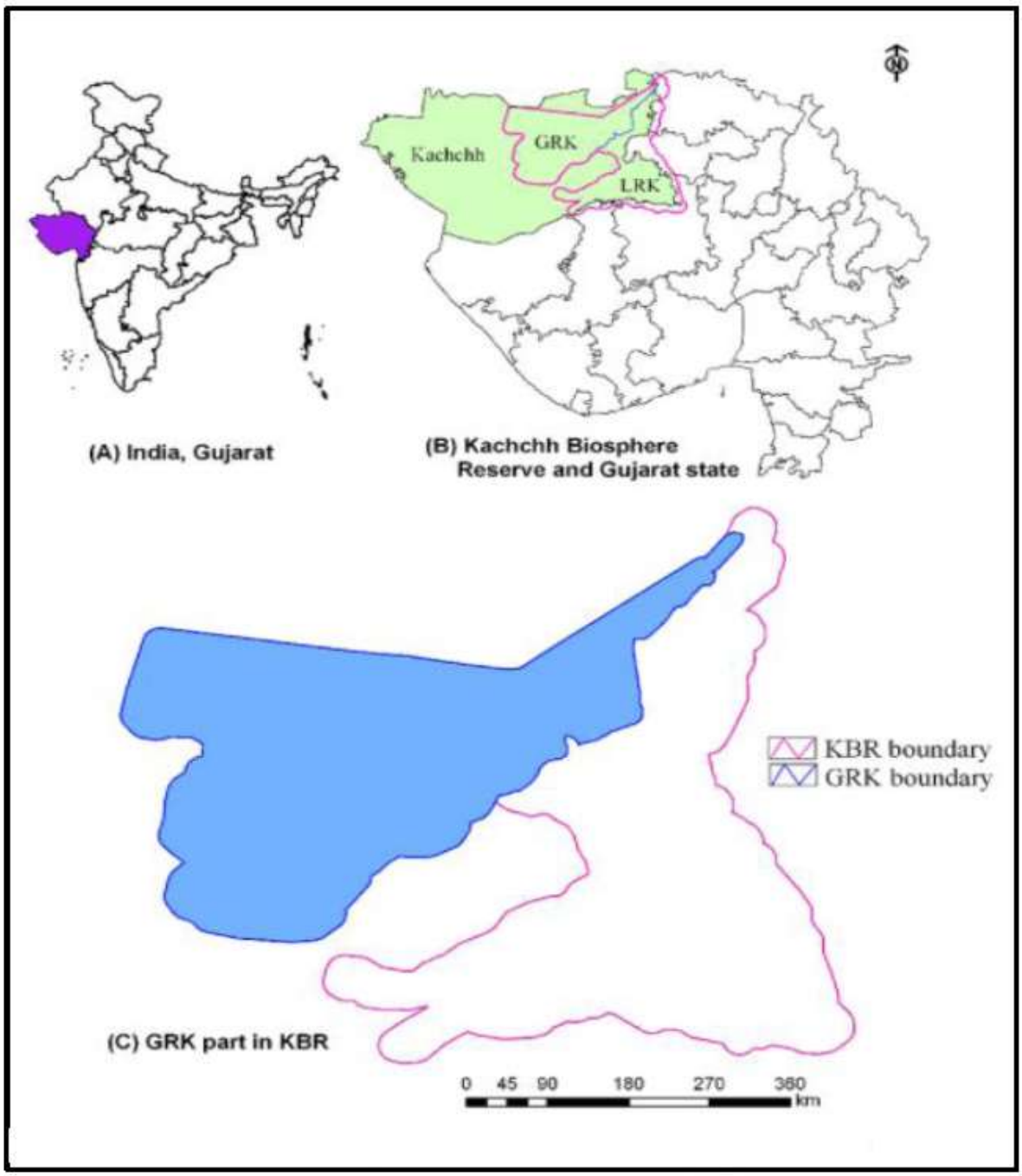


Figure 9: Location of Kutch Biosphere Reserve (KBR)

Figure 10 shows the location of GIPCL project site with reference to Kutch Biosphere Reserve (KBR), Flamingo city (the only area in India where flamingo congregate in large numbers to breed) located near Nirviri, Kala Dongar Sanctuary and Chhari-Dhandh wetland reserve (Vazeed Pasha et al., 2014).

The Chhari-Dhandh wetland reserves are located about 47 km southwest from project site. Kala Dongar sanctuary is located approximately 23 km south east of the project site. Flamingo city is situated in Great Rann of Kutch at approximately 53 km east of the GIPCL project site.

Figure 10: Eco-sensitive areas around the RE Park

3 NATURAL HAZARDS AND RISKS ASSESMENT

Natural hazards are naturally occurring physical phenomena caused either by rapid or slow onset events which can be geophysical (earthquakes, landslides, tsunamis and volcanic activity), hydrological (avalanches and floods), climatological (extreme temperatures, drought and wildfires), meteorological (cyclones and storms/wave surges) or biological (disease epidemics and insect/animal plagues).

In the present study earthquakes, tsunamis, volcanic activity, floods, and cyclones have been considered as natural hazards.

Risk is a technical concept aimed at estimation of losses in the event a disaster and the expected probability of its occurrence the probability of harmful consequences or expected losses resulting from interactions between natural hazards.

3.1 Earthquake Hazard

The site falls under seismic Zone-V, i.e., susceptible to very high higher damage risk (>MSK IX) of earth quakes and the most seismically active region of Gujarat (***Figure 11***).

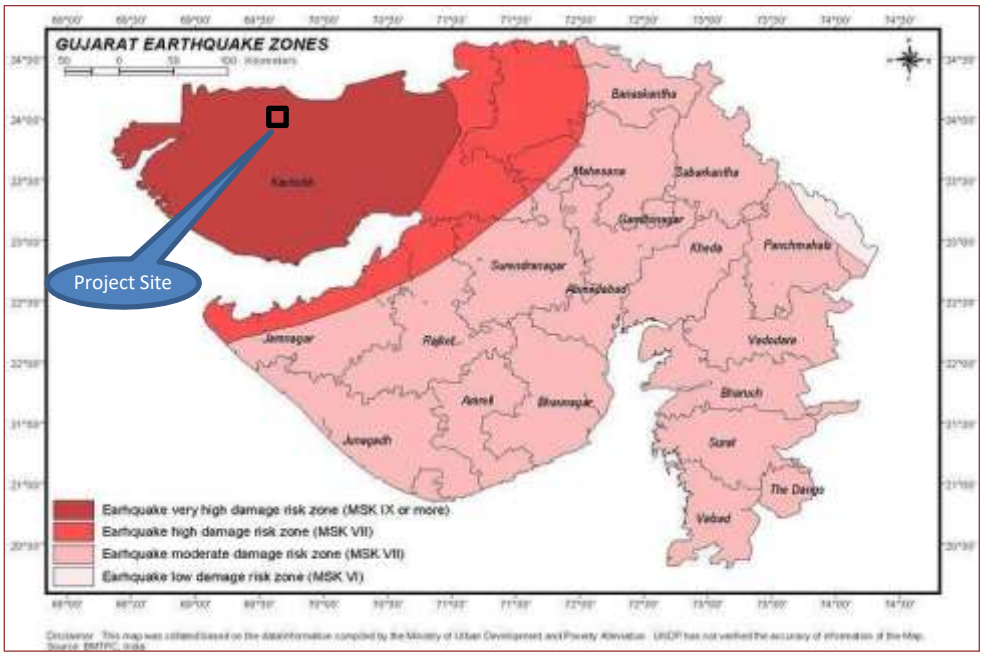


Figure 11: Earthquake Zonation map of Gujarat

The area is earthquake prone and many epicenters are located here. Major part of the district lies in very high-risk zone of seismicity, while a comparatively smaller part in the east lies in high-risk zone of seismicity.

3.1.1 Earthquake / Fault line in and surrounding area

The study area is within very close proximity or passing through 1819 Allah Bund fault based on the superimposition of the Gujarat State Disaster Management Authority (GSDMA) earthquake management plan map over the site boundary as shown in ***Figure 12***. The fault and lineaments are mainly aligned parallel/sub-parallel to the major tectonic grains.

Impacts may occur due to excessive spillage/leakage of wastewater from broken pipeline/crack in storage tank during earthquake, which may contaminate groundwater. All type of Built-up structures are prone to damage due to any tectonic activities at Allah bund fault. Project site falls in a close proximity to a historic Allah Bund fault of 1819.

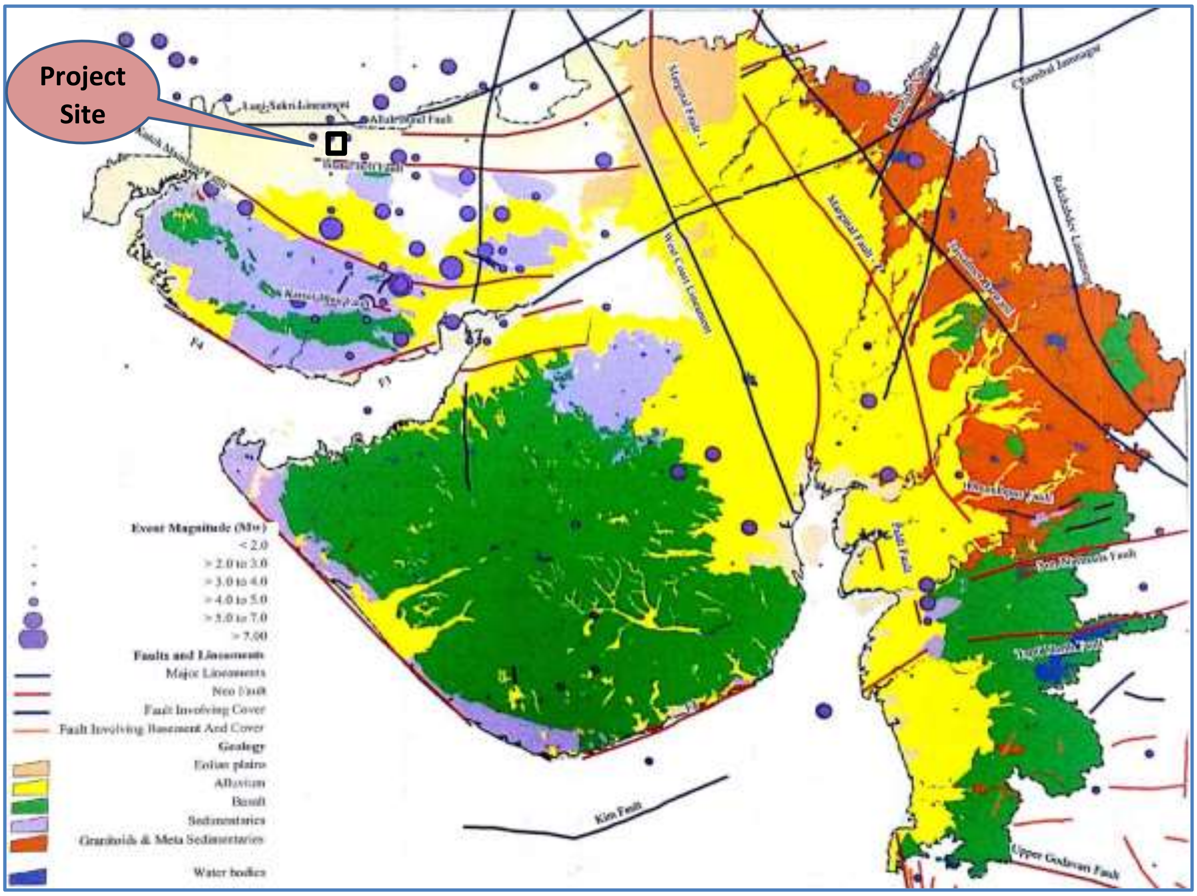


Figure 12: Seismotectonic features in Gujarat

3.1.2 Gujarat Hazard Risk Zonation

The estimated mean Taluka Peak Ground Acceleration (PGA) (in g) zonation for a 100-year return period is presented in the ***Figure 13***. This zonation is typically used for the design of critical buildings that need to have a mean design service life of 100 years.

The boundaries of key structural features emerge in this zonation map with the broad boundaries of the Cambay Graben and the eastern hilly region emerging due a mix of the influence of active faults, distance from historical events and ground amplification due to the deep alluvium within the basins.

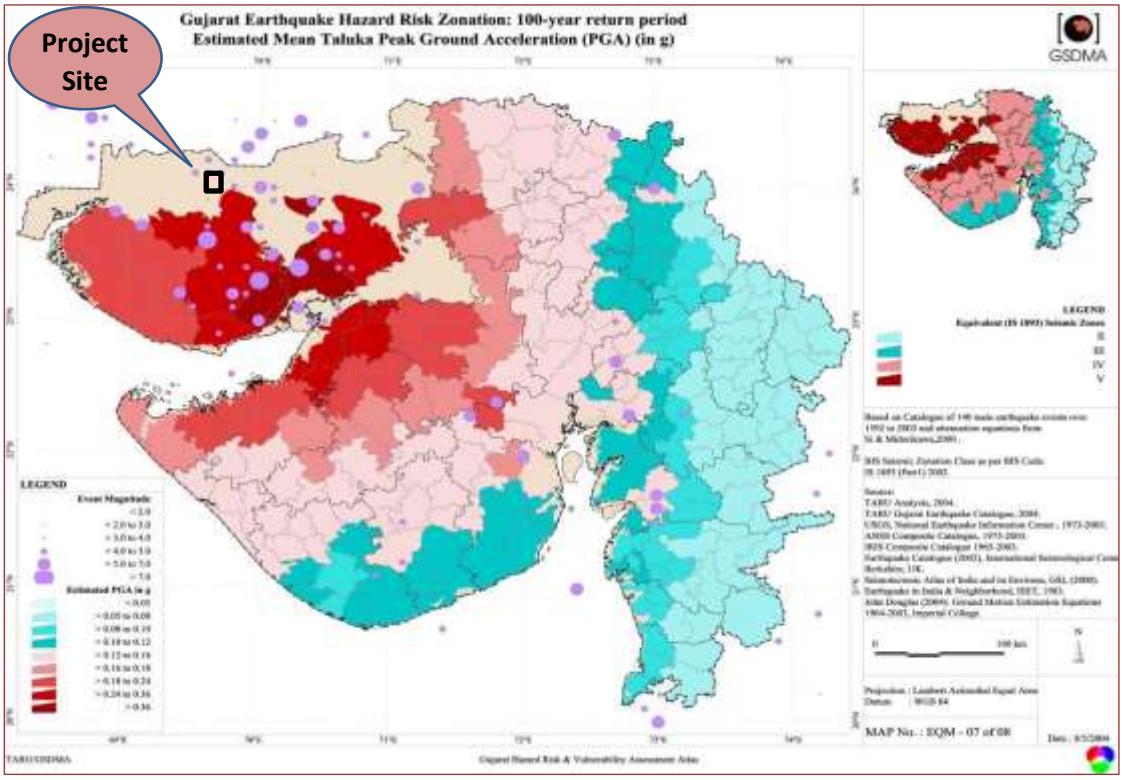


Figure 13: Gujarat Earthquake Hazard Risk Zonation

The Kutch district has two pockets of low to moderate intensity with the maximum estimated Peak Ground Acceleration (PGA) values between 0.05 to 0.10 g in units of gravity (the acceleration due to Earth's gravity, equivalent to g-force). Four moderates to very high intensity earthquake pockets are located in Kutch and north coastal Rajkot and Jamnagar districts clustered around the major events in this region.

The eastern hilly region of Gujarat consists of stable Granatoids and Basalt has relatively low estimated intensities – a departure from seismic zonation.

3.2 Tsunami Hazard

A tsunami is a series of waves most commonly caused by an earthquake under the sea floor. As tsunamis enter shallow water near land, they increase in height and can cause great loss of life and property damage.

Gujarat has no record on tsunami though number of earth quakes have been recorded in the area. During the earthquakes of 1819 and 1845 near the Rann of Kutch, there were rapid movements of water into the sea. There is no record of waves resulting from these earthquakes along the coast adjacent to the Arabian Sea, and it is unlikely that Tsunamis were generated. Further west, in the Persian Gulf, the 1945 Makran earthquake (magnitude 8.1) generated Tsunami of 12 to 15 m height. This caused a huge deluge, with considerable loss of life and property at Ormara and Pasi (now in Pakistan). The estimated height of Tsunami at Gulf of Cambay was 15 m but no report of damage is available.

Above facts indicate the coastal region of Gujarat is vulnerable to Tsunamis from great earthquakes in Makran coast. Earthquake of magnitude 7 or more in this region may be dangerous to Gujarat. It may be noted that all earthquake does not generate Tsunami.

The basics of Tsunami risk & vulnerability assessment is the record of seismic activities in the oceans & seas around the landmass for which the assessment is being done. Also, the vulnerability assessment is carried out based on tsunami run-up model for that area. Such a model for Gujarat is yet to be prepared.

In the absence of scientific data on tsunamigenic submarine earthquakes for the Arabian Sea and North Indian Ocean in the Gujarat, planning for risk assessment is done on the basis of worst-case Storm surge scenario i.e. PMS (Possible maximum Surge) at HHTL (Highest High Tide Level) to be the area

potentially exposed to tsunami impact. ***Figure 14*** shows the Gujarat tsunami hazard risk zones based on highest high tide levels.

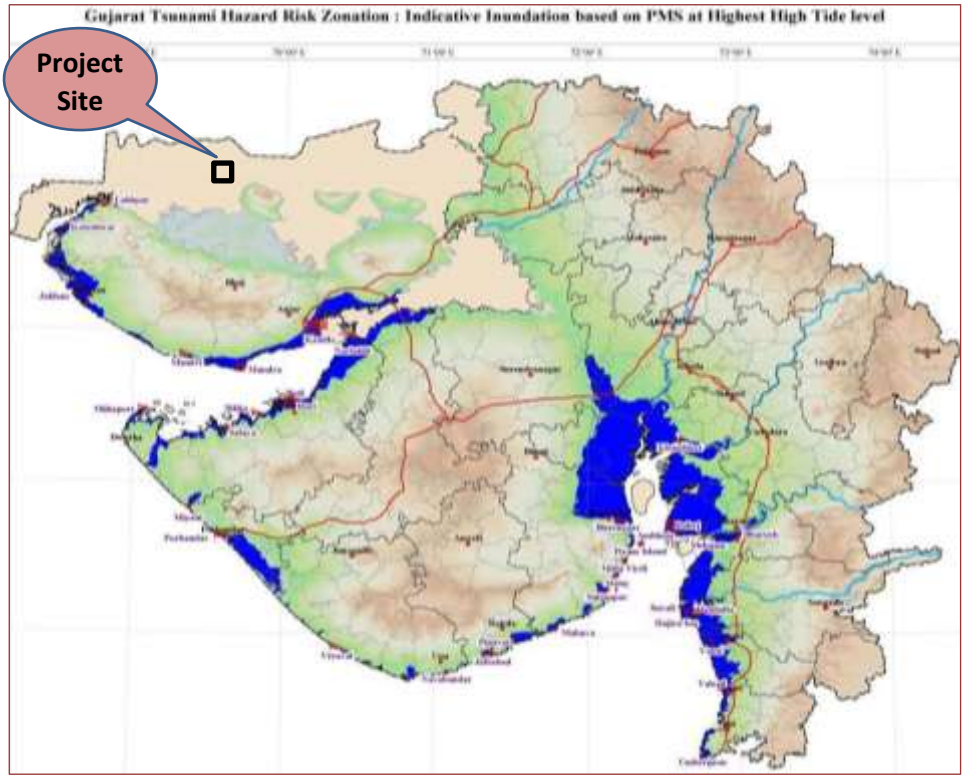


Figure 14: Gujarat Tsunami Hazard Risk Zonation Map

3.3 Cyclone Hazard

Cyclones are huge revolving storms caused by winds blowing around a central area of low atmospheric pressure. In the northern hemisphere, cyclones are called hurricanes or typhoons and their winds blow in an anti-clockwise circle. In the southern hemisphere, these tropical storms are known as cyclones, whose winds blow in a clockwise circle. Tropical cyclone is a storm system characterized by a large low-pressure center and numerous thunderstorms that produce strong winds and heavy rain. Tropical cyclones fall under the purview of warm core system of storms.

Gujarat falls in the region of tropical cyclone. With the longest coast line of 1600km in the country, it is highly vulnerable to associated hazards such as floods, storm surges etc. Most of the cyclones affecting the State are generated in the Arabian Sea. They move northeast and hit the coast particularly the

southern Kutch and southern Saurashtra and the western part of Gujarat. Two cyclonic storm seasons are experienced in Gujarat: May to June (advancing southwest monsoon) and September to November (retreating monsoon). Many severe cyclones had originated in the Arabian Sea and passed through the state in last 100 years. Apart from other areas, the Gulf of Kutch and Gulf of Khambhat also witness surge as the funneling effect takes place at both the places. The eastern reach of the Gulf of Kutch is the quite vulnerable region due to its low-lying flat topography and high population density.

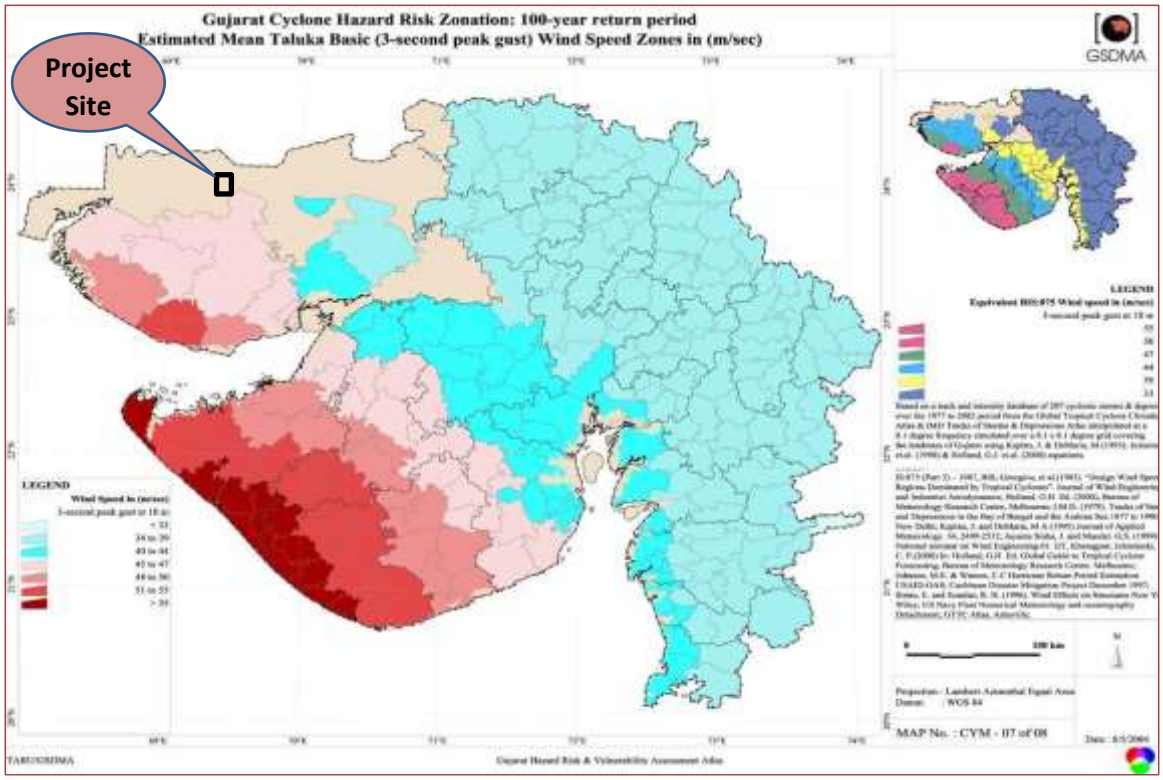


Figure 15: Gujarat Cyclone hazard risk zones

The Hazard Risk and Vulnerability Atlas prepared by GSDMA shows the Cyclone hazard zonation along with the basic wind speed at the taluka level (***Figure 15***). Over 120 cyclones originating in the Arabian Sea had passed through Gujarat over a period of 100 years. ***Figure 15*** shows a maximum wind speed class of more than 55 m/sec along the Saurashtra coast, specifically in Porbandar, Jamnagar and Junagadh districts, which are exposed to high intensity cyclonic and storm impact. The 51 to 55 m/sec class

extends further inland to cover much of Jamnagar, part of Rajkot, Junagadh and Kutch districts. The 48 to 50 m/sec class extends to most of Rajkot, part of Amreli and Jamnagar districts including Jamnagar, Rajkot cities and parts of Kutch. The 45 to 47 m/sec class covers much of Saurashtra and all of Kutch. This is followed by the 40 to 44 m/sec class that gets its swathe from Kutch through northern Saurashtra all the way to the coast of Gulf of Khambhat and southern Gujarat. The rest of the State falls into the 34 to 39 m/sec class.

3.4 Volcanic Risk Assessment

A volcano is a rupture in the crust of a planetary-mass object, such as Earth, that allows hot lava, volcanic ash, and gases to escape from a magma chamber below the surface.

In Gujarat the volcano existed at Dinodhar hills in Kutch district and a volcanic plug has been identified in rising through the sedimentary rocks. The volcano was active 500 million years ago. No new activity has been reported in recent times. The latest volcanic activity in the state of Gujarat is represented by basaltic rocks of Deccan Traps. The last activity of the Deccan trap volcanos is reported to have ceased 66 million years ago.

3.5 Flood Risk Assessment

Floods are amongst the most frequent and destructive type of disaster, causing significant damage and disrupting livelihoods throughout the world. Proper estimation of risk is challenging and requires careful consideration of a number of factors, including watershed properties such as size, topography, and land use, the types and characteristics of storms that produce rainfall and flooding in the region, and the number, location, and types of buildings and other assets that could be damaged.

Hazards associated with flooding can be divided into primary hazards that occur due to contact with water, secondary effects that occur because of the flooding, such as disruption of services, health impacts and disease, and tertiary effects such as changes in the position of river channels.

Gujarat has seen many damaging floods. Almost all major rivers in the state pas through a wide stretch of very flat terrain (often more than 50 km) before reaching the sea. These flat low lands of lower river basins are prone to flooding. Flood prone area in Gujarat (settlement wise flood frequency) is shown in ***Figure 16***.

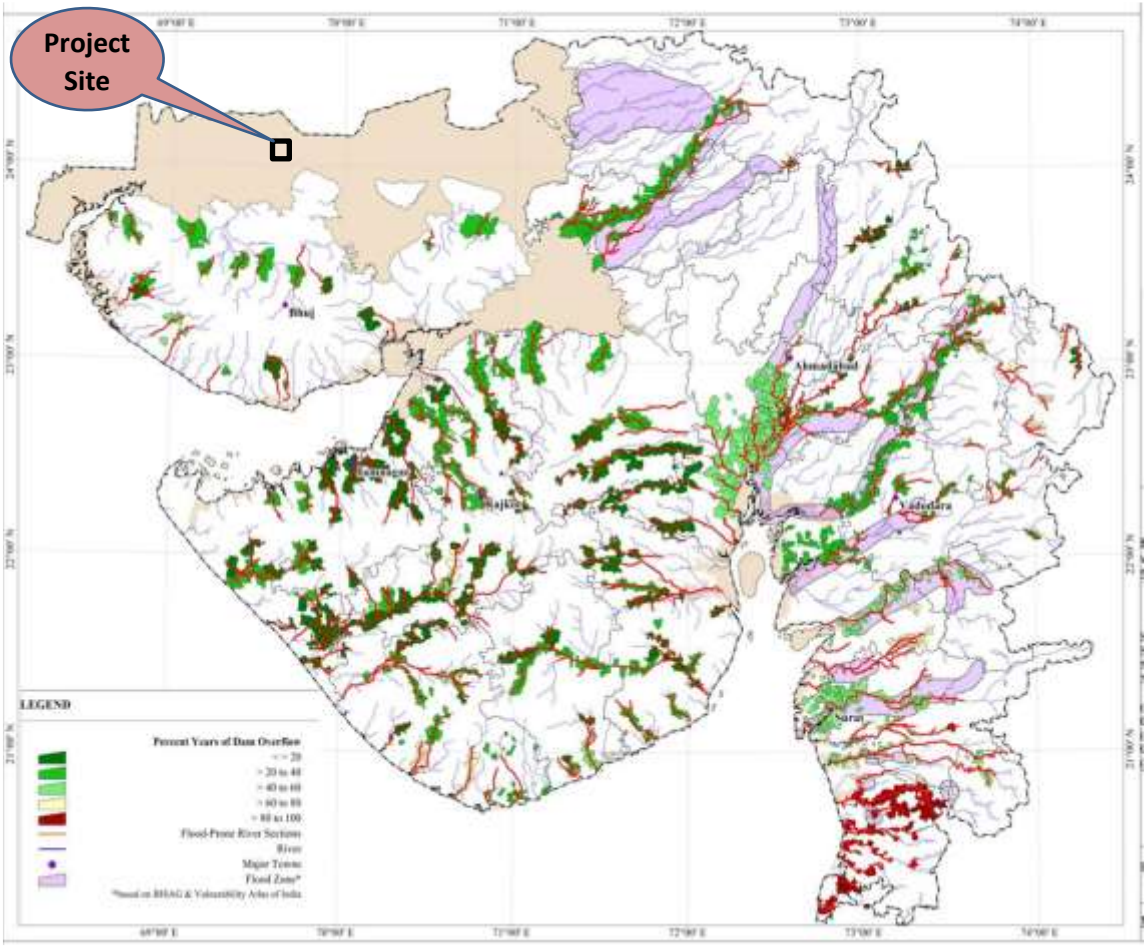


Figure 16: Gujarat Flood hazard risk zones

Because, there are no major rivers in the Rann of Kutch, so there is no risk of flooding in the study area. Further, detail study of flood risk assessment in the project area is given in *Chapter 11*.

4 MATERIAL AND METHODOLOGY

4.1 Data used

Three major inputs have been used in this study:

- *Rainfall data*: The daily gridded rainfall data (0.25^ox0.25^o) was obtained from the IMD (1901 to 2018) for the grid representing the study site in Khavda village in Great Rann of Kutch, Gujarat.

- *Soil and LULC*: The soil type and land cover determine runoff and absorption rates. This data was acquired from http://bhukosh.gsi.gov.in/Bhukosh/Public and Central Ground Water Board (CGWB).

- *Elevation Data*: The elevation survey data was obtained from the GIPCL. For broader understanding of area study, Google earth, ASTER (30 m) DEM from USGS earth explorer and ALOS PALSAR (12.5m) DEM (https://asf.alaska.edu/data-sets/sar-data-sets/alos-palsar/) were used.

- *Groundwater Data:* The data related with groundwater (i.e. water table, well locations, water quality, and resistivity survey data) was obtained from GIPCL.

4.2 Methodology

The methodology adopted in the present study is discussed in subsequent sections here.

4.2.1 Statistical analysis of rainfall

The analysis of average annual, seasonal and monthly rainfall have been carried out using daily rainfall obtained from IMD grid for the proposed project site. Different statistics related with such as mean (μ), and standard deviation (σ) have been estimated (Eqn. 1 and 2). Also, top ten extreme rainfall events of average annual maximum daily rainfall have been computed for the site over a period of 118 years.

$$\mu = \frac{\sum x_i}{N} \qquad \text{(Eqn. 1)}$$

$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{N}} \qquad \text{(Eqn. 2)}$$

Where, σ is the standard deviation; N is the size of the population; x_i is each value from the population; μ is the mean.

4.2.2 Intensity-Duration-Frequency Curves

The gridded rainfall data has been obtained from IMD (1901 to 2018) at a scale of 0.25° x0.25° latitude and longitude grids. Storm wise daily rainfall data was not available for the study site. Therefore, the annual maximum rainfall intensity derived from daily rainfall intensity has been disintegrated to hourly intensities using IMD reduction formula (Chowdhury et al. 2007) (Eqn. 3).

$$P_t = P_{24}\left(\frac{t}{24}\right)^{\frac{1}{3}} \qquad \text{(Eqn. 3)}$$

Where, P_t is the rainfall depth in mm at t-hour duration, P_{24} is the daily rainfall depth on mm and t is the duration of rainfall for which the rainfall depth is required in hours.

The Intensity-Duration-Frequency Curves (IDF) curves of the different return periods have been then derived for the proposed study site using different statistical distributions. These includes Gumbel's Extreme Value distribution (GEV), Extreme Value Type-I, Gamma, Exponential and Lognormal distributions (Wikipedia, 2021). These distributions have been applied to the rainfall data of the site and best fit distribution was identified. For example, GEV distribution is described in Eqn. 4 and 5 below:

$$x_T = \bar{x} + K_T S \qquad \text{(Eqn. 4)}$$

$$K_T = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + \ln\left[\ln\left(\frac{T}{T-1}\right)\right]\right\} \qquad \text{(Eqn. 5)}$$

Where x_T is the average annual daily maximum rainfall, mm; T is the return period, years, $\bar{x}$ is the mean and S is the standard deviation of annual daily maximum rainfall, mm and K_T is the frequency factor for corresponding return period T. Based on the field conditions of the site, 2 years return period can be selected for design of the stormwater drainage system (CPHEEO, 2019).

4.2.3 Runoff Estimation

Computation of runoff volume

The runoff volume from the AoI is estimated using Soil Conservation Service (SCS, now Natural Resources Conservation Service, NRCS) Curve Number (*CN*) method (NRCS, 2004). This method is popular among hydrology practitioners due to its simplicity, predictability, and stability.

$$Q = \frac{(P - 0.2 \times S)^2}{(P + 0.8 \times S)} \qquad \text{If } P \geq 0.2S$$

&

$$Q = 0 \quad \text{If } P \leq 0.2S \qquad \text{(Eqn. 6)}$$

Where Q is the runoff depth in mm; P is the event rainfall in mm and S is the potential maximum retention capacity, which is estimated from CN depends on soil and land cover conditions of the watershed (Eqn. 7).

$$S = \frac{25400}{CN} - 254 \qquad \text{(Eqn. 7)}$$

CN varies from 0 for impervious surface (minimum runoff) to 100 for concrete surface (maximum runoff). The major factors that determine CN are the Hydrologic Soil Group (HSG) type, treatment, hydrologic condition, and Antecedent Moisture Conditions (AMC). AMC is pre-storm indicator of basin wetness and soil storage availability. In CN method, three levels of AMC are used such as AMC-I for dry, AMC-II for normal and AMC-III for wet conditions. In this study, the dormant season is considered while estimating the AMC conditions based on Table 3. The CN values were estimated according to the case of AMC-I and AMC-III conditions (Mishra and Singh 2013; Subramanya et al. 2013), which are given below,

$$CN(I) = CN(II)/(2.281 - 0.0128 * CN(II)) \qquad \text{(Eqn. 8)}$$

$$CN(III) = CN(II)/(0.427 + 0.00573 * CN(II)) \qquad \text{(Eqn. 9)}$$

Where, *CN(I), CN(II)* & *CN(III)* are the curve number for AMC-I, II & III conditions, respectively.

Soils are classified into four HSG's (A, B, C, and D). A represents well drained sand or gravel, high infiltration rate, B represents moderately well drained soil, moderate infiltration rate, with fine to moderately coarse texture, C indicates slow infiltration rate, moderate to fine texture, and D represents very slow infiltration, mainly clay material, relatively impervious. In the present study, soil hydrologic group C is considered based on the infiltration characteristics of the project area.

Table 3: AMC conditions and the related curve number (CN)

AMC	Curve Number	5-Days Antecedent Rainfall (mm)	
		Growing Season	Dormant Season
I	CN(I)	<35.6	<12.7
II	CN(II)	35.6-53.3	12.7-27.9
III	CN(III)	<53.3	<27.9

For a watershed with sub-catchment areas having different land uses and soil types, a composite CN's is determined by weighting of CN values for different sub-catchments (Eqn. 10).

$$CNw = \frac{\sum Ai*CNi}{\sum Ai} \quad \text{(Eqn. 10)}$$

CN_w is the weighted average curve number; Ai is the area of respective class for i=1…n.

Finally, the runoff volume is estimated by multiplying watershed area into runoff depth.

Computation of peak runoff

Drains are designed based on peak rate of runoff potential, which is the flow when the entire catchment is contributing to its outlet. This will occur when the given intensity of rainfall begins instantaneously and continues until the time of concentration (t_c) (CPHEEO, 2019). Rational method has been used successfully to design storm drains size, inlets and small on-site detention catchments based on peak rate of runoff (Eqn. 11):

$$Q_p = \frac{CiA}{360} \quad \text{(Eqn. 11)}$$

Where, Q_p is the peak rate of runoff (m^3/s), C is a runoff coefficient (dimensionless), i is the average rainfall intensity equal to the t_c (mm/h) and A is the catchment area (ha). The major factors affecting the runoff coefficient are the land use, soil type and slope of the catchment area. The assumptions used in the Rational method can be referred in the CPHEEO (2019). For the study site, runoff coefficients are adopted from the ***Annexure-A***. Further, weighted runoff coefficient (C) has been estimated using following equation:

$$C = \frac{C_1A_1 + C_2A_2}{A_1 + A_2} \quad \text{(Eqn. 12)}$$

Where, C_1 and C_2 are runoff coefficients, and A_1 and A_2 are respective areas of paved and general ground.

Computation of time of concentration (t_c)

It is defined as "the time required for water to travel from the most hydraulically distant point in the total contributing catchment to the design outlet (CPHEEO, 2019). The t_c is generally depends on distance of a farthest point in the drainage catchment to the shape, characteristics and topography of the catchment. Typically, it is estimated using Eqn. 13:

$$t_c = 0.0195L^{0.77} * S^{-0.385} \quad \text{(Eqn. 13)}$$

Where, L is the length of main stream (m), S is the surface/longitudinal slope (ratio).

4.2.4 Soil Erosion

The RUSLE equation is applied to estimate soil erosion within a watershed. In RUSLE can be expressed as follows (Williams, 1975a and 1975b):

$$A = R \times K \times LS \times C \times P \quad \text{(Eqn. 14)}$$

where A is the average annual soil loss (t/ha/yr), R is the rainfall erosivity factor, K is the soil erodibility factor can be obtained from soil properties; LS is the slope length and gradient factor; C is the cover management factor can be derived from land cover data and P is the erosion control practice factor.

In case of RUSLE application for soil erosion estimation, R factor for the given storm was estimated using Eqn. 15 (Singh, 1981).

R= 79+0.363*Pa (Eqn. 15)

Where, P_a represents the mean annual rainfall in mm.

Soil Erodibility Factor

Soil erodibility (K) is a function of soil horizon and soil profile parameter, which was computed based on the study of Wischmeier et al. (1978). In the present study, the K factor can be estimated using Eqn. 16:

$$K = \frac{2.1\times10^{-4}(12-OM)M^{1.14}+3.25(s-2)+2.5(p-3)}{759.4} \quad \text{(Eqn. 16)}$$

K is soil erodibility (tonnes-yr/MJ-mm), *OM* is percentage organic matter, *p* is soil permeability code, *s* is soil structure code and *M* is a function of the primary particle size fraction.

Desert soil is generally found in the project area. It is sandy to sandy loam with silt clay loam in structure. The K factor is taken as 0.37 based on literature survey (Haan et al., 1994).

Determining LS Factor

The LS factor reflects the effect of topography on soil erosion. The dimensionless LS factor has been estimated from Eqn. 17 (Morgan 2005);

$$LS = \left(\frac{flow\ accumulation \times cell\ size}{22.13}\right)^{0.2} \times \left(0.065 + 0.045 \times S + 0.0065 \times S^2\right) \quad \text{(Eqn. 17)}$$

where, L is the slope length in m, and S is the slope steepness in %.

The computation of the LS factor requires flow accumulation and slope steepness factor, which was computed from the DEM (5m resolution).

Estimation of C and P Factor

The factor C measures the combined effect of all the interrelated vegetative cover and management variables, which was adapted from Pandey et al. 2010. While, the P-factor reflects the impact of support practices that will reduce the amount and rate of direct runoff as well as the amount of soil erosion. The C-factors for different LULC were taken from the literature (Haan et al. 1994; Chatterjee al., 2014) (***Table 4***). Since in the study area, no major conservation practices are followed, the P factor was taken equal to 1 for all LULC types as majority of land areas have not been provided with any conservation support.

Table 4: The vegetation cover factor C for the study area

SN	Class	C-factor
1	Grass	0.03
2	Grass and Open Scrub	0.03
3	Rann (Salt Waste-Dry)	1.00
4	Sarbela Bet	0.03

4.2.5 Sediment Yield

To quantify the amount of deposition occurring, a sediment delivery ratio (SDR) has been defined as (Haan et al., 1994):

$$SDR = \frac{Y}{(Grosserosion \times Watershed\ area)} \qquad \text{(Eqn. 18)}$$

Where, Y is the sediment yield (tons). For the present study, value of SDR was taken as 0.22 (adapted from Haan et al., 1994).

4.2.6 Risk assessment

Based on the design layout provided by GIPCL, field visit, primary data analysis and literature, the proposed site have been investigated and evaluated to ascertain the flood, seismic and tsunami risk.

4.2.7 Water availability and its requirement estimation

The water available from various sources such as surface water, groundwater, imported source and fresh water after desalination have been explored and assessed in the present study. Also, the groundwater availability and its quality have also been investigated in detail. The water requirement for the proposed project for different purposes has been estimated using different data sources and the inputs received from the GIPCL.

4.2.8 Storm-water management and rainwater harvesting

The storm-water drains and storage tanks can be designed to store the rainwater, which can be used for different purposes in the site. These can be estimated by considering the design rainfall event over the catchment area of the storage tank. The storage volume has been estimated in the site where appropriate rainwater harvesting tank can be designed.

5 FIELD INVESTIGATIONS

A team of scientists along with official of GIPCL made a field visit from December 29, 2020 to Jan 01, January, 2021 to get an insight into the hydrological conditions. Some of the photographs of the area are given in ***Figure 17*** to ***Figure 23***.

(a) Flat terrain with clayey loam type of soil without any vegetation

(b) Undulating terrain due to channel erosion

Figure 17: Topographical conditions at the proposed project site

Figure 18: Sparse vegetation (Bunny grass) and Acacia trees.

Figure 19: Streams / Channels in the AOI

Figure 20: Streams dissecting though the elevated areas

Figure 21: Clayey soil in low lying areas

Figure 22: Saline Groundwater in the proposed project site

Figure 23: Inter-connected drains between GIPCL project site

6 LAND USE / LAND COVER

Land use is the description of how people utilize the land for the socio-economic activities. Land use maps play a significant role in planning, management and monitoring programs at local, regional and national levels. For ensuring sustainable development, it is necessary to monitor the ongoing process on LULC patterns and any upcoming changes within the surrounding area.

6.1 LULC before establishment of RE Park

The study area falls in Rann of Kutch, Gujarat. The Rann of Kutch is a large area of salt marshes that span the border between India and Pakistan. The Rann of Kutch is divided into two parts, the Great Rann and the Little Rann.

Trees are rare except on the bets which rise above the flood zone. The non-native tree *Prosopis juliflora* has become established on the bets, and its seed pods provide year-round food for the wild asses.

The predominant land use of this site is barren land (also called Rann) with scanty vegetation of arid grassland ecosystem called as ***Banni grasslands***. The total area covered by the Grass and Open Scrubs is approximately 17% of the total study area and remaining Rann (Salt Waste-Dry) area. There is no settlement/ habitat within the study area. Areal statistics of the LULC is presented in ***Table 5.***

Table 5: LULC statistics of the study area

SN	Class	Area (ha)	% area
1	Grass	16	0.34
2	Grass and Open Scrub	801	16.86
3	Rann (Salt Waste-Dry)	3894	81.98
4	Sarbela Bet	39	0.82
	Total	**4750**	**100.00**

Present landuse in the study area and its buffer is shown in ***Figure 24.*** The landuse map has been prepared using SoI toposheet and remote sensing imagery.

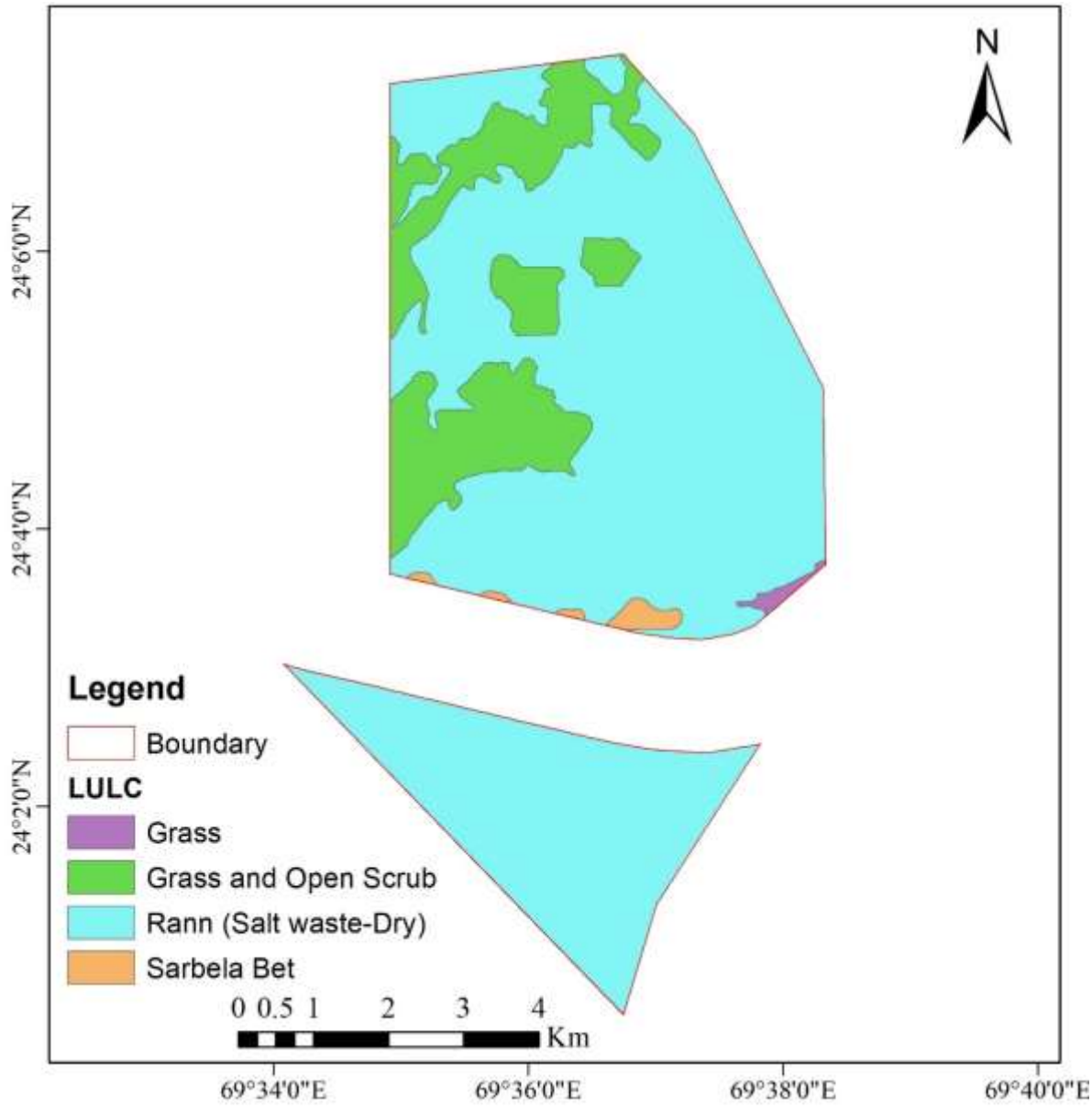


Figure 24: LULC Map of GIPCL RE Park area

Rann receives an average rainfall of 35 cm per year. The region does not have any perennial river and the development of drainage is poor. Only seasonal rivulets, originating from the central highland, drain the rain water of Kutch region through the Rann. The streams flowing to the north of the highland and disappearing in the vast expanse of the GRK are Nara, Panjarwati, Chhari, Bhukhi, Tramdo, Kaila, Pur and Kaswali. The drainages of Bhamban, Kankavati, Machchhu, Godhra and Umai from the southern fringe, Saraswati and Rupan from eastern fringe and Banas from northern fringe debouch into the LRK. Therefore, inundation in LRK is mainly by tidal waters from the Gulf

of Kutch with major contribution from surface runoff from various inland rivers draining the adjoining region.

In the project site area, there is no major river. There are numerous Gullies and temporary streams which passes through the study area. These gullies are temporary and flows only during the monsoon season. There are some 2nd or 3rd order non-perennial streams which appears to have existed for atleast few decades. No drainage is marked even on 1:50,000 toposheet of SoI. Some of the dry streams observed in the field have depth upto 1 to 1.5 feet and width of 3-4 feet (***Figure 25***).

Figure 25: Dry stream channel/gullies observed in the field

6.2 LULC after establishment of RE Park

As per the planning for establishment of RE Park by GIPCL, the expected LULC has been estimated. GIPCL is planning to install 6,527,000 solar panels of 540 W with dimensions of 2x1 m. The RE Park is proposed to be divided into 24 plots with each plot having solar power generation of 100 MW. The land use after setting up of RE Park, is expected to be as given in ***Table 6***, it is estimated that the area under infrastructure (workshop, administrative building etc.) may be only 2 ha with 1.50 ha building and paved area and remaining 0.50 ha as open space with green belt.

Table 6: Land use pattern of project area of GIPCL

Sr. No	Activity	Existing (ha)	After completion of Solar Park (ha)
1	Total area disturbed	0.0	1,998
2	Infrastructure (workshop, administrative building etc.)	0.0	2
3	Area covered by Solar Panels	0.0	1,330
4	Paved area due to construction of Roads (20% of Solar Panel area)	0.0	266
5	Open Area (30 % of solar panel area)	0.0	400
6	Undisturbed area	4,750	2,752

7 SOIL TYPE

From hydrological point of view, soil study is carried out to determine its texture and infiltration characteristics.

The soil of the study area is uniform in nature and based on visual inspection it seems to be very fine silt clay varying in colour from yellow, yellowish Brown to back in colour at different locations. Mostly the soils are silt and clays and their mixtures in different proportions. Few pockets / lenses of silt, silty - clayey sands are also observed. In most of the area, salt encrustations have formed due to evaporation of water from the surface.

Dark brown silty clay with fine to very fine sand windblown particles size can be observed on Bet Zones.

The field permeability has been tested at one location in the study area by M/s Unique Engineering Services, Gandhidham and have reported that the permeability varies from 5.44 X 10^{-2} to 6.25 X 10^{-2} cm/hr. The permeability value is quite low and may not allow the vertical infiltration of water into the ground.

Stratification observed typically comprises of very soft saturated silty clays of low to high plasticity near ground level followed by soil of same character but with soft and stiff consistency towards greater depths. The soils within generally considered founding depths are highly compressible with very low to low shear strength. The consistency of clayey soils below 15 m depth is stiff to very stiff and hard towards higher depth. Mostly the soils are silty clay but few pockets / lenses of silt, silty - clayey sands are also observed. Soil characteristics are given in ***Appendix-A***.

8 METEOROLOGICAL ANALYSIS

The daily gridded rainfall data for 118 years (1901 to 2018) for the site region (0.25°x0.25°) was collected from Indian Meteorological Department (IMD). The data was analysed statistically and it has been found that the site received average annual rainfall 348.9 mm with minimum of 1.2 mm in the year 1987 and maximum 948.9 mm in the year 1961. Annual maximum daily rainfall and Total annual rainfall data for the period 1901 to 2018 is shown in ***Figure 26***. Further analysis indicates that a rainfall event of 339.4 mm occurred in month of May 1999. As this event is a single event of this intensity, the same was ignored in further analysis.

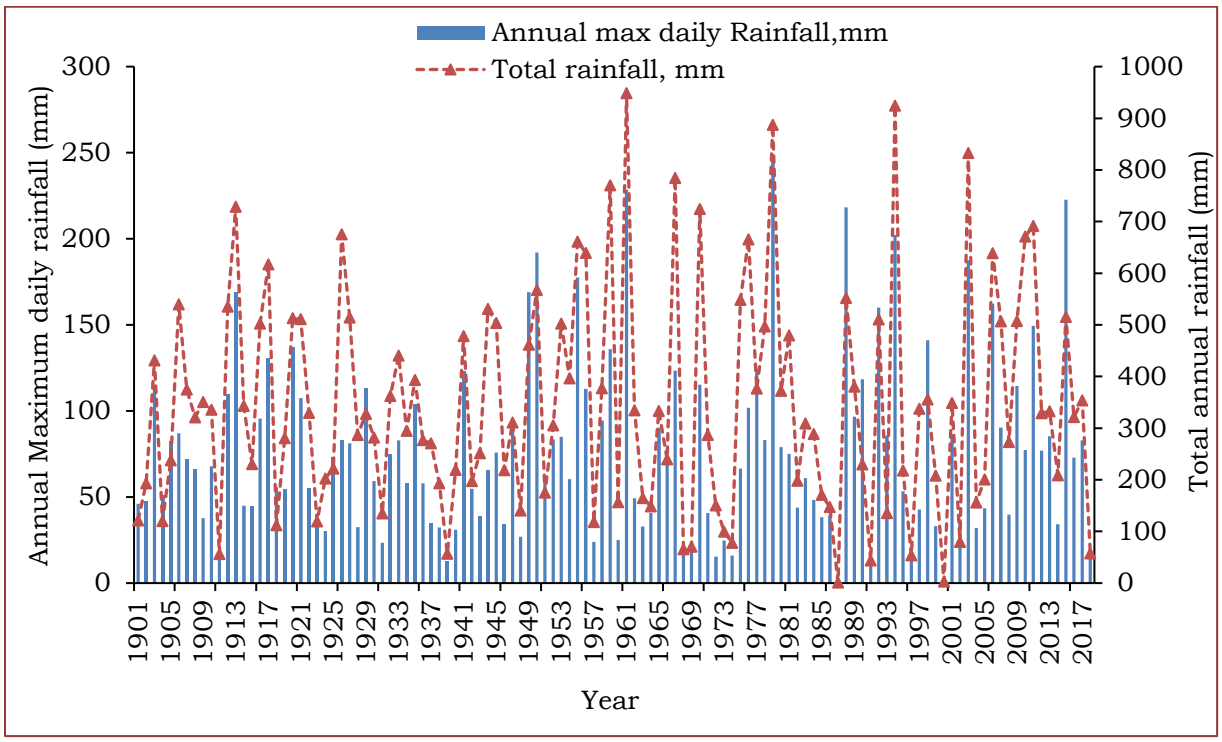


Figure 26: Annual maximum daily rainfall and total rainfall.

8.1 Statistical analysis of rainfall data

The monthly average daily rainfall statistics (1901 to 2018) observed at the site is presented in ***Table 7*** and ***Figure 27***. Also, Standard Deviation (SD) of the monthly and average annual rainfall for the site is presented in ***Table 7***. The top ten wettest days (i.e., extreme events of rainfall) for the proposed study site are listed in ***Table 8***. Seasonal analysis of the rainfall was carried out on

basis of IMD seasonal classes (i.e., winter, summer, monsoon and autumn) (***Figure 28***).

Table 7: Monthly statistics of average daily rainfall (mm)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.9	2.0	0.7	0.6	1.2	36.0	142.8	93.2	57.6	8.9	4.1	1.0
SD	3.1	6.0	3.6	2.2	3.8	51.0	140.4	110.3	98.4	28.2	15.8	4.7

Table 8: Top ten wettest day

Year	Month	Top ten wettest day, mm
1979	Aug	246.7
1961	Sep	228.4
2015	Jul	222.6
1988	Jul	218.2
1994	Sep	202.2
1950	Jul	192.1
2003	Jul	187.5
1955	Sep	177.6
1913	Jul	169.1
1949	Jul	168.9

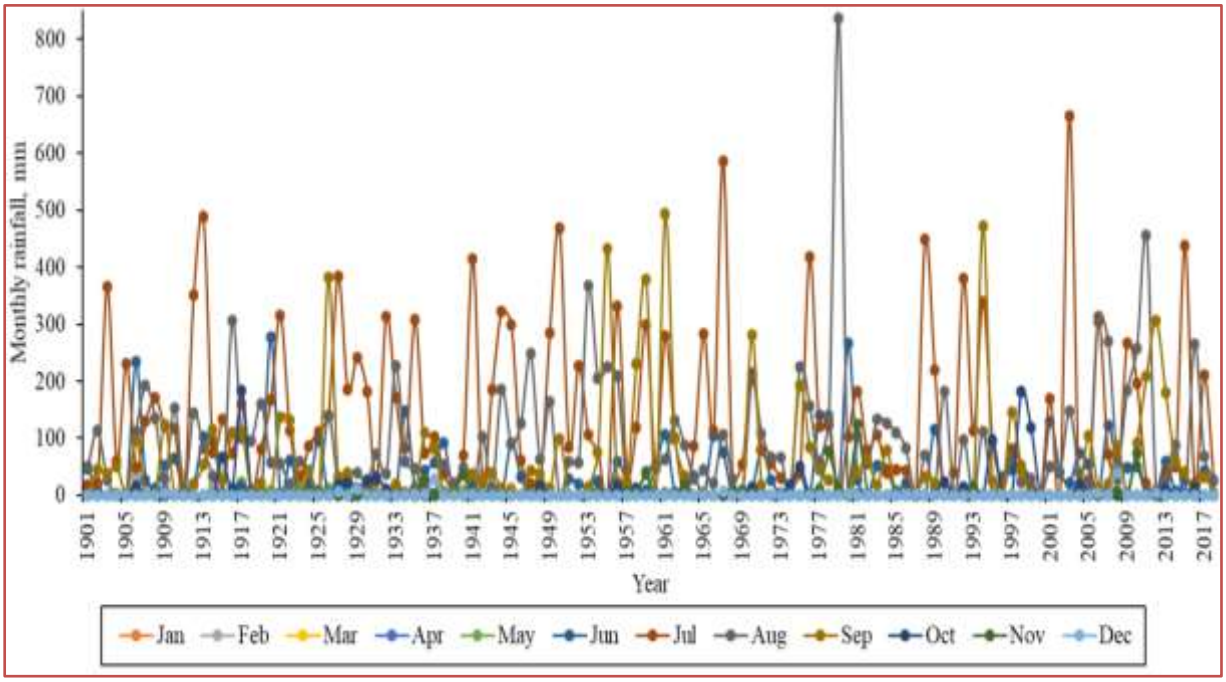


Figure 27: Monthly rainfall in the site (1901 to 2018)

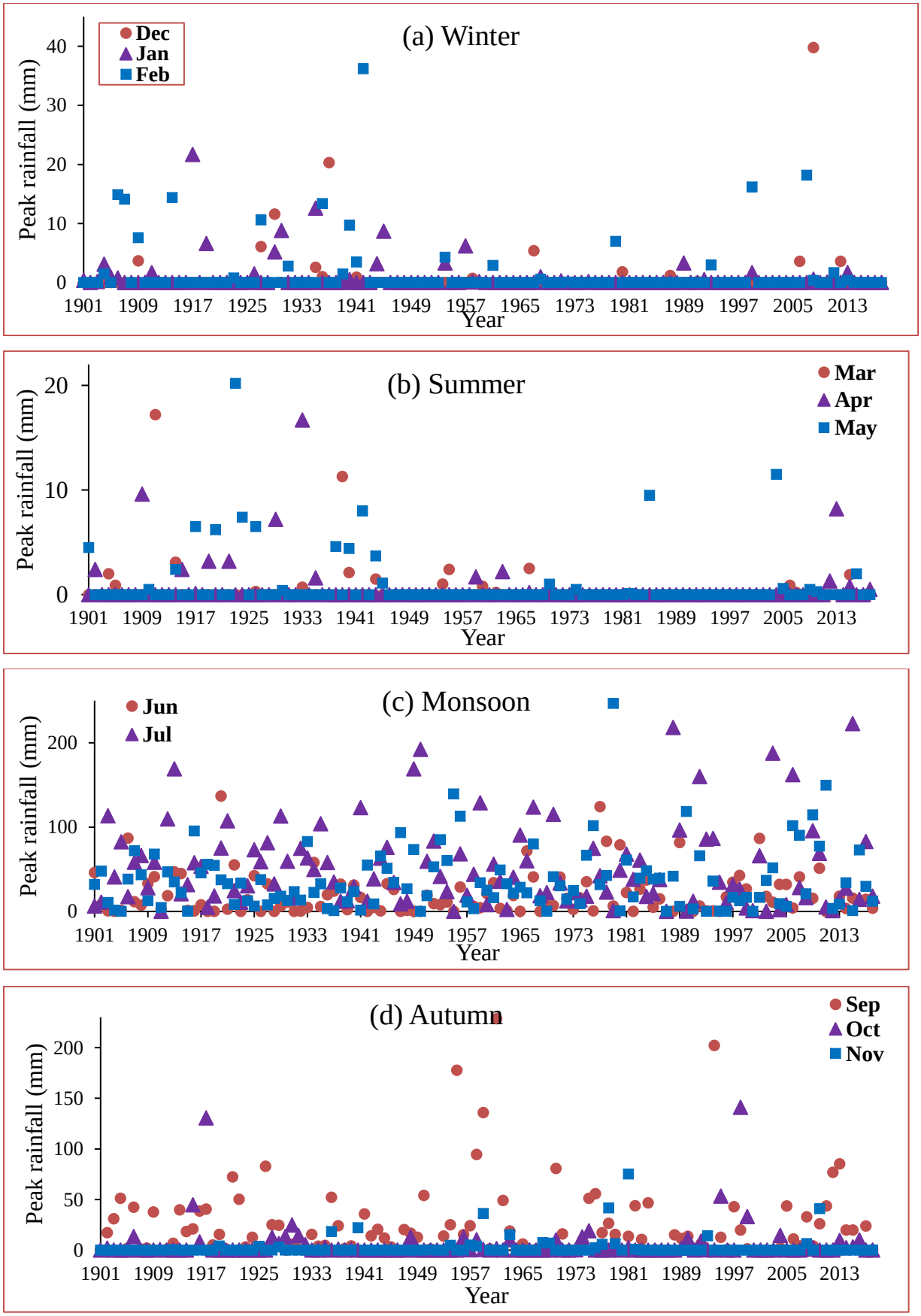


Figure 28: Maximum daily rainfall observed in different seasons

8.2 Derivation of IDF Curves

An IDF curve is a mathematical function that relates the rainfall intensity with its duration and frequency of occurrence. These curves are commonly used in hydrology for assessing rainfall events, classifying climatic regimes, to deriving design storms and assisting in designing drainage systems, etc. The deriving procedure of IDF curves, however, requires long-term historical rainfall observations, whereas lack of fine-timescale rainfall records (e.g. sub-daily) often results in less reliable IDF curves.

The IDF curve parameters have been computed for different duration of storms of different return periods from IMD rainfall gridded dataset (***Table 9 & Figure 29)***. Based on field conditions, suitable return period with rainfall intensity can be selected for design of the storm-water management system. IDF parameters indicate that the maximum rainfall intensity of 88.8 mm/hr can be expected for a storm of one hour for 100 years return period.

Table 9: IDF curve statistics for the site

Duration	Return Period / Rainfall intensity (mm/hr)					
	2 yr.	5 yr.	10 yr.	25 yr.	50 yr.	100 yr.
1 hr.	22.5	40.1	52.1	67.1	78.0	88.8
2 hr.	14.2	25.3	32.8	42.3	49.2	55.9
3 hr.	10.8	19.3	25.0	32.3	37.5	42.7
4 hr.	8.9	15.9	20.7	26.6	31.0	35.2
6 hr.	6.8	12.2	15.8	20.3	23.6	26.9
8 hr.	5.6	10.0	13.0	16.8	19.5	22.2
10 hr.	4.9	8.6	11.2	14.5	16.8	19.1
12 hr.	4.3	7.7	9.9	12.8	14.9	16.9
24 hr.	2.7	4.8	6.3	8.1	9.4	10.7

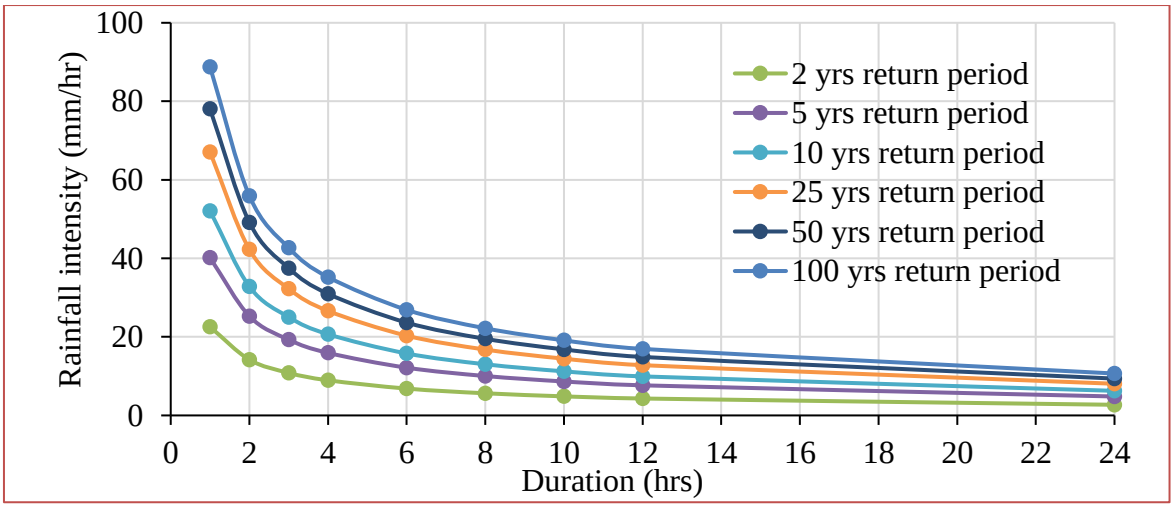


Figure 29: IDF curves for different return periods

9 WATERSHED ANALYSIS

9.1 Digital Elevation Model

Digital Elevation Model (DEM) is the digital representation (digital map) of the ground elevation data in meters. In the present study, the projection and datum WGS-84 UTM (meters) have been used for geo-referencing of all maps. Contour map of the RE Park area with contour interval of 0.5 m has been provided by GIPCL has been used (***Appendix – B***). Geographic geo-referencing points extracted from the toposheet and the map based on recent topographic survey and geo-reference point given by GIPCL have been used.

9.1.1 Procedure for DEM preparation

ARC-GIS software has been used for preparation of the DEM. The contours in shape file have been interpolated to obtain digital elevations of the equally sized grid cells. Size of a grid cell is 5 m × 5 m.

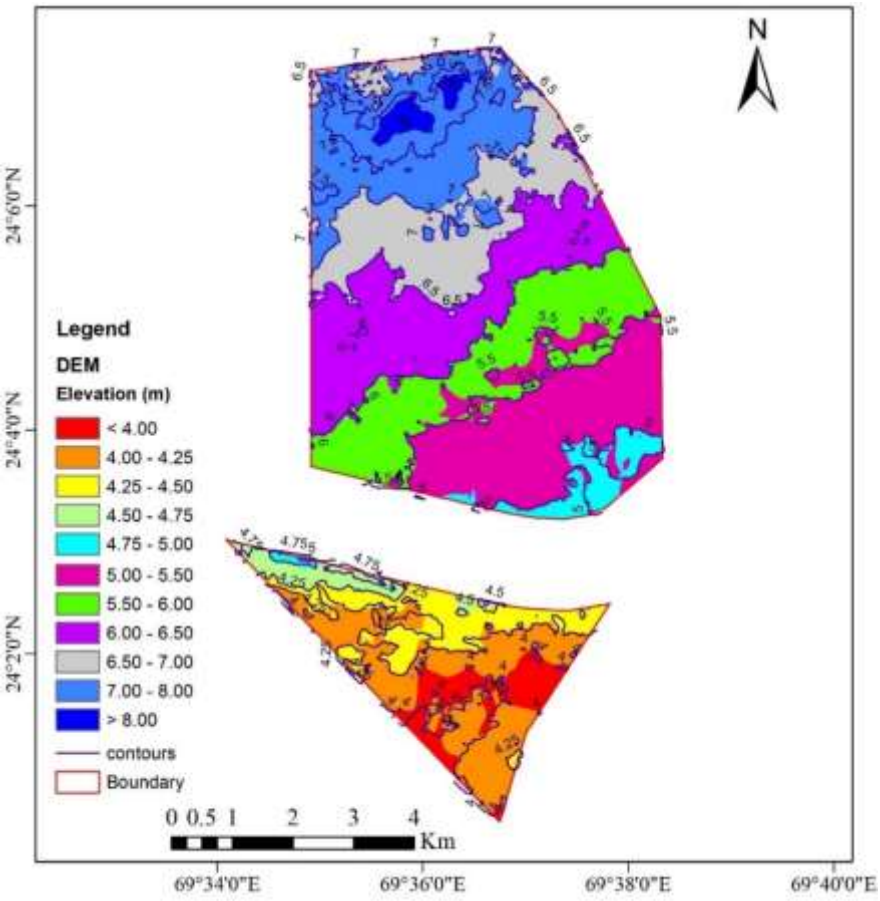


Figure 30: DEM of the GIPCL RE Park area

The DEM of the area within boundary of GIPCL RE Park area is shown as contour zoning map in ***Figure 30***. Variation in elevation from 3.85m to 8.75m is depicted through different colours. It is also shown as single colour intensity map in ***Figure 31*** in which terrain and natural drainage can be clearly identified.

Northern part of the project site area is higher in elevation than the southern part. Some of the higher land area are characterized with some patches of scanty vegetation (grassland).

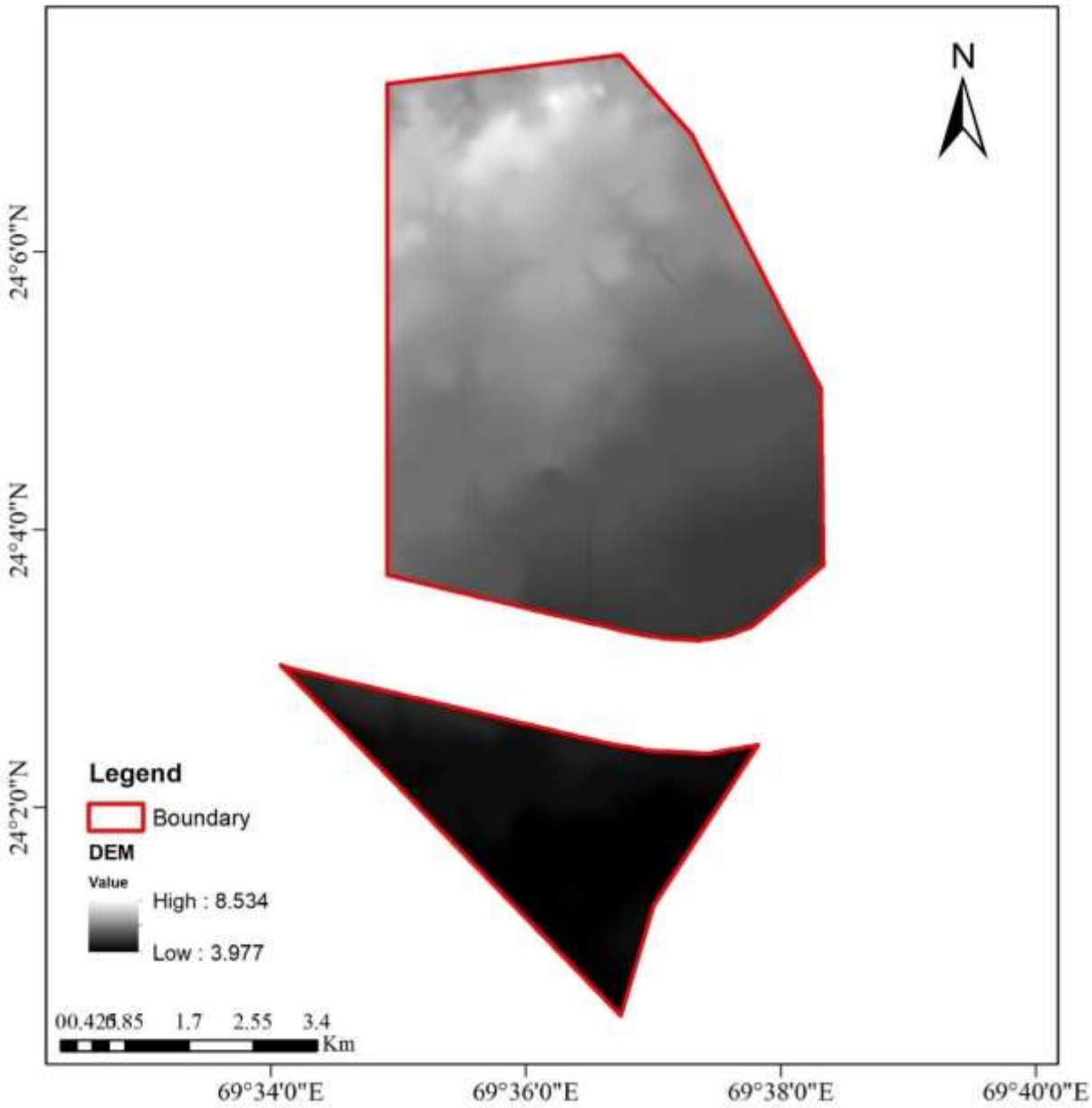


Figure 31: DEM - terrain colour intensity map

9.1.2 Distribution of land in different elevation ranges

The DEM has been used to compute the area (within project boundaries) between different elevation ranges. ***Table 10*** shows distribution of area from 3.85 m to 8.75 m elevation. The DEM computes number of pixels in each interval. DEM pixel size is 25 m^2 (5 m × 5 m). Approximately 2360 ha (50%) of the land area lies below 5.8 m elevation from msl.

Figure 32 is graphical depiction of the cumulative area distribution up to different elevation in the area. The graph suggests that the land is gradually sloping. This information derived from DEM study can be used to arrive at cost effective levels at which different plant components should be finally located.

Table 10: Areal distribution with elevation in study area as per DEM

S.N.	Elevation (m)	Pixel Count	Area (m^2)	Area (ha)	Area (%)	Cumulative Area (ha)	Cumulative Area (%)
1	<4.00	71242	1781048	178.10	3.75	178.10	3.75
2	4.00-4.25	201503	5037584	503.76	10.61	681.86	14.36
3	4.25-4.50	108985	2724623	272.46	5.74	954.33	20.09
4	4.50-4.75	36524	913107	91.31	1.92	1045.64	22.01
5	4.75-5.00	67231	1680783	168.08	3.54	1213.71	25.55
6	5.00-5.25	147150	3678754	367.88	7.74	1581.59	33.30
7	5.25-5.50	161280	4031999	403.20	8.49	1984.79	41.79
8	5.50-5.75	148824	3720601	372.06	7.83	2356.85	49.62
9	5.75-6.00	107044	2676088	267.61	5.63	2624.46	55.25
10	6.00-6.25	178458	4461453	446.15	9.39	3070.60	64.64
11	6.25-6.50	112898	2822442	282.24	5.94	3352.85	70.59
12	6.50-6.75	129013	3225320	322.53	6.79	3675.38	77.38
13	6.75-7.00	130092	3252295	325.23	6.85	4000.61	84.22
14	7.00-7.25	122934	3073351	307.34	6.47	4307.94	90.69
15	7.25-7.50	80589	2014714	201.47	4.24	4509.42	94.94
16	7.50-7.75	54048	1351195	135.12	2.84	4644.54	97.78
17	7.75-8.00	20140	503491	50.35	1.06	4694.88	98.84
18	8.00-8.25	20430	510753	51.08	1.08	4745.96	99.91
19	8.25-8.50	1453	36333	3.63	0.08	4749.59	99.99
20	8.50-8.75	163	4067	0.41	0.01	4750.00	100.00
			Total	**4750.00**	**100.00**		**100.00**

Note: Pixel size (DEM Cell size) =5 m × 5 m

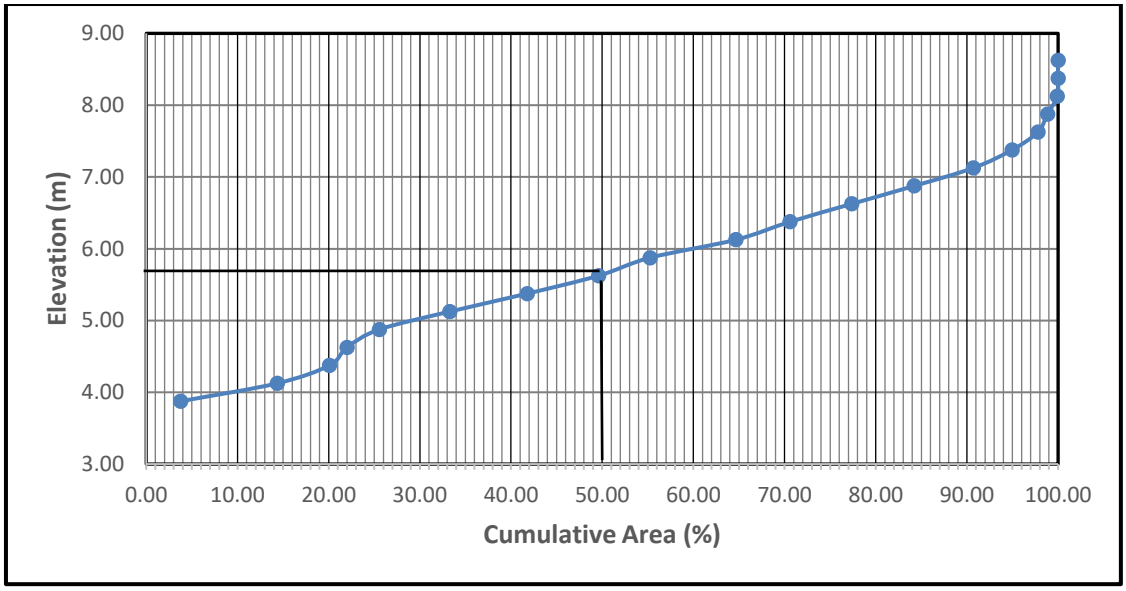


Figure 32: Cumulative areal distributions with elevation

9.2 Slope Analysis

Further, a slope map for the site was also developed (***Figure 33***) to ensure that areas with steep slope (i.e. > 4%) may be earmarked as keep out areas in the plant design. In the proposed site, all the area comes within 4% slope range (***Figure 33***).

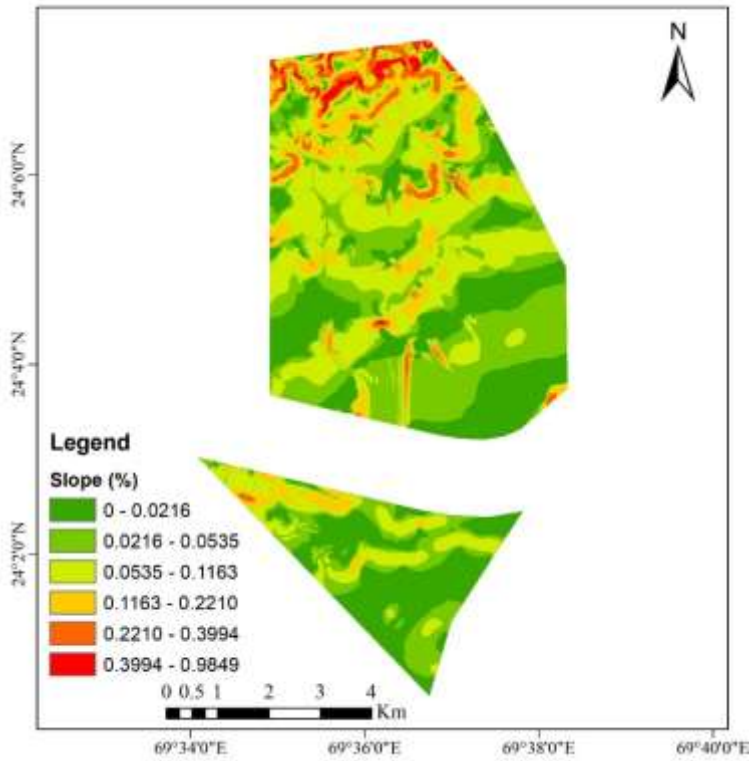


Figure 33: Slope map of the GIPCL RE Park area

9.3 Stream network delineation

Using the DEM, surface depressions on the land surface have been first delineated. The streams in the AOI were then mapped and the watershed boundary was delineated with the elevation points in the AOI (***Figure 34***). The delineated streams were used to identify the outlets points, which were further used to delineate the watersheds inside the lease area. There are eight sub-watersheds found in the project area which drains outside the project area.

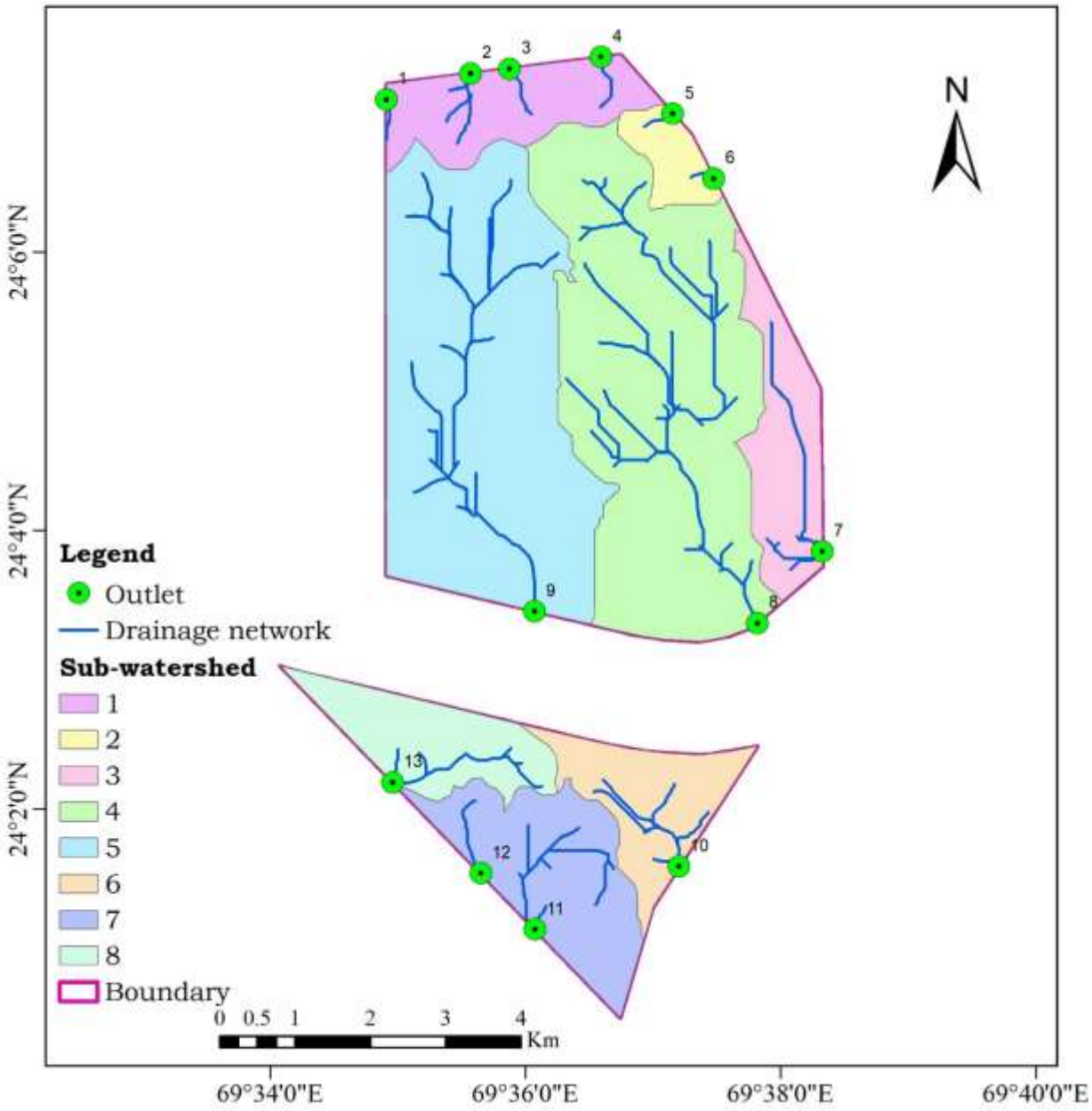


Figure 34: Watershed boundaries and drainage network of the site

There are very small streams and catchment found in the northern side of the project area. Therefore, surface runoff coming from these small catchments can be routed along the project boundary to a common outlet at proper place ***(Figure 34)***. Therefore, these watersheds have been merged together and considered single watershed where suitable water conservation measures can be taken.

The ***Figure 34*** shows that in Block-1 no stream enters in the RE Park, whereas 2 small first order streams enter the Block-2 from the northern side. The stream which is passing through Block-1 is observed dry from last 20-25 years based on the satellite images.

10 RUNOFF POTENTIAL

10.1 Runoff volume

In the present study, surface runoff (mm) has been estimated using SCS-CN method. The CN_{II} was obtained for the project area considering Soil Hydrologic Group-C and desert soils/waste land under poor hydrologic conditions. The $CN(I)_I$, and CN(III) values were determined using Eqn. (8 and 9) associated with AMC-I, and AMC-III conditions, respectively. Further, weighted CN value was estimated considering LULC characteristics and respective areas of classes using eqn. 10. The values of CN(I), CN(II) and CN(III) are computed to be 71.25, 85 and 93 for project site, respectively. Further, maximum potential surface retention capacity (*S*) has been determined using Eqn. 2.7 for the respective AMC conditions. Using Eqn. 6, the surface runoff from the GIPCL project site has been calculated in terms of depth of runoff in mm over a period of 1901 to 2018. The average annual surface runoff was estimated to be 52.58 mm and runoff coefficient (i.e. runoff/rainfall) of 0.15.

The volumetric runoff (m^3) from the entire project site is estimated by multiplying runoff depth (mm) with project area. The surface runoff from Block-1 and Block-2 have been estimated 1.9 Mm^3 and 0.6 Mm^3, respectively. The total average annual runoff from the project site is estimated 2.5 Mm^3. The volumetric average annual runoff estimation from the project area is presented in ***Table 11***. Also, the monthly runoff received from the project area is presented in ***Annexure-F***. The maximum monthly runoff was occurred in the month of August (i.e. 458.59 mm) from the project area. The variation in the average monthly rainfall and runoff from the project (1901 to 2018) is shown in the ***Figure 35***.

Table 11: Runoff estimation by SCS-CN method

SN	Site	Annual rainfall	Runoff	Area	Runoff	Runoff
		mm	(mm)	(ha)	(m^3)	(Mm^3)
1	**Block-1**	348.9	52.58	3693	1941779	1.9
2	**Block-2**			1057	555771	0.6
			Total	**4750**	**2497550**	**2.5**

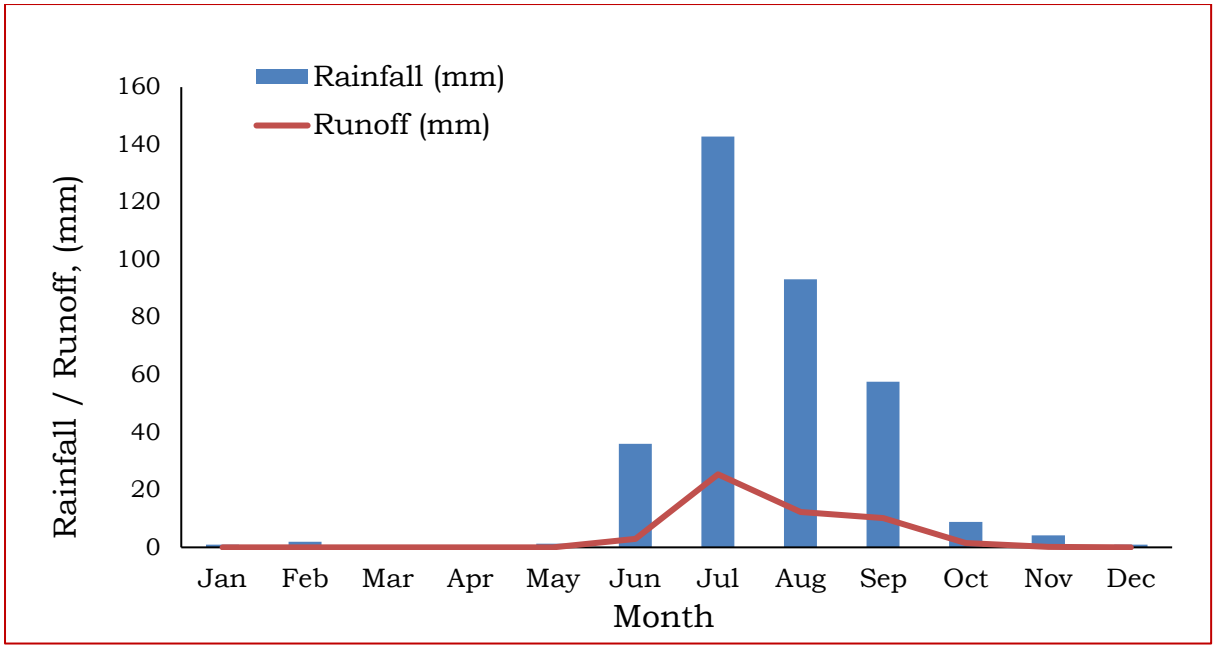


Figure 35: Variation of monthly rainfall and runoff in the site

10.2 Peak Runoff potential

The Rational method has been used to estimate the peak runoff potential based on runoff coefficient, design rainfall intensity and catchment area of AOI. In this computation, the runoff coefficient for rural watershed is takes as 0.31 (C=0.11+0.05+0.10+0.05) for the proposed site (***Appendix-C***) (Thomason, 2019). **Figure 36** shows the outlets for flow of water from the watershed. In the sub-watershed-1, runoff coming from small streams can be routed to common outlet where suitable water conservation measures can be taken (**Figure 36**).

Further, total drainage area of the project site is 4750 ha and design rainfall intensity based on time of concentration (t_c) have been considered. Estimation of t_c for various sub-watersheds is given in ***Table 12***. Rainfall intensity estimated as per t_c is given for different return periods (***Table 13)***. The runoff estimation for the GIPCL site is presented in ***Table 14***.

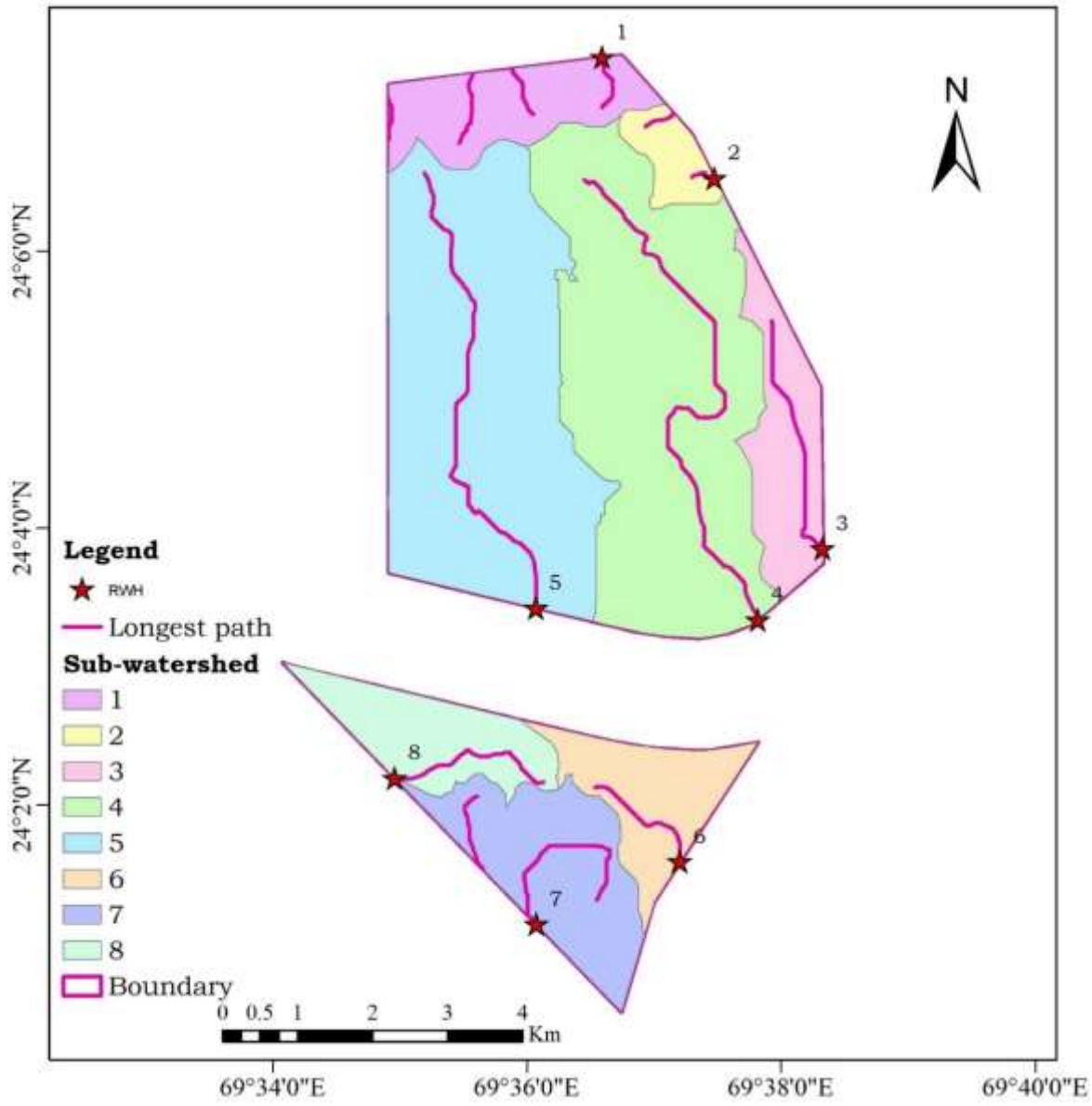


Figure 36: Longest path streams in the catchment area of the site

Table 12: Estimated time of concentration (t_c)

Sub-watershed	Longest Stream length (m)	Av. Slope (%)	t_c (min)	t_c (hr)*
Block-1				
1	799.80	0.08	53.03	0.88
2	384.13	0.02	47.61	0.79
3	3364.56	0.03	235.14	3.92
4	8071.23	0.03	480.88	8.01
5	6809.05	0.04	369.92	6.17
Block-2				
6	1761.87	0.015	182.73	3.05
7	2789.25	0.001	838.83	13.98
8	2374.01	0.008	292.68	4.88

Note: * The t_c is high due to flat land (slope <1%) and merging of some of the sub-watersheds

Table 13: Estimated rainfall intensity as per time of concentration (t_c)

Sub-watershed	Duration (t_c) (hr)	Return Period / Rainfall intensity (mm/hr)	
		50 yr.	100 yr.
Block-1			
1	0.88	84.99	96.68
2	0.79	91.33	103.89
3	3.92	31.39	35.71
4	8.01	19.50	22.18
5	6.17	23.20	26.39
Block-2			
6	3.05	37.11	42.21
7	13.98	13.45	15.30
8	4.88	27.13	30.86

The peak runoff potential of each sub-watershed from a rainfall of 50 and 100 years return period is estimated and presented in ***Table 14.*** It is understood from the ***Table 14*** that from a precipitation of 50 and 100 year return period may have potential to generate surface runoff, which may vary from 5.2 m^3/s to 28.7 m^3/s and 5.9 m^3/s to 32.6 m^3/s, respectively.

Table 14: Peak runoff potential for 50 and 100 year return periods

Sub-watershed	**Runoff coefficient**	**Return Period / Rainfall intensity (mm/hr)**		**Area**	**Peak runoff (m^3/s)**	
	C	**50 yr**	**100 yr**	**(ha)**	**50 yr**	**100 yr**
Block-1						
1	0.31	84.99	96.68	332.2	24.3	27.7
2	0.31	91.33	103.89	107.9	8.5	9.7
3	0.31	31.39	35.71	318.2	8.6	9.8
4	0.31	19.50	22.18	1499.0	25.2	28.6
5	0.31	23.20	26.39	1435.2	28.7	32.6
Block-2						
6	0.31	37.1	42.2	300.2	9.6	10.9
7	0.31	13.4	15.3	450.6	5.2	5.9
8	0.31	27.1	30.9	306.2	7.2	8.1

The engineering measures should be decided on the basis of each sub-watersheds runoff potential (volume and peak rate of runoff potential). The study results indicate that project area will be prone to temporary water impoundment during peak rainfall. However, appropriate arrangement of drainage structures will not create impounding in the project area.

11 FLOOD RISK ASSESSMENT

A Flood Risk Assessment (FRA) is an assessment of the risk of flooding from all flooding mechanisms, the identification of flood mitigation measures and should provide advice on actions to be taken before and during a flood.

The sources of water which may produce floods in the present case include: (a) Surface water, (b) Artificial water (burst water mains, canals or reservoirs), (c) Rivers, streams or watercourses, (d) Sewers and drains, (e) High groundwater or saturated vadose zone and (f) Flooding of low-lying coastal regions due to sea level rise.

For each of the sources of water, different flood hydraulic intensities occur. Floods can also occur because of a combination of sources of flooding, such as high groundwater and an inadequate surface water drainage system. The topography, hydrogeology and physical attributes of the existing or proposed development need to be considered. A flood risk assessment should be an evaluation of the flood risk and the consequences and impact and vulnerability.

Numerous Gullies and temporary streams are passing through study area. These gullies are temporary and flows during only monsoon season and there are some major streams which are in existence for a very long time (but non-perennial in nature). Previous satellite images also confirm the presence of some streams.

This should be considered in design of infrastructure of earthen bunds, storm water drainage for smooth passage of water if possible.

Gullies are formed by increased surface runoff which acts as a cutting agent. The size of gullies depends on the surface runoff generated from the nearby area. The main physical factors effecting the rate and amount of surface run-off generation are precipitation, topography, soil properties and vegetative cover.

Surface water risk includes risk from flooding of streams / channels and flooding due to rainfall.

11.1 Flooding risk due to streams/channels

There are no major dams/streams in the project site (***Figure 34***). Kutch Disaster Management Plans 2017-18 indicates that River flooding is a not major hazard faced by the district. All the river systems in the Rann of Kutch district are very low flooding, as captured in the Vulnerability Atlas. No major flood event record is available from the study area. Some of the areas in the southern part of the district faces flooding, primarily due to heavy rain and drainage issues.

The proposed site for RE-Hybrid Park is mostly located over a flat terrain except for few patches of undulating land (***Figure 33***). This is also clearly observed in the Google Earth Image (***Figure 37***). There are few topographical low-lying areas in some portion of the site and rest of the portions of the site is located more or less on the plain grounds. The topographical high lands of the site are mainly acting as the runoff zones wherein there will not be any impoundment of storm water during rainy days. Whereas, the topographical low lands may have temporary storm water impoundments during high intensity rainfall. A network of streams has developed, which will drain the water from the AOI.

Drainage map derived from GIPCL provided survey data indicates that slope, in general, is gentle and it is in five directions in the Block-1 and in two directions in the Block-2 (***Figure 34***).

Course of channels/streams varies depending on the upstream catchment area and slope. As far as the AOI is concerned, the historical data reveals that the south, south-eastern, north-eastern, north and north-western part of the Block-1 of GIPCL only shows changes in the temporary streams/gullies whereas rest of the area does not show any change. While in Block-2, eastern and western part of the block show some changes in drainage network

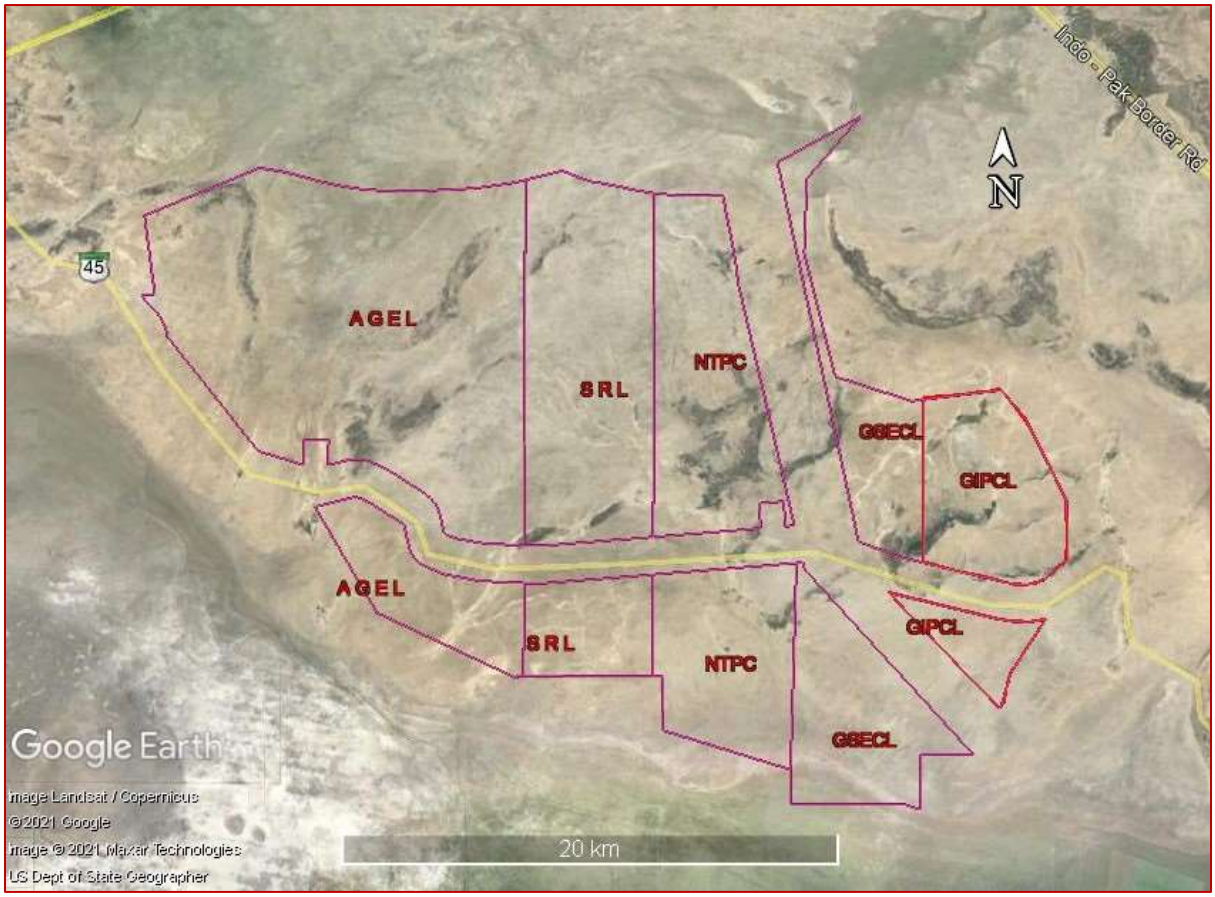


Figure 37: Proposed project sites for different agencies

11.2 Flood risk from nearby water bodies

The study of google earth images and ASTER DEM of the area shows that there is no surface water inflow into the GIPCL lease area. Moreover, the water bodies lying towards east and south have never shown any advancement towards the lease area over 35 years of satellite data available (1995 to 2000). Therefore, there is no risk from nearby water bodies to the GIPCL project site (***Figure 38***). Based on contour survey data provided by GIPCL, a 5m DEM has been generated and streams are extracted for the project area. It is found that all the streams and tributary of channels/streams are flowing away from the GIPCL site (***Figure 38***).

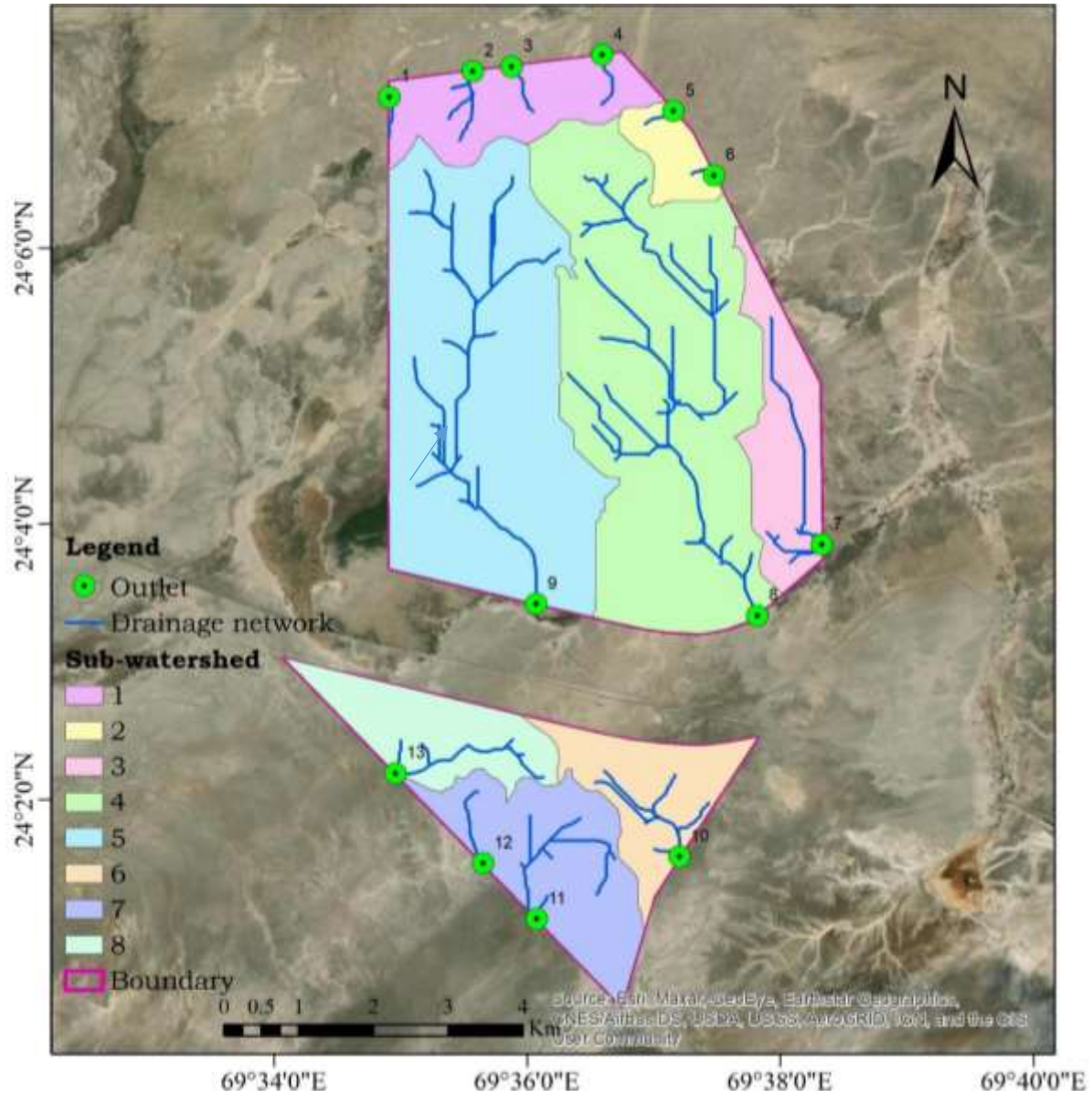
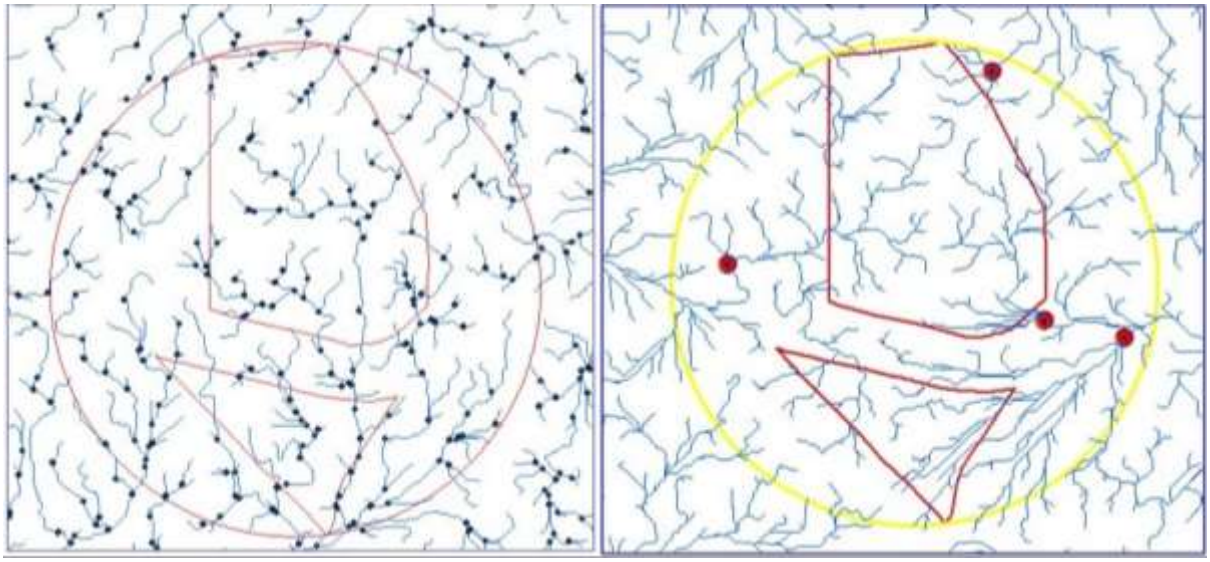


Figure 38: Streams extracted using DEM based on contours survey data

This was further confirmed with drainage generated from ALOS PALSAR (12.5 m resolution) and ASTER (30 m resolution) DEM (***Figure 39***).

The stream network was delineated using lower value of accumulation derived from ALOS PALSAR and ASTER DEM. The reduction in pixel value increased the stream density and very small stream were detected in the AOI (***Figure 39***). Since, the elevation difference of the site significantly lesser than vertical accuracy of these DEMs (15 to 20 m with 90% confidence level), we consider only main streams delineated from DEM (5m resolution) based on GIPCL contour survey data. Further to verify the existence of drainage network on site physical survey was also carried out.



(a) (b)

Figure 39: Streams extracted from a) ALOS PALSAR & b) ASTER DEMs

Superimposition of the contour maps on the available satellite images of the previous years, indicates that the High Flood Level in the Rann of Kutch had reached to the elevation of 2.4 m to 2.7 m above mean sea level (amsl) during the earlier year of 1984 and 1992. While comparing the images of the recent years of 2019 and 2020, it is seen that the water level stays near the elevation of approx. 1.5 m. The minimum elevation in the RE Park is 3.88 m amsl.

From the field investigations, historical satellite images and the interpreted stream lines for the past years has revealed that the site is not in major flood risk zone.

11.3 Flood risk due to rainfall

As per the rainfall data available, the site has received maximum rainfall of 339.8 mm during May 1999. This event was related to *Very Severe Cyclonic Storm* (intensity of T-5.5) developed in Arabian Sea which had hit the Kutch area of Gujarat. Most intense cyclones that hit west coast on India including Gujarat during 1970 to 2021 are listed in ***Appendix-D***. Risk assessment due to rainfall has been already assessed and discussed in the runoff potential estimation *Chapter 10*.

12 SOIL EROSION ASSESSMENT

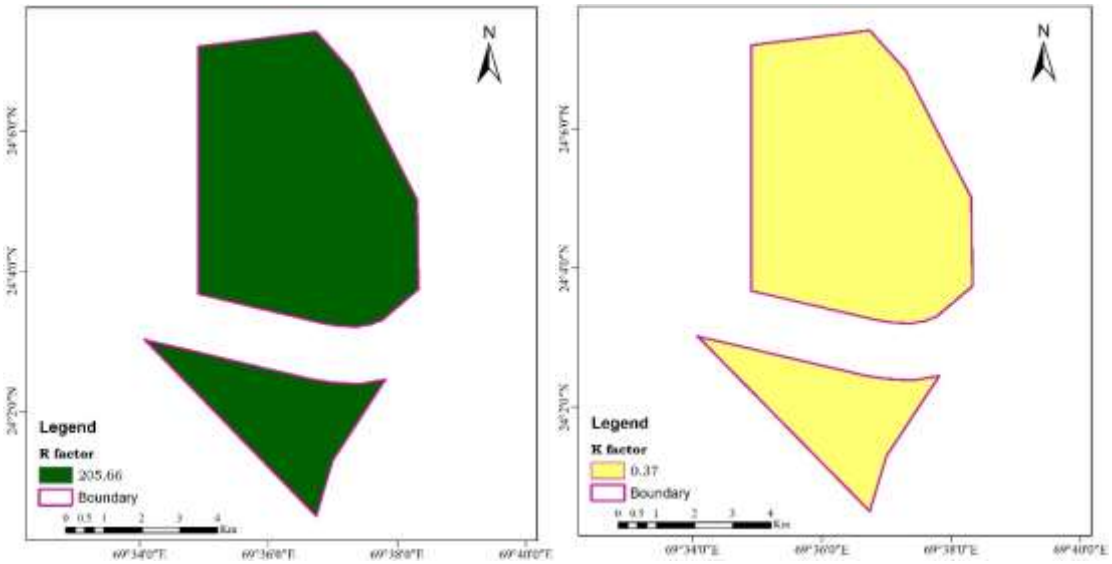
Soil erosion is an important economic and environmental concern throughout the world. Soil erosion is a complex process that is related to soil properties, topography, land cover, and human activities. In order to assess soil erosion risk and conserve soil and water soil resources, soil erosion modeling has been carried out at the watershed scale in the project area. This study estimated soil erosion using Revised Universal Soil Loss Equation (RUSLE) in a Geographic Information System (GIS) platform. This study will be an important input for identification and prioritization of critical areas for soil erosion control measures/practices in the project area.

For soil erosion estimation, USLE and its derivatives, Revised USLE (RUSLE) is the most widely used empirical models because of their minimal data and computation requirements (e.g. Merritt et al., 2003). The USLE and RUSLE models estimate average annual gross erosion as a function of rainfall energy.

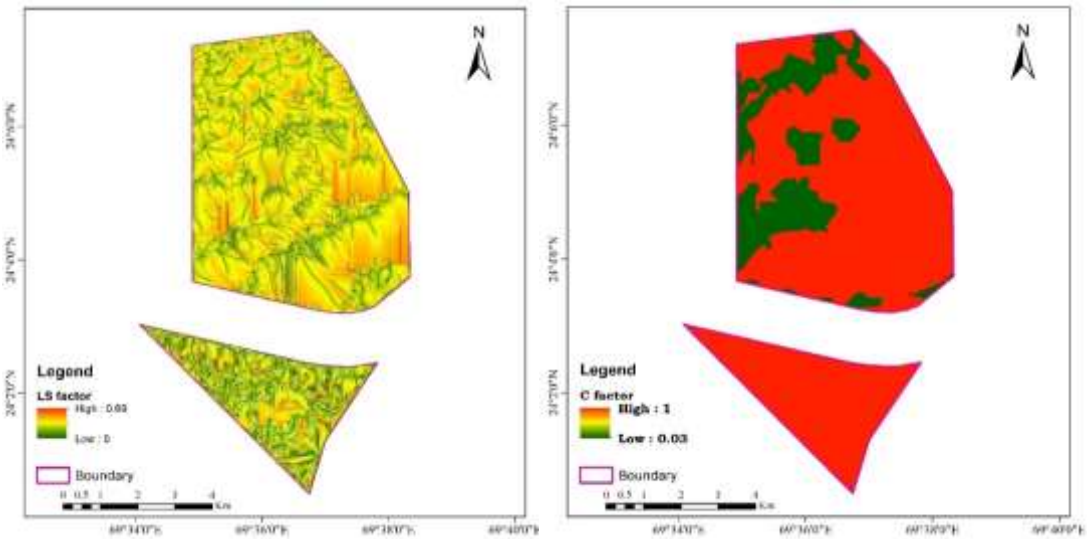
12.1 Estimation of Soil Erosion

The average annual soil loss map of the GIPCL project area was prepared using RUSLE method. The values for the factors R, K, LS, C and P are computed for different grids based on the DEM and database available from literature survey. The detail methodology adopted for the computation of each of these factors is presented in *Chapter 4, section 4.2.4*.

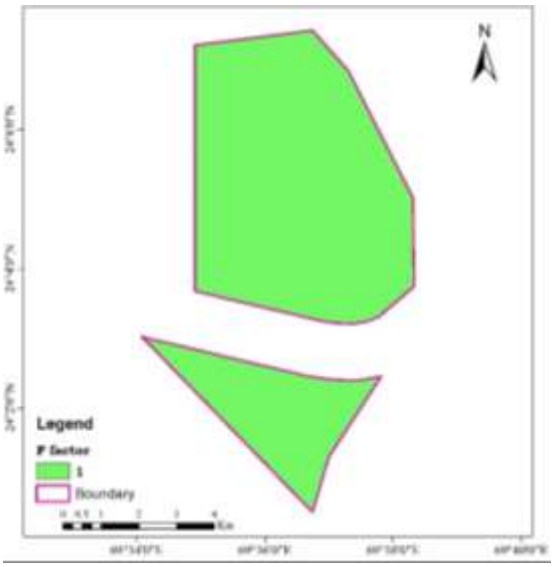
The USLE parameters, i.e., R,K,LS,C,P maps (***Figure 40***) were integrated in ArcGIS using raster calculator to derive the composite map of soil erosion potential (***Figure 41***). Maps depicting gross amount of soil erosion from different descretized cells of the project areas were computed by multiplication of the erosion potential map produced by integration of RKLSCP maps. The net erosion estimated on a cell basis for the project area was grouped into the following scales of priority: *Slight* (0 to 5 t ha^{-1} y^{-1}), *Moderate* (5 to 10 t ha^{-1} y^{-1}), *High* (10 to 20 t ha^{-1} y^{-1}), *Very High* (20 to 40 t ha^{-1} y^{-1}) and *Severe* (> 40 to t ha^{-1} y^{-1}) erosion classes as per the guidelines suggested by Singh et al. (1992) for Indian conditions ***(Table 13)***.



a) R factor map b) K factor map



c) LS factor map d) C factor map



e) P factor map

Figure 40: Thematic input database used for soil erosion estimation

Results indicated that 55% area is under moderate erosion class, whereas 32.87% area falls under the slight class erosion zone (***Table 15***). ***Figure 41*** clearly indicates that treatment of soil conservation with the help of runoff potential will be a key factor for excellent watershed management.

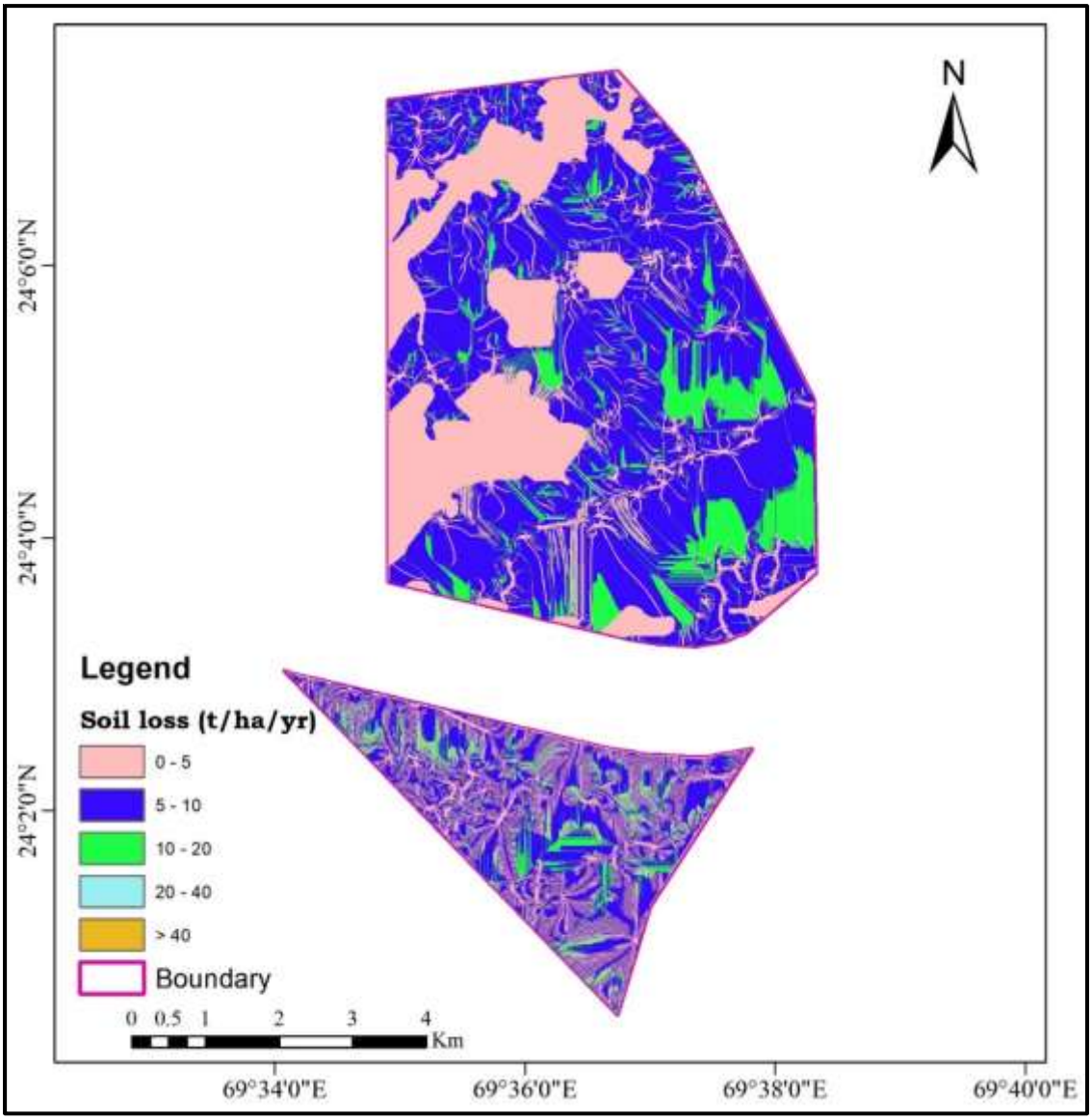


Figure 41: Average annual soil erosion from the project area

Table 15: Different classes of soil erosion in the project area

SN	Net Erosion (t ha^{-1} y^{-1})	% area	Severity
1	0-5	32.87	Slight
2	5-10	55.13	Moderate
3	10-20	11.38	High
4	20-40	0.53	Very High
5	> 40	0.08	Severe

Area covered by moderate, high, very high and severe erosion zones taken together found to be 67% and can be termed as critical erosion prone areas requiring immediate attention from soil conservation point of view.

12.1 Estimation of Sediment Deposition

The average annual soil loss within watershed was found to be 9.96 t ha^{-1} y^{-1}. The information shown in **Figure 41** could be utilized for identification of the sediment source areas of the watersheds. Gross soil erosion is estimated to be 47,316 tonnes. Based on gross soil erosion and sediment delivery ratio, the sediment yield is estimated to be 10,410 tonnes.

Depending upon priority levels, the watershed area should be treated with suitable vegetative and structural measures. Remedial measures are needed in high runoff potential zones to minimize the surface runoff and soil erosion in the watersheds. The suitable catchment treatment measures (i.e. engineering and biological measures) such as contour bunds, terraces, pasture development, afforestation and gully control structures can be adopted based on the severity of erosion in the watershed according to the soil, climatic and topographical conditions (Das 2008).

13 GROUNDWATER ASSESSMENT

Ground water regime monitoring in Kutch district is carried out by CGWB four times a year i.e., during January, May, August and November through 48 National Hydrograph Network Stations (NHNS). But unfortunately, no monitoring is being done even by CGWB in the Great Rann of Kutch.

13.1 Groundwater Conditions

For determining the groundwater conditions, 28 bore wells were constructed by M/s GIPCL through M/s Unique Engineering Services, Gandhinagar. Groundwater was encountered from 2.00m to 4.50m depth below ground level during the month of December 2020. Depth to water table and water table position is given in ***Table 16.***

Table 16: Groundwater levels observed in GIPCL project area

SN	Well No.	Northing	Easting	Ground Elevation	Well Depth	Depth to Water Table	Water Table
		m	m	m amsl	m bgl	m bgl	a msl
1	BH-1	2659249	558986	4.70	50	2.20	2.50
2	BH-2	2658766	560446	4.25	30	2.20	2.05
3	BH-4	2658420	563002	4.21	50	2.20	1.99
4	BH-5	2658086	559888	4.29	50	2.00	2.29
5	BH-6	2657351	561330	3.99	30	1.90	2.09
6	BH-7	2656232	562087	4.10	50	2.20	2.10
7	BH-9	2661383	559525	5.83	50	4.50	1.33
8	BH-10	2661089	560920	5.21	50	4.00	1.21
9	BH-11	2660618	562465	5.24	30	4.20	1.04
10	BH-12	2661281	564073	4.86	50	4.50	0.35
11	BH-13	2662474	559509	6.26	30	3.90	2.36
12	BH-14	2662677	561075	7.12	50	4.40	2.72
13	BH-15	2662004	562554	5.43	50	4.30	1.13
14	BH-16	2662169	564254	5.06	50	4.30	0.76
15	BH-17	2663596	559482	6.19	50	3.00	3.19
16	BH-18	2663906	560804	6.14	50	3.50	2.64
17	BH-19	2663576	562593	5.87	50	4.30	1.57
18	BH-20	2663509	564159	5.51	50	4.40	1.11
19	BH-21	2664999	559688	6.60	50	3.50	3.10
20	BH-22	2665252	561390	6.90	30	4.40	2.50
21	BH-23	2664879	562834	6.30	30	4.30	2.00
22	BH-24	2664666	563996	6.05	50	4.40	1.65

SN	Well No.	Northing	Easting	Ground Elevation	Well Depth	Depth to Water Table	Water Table
		m	m	m amsl	m bgl	m bgl	a msl
23	BH-25	2665989	559725	7.39	30	4.40	2.98
24	BH-26	2666558	561205	7.74	50	4.00	3.74
25	BH-27	2666128	562981	6.77	50	4.30	2.47
26	BH-28	2667219	559649	7.83	35	3.30	4.53
27	BH-29	2667619	560896	6.90	30	3.00	3.90
28	BH-30	2667442	562307	7.07	50	4.30	2.77

Depth to water level map and Groundwater flow direction maps are shown in ***Figure 42*** and ***Figure 43***.

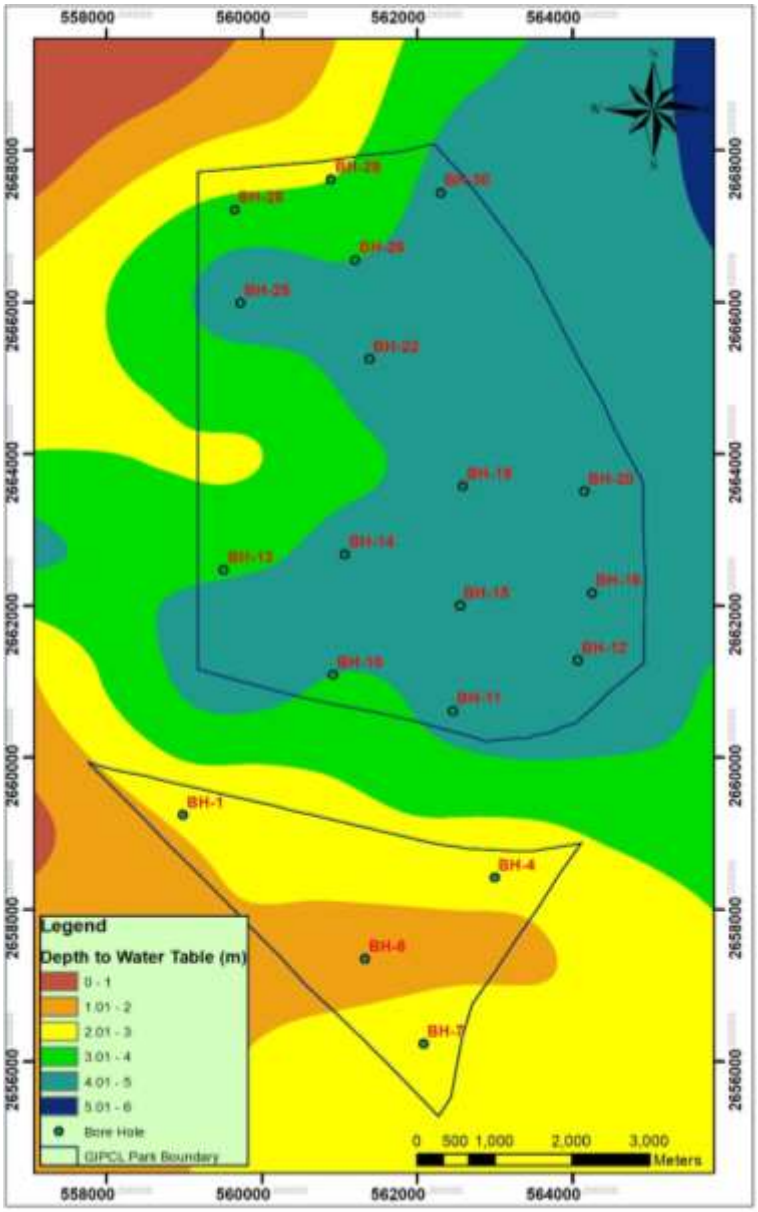


Figure 42: Depth to water level in the project site area

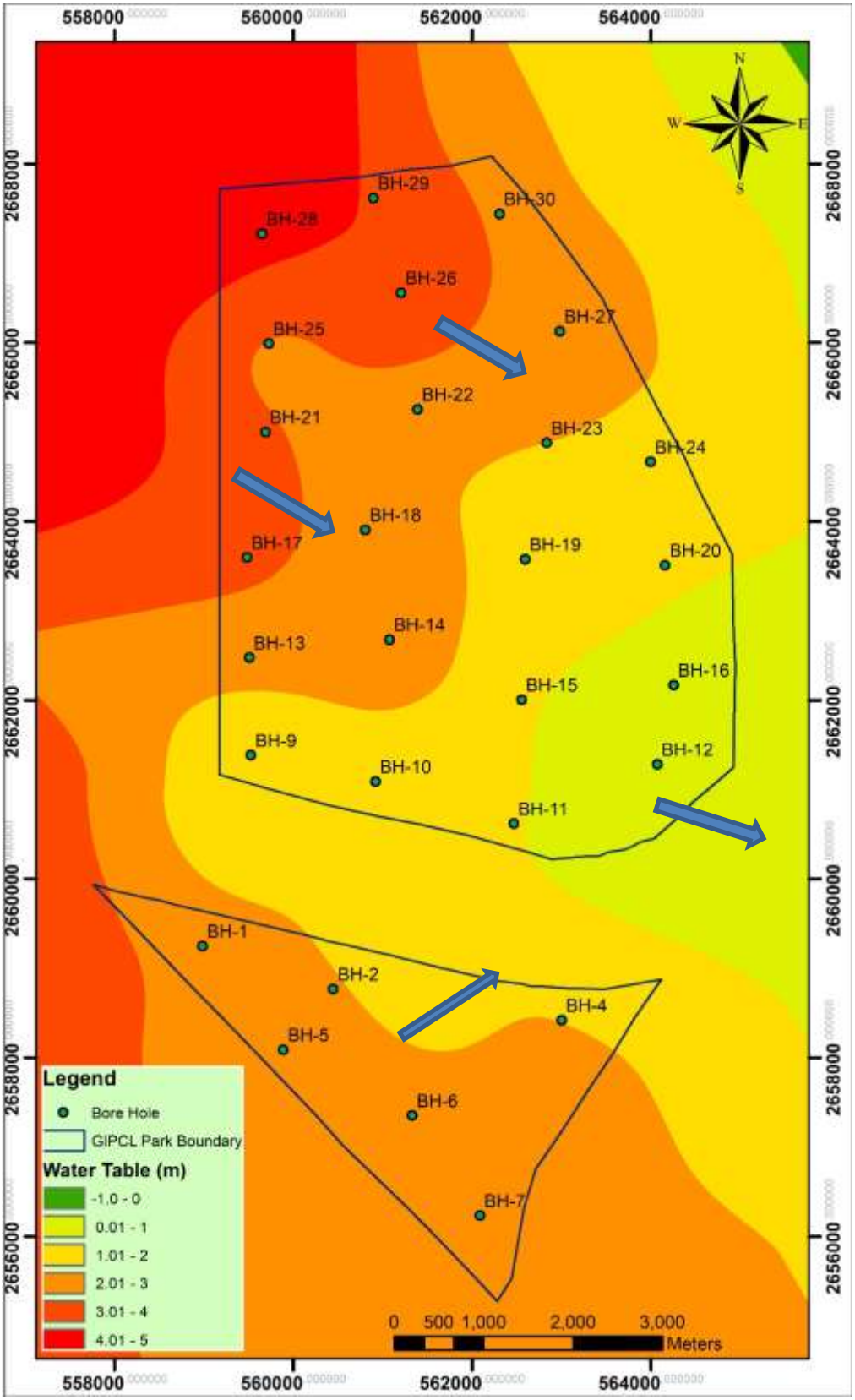


Figure 43: Water Table map of the project site area

(Blue arrows indicate general groundwater flow direction)

The Rann is reported to be flooded seasonally during the monsoon rains. During the Monsoon the western part of Great Rann is inundated by sea water which reaches as Far East as Kuar bet and Pachchham Island and foot hills of Kalo Dungar. Major part of the area is flooded annually due to rainwater and discharge from the rivulets and stream draining from the Kutch Mainland and Banni plains. It is also influenced by the intertidal creeks. Hence the area is an eco-sensitive zone showing predominantly marine influence. Owing the impervious nature of the Rann Clays, it takes several months to become dry again. The low-lying portion of the Rann remains permanent wet with salt encrustation layer.

13.2 Groundwater Quality

The quality of ground water in the area has been determined in 19 borewells drilled. Groundwater in the area is very saline with TDS in the range of 99,000 mg/L to 108,000 mg/L (***Table 17***).

Table 17: Water quality of groundwater in the project site area

Sr. No.	Bore Hole	pH	TDS (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)
1	BH-1	6.81	108,520	7	2,181
2	BH-4	6.72	107,321	5	2,262
3	BH-6	7.00	108,521	5	4,032
4	BH-7	6.62	107,852	7	3,528
5	BH-10	7.05	102,641	5	2,632
6	BH-11	6.71	107,493	8	2,305
7	BH-12	6.92	105,241	5	3,064
8	BH-13	6.81	103,210	6	3,236
9	BH-14	6.53	108,361	8	2,218
10	BH-15	6.61	105,211	5	2,205
11	BH-16	6.52	105,923	6	2,854
12	BH-19	6.58	106,852	7	2,157
13	BH-20	6.55	103,794	5	3,125
14	BH-22	6.82	99,871	6	2,987
15	BH-25	7.01	106,194	8	2,635
16	BH-26	6.73	107,932	7	2,197
17	BH-28	6.65	108,126	6	2,152
18	BH-29	6.59	107,623	7	2,105
19	BH-30	7.02	106,321	10	2,595

TDS distribution in the area is shown in the ***Figure 44***. The data indicates high TDS and Sulphate values. Nitrates are low and are within acceptable limits.

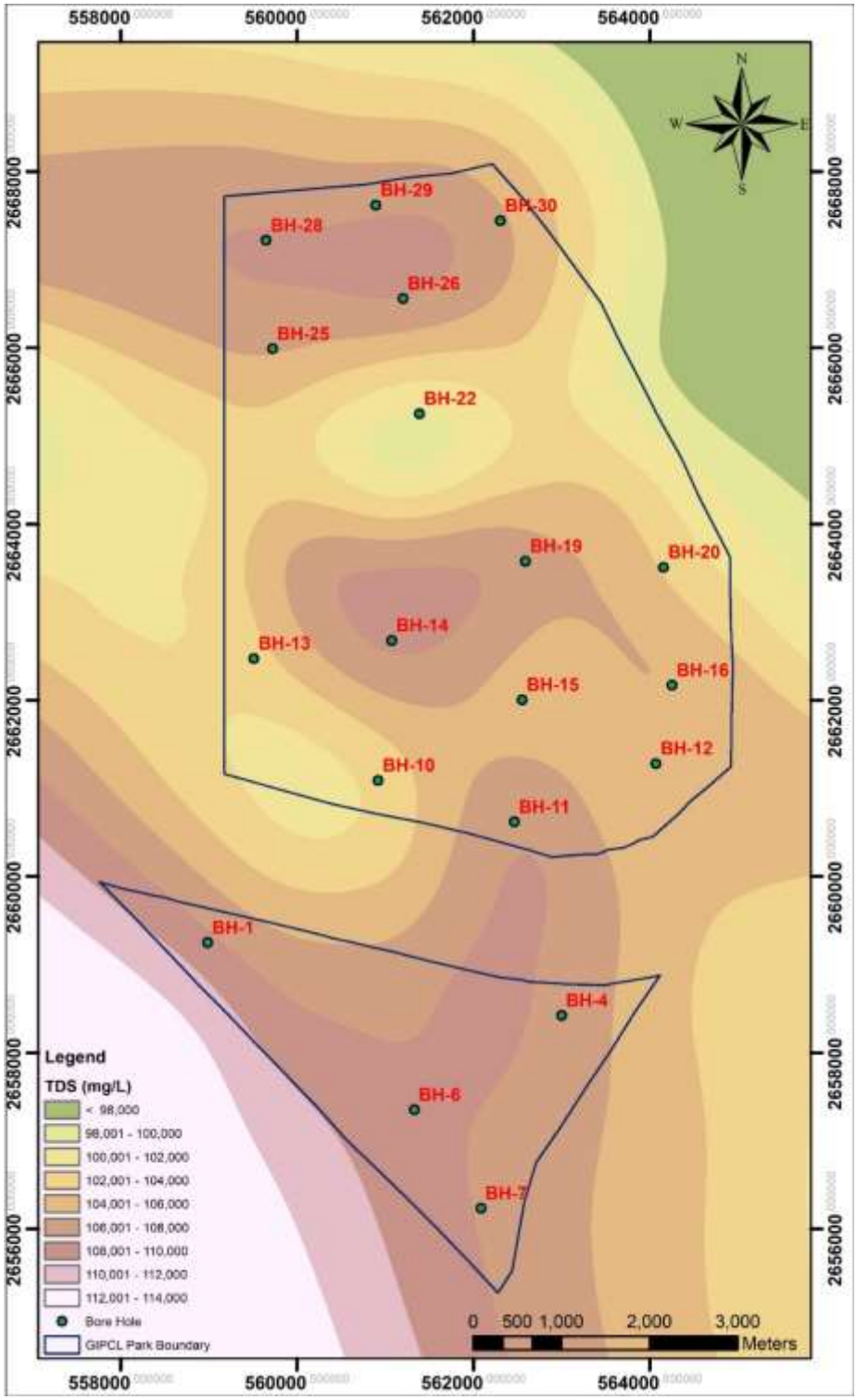


Figure 44: TDS variation in the GIPCL RE Park area

13.3 Resistivity survey

Geophysical survey is ground-based physical sensing techniques used for mapping of subsurface geology. One of the geophysical methods used in the study was surface electrical resistivity to measure the physical properties of the subsurface, along with the anomalies in those properties.

Resistivity surveys have proven to be one of the most useful geophysical techniques in groundwater investigation. In Resistivity method, a known electrical current (I) is sent into the ground through a pair of electrodes (current electrodes) and the potential (V) developed due to this current is measured across two other pair of electrodes (potential electrodes).

The survey was carried out by M/s Unique Engineering Services, Gandhidham using Wenner's configuration of electrodes.

In Wenner's Configuration four electrodes A, B, M, and N are placed at the surface of the ground along a straight symmetrically about a point O. The observation point in such a way that the distance between AM = MN =NB = a, where 'a' is called electrode separation (***Figure 45***). The current 'I' is sent generally through outer electrodes A and B and the potential difference (V) is measured between M and N. The configuration factor (K) for this array is K = 2πa and apparent resistivity, which is used for further analysis, is calculated with the formula:

$$a = KR = 2\pi aR$$

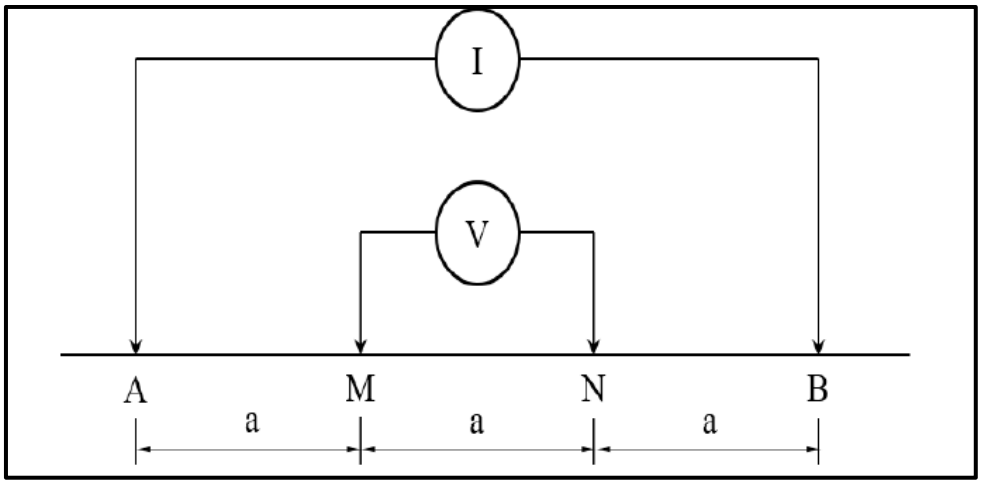


Figure 45: Wenner's Configuration for resistivity measurement

Apparent resistivity was measured at 15 locations (***Figure 46***).

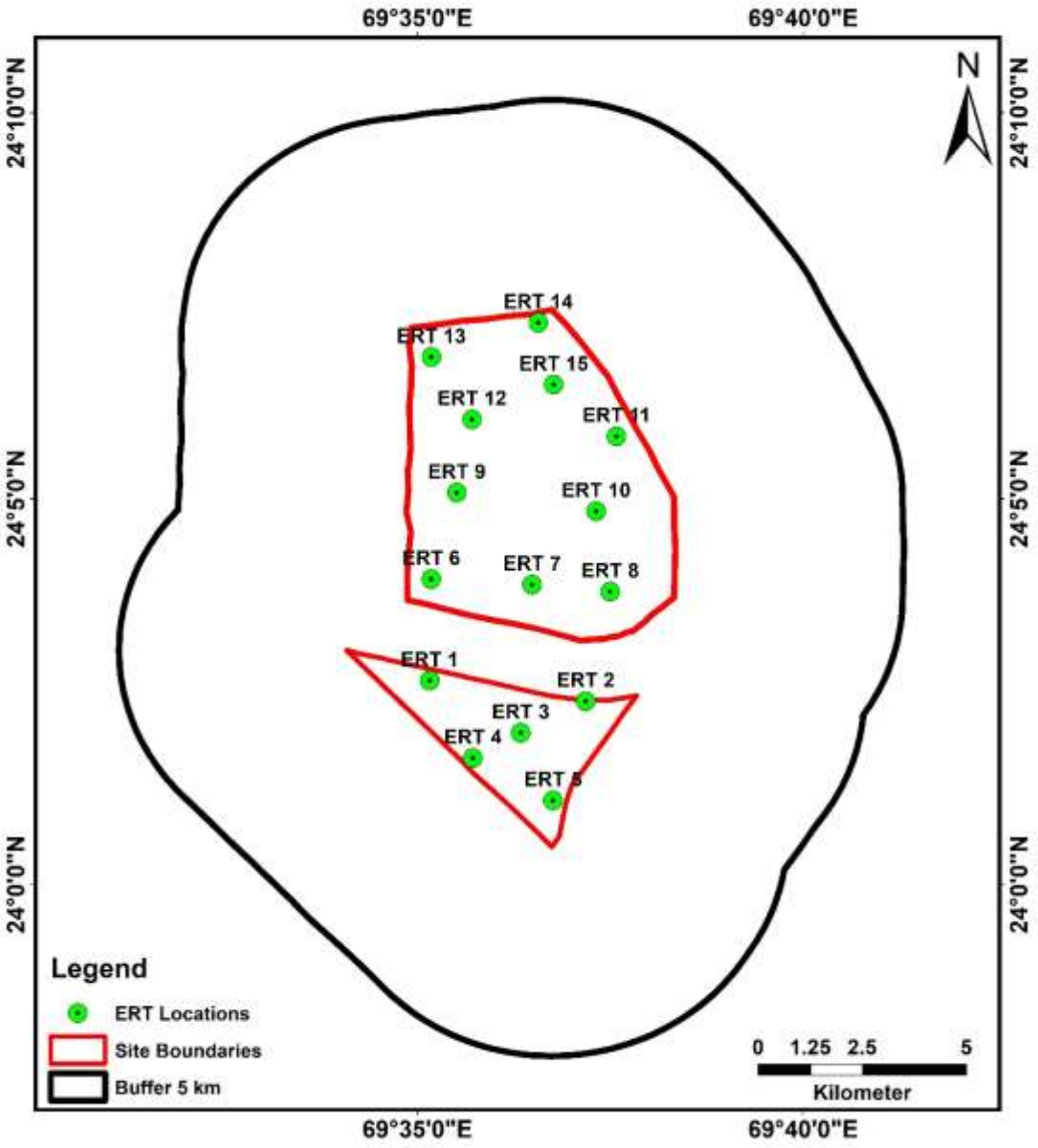
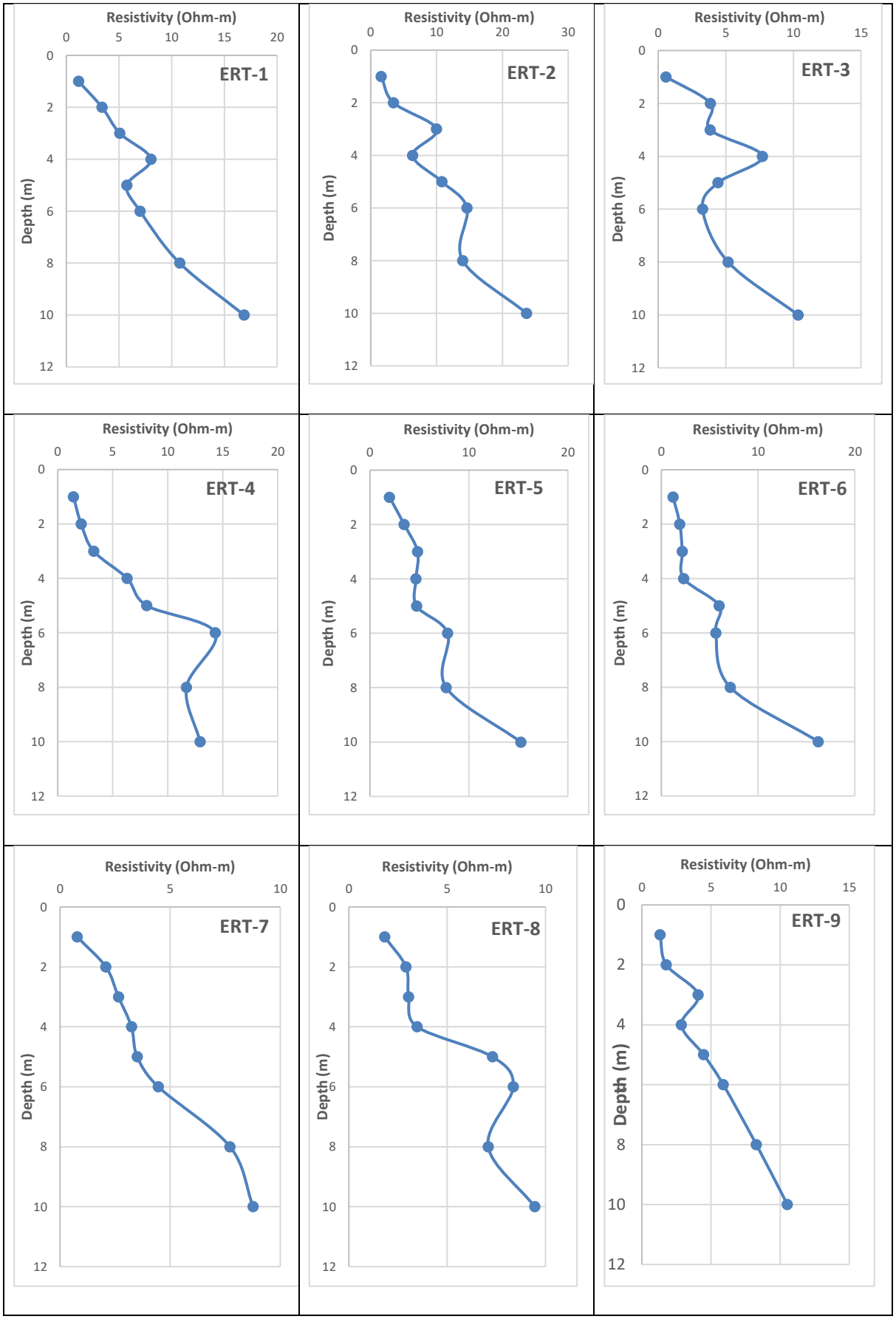


Figure 46: Location map of resistivity measurement sites

Apparent resistivity values with depth are tabulated in ***Table 18*** and are plotted in ***Figure 47***. The resistivity data shows apparent resistivity values generally lower than 10 and maximum upto 20 ohm-m, which indicates presence of clayey soils / highly saline soils/ saline water. The resistivity results match with the finding obtained from borehole drilling.


Resistivity (Ohm-m)
Depth (m)
ERT-1
ERT-2
ERT-3
ERT-4
ERT-5
ERT-6
ERT-7
ERT-8
ERT-9

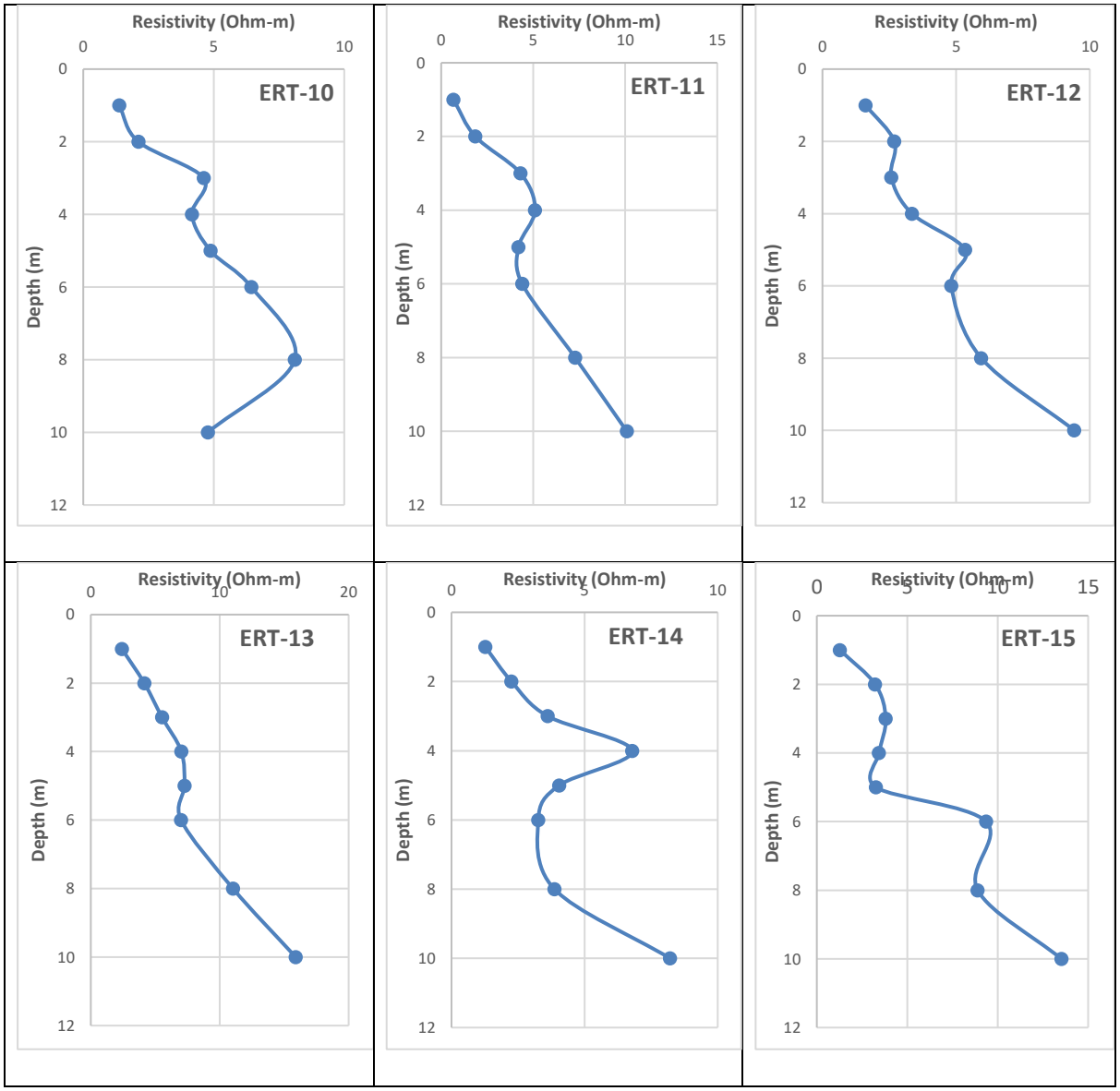


Figure 47: Apparent Resistivity with depth at various locations

Table 18: Apparent resistivity measured at various locations

No.	Latitude	Longitude	Depth (m)							
			1m	2m	3m	4m	5m	6m	8m	10m
ERT 1	24.0440	69.5860	1.161	3.390	5.075	8.024	5.741	7.003	10.757	16.870
ERT 2	24.0396	69.6197	1.604	3.453	10.009	6.359	10.816	14.618	13.974	23.672
ERT 3	24.0327	69.6056	0.589	3.870	3.850	7.716	4.422	3.289	5.177	10.352
ERT 4	24.0273	69.5953	1.425	2.127	3.266	6.308	8.097	14.316	11.699	12.943
ERT 5	24.0182	69.6126	1.982	3.465	4.821	4.656	4.720	7.860	7.716	15.252
ERT 6	24.0660	69.5863	1.214	1.916	2.168	2.318	5.985	5.636	7.125	16.226
ERT 7	24.0648	69.6081	0.779	2.080	2.653	3.242	3.503	4.458	7.716	8.765
ERT 8	24.0632	69.6250	1.828	2.906	3.035	3.475	7.304	8.360	7.087	9.456
ERT 9	24.0846	69.5918	1.318	1.769	4.072	2.859	4.469	5.890	8.281	10.524
ERT 10	24.0806	69.6219	1.376	2.114	4.613	4.166	4.877	6.437	8.105	4.775
ERT 11	24.0968	69.6263	0.669	1.857	4.312	5.102	4.202	4.401	7.276	10.085
ERT 12	24.1004	69.5951	1.613	2.689	2.576	3.349	5.341	4.825	5.944	9.425
ERT 13	24.1139	69.5863	2.410	4.147	5.528	7.025	7.265	7.003	11.033	15.896
ERT 14	24.1213	69.6094	1.268	2.253	3.610	6.792	4.045	3.261	3.870	8.215
ERT 15	24.1080	69.6128	1.277	3.226	3.812	3.443	3.267	9.359	8.897	13.525

14 FRESH WATER AVAILABILITY

As per CGWB reports, only Pachchham Island is the only fresh water source near to the buffer zone from project boundary (***Figure 48***). The Pachchham Island lies at a distance of approximately 15 km from the project boundary. Geological formations of the Pachchham Island belongs to the Tertiary System of Mesozoic Period.

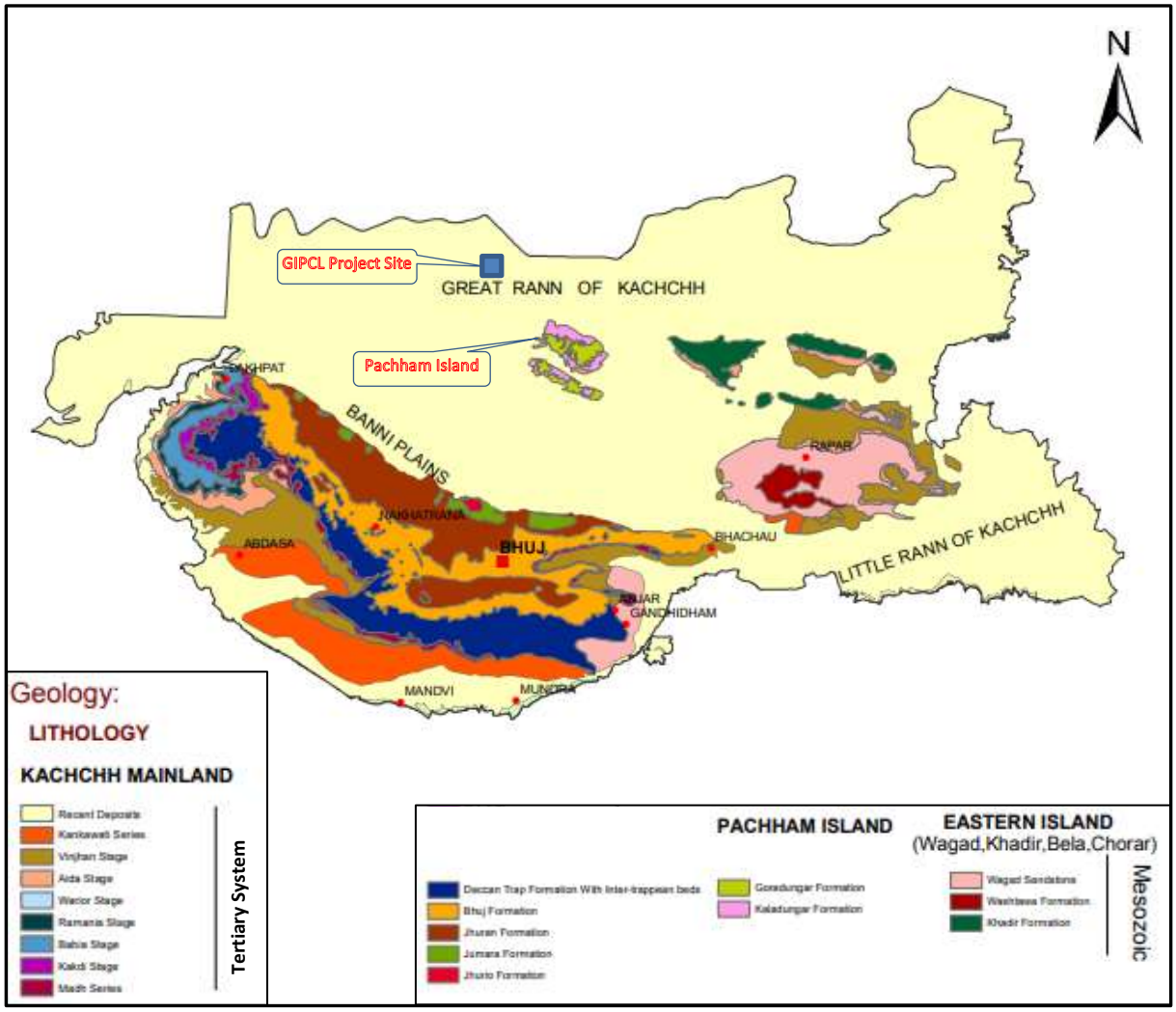


Figure 48: Proximity of fresh water source GIPCL RE Park area

The sediments belonging to Mesozoic period include both marine and non-marine sedimentary formations. The rocks of this series consist of yellow and greyish coloured sandstone, shale, and fossiliferous. Limestone and represent marine sedimentary sequence. The groundwater occurs under water table and confined conditions in the sandstone/shale sequence belonging to this group.

The semi-consolidated sandstone exposed in the lower reaches forms phreatic aquifer and is being developed locally for domestic and irrigation purposes. The dug wells tapping this aquifer ranges in depth from 10 to 24 m below ground level (m bgl) whereas the depth to water level during summer varies from 15 to 20 m bgl. Their yield varies from 50 to 175 m^3/day. The quality of groundwater is potable to slightly brackish near Rann and lower reaches while the deeper groundwater is saline.

14.1 Groundwater regime in nearby area

Hydro-Geologists of the Indian Geomatics Research Institute have carried out Well Inventory Survey to check nearby freshwater potential sites and hydrological conditions of the area.

One Artesian Well found in the valley of Kalo Dungar is constantly overflowing on the surface due to enough pressure in the aquifer. Artesian well is locally known as Samdha Vav. The coordinates of the well are 23°51'32.2"N latitude and 69°48'54.8"E longitude. Maldhari resident's uses artesian well water for drinking purpose of humans and also of animals.

The nearest fresh ground aquifer from the proposed project site is approximately 15 km in South East direction near Khavda in Pachham island. Water level in the area is around 9 m. The quality of the water is good and most of the parameter fall within permissible limits except fluoride which was found to be slightly above permissible limits.

14.2 Surface water availability

There is no perineal stream flowing through the RE Park or its 5 km buffer area. Also, there is no reservoir at 3-5 km from the plant. Nearest fresh water source is Bandi River which is located at 10-12 km south east of the RE Park area (***Figure 49***). Bandi River originates from the Kalo Dungar hills and through the Khavda village. Two small reservoirs have been created on the river and its tributary to store water.

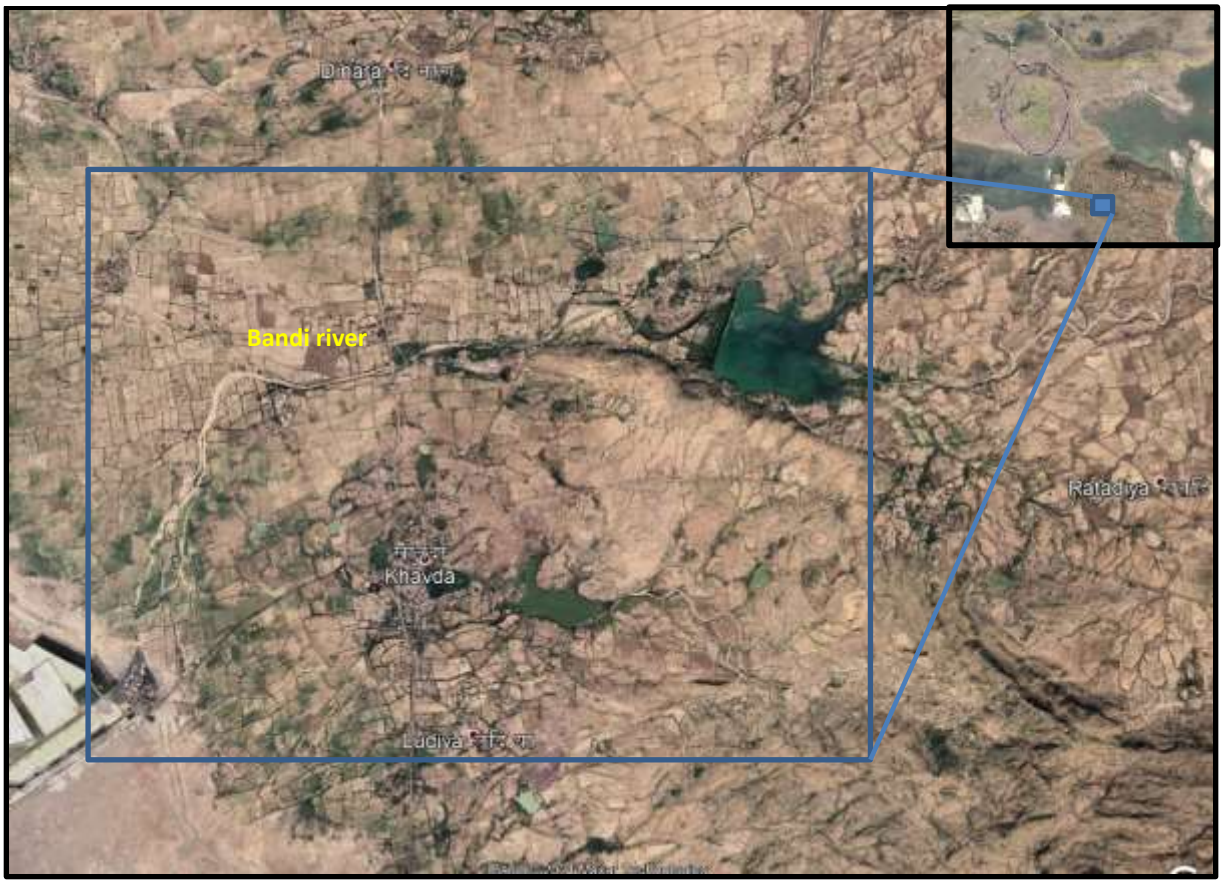


Figure 49: Bandi River vis-à-vis RE Park

As per information from the local people, Bandi river is not a perineal river and flows only during Monsoon season. The water from the river may not be enough to meet the fresh water requirement of the RE Park.

14.3 Fresh water from desalination of groundwater

The total freshwater requirement of the RE Park is 3.1 MLD or 31 or 3,000 m^3/day. As fresh surface water and groundwater are not available in the RE Park area or in the 5 km vicinity of the Park, possibility of obtaining fresh water through desalinization of saline groundwater has been explored.

Considering the recovery of 70% fresh water from saline groundwater, approximate 4.5 MLD of saline water is required.

Saline water can be pumped by installing tubewells. Location and depth of tubewells may be determined detailed geophysical / geological investigations.

As the saline groundwater is locally available, only one day storage of saline water has been considered.

Dimensions of water storage reservoirs

Total saline water to be stored = 4500 m^3

Volume = Length (L) x Width (W) x Height (H)

As the groundwater is shallow (<5 m), the maximum depth considered for the reservoir is 4.5 m.

So the area of reservoir for storage of saline water = 4500/4.5 = 1000 m^2.

Therefore, dimensions of the saline water storage reservoir = 40 X 25 X 4.5 m.

Fresh water from the desalinization plant may be transferred to the 24 plots, where the water can be stored in small tanks / ponds. Size for storing fresh water for each plot for 2 days is calculated below:

Water to be stored for days at each plot = 2 days * (3.1 MLD /24 Plots)

= 0.258 Million liter = 258 m^3

Dimension of the Pond / Tank = 8 m X 8 m X 4.5 m

Disposal of concentrate:

Brine disposal is an environmental problem that should be considered while installing a desalination plant. In most cases, the easiest way to get rid of the important brine flow is to discharge it in the sea via a brine outfall pipe. Brine concentration has a much higher density than seawater and therefore tends to fall on the sea floor near the brine outfall outlet (plume effect), creating a very salty layer which can have negative impacts on the flora and the marine life and any related human activities. To avoid the plume effect, the brine outfall should end within a strong sea current to aid mixing the brine with seawater.

There various methods available to dispose concentrate includes dispose to surface waters (in creek, tidal rivers), deep well injection, land application,

evaporation ponds and zero liquid discharge. The most suitable methods are zero liquid discharge and evaporation pond for the present study area.

The waste water or brine concentrate needs to be disposed of in a safe area to minimize the impact of the surrounding aquatic life and fauna etc. as per the guidelines.

15 ESTIMATION OF WATER EQUIREMENT

Water in the RE Park is required for human consumption, cleaning of solar panels and other miscellaneous activities.

15.1 Water requirement for human consumption

As per plan, GIPCL divided the area into 24 plots, each for generation of 100MW power. It is estimated that 15 persons will work for the maintenance of the one plot. As per Estimation of Water Requirements for drinking and domestic use, National Building Code 2016, BIS approx. 150 liters (*l*) of water is required per head per day. Considering the same value for total requirement for a single plot.

15 persons x 150 *l/d* = 2250 *l/d* water would be required.

Assuming 300 working days, maximum storage requirement of any water tank.

Domestic water requirement per year per plot = 2250 *l* x 300 days=675,000 *l*.

Total annual water requirement for 24 plots = 675,000 X 24 = 16,200,000 *l*.

Daily water requirement for Domestic usage = 16,200,000 / 365 = 44,384 *l/d*.

15.2 Water requirement for cleaning of solar panels

Water requirement for cleaning panels (and its frequency) mainly depends on the location of the installation. Roughly 9,000 to 15,000 liters (average 12,000 liters) of water is required for cleaning 1 MW power solar panels per wash. This range is huge because the location of the site and its surroundings plays a crucial role.

If the site in a very dusty (near desert) location, it may require more water to clean such panels and vice versa. Usually, the cleaning frequency may be 2 times a month.

As per plan of GIPCL 2400 MW capacity solar panels are to be in the RE Park in Rann of Kutch. Total water requirement has been calculated as:

Total annual water req. = 2400 (MW) X 12,000 (liter) X 2 (cycle/month) X 12 (months) = 691,200,000 liter = 691.2 million liter

Water requirement per day = 691,200,000 / 365 = 1,893,699 litre

The RE Park area of the GIPCL shall be divided into 24 plots of 100 MW each.

Water requirement for each plot per day = 1,893,699 / 24 plots= 78,904 liter

15.3 Total water requirement during O&M stage

Total water requirement during O&M stage of the RE park shall include the requirement for domestic usage, solar panel cleaning and for other miscellaneous purposes. In the present study, water requirement for miscellaneous purposes is assumed to be 10% of the daily domestic water requirement.

Total water requirement per day per plot = 44,384+4,438+78,904

= 127,690 l/d

Total water requirement for RE Park = 127,690 X 24

= 3,064,560 l/d

= 3.1 MLD

Therefore, 3.1 MLD water is required for O&M of the GIPCL RE Park.

16 RAIN WATER HARVESTING

Rainwater harvesting (RWH), in its broadest sense, used for collecting and storing rainwater for human use from rooftops, land surfaces or rock catchments. As RWH is neither energy intensive nor labor- intensive, it can be a cost-effective alternative to other water-accruing methods. RWH is a technically feasible solution for overcoming the problem of water scarcity in cities and rural areas. Water from harvested rainfall may also infiltrate, thus recharging the aquifer. The water is stored in the aquifer, from where it can be retrieved for future use. RWH is considered a reliable solution for augmenting groundwater level to attain self-sufficiency in public distribution of water in drought-prone areas. In this context, rooftop RWH can become a popular technique to improve the storage and recharge of water. Proper recharge of harvested water can augment the ground water storage and increase the ground water level. It would also reduce the wastage of water due to surface runoff.

The application of appropriate RWH technology is important for the utilization of rainwater as a water resource. Among the various alternative technologies to augment freshwater resources, RWH and its utilization is a decentralized, environmentally sound solution, which can avoid many environmental problems often caused in conventional large-scale projects using centralized approaches. Typically, once an industrial unit is constructed, the paved surface area increases and infiltration/percolation area decreases. It has been reported that surface runoff can increase from 10% to 55% and infiltration volume can decrease from 50% to 15%. This causes two types of problems, e.g., (i) lowering of the groundwater table due to less recharges, and (ii) increase in localized flooding. If designed properly good RWH system can address both the issues.

16.1 Components of RWH System

Typically, a RWH system consists of three basic elements: the collection system, the conveyance system and the storage system.

Collection systems

Collection systems can vary from simple types within a household to bigger systems where a large catchment area contributes to an impounding reservoir from which water is either gravitated or pumped to water treatment plants.

The catchment of a water harvesting system is the surface, which directly receives the rainfall and provides water to the system. It can be a paved area like a terrace or courtyard of a building, or an unpaved area like a lawn or open ground. A roof made of Reinforced Cement Concrete (RCC), galvanized iron or corrugated sheets can also be used for water harvesting.

The runoff can be estimated by the following formula.

Runoff = Catchment Area × Runoff Coefficient for different catchment surfaces. Runoff Coefficients for various catchment surfaces are given in **Table 19**.

Table 19: Runoff coefficients for various surfaces

Type of Catchments	**Runoff Coefficients**
Roof Catchments Tiles Corrugated Metal sheets	0.8-0.9 0.7-0.9
Ground surface coverings: Concrete Brick pavements	0.6-0.8 0.5-0.6
Untreated Ground Catchments: Soil on slopes less than 10% Rocky natural catchments	0.0-0.3 0.2-0.5
Green Belt	0.05-0.1

Conveyance system

Conveyance system or conduits are the pipelines or drains that carry rainwater from the catchment or rooftop area to the harvesting system. Conduits can be of any material like Polyvinyl Chloride (PVC) or Galvanized Iron (GI), materials that are commonly available.

Storage Structures

Storage tanks may be constructed with respect to the shape, size and the material of construction. Rainwater may be charged into the groundwater aquifers through any suitable structures like dug wells, bore wells, recharge trenches and recharge pits.

16.2 Rainwater Harvesting Plan

The water harvesting potential of storm water is the amount of water that can be efficiently harvested from the total amount of water that is received in the form of precipitation over an area. This is influenced by catchment type and climatic conditions such as rainfall, and its pattern. Land use pattern after setting up of the solar park. As discussed above, average annual rainfall in the area is around 349 mm. The LULC after establishment of RE Park is given in **Table 6**.

Out of the total land of 4,750 ha, roof-water harvesting system can be implemented in the area under infrastructure. It can be seen from the **Table 6.** The estimated RWH potential as per estimated LULC after establishment of RE Park is given in **Table 20**.

Table 20: Annual RWH potential for GIPCL RE Park Area

LULC	Area		Average Rainfall	Runoff Coefficient	Runoff Potential
	Ha	*m^2*	*(m)*		*(m^3/yr)*
A) Infrastructure					
Building area	1.50	15000	0.349	0.75	3,926.25
Open / Green Belt	0.50	5000	0.349	0.30	523.50
Sub Total (A)					4,449.75
B) Area under Solar Park					
Area covered under solar panels	1,330	13300000	0.349	0.85	3,945,445.00
Roads / paved area	266	2660000	0.349	0.60	557,004.00
Open Area	400	4000000	0.349	0.30	418,800.00
Sub Total (B)					**4,921,249.00**
C) Total undisturbed area	2752	27520000	0.349	0.31	**2,497,164.80**
Total (A+B+C)					***7,903,087.75 =7.423 * 10^6***

Total annual RWH potential of GIPCL RE Park is estimated to be $7.906*10^6$ m^3/yr or 7.423 Mm^3.

The suitable design for RWH structure has to be prepared based on the basis of monsoon rainfall, LULC and hydrogeology of the area. The maximum rainfall observed in a day for the area is 246.7 mm (***Table 8***). It means that the average hourly rainfall intensity is approximately 10.3 mm. But, there is large variation in the rainfall intensity and number of rainy days in the area. ***Table 21*** shows the average rainfall during each rainy day in monsoon months (IMD, 2020).

Table 21: Number of rainy days & rainfall intensity in Kutch area

Month	Rainy Days	Average Rainy days	Average Rainfall (mm)	Average rain per rainy day (mm)
June	2 to 3.98	3	36.0	12.0
July	7 to 9.42	8	142.8	17.9
August	5 to 8.13	7	93.2	13.3
September	2 to 3.98	3	57.6	19.2
Annual	***22 to 28.7***	***25***	***349.0***	***14.0***

For this study daily annual monsoon rainfall of 14 mm/d has been used to calculate the volume of water generated from the RE Park per day (***Table 22***). The total water generated from the RE Park area comes out to be about $0.317*10^6$ m^3/d. The water collected from the RWH can be utilized for domestic activities, plantation and cleaning and washing etc.

Table 22: Maximum daily RWH potential

LULC	Area		Average Rainfall	Runoff Coefficient	Runoff Potential
	Ha	***m^2***	***(m/d)***		***(m^3/d)***
A) Infrastructure					
Building area	1.50	15000	0.014	0.75	157.50
Open / Green Belt	0.50	5000	0.014	0.30	21.00
Sub Total (A)					***178.50***
					B) Area under Solar Park
Area covered under solar panels	1330	13300000	0.014	0.85	158,270.00
Roads / paved area (20% of Solar Panels)	266	2660000	0.014	0.60	22,344.00
Open Area (30% of solar panel area)	400	4000000	0.014	0.30	16,800.00
Sub Total (B)					**1,97,414.0**
C) Total undisturbed area	2752	27520000	0.014	0.31	**119,436.80**
Total (A+B+C)					***317,029.30 ≈0.317 X 10^6***

16.3 Rainwater Harvesting Structures

Artificial structures can be constructed for the storage of rain water in small tanks as per the plotting of the Solar Park. This would provide every individual plot enough of freshwater for their domestic activities and gardening purpose.

As the area is water deficient, it is advisable to collect every drop of water. Therefore, it is proposed to construct RWH structures considering the storm of 2 days during monsoon season. Therefore, structures have been proposed to collect water available in 2-days, i.e., 2*0.317 =0.634 Mm^3.

Since, the groundwater is shallow in the RE Park area of GIPCL, it is proposed to construct 1 pond for each plot, so that depth of the pond may be kept above the water table.

16.4 Rainwater Recharge to Groundwater

The selection of a suitable technique for artificial recharge of ground water depends on various factors, which includes:

a) Quantum of non-committed surface runoff available.
b) Rainfall pattern
c) Land use and vegetation
d) Topography and terrain profile
e) Soil type and soil depth
f) Thickness of weathered / granular zones
g) Hydrological and hydro-geological characteristics
h) Socio-economic conditions and infrastructural facilities available
i) Environmental and ecological impacts of artificial recharge scheme proposed.

The main water bearing formation of the area is clay / silt which mostly have poor permeability.

To manage the ground water resource properly, artificial recharge to ground is recommended in the areas where groundwater table is >3m below ground level.

Due to low permeability of the soil, rain water recharge through recharge well does not seem feasible, however if any new technology is available then it should be explored on the experimental basis.

Further, due to the saline nature of the soil of Rann area the rainfall runoff may not be suitable for rainwater recharge.

17 WATER MANAGEMENT

Based on the hydrological investigations and field visit, it was found that the proposed area for RE Park of GIPCL has shallow groundwater table with desert soils. The field investigation and stream network generated based on DEM reveals that proper attention is required to be given for the selection of the proposed hybrid solar park site where the site area found normally with gentle slope so that runoff water can be dispose of safely. It has also been confirmed that the storm water from the proposed project site can be tapped and diverted to nearest RWH tank through natural streams (***Figure 50***).

Based on the hydrological assessment, it is understood that the site is selected as independent zone and not having any catchment from the upstream directions. Hence, the runoff estimations are considered only within the site boundary. Since, the historical river course lines are not protruding into the site, the chances of flood from the nearby areas into the site is very minimal. Hence, the flooding of site will take place only through the runoff generated within the site during rainy days. In order to avoid the flooding situations, a storm water management model can be planned by constructing suitable storm water drainage network system in the proposed site as well as some suitable safety measures should be taken during the installation of the hybrid power system. For example, the details of the storm water drainage network and possible location of RWH tanks/ponds are presented in the ***Figure 50***.

Depends on the local constraints, soil and water conservation engineering measures such as tanks/ponds, bunding, contour stone wall and vegetative filter strips may be constructed in the project area. In order to divert the outside runoff into the site along the margin of the site boundary a storm water drain can also be planned.

The size of the drains/bunds should be decided as per the requirement and local conditions (***Figure 51***). Water harvested shall have to be processed for desiltation before using for domestic or solar panel cleaning.

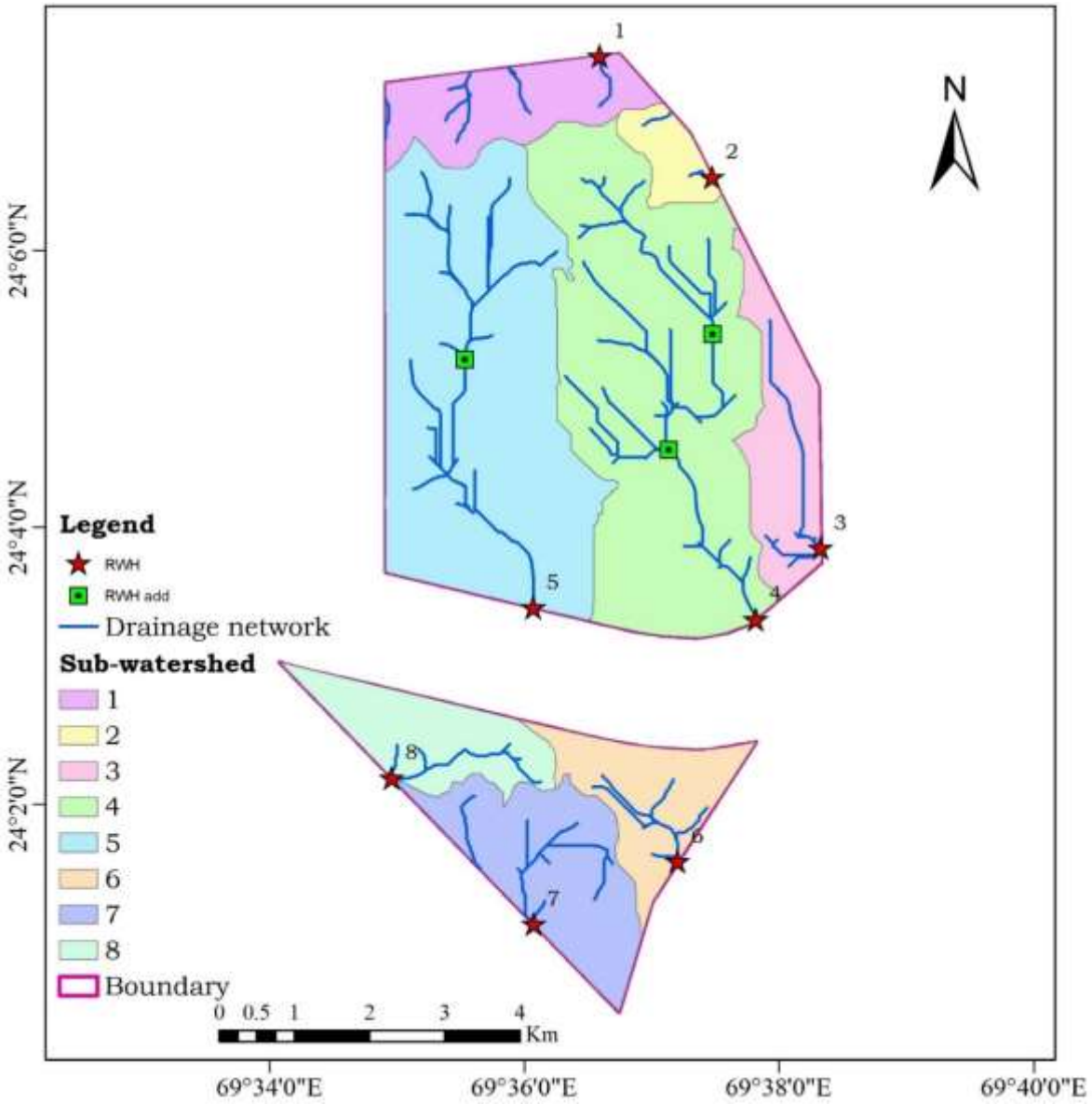


Figure 50: Storm water management and rainwater harvesting plan

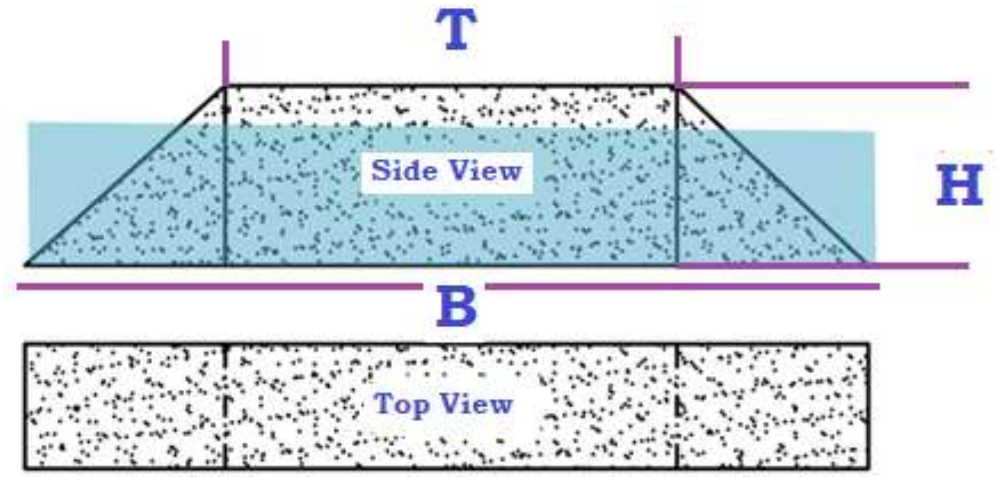


Figure 51: Tentative Design of the Bund

18 SUMMARY AND CONCLUSIONS

To study the hydrology and hydrogeology of the lease area of M/s GIPCL, various types of available data were analysed and field surveys were conducted including topography survey, well inventory etc.

Location:

- M/s GIPCL has been allocated an area of 4750 ha falling between 69°34'5.329" to 69°38'20.829" E Longitudes and 24°00'29.002" to 24°07' 24.235" N Latitudes in Great Rann of Kutch, District Kutch, Gujarat. Project Site is located around 12 to 15 km in south / southwest direction from Indo-Pak International border.
- The area is divided into 2 parts by Khavda-Vighakot road. Most of the area is mostly vast mud flats and is devoid of any major drainage system.

Topography:

- The project area is almost flat with elevation ranging from of 3.5 m to 9.0 m amsl. In general, the northern part is higher and is very gently dipping slopping towards south. The high grounds devoid of flooding are called island bets.

Climate:

- The area experiences extreme climatic conditions characterized by its aridity, low rainfall and extreme temperatures. Mean maximum temperature ranges between 26.7°C during January to about 39.5°C during May and the mean minimum temperatures vary between 9°C during January and 27°C during June.
- Long-term average annual rainfall for Bhuj IMD station is 378.2 mm. More than 95% rainfall occurs during the monsoon months of June to September. The number of rainy days varies between 20 and 30 or even less and coefficient of variation of rainfall is between 30 and 70%.

Soil properties:

- Mostly the soils are silty clay but few pockets / lenses of silt, silty - clayey sands are also observed. It is very fine silt clay varying in colour from yellow, yellowish brown to black colour at different location.
- The permeability value is quite low and allows restricted vertical infiltration of water into the ground.

Hydrogeology:

- The study area is located mostly in the Rann clay formation of Marine and Fluvio-marine origin.
- The geology is comprised of the alluvium (Quaternary sediments) comprising of brown loam, kankars, silt, clays, sand, and gravel.

LULC:

- The predominant land use of the project site is barren land (also called Rann) with scanty vegetation of arid grassland ecosystem (i.e. Banni grasslands).
- Most of the area surrounding the projects site is mud flats dry salt playa, scrubs and non-perineal seasonal drainage network. There is apparently only one road passing in between the two blocks of project site. Presence of Bet area indicates that there are few portion of the land which is above the flood level.

Flora and Fauna

- The predominant vegetation in the Rann of Kutch are grassland and thorny scrubs. Common grass species includes: *Apluda aristate*, *Cymbopogon spp., Eragrostis spp., and Elionurus spp., Cenchrus spp., Pennisetum spp.*
- Several large herbivores, including Indian wild ass chinkara (*Gazella bennettii*), nilgai (*Boselaphus tragocamelus*), and blackbuck (*Antilope cervicapra*), and the large predators wolf (*Canis lupus*), striped hyena (*Hyaena hyaena*), desert wildcat (*Felis lybica*), and caracal (*Felis caracal*) are found in and around the project area.

Eco-sensitive zones:

- The project site does not have any eco-sensitive zone or wild life sanctuary.
- Project site is 47 km away from eco-sensitive zone of Chhari-Dhand and 53 km away from Flamingo City, and 23 km from Kala Dongar sanctuary. However, there is a small temporary Vulture resting area lying 2 km northeast of project site and 47 km southwest from project site.

Natural hazards and risks:

- The area is earthquake prone and many epicenters are located near project site. It falls in a seismic zone - V and is susceptible to very high higher damage risk (>MSK IX) of earth quakes.
- Allah Bund fault lies in the close vicinity of the project site.
- There is no record available on tsunami as well as no volcanic activity found in and around the project area.
- There are no rivers in Rann of Kutch, so there is no risk of flooding in the study area.

Meteorological analysis:

- The statistically analysis of rainfall (118 years) indicates that the site received average annual rainfall 348.9 mm.
- It was found that site receives extreme annual maximum daily rainfall of 246.7 mm in the month of August, 1979.
- IDF curves of the rainfall indicates that the maximum rainfall intensity of 88.8 mm/hr can be expected for a storm of one hour for 100 years return period.

Watershed analysis:

- The project site is located between the elevations 3.85 m to 8.75 m from mean sea level. Northern part of the project site area is higher in elevation than the southern part.

- The relationship between cumulative area (%) and elevation (m) of the project site suggests that the land is gradually sloping.
- Slope map indicates that all the area of the site comes within 4% slope.
- There are eight sub-watersheds found in the project area which drains outside the project area.
- There are very small streams and catchments found in the northern side of the project area. Therefore, surface runoff coming from these small catchments can be routed along the project boundary to a common outlet where suitable water conservation measures can be taken.
- In Block-1, no stream enters in the RE Park, whereas few streams enter the Block-2 from the northern side.

Runoff Potential:

- The total average annual surface runoff potential from the project site is estimated 2.5 Mm^3 (in terms of depth is 52.58 mm). The average annual surface runoff from Block-1 and Block-2 have been estimated 1.9 Mm^3 and 0.6 Mm^3, respectively.
- The maximum monthly runoff was occurred in the month of August (i.e. 458.59 mm) from the project area. This is the rare event found in the site over a period of 118 years.
- The peak runoff potential of each sub-watershed from a rainfall of 50 and 100 years return period may have potential to generate surface runoff of 5.2 m^3/s to 28.7 m^3/s and 5.9 m^3/s to 32.6 m^3/s, respectively.
- The engineering measures should be decided on the basis each sub-watersheds runoff potentials.

Flood risk analysis:

- There are no major dams/streams in the project site area. Flooding is not a major hazard faced by the District. All the river systems in the Rann of Kutch district are very low flooding, as captured in the Vulnerability Atlas. No major flood event record is available from the study area. River flooding is not a major hazard faced by the District.

- There is no risk from nearby water bodies to the GIPCL project site. It is also found that all the streams and tributary of channels/streams are flowing away from the GIPCL site.
- The High Flood Level had reached to the elevation of 2.4 m to 2.7 m during the earlier year of 1984 and 1992 in Rann of Kutch, whereas in 2019 and 2020, it was at approx. 1.5 m. On an average the flood level in Rann is 1.5 m amsl. The RE Park land has minimum elevation 3.88 m amsl. Therefore, there is no risk of flooding from external water bodies.
- The study results show project area will be prone to temporary water impoundment during peak rainfall. However, appropriate arrangement of drainage structures will not create impounding in the project area.

Soil erosion & Sediment deposition:

- The soil erosion estimated by using RUSLE indicated that 55% area is under moderate erosion class, whereas 32.87% area falls under the slight class erosion zone.
- The average annual soil loss within the site is found to be 9.96 t ha^{-1} y^{-1}, while gross soil erosion is estimated to be 47,316 tonnes and sediment yield has been found to be 10,410 tonnes.
- It is revealed that treatment of soil conservation with the help of runoff potential will be a key factor for excellent watershed management in the project areas.
- Depending upon priority levels, the watershed area should be treated with suitable vegetative and structural measures.

Groundwater assessment:

- Groundwater in the area lies at the depth of 2 to 5 m from the ground surface.
- Groundwater flow direction in Block-1 is from NW to SE. In Block-2, the flow direction is from SW to NE.
- Groundwater is highly saline with TDS of approximately 100,000 mg/l.
- No tube well exists within 5 km radius of project site.

- Rainwater recharge is not feasible at the project site due to inherent salinity and clayey soil type.
- Low values of apparent resistivity indicate presence of highly saline and conductive zones. Results of the subsurface study area confirms the presence of highly saline water at shallow depth.

Freshwater availability and Requirement:

- Pachchham Island is the nearest fresh water source near to the project boundary area and is approximately 15 km away from the site.
- There is a presence of 3 artesian wells surrounding 20 km radius of the project site namely Gainda, Khardoi and Kala Dungar.
- The water quality was found to be potable with most of the parameters falling with the permissible limits except fluoride, which was found to be slightly above permissible limit from the sample collected from Kalo Dungar well.
- Only surface water source near the RE Park area is seasonal Bandi River. Water in the river may not be sufficient to meet the fresh water requirement.
- Total daily freshwater requirement of the project is 3.1 MLD.

Rainwater harvesting potential:

- Out of the total land of 4,750 ha, about 2 ha shall be under infrastructure (workshop, administrative building etc.), 1330 ha under solar panels 266 ha under roads and pavements, 400 ha open area and 2752 ha undisturbed area.
- Total annual rainwater harvesting potential of GIPCL RE Park is estimated to be $7.907*10^6$ m^3/yr or 7.907 Mm^3.
- Average daily monsoon rainfall of 14 mm/d is used to calculate daily volume of water generated from the RE Park. The total water generated from the RE Park area comes out to be about $0.317*10^6$ m^3/d. The water collected from the rainwater harvesting can be utilized for domestic activities, plantation and cleaning and washing etc.

Rainwater harvesting structures:

- Artificial structures can be constructed for the storage of rain water in small tanks as per the plotting of the Solar Park. This would provide every individual plot enough of freshwater for their domestic activities and gardening purpose.
- As the area is water deficient, it is advisable to collect every drop of water. Therefore, it is proposed to construct rainwater harvesting structure considering the storm of 2 days during monsoon season. Therefore, structures have been proposed to collect water available in 2-days, i.e., 2*0.317 =0.634 Mm^3.
- Since, the groundwater is shallow in the RE Park area of GIPCL, it is proposed to construct 1 pond for each plot, so that depth of the pond may be kept above the water table.

Rainwater recharge to groundwater

- The main water bearing formation of the area is clay / silt which mostly have poor permeability.
- Due to low permeability of the soil, rain water recharge through recharge well does not seem feasible, however if any new technology is available then it should be explored on the experimental basis.
- To manage the ground water resource properly, artificial recharge to ground is recommended in the areas where groundwater table is >3m.
- Further, due to the saline nature of the soil of Rann area the rainfall runoff may not be suitable for rainwater recharge.

Desalinization of saline water:

- For meeting the fresh water requirement approximately 4.5 MLD saline water would be needed. The saline water can be pumped from the groundwater by installing tubewells.
- The waste water or brine concentrate needs to be disposed of in a safe area to minimize the impact of the surrounding aquatic life and fauna etc. as per the guidelines.

Water Management:

- Eight probable locations for water harvesting from sub-watersheds have been identified, where suitable water conservation structures can be constructed.
- In addition, some structures may be taken into consideration inside the project area based on local constraints.
- Water harvested shall have to be processed for desiltation before using for domestic or solar panel cleaning.

19 RECOMMENDATIONS

The following recommendations may be considered:

- Suitable storm-water drainage network may be constructed to avoid waterlogging within the park site.
- Soil & water conservation engineering measures such as tanks/ponds, bunding, contour stone wall and vegetative filter strips may be constructed in the project area.
- In order to divert the outside runoff into the site along the margin of the site boundary a storm water drain may be planned. Size of the drains/bunds should be decided as per the requirement & local conditions.
- To augment the groundwater, the rainwater harvested water may be be recharged to shallow groundwater, as it is saline in nature and is very shallow. Further the possibility of recharging the harvested water to deeper aquifers may be explored, if available.
- It is recommended that the proper provision of regular operation and maintenance should be made for the successful performance of the stormwater drainage system.
- The possibility of less saline water in deeper aquifers may be explored for desalination of water for use in RE Park.

Limitations of the study

In this study, IMD grid wise (0.25^{o}x0.25^{o}) rainfall data has been used in the absence of observed rain gauge data (i.e., long term historical) for the grid representing GIPCL site, which may result slight differences in the actual estimates of the runoff potential from the site. This has to be taken into consideration.

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APPENDIX

APPENDIX – A

Soil characteristics as reported by M/s Unique Engineering Services, Gandhidham.

Bore Hole No	Depth From	Depth To	Soil Type	Soil Description
BH-1	0.00	3.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	3.00	9.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	9.00	10.50	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles
	10.50	21.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	21.00	43.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	43.50	50.50	Sandy Clay	Reddish Greyish consolidated Clayey Sand of low Plasticity mixed with little kankars in form of soft rock
BH-2	0.00	0.50	Clay (IP)	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	0.50	6.00	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles
	6.00	12.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	12.00	18.10	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles
	18.10	19.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	19.50	21.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	21.00	30.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
BH-4	0.00	3.00	Clay (IP)	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	3.00	6.00	Silt (IP)	Greyish Silt of Intermediate Plasticity Mixed With Little Fine Sand & Gravel
	6.00	12.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	12.00	16.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	16.50	19.50	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles
	19.50	39.45	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	39.45	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
BH-5	0.00	1.50	Silt (IP)	Brownish Silt of Intermediate Plasticity mixed with little Fine Sand & Gravel
	1.50	10.51	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	10.51	13.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	13.50	19.46	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	19.46	30.55	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
BH-6	0.00	0.50	Clay (LP)	Brownish Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	0.50	5.90	Silt (IP)	Greyish Silt of Intermediate Plasticity mixed with little Fine Sand & Gravel
	5.90	22.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	22.50	30.57	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
BH-7	0.00	5.90	Clay (LP)	Brownish Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	5.90	22.40	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines

Bore Hole No	Depth From	Depth To	Soil Type	Soil Description
	22.40	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
BH-9	0.00	8.75	Clay (LP)	Brownish greyish Silty Clay of Low Plasticity Mixed With Kankars
	8.75	13.55	Silt (LP)	Greyish brownish non-plastic clayey silt mixed with little Fines
	13.55	16.50	Silty Sand	Greyish Silty Sand with Kankars
	16.50	25.51	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	25.51	48.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars
	48.00	50.00	Clay (HP)	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles
BH-10	0.00	0.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	0.50	7.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	7.50	12.00	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles
	12.00	15.10	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	15.10	22.40	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	22.40	42.10	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	42.10	50.50	Clay (HP)	Brownish Clay of High Plasticity Mixed With Little Gravel and Sand Particles
BH-11	0.00	1.40	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	1.40	16.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	16.50	21.10	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	21.10	30.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
BH-12	0.00	0.30	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	0.30	2.50	Clay (HP)	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles
	2.50	7.50	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	7.50	23.60	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	23.60	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
BH-13	0.00	7.40	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	7.40	10.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	10.50	13.40	Silty Sand	Greyish Silty Sand with Kankars
	13.40	17.70	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	17.70	25.30	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	25.30	30.60	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
BH-14	0.00	18.00	Silt (LP)	Brownish Greyish Non-Plastic Clayey Silt mixed with little Fines
	18.00	39.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles
	39.00	50.50	Clay (HP)	Greyish Silty Clay of High Plasticity mixed with Fine Grained Sand Particles
BH-15	0.00	3.00	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	3.00	7.45	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	7.45	15.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	15.00	24.00	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle

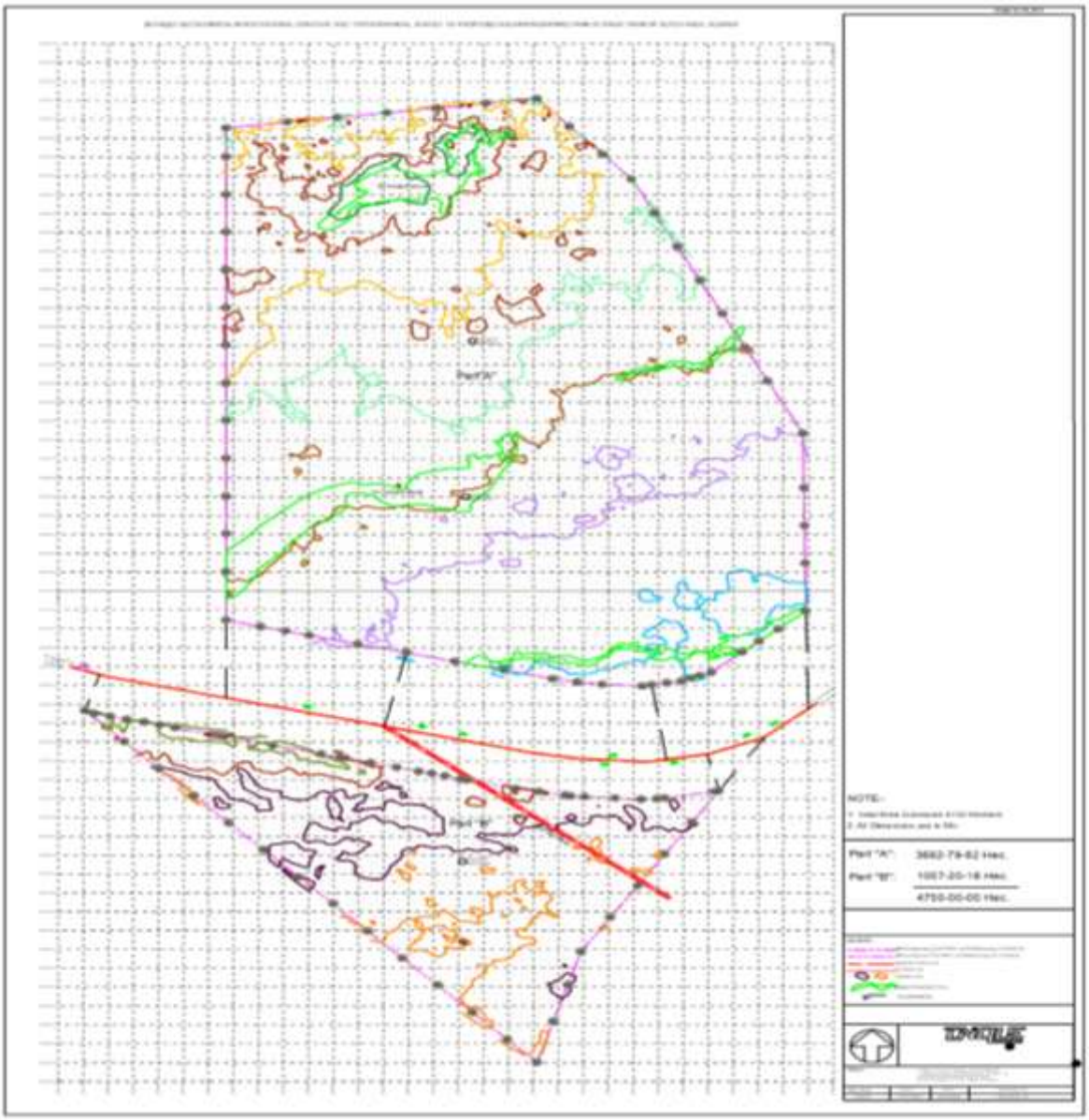
Bore Hole No	Depth From	Depth To	Soil Type	Soil Description
	24.00	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
BH-16	0.00	1.50	Clay (LP)	Greyish Brownish Silty Clay of Low Plasticity mixed with Little Sand Particles
	1.50	6.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	6.00	15.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	15.00	19.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	19.50	22.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	22.50	25.50	Clay (IP)	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel
	25.50	28.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	28.50	50.50	Clay (IP)	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel
BH-17	0.00	0.30	Clay (IP)	Brownish Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	0.40	2.90	Clay (HP)	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles
	2.90	6.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	6.50	20.70	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	20.70	34.30	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	34.30	39.00	Clay (HP)	Greyish Consolidation Clay of High Plasticity Mixed With Little Gravel and Sand Particles
	39.00	50.45	Clay (HP)	Greyish Consolidation Clay of High Plasticity Mixed With Little Gravel and Sand Particles
BH-18	0.00	6.10	Clay (IP)	Brownish Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	6.10	15.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	15.00	26.90	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	26.90	41.80	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	41.80	48.90	Clay (HP)	Greyish Clay of High Plasticity Mixed With Little Gravel and Sand Particles
	48.90	50.50	Clay (HP)	Reddish Brownish Clay of High Plasticity Mixed With Little Gravel and Sand Particles
BH-19	0.00	0.50	Silt (IP)	Greyish Silt of Intermediate Plasticity Mixed With Little Fine Sand & Gravel
	0.50	6.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles
	6.00	10.50	Silt (LP)	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel
	10.50	15.00	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles
	15.00	22.50	Silt (LP)	Greyish Clayey Silt of Low Plasticity mixed with little Fines and Gravel
	22.50	24.00	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles
	24.00	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles
BH-20	0.00	3.10	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles
	3.10	5.90	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	5.90	7.50	Clay (HP)	Greyish Silty Clay of High Plasticity mixed with Fine Grained Sand Particles
	7.50	19.40	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	19.40	24.20	Clay (LP)	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles

Bore Hole No	Depth From	Depth To	Soil Type	Soil Description
	24.20	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles
BH-21	0.00	1.50	Clay (IP)	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	1.50	6.00	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles
	6.00	7.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	7.50	22.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	22.50	42.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	42.00	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
BH-22	0.00	3.00	Clay (LP)	Greyish Brownish Silty Clay of Low Plasticity mixed with fine grained sand particles
	3.00	9.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	9.00	24.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	24.00	30.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
BH-23	0.00	1.50	Clay (HP)	Greyish Brownish Silty Clay of High Plasticity
	1.50	4.50	Clay (IP)	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	4.50	12.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	12.00	18.00	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles
	18.00	22.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	22.50	30.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
BH-24	0.00	6.00	Clay (LP)	Greyish Brownish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particles
	6.00	16.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	16.50	19.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles
	19.50	24.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	24.00	45.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles
	45.00	50.50	Clay (IP)	Silty Clay of Intermediate Plasticity mixed with Fine Grained Sand Particles
BH-25	0.00	4.50	Silt (IP)	Greyish Silt of Intermediate Plasticity Mixed With Little Fine Sand
	4.50	7.50	Clay (LP)	Greyish Silty Clay of Low Plasticity Mixed With Fine Grained Sand Particles
	7.50	18.00	Silt (LP)	Greyish Clayey Silt of Low Plasticity mixed with little Fines
	18.00	19.50	Clay (LP)	Greyish Silty Clay of Low Plasticity Mixed With Fine Grained Sand Particles
	19.50	22.50	Silt (LP)	Greyish Clayey Silt of Low Plasticity mixed with little Fines
	22.50	30.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars
BH-26	0.00	6.00	Silt (IP)	Brownish Greyish Non - Plastic Silt Mixed With Little Fine Sand
	6.00	9.00	Silty Sand	Greyish Silty Sand mixed with kankars
	9.00	24.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	24.00	43.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars
	43.50	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars
BH-27	0.00	1.50	Clay (LP)	Greyish Silty Clay of Low Plasticity Mixed With Kankars
	1.50	6.00	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars
	6.00	12.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	12.00	15.00	Clay (LP)	Greyish Silty Clay of Low Plasticity Mixed With Kankars

Bore Hole No	Depth From	Depth To	Soil Type	Soil Description
	15.00	22.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	22.50	28.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars
	28.50	39.00	Clay (HP)	Greyish Silty Clay of High Plasticity Mixed With Kankars
	39.00	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars
BH-28	0.00	0.60	Clay (LP)	Brownish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	0.60	5.90	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with Little Sand Particles
	5.90	12.70	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	12.70	25.50	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with Fine Grained Sand Particle
	25.50	33.00	Sandy Clay	Brownish greyish Consolidated Clayey Sand of Low to Intermediate Plasticity mixed with little Gravel
	33.00	35.00	Gravel	Greyish Highly Weathered Over Consolidated Sand Stone Fragments
BH-29	0.00	4.50	Clay (IP)	Greyish Brownish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
	4.50	13.50	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	13.50	24.00	Clay (LP)	Greyish Silty Clay of Low Plasticity mixed with fine grained sand particles
	24.00	27.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	27.00	30.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity mixed with fine grained sand particles
BH-30	0.00	4.50	Silt (LP)	Greyish Brownish Non-Plastic Clayey Silt mixed with little Fines
	4.50	18.00	Silt (LP)	Greyish Non-Plastic Clayey Silt mixed with little Fines
	18.00	27.00	Clay (LP)	Brownish Sandy Clay of Low Plasticity Mixed With Kankars
	27.00	50.50	Clay (IP)	Greyish Silty Clay of Intermediate Plasticity Mixed With Kankars

Appendix - B

Elevation contour map of the site provided by the GIPCL



Appendix - C

Rational method runoff coefficients for rural watersheds

Watershed characteristic	Extreme	High	Normal	Low
Relief - C_r	0.28-0.35 Steep, rugged terrain with average slopes above 30%	0.20-0.28 Hilly, with average slopes of 10-30%	0.14-0.20 Rolling, with average slopes of 5-10%	**0.08-0.14** Relatively flat land, with average slopes of 0-5%
Soil infiltration - C_i	0.12-0.16 No effective soil cover; either rock or thin soil mantle of negligible infiltration capacity	0.08-0.12 Slow to take up water, clay or shallow loam soils of low infiltration capacity or poorly drained	**0.06-0.08** Normal; well drained light or medium textured soils, sandy loams	0.04-0.06 Deep sand or other soil that takes up water readily; very light, well-drained soils
Vegetal cover - C_v	0.12-0.16 No effective plant cover, bare or very sparse cover	**0.08-0.12** Poor to fair; clean cultivation, crops or poor natural cover, less than 20% of drainage area has good cover	0.06-0.08 Fair to good; about 50% of area in good grassland or woodland, not more than 50% of area in cultivated crops	0.04-0.06 Good to excellent; about 90% of drainage area in good grassland, woodland, or equivalent cover
Surface Storage - C_s	0.10-0.12 Negligible; surface depressions few and shallow, drainage ways steep and small, no marshes	**0.08-0.10** Well-defined system of small drainage ways, no ponds or marshes	0.06-0.08 Normal; considerable surface depression, e.g., storage lakes and ponds and marshes	0.04-0.06 Much surface storage, drainage system not sharply defined; large floodplain storage, large number of ponds or marshes

Note: The total runoff coefficient based on the four runoff components is C = Cr + Ci + Cv + Cs (Source: Thomason, 2019)

Appendix – D

Most Intense Cyclones hitting Indian West Coast from 1970 to 2020

S. No.	*Name of Cyclone*	*Date and Year*	*Intensity (T-Number)*	*Observed/ Estimated Max. Wind*	*Damage*
1	Severe Cyclonic Storm over the Arabian sea	October 19-24, 1975	N/A	97 Knots 180 Kmph	85 people died in the districts of Junagarh. Jamnagar and Rajkot of Gujarat state. This Cyclone caused considerable damage, estimated to be about Rs. 75 Crores.
2	Severe Cyclonic Storm over the Arabian sea	May 31 - June 5, 1976	N/A	90 Knots 167 Kmph	This Cyclone caused damage to property which was estimated to be about Rs. 3 Crore. 4 Burges each. Containing Rs. 5 Lakh and 6 fishing boats were swept away. Mehasana, Bhavnagar, Kaira, Panchmahal, Rajkot and Broach districts of Gujarat State were most affected areas.
3	Severe Cyclonic Storm over the Arabian sea	November 13-23, 1977	T- 5.5 (as per US satellite)	90 Knots 167 Kmph	Kerala and Lakshadweep were most affected areas due to this storm. People killed - 72. Houses damaged - 8400 and 620 fishing Vessels damaged in Kerala coast. Total loss was estimated to be about Rs 10 crores.
4	Gujarat Cyclone	November 5-13,1978	N/A	278 Kmph	Damage to Property reported.
5	Severe Cyclonic Storm over the Arabian sea	October 28 - November 3, 1981	T - 4.0 (as per US satellite)	65 Knots 120 Kmph	Junagarh, Rajkot and Jamnagar of Gujarat state were most affected areas, Total loss of damage to property was estimated to be about Rs. 52 Crores.
6	Severe Cyclonic Storm over the Arabian sea	November 4-9, 1982	N/A	N/A	Saurastra Coast of Gujarat about 45 km east of Veraval was affected very much by this storm. 507 people died and 1.5 lakh livestock perished.
7	Severe Cyclonic Storm over the Arabian sea	November 4-9, 1982	T- 4.0	50 Knots 93 Kmph	50 fishermen were reported missing in Gujarat Coast.
8	Severe Cyclonic Storm over the Arabian sea	June 17-20, 1996	T-3.5	60 Knots 111 Kmph	19 Districts of Gujarat State were affected. 33 people died. 27964 pucca houses were destroyed. Total estimated loss was Rs.1803.52 lakh.
9	Severe Cyclonic Storm over the Arabian sea	October 23-28, 1996	T-4.0	60 Knots 111 Kmph	As the system did not cross the coast no significant damage was reported.
10	Very severe Cyclonic Storm over the Arabian sea	June 4-10, 1998	T-5.0	90 Knots 167 Kmph	Gujarat & Rajasthan states were affected. Porbander of Gujarat state was the most affected area. Loss incurred due to storm was estimated to be about Rs.1855.38 Crores in Kandla. Number of lines lost 1173 and number of persons missing 1774 in Gujarat.
11	Very severe Cyclonic Storm over the Arabian sea	May 16-22, 1999	T- 5.5	55 Knots 102 Kmph	This system caused severe damage in Kutch and Jamnagar districts of Gujarat. 453 people died. In Rajasthan one person died and 5104 cattle heads perished. 5133 houses were partially damaged.

S. No.	***Name of Cyclone***	***Date and Year***	***Intensity (T-Number)***	***Observed/ Estimated Max. Wind***	***Damage***
12	Severe Cyclonic Storm over Arabian sea	May 5-10, 2004	3.5	Weakened over sea	Widespread damage caused at Lakshadweep. Several houses damaged due to wind, sea wave, falling of trees and floods. 16 boats reported sunk and cargo boat damaged. Sea erosion reported over Kerala and 9 people dead and 17 people missing.
13	Severe Cyclonic" Storm MUKDA" over Arabian sea	September 21-24,2006	3.5	55 Knots 102 Kmph	No damage as dissipated over the Arabian Sea.
14	Super cyclone “GONU"	01-07 June 2007	T-6.5	127 knots	The system crossed Makaran coast and hence there was no damage in India
15	Cyclonic storm "YEMYIN"	25 - 26 June 2007	T - 2.5	35 knots	The system crossed Pakistan coast and hence there was no damage in India
16	OCKHI Very Severe Cyclonic Storm	29 Nov – Dec 2017	T-3.0	155 kmph	Caused heavy rainfall along the western coast of India, particularly in Maharashtra and Gujarat
17	NILOPHER	25-31 October 2014	T – 4.0	205 kmph	Nilopher weakened into a depression on October 31, and soon after degenerated into a remnant low off coast of the Indian state of Gujarat
18	VAYU	10-17 June, 2019	T – 3.0	150 kmph	It was the strongest tropical cyclone to affect the Saurashtra Peninsula of north western India since the 1998 Gujarat cyclone.
19	Cyclone “NISAGRA”	01-04 June 2020	T – 3.5	110 kmph	Hit the coast of Maharashtra, did not cause any damage in Gujarat
20	Cyclone TAUKTAE	14-19 May 2021	T-4.0	195 kmph	The strongest tropical cyclone to make landfall in the Gujarat since the 1998 Gujarat cyclone.

Appendix-E

Runoff curve numbers for arid and semiarid rangelands (USDA 2004) [1/]

Cover description		Hydrologic soil group -			
cover type	**hydrologic condition [2/]**	**A [3/]**	**B**	**C**	**D**
Herbaceous—mixture of grass, weeds and	Poor		80	87	93
low-growing	Fair		71	81	89
brush, with brush the minor element	Good		62	74	85
Oak-aspen—mountain brush mixture of oak	Poor		66	74	79
brush, aspen,	Fair		48	57	63
mountain mahogany, bitter brush, maple, and other brush	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both;	Poor		75	85	89
grass understory	Fair		58	73	80
	Good		41	61	71
Sage-grass—sage with an understory of	Poor		67	80	85
grass	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include	Poor	63	77	85	88
saltbush, greasewood, creosotebush,	Fair	55	72	81	86
blackbrush, bursage, paloverde, mesquite, and cactus	Good	49	68	79	84

[1/] Average runoff condition, and Ia = 0.2s. For range in humid regions, use table 9–1.
[2/] Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.
[3/] Curve numbers for group A have been developed only for desert shrub.

Appendix-F

Monthly and annual average runoff (mm) estimated by SCS-CN method

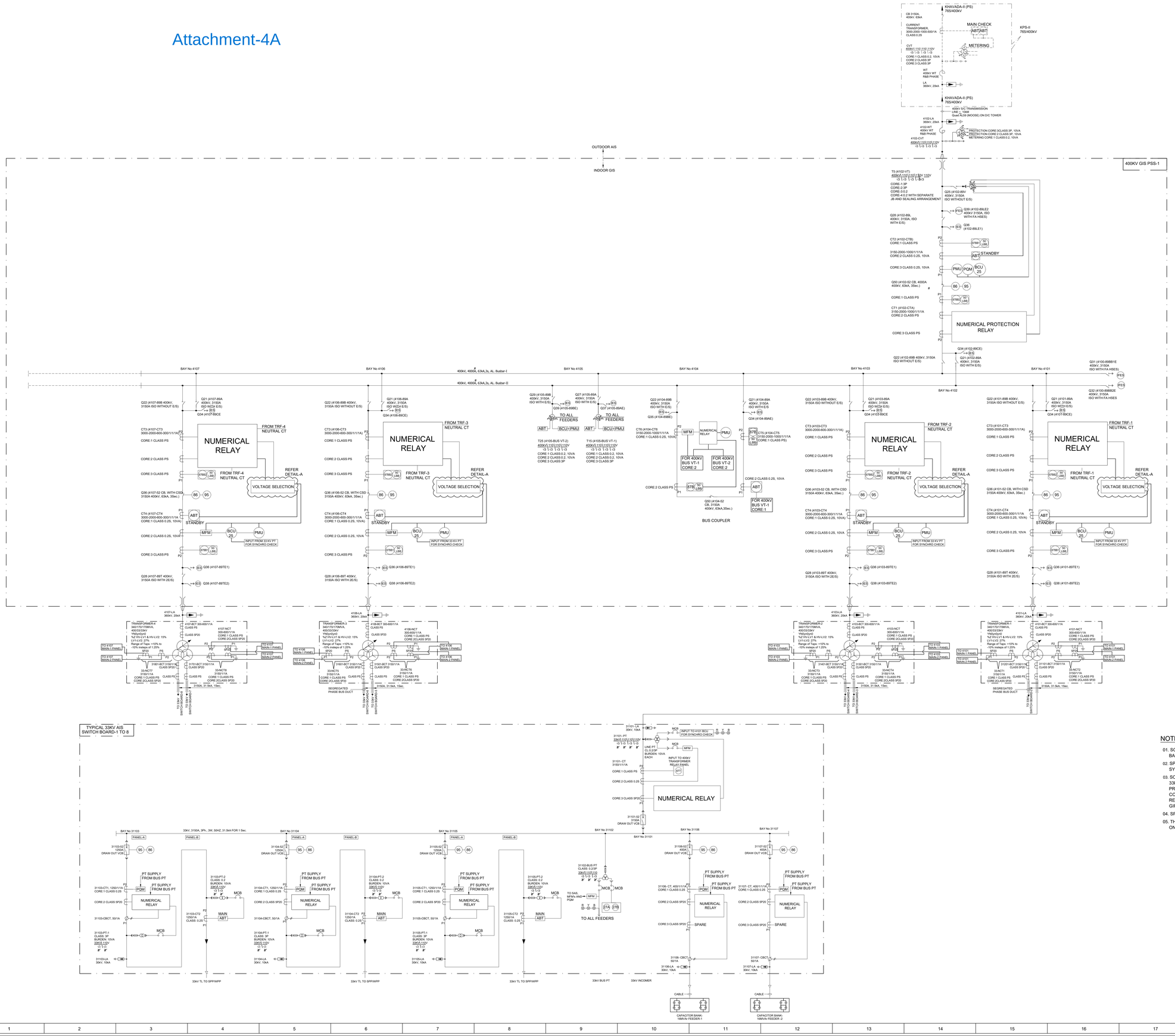
Month/Year	Jun	Jul	Aug	Sep	Oct	Nov	Annual Runoff
1901	0.00	0.00	0.03	0.00	0.00	0.00	0.03
1902	0.00	0.00	12.81	0.46	0.00	0.00	13.28
1903	0.00	124.81	0.00	0.00	0.00	0.00	124.81
1904	0.00	0.05	0.00	0.00	0.00	0.00	0.05
1905	0.00	45.94	0.00	0.00	0.00	0.00	45.94
1906	30.47	0.00	10.08	10.75	0.00	0.00	51.29
1907	0.00	18.93	0.31	0.00	0.00	0.00	19.24
1908	0.00	24.65	0.00	0.00	0.00	0.00	24.65
1909	0.00	2.91	0.00	12.30	0.00	0.00	15.22
1910	0.00	5.59	10.65	0.00	0.00	0.00	16.24
1911	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1912	0.00	67.53	5.23	0.00	0.00	0.00	72.76
1913	0.00	112.24	5.67	0.00	0.00	0.00	117.91
1914	10.79	0.00	0.00	0.64	0.00	0.00	11.43
1915	0.00	4.24	0.00	0.00	1.35	0.00	5.59
1916	0.00	0.00	26.70	1.11	0.00	0.00	27.80
1917	0.00	31.70	1.54	0.00	76.51	0.00	109.75
1918	0.00	0.00	6.79	0.00	0.00	0.00	6.79
1919	0.00	0.00	13.77	0.00	0.00	0.00	13.77
1920	110.07	19.60	0.36	0.00	0.00	0.00	130.03
1921	0.00	77.80	0.00	9.72	0.00	0.00	87.51
1922	0.00	0.74	0.00	14.94	0.00	0.00	15.68
1923	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1924	0.00	4.33	0.00	0.00	0.00	0.00	4.33
1925	0.01	0.08	0.00	0.00	0.00	0.00	0.08
1926	0.00	1.70	5.55	59.88	0.00	0.00	67.13
1927	0.00	53.09	0.00	0.00	0.00	0.00	53.09
1928	0.00	4.19	0.00	0.00	0.00	0.00	4.19
1929	0.00	65.63	0.00	0.00	0.00	0.00	65.63
1930	0.00	11.08	0.00	0.00	0.00	0.00	11.08
1931	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1932	0.00	17.15	0.00	0.00	0.00	0.00	17.15
1933	0.00	25.46	33.25	0.00	0.00	0.00	58.71
1934	0.38	0.00	0.00	0.00	0.00	0.00	0.38
1935	0.00	84.30	0.00	0.00	0.00	0.00	84.30
1936	0.00	18.74	0.00	2.89	0.00	0.00	21.63
1937	0.48	0.16	0.00	1.56	0.00	0.00	2.19
1938	0.18	0.00	0.11	0.00	0.00	0.00	0.28
1939	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1940	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Month/Year	Jun	Jul	Aug	Sep	Oct	Nov	Annual Runoff
1941	0.00	135.19	0.00	0.00	0.00	0.00	135.19
1942	0.00	0.00	10.13	0.00	0.00	0.00	10.13
1943	0.00	13.60	0.00	0.00	0.00	0.00	13.60
1944	0.00	26.32	28.61	0.00	0.00	0.00	54.93
1945	0.06	28.87	0.37	0.00	0.00	0.00	29.31
1946	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1947	0.00	0.00	34.48	0.00	0.00	0.00	34.48
1948	0.00	0.00	2.58	0.00	0.00	0.00	2.58
1949	0.00	23.23	6.62	0.00	0.00	0.00	29.85
1950	0.00	221.05	0.00	8.02	0.00	0.00	229.06
1951	0.00	4.86	0.04	0.00	0.00	0.00	4.90
1952	0.00	38.69	0.00	0.00	0.00	0.00	38.69
1953	0.00	0.00	89.75	0.00	0.00	0.00	89.75
1954	0.00	0.00	42.29	0.42	0.00	0.00	42.71
1955	0.00	0.00	87.57	144.15	0.00	0.00	231.72
1956	0.00	56.53	62.21	0.00	0.00	0.00	118.74
1957	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1958	0.00	11.37	0.00	22.41	0.00	0.00	33.79
1959	0.00	41.13	0.00	124.98	0.00	0.00	166.12
1960	0.00	0.00	0.17	0.00	0.00	0.00	0.17
1961	5.44	37.05	0.00	248.25	0.00	0.00	290.74
1962	0.00	0.23	13.55	0.00	0.00	0.00	13.78
1963	0.00	0.00	0.06	0.00	0.00	0.00	0.06
1964	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1965	0.00	21.81	0.00	0.00	0.00	0.00	21.81
1966	28.27	20.30	0.00	0.00	0.00	0.00	48.57
1967	8.68	193.69	0.40	0.00	0.00	0.00	202.77
1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1969	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1970	0.00	69.02	10.03	66.41	0.00	0.00	145.45
1971	0.00	0.10	3.94	0.16	0.00	0.00	4.20
1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	0.00	0.00	0.26	0.00	0.00	0.00	0.26
1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	0.00	0.00	30.38	11.37	0.00	0.00	41.75
1976	0.00	101.96	51.96	17.24	0.00	0.00	171.16
1977	7.91	8.36	0.53	0.00	0.00	0.00	16.80
1978	0.62	0.21	1.09	0.00	0.00	1.21	3.13
1979	0.00	0.00	458.59	0.00	0.00	0.00	458.59
1980	60.57	21.10	0.00	0.00	0.00	0.00	81.67
1981	0.00	27.23	1.27	0.00	0.00	12.76	41.26
1982	0.00	7.12	0.00	0.76	0.00	0.00	7.89
1983	0.00	5.35	0.23	0.00	0.00	0.00	5.59
1984	0.00	0.00	0.00	11.81	0.00	0.00	11.81
1985	0.00	0.00	7.44	0.00	0.00	0.00	7.44

Month/Year	Jun	Jul	Aug	Sep	Oct	Nov	Annual Runoff
1986	0.00	0.00	3.49	0.00	0.00	0.00	3.49
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	0.00	165.54	0.86	0.00	0.00	0.00	166.40
1989	35.85	49.35	0.00	0.00	0.00	0.00	85.19
1990	0.00	0.00	12.28	0.00	0.00	0.00	12.28
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	121.37	0.00	0.00	0.00	0.00	121.37
1993	0.00	0.86	0.00	0.00	0.00	0.00	0.86
1994	0.00	88.38	0.24	244.30	0.00	0.00	332.92
1995	0.00	0.15	0.00	0.00	15.84	0.00	16.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.01	0.00	17.20	0.00	0.00	17.22
1998	0.00	0.00	0.00	0.00	85.79	0.00	85.79
1999	0.00	0.00	0.00	0.00	3.64	0.00	3.64
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	39.50	26.89	0.00	0.00	0.00	0.00	66.39
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.00	169.81	2.71	0.00	0.00	0.00	172.52
2004	4.43	0.00	0.00	0.00	0.00	0.00	4.43
2005	0.00	0.00	0.00	10.02	0.00	0.00	10.02
2006	0.00	78.65	51.31	0.00	0.00	0.00	129.96
2007	8.57	0.48	48.74	0.00	0.00	0.00	57.79
2008	0.00	0.00	0.00	2.32	0.00	0.00	2.32
2009	0.00	52.00	26.71	0.00	0.00	0.00	78.70
2010	0.00	26.31	37.11	2.35	0.00	0.00	65.78
2011	0.00	0.00	147.34	32.47	0.00	0.00	179.81
2012	0.00	0.00	0.00	76.71	0.00	0.00	76.71
2013	0.42	0.00	0.00	45.67	0.00	0.00	46.08
2014	0.00	0.00	0.00	1.37	0.00	0.00	1.37
2015	0.00	239.56	0.00	0.00	0.00	0.00	239.56
2016	0.00	0.00	48.74	0.00	0.00	0.00	48.74
2017	0.00	39.00	0.00	0.00	0.00	0.00	39.00
2018	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total (mm)	352.7	2995.4	1456.9	1202.6	183.1	13.97	6204.7
MEAN (mm)	2.99	25.38	12.35	10.19	1.55	0.12	52.6
SD (mm)	12.91	47.44	46.37	37.35	10.57	1.17	76.8
Min (mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Max (mm)	110.07	239.56	458.59	248.25	85.79	12.76	458.6

****

Attachment-4A



NOTES:-

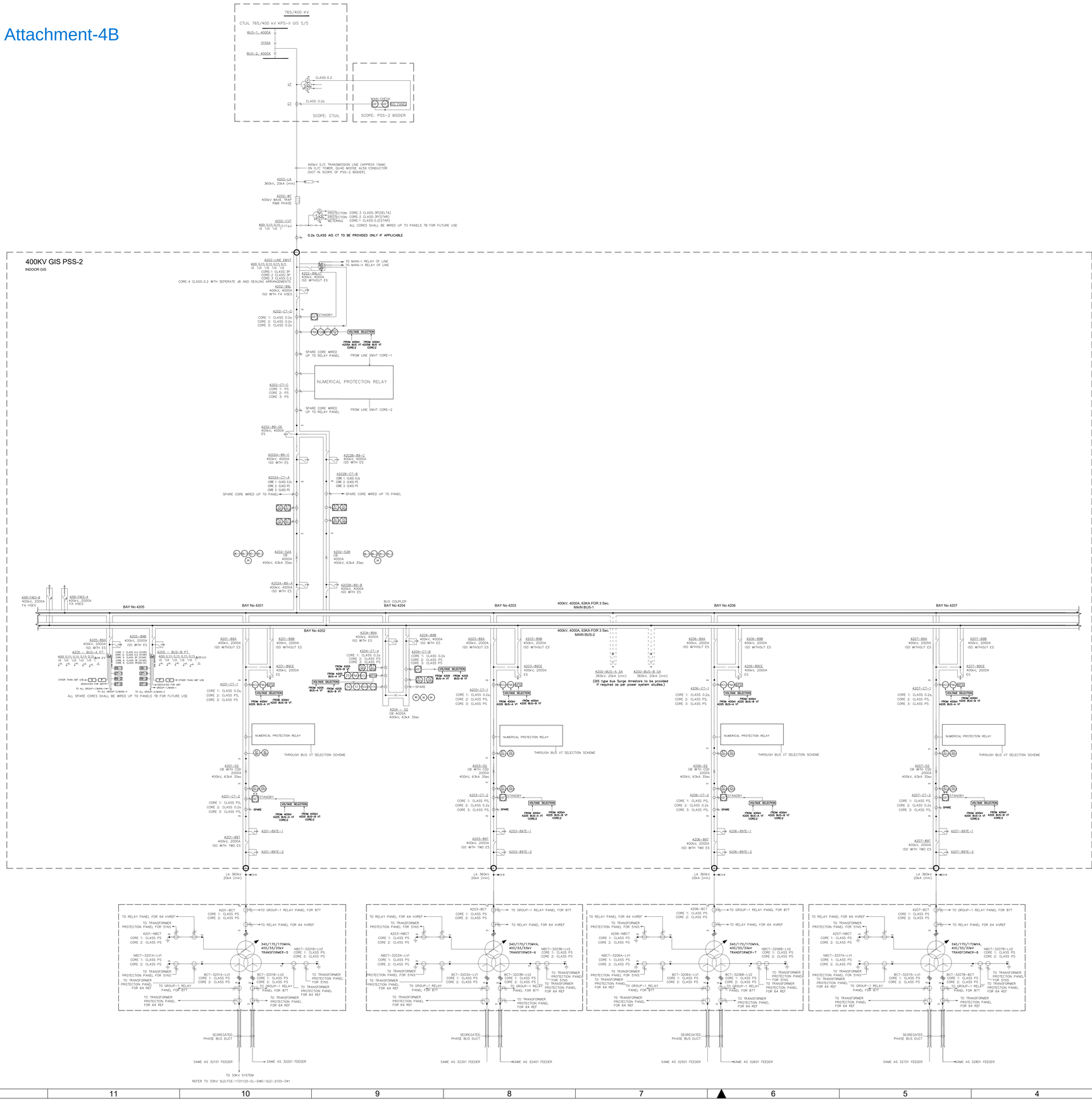
01. SOLAR / WIND POWER DEVELOPER'S 33KV TRANSMISSION LINES TO BE TERMINATED AS PER ALLOCATED 33KV BAY AT PSS.
02. SPD/WPD SHALL PROVIDE SPACE PROVISION FOR INSTALLATION OF 33KV LINE DIFFERENTIAL PROTECTION SYSTEM AT GENERATION END (INCLUDING BUT NOT LIMITED TO PS CLASS CT, DIFFERENTIAL RELAY ETC.
03. SOLAR PROJECT DEVELOPER (SPD) / WIND PROJECT DEVELOPER(WPD) SHALL PROVIDE 3Rx3Cx500 SQMM 33KV XLPE ARMOURED CABLES FOR EVACUATION OF EACH 50MW 33KV TRANSMISSION LINE FROM SPD/WPD PROJECTS UP TO PSS. THE SPD/WPD SCOPE INCLUDES BUT NOT LIMITED TO SUPPLY, ERECTION, COMMISSIONING, ALONG WITH SUPPLY OF END TERMINATION /JOINTING KITS, COMMUNICATION CABLES WITH REQUIRED ACCESSORIES ETC. THE DETAIL CABLE LAYING METHODOLOGY SHALL BE PRE-APPROVED FROM GIPCL.
04. SPD/WPD SHALL PROVIDE ONE NUMBER 3Cx500SQMM SPARE 33KV CABLE FOR EACH 100MW BLOCK.
05. THERE IS AN INTERLOCK BETWEEN TWO CAPACITOR BANK FEEDERS OF EACH 33KV BOARD SO AS AT A TIME ONLY ONE CAPACITOR BANK CAN BE TAKEN IN TO SERVICE.

OWNER	GUJARAT INDUSTRIES POWER CO. LTD.
PROJECT:	POOLING SUBSTATION 400/33 KV, 1200 MW (PSS-1, PHASE-I & PHASE-II OF 600 MW EACH) OF SOLAR/ WIND / HYBRID RE PARK OF 2375 MW CAPACITY AT GREAT RANN OF KUTCH AREA, GUJARAT.
SUBSTATION:	400/33 kV PSS-1 GIS SUBSTATION
TITLE:	TENTATIVE OVERALL SINGLE LINE DIAGRAM OF 400/33 KV 1200MW PSS-1 SUBSTATION FOR TENDER PURPOSE
DIVISION:	ELECTRICAL SUBSTATION
DWG.NO.	SCALE: NTS / SHEETS 1 OF 1
CLIENT DRG. NO:	REV.

SIZE-A0

FILE PATH:Design Common Drive (\\excnumpdfs)\(...)\04- Other\KEC STD SHEET\FINAL\HORIZONTAL SHEET\KEC-STD-SHEET-A0 (L SHAPE).dwt R0

Attachment-4B



LEGEND:–

– BREAKER	MW	–	MEGA WATT
– CURRENT TRANSFORMER (CT)	MVA	–	MEGA VOLT AMPERE
– MULTI CORE POTENTIAL TRANSFORMER (PT)	PQM	–	POWER QUALITY METER
– THREE PHASE TRANSFORMER,	PMU	–	PHASOR MEASUREMENT UNIT
– SEGREGATED PHASE BUS DUCT (SPBD)	ABT	–	AVAILABILITY BASED TARIFF
– GIS BARRIER	CT	–	CURRENT TRANSFORMER
– LIGHTNING ARRESTER	V	–	VOLT METER
– ISOLATOR	VT	–	VOLTAGE TRANSFORMER
– TERMINATION	EMVT	–	ELECTRO MAGNETIC VOLTAGE TRANSFORMER
– SF6 TO AIR BUSHING	F	–	FREQUENCY
– WAVE TRAP (R & B PHASE ONLY)	ES	–	EARTH SWITCH
– INDICATION LAMP	KV	–	KILO VOLT
MFM – MULTI FUNCTION METER	CVT	–	CAPACITIVE VOLTAGE TRNSFORMER
kA – KILO AMPS	PRV	–	PRESSURE RELIEF VALVE
GIS – GAS INSULATED SUBSTATION	OSR	–	OIL SURGE RELAY
AIS – AIR INSULATED SUBSTATION	SPP	–	SOLAR POWER PLANT
MOG – MAGNETIC OIL GAUGE	CB WITH CSD	–	CIRCUIT BREAKER WITH CONTROLLED SWITCHING DEVICE
FA HSES – FAST ACTING HIGH SPEED EARTH SWITCH	TL	–	TRANSMISSION LINE
SAS – SUBSTATION AUTOMATION SYSTEM	WPP	–	WIND POWER PLANT

NOTES:-

01. SOLAR / WIND POWER DEVELOPER'S 33KV TRANSMISSION LINES TO BE TERMINATED AS PER ALLOCATED 33KV BAY AT PSS.
02. SPD/WPD SHALL PROVIDE SPACE PROVISION FOR INSTALLATION OF 33KV LINE DIFFERENTIAL PROTECTION SYSTEM AT GENERATION END.(INCLUDING BUT NOT LIMITED TO PS CLASS CT, DIFFERENTIAL RELAY ETC).
03. SOLAR PROJECT DEVELOPER (SPD) / WIND PROJECT DEVELOPER(WPD) SHALL PROVIDE 3Rx3Cx500 SQMM 33KV XLPE ARMOURED CABLES FOR EVACUATION OF EACH 50MW 33KV TRANSMISSION LINE FROM SPD/WPD PROJECTS UP TO PSS. THE SPD/WPD SCOPE INCLUDES BUT NOT LIMITED TO SUPPLY, ERECTION, COMMISSIONING, ALONG WITH SUPPLY OF END TERMINATION /JOINTING KITS, COMMUNICATION CABLES WITH REQUIRED ACCESSORIES ETC. THE DETAIL CABLE LAYING METHODOLOGY SHALL BE PRE-APPROVED FROM GIPCL.
04. SPD/WPD SHALL PROVIDE ONE NUMBER 3Cx500SQMM SPARE 33KV CABLE FOR EACH 100MW BLOCK.

FOR TENDER PURPOSE

REV.	DATE	DESCRIPTION	DRN.	STR.	MECH.	ELEC.	INST.
				APPROVED BY			
0		ISSUED FOR TENDER PURPOSE	LD			KA	

FICHTNER
Consulting Engineers
(India) Private Limited
Chennai, Bangaluru

GUJARAT INDUSTRIES POWER CO. LTD
2375 MW CAPACITY SOLAR/WIND/HYBRID
RENEWABLE ENERGY PARK AT GREAT RANN
OF KUTCH AREA, GUJARAT

	SIGNATURE	DATE
DRAWN	LD	10.02.2023
DESIGNED	MC	10.02.2023
CHECKED	KA	10.02.2023
DEPT.HEAD	KA	10.02.2023
PROJ.MGR.	ENN	10.02.2023

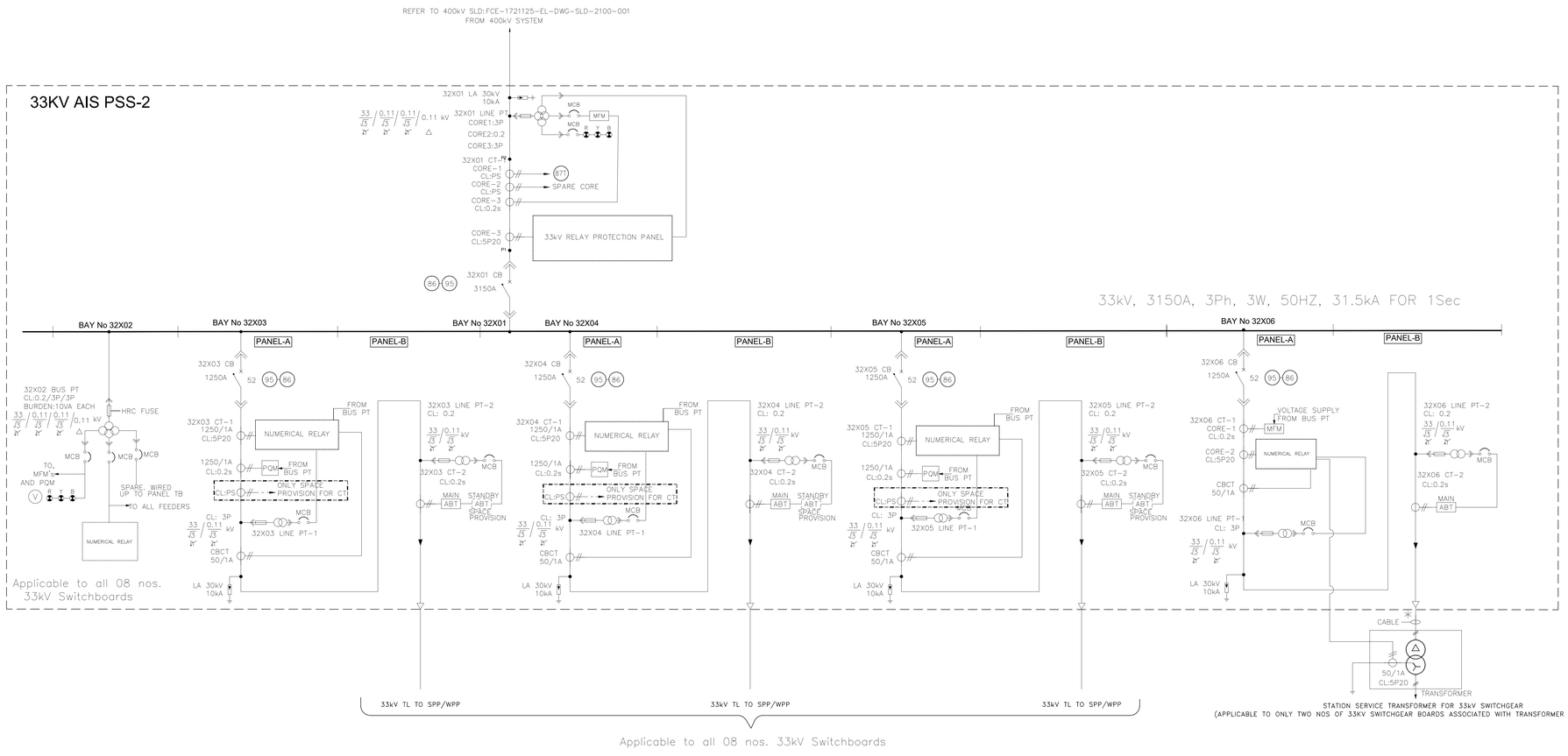
TITLE
TENTATIVE OVERALL SINGLE LINE DIAGRAM OF
400/33 KV 1200MW PSS-2 SUBSTATION FOR TENDER PURPOSE

RELEASED FOR: PRELIMINARY | TENDER ✓ | ENGINEERING | CONSTRUCTION

DEPT. ELECTRICAL | JOB NO. 1721125 | SCALE: NTS | REV.

DWG.NO. FCE-1721125-EL-DWG-SLD-2100-001 | 0

SIZE–A1



LEGEND:–

– 33kV BREAKER (DRAWOUT TYPE)		– LIGHTNING ARRESTER	
– CURRENT TRANSFORMER (CT)	PQM	– POWER QUALITY METER	
– MULTI CORE POTENTIAL TRANSFORMER (PT)	PMU	– PHASOR MEASUREMENT UNIT	
– LIGHTNING ARRESTER	ABT	– AVAILABILITY BASED TARIFF	
– WAVE TRAP (R & B PHASE ONLY)	CT	– CURRENT TRANSFORMER	
– INDICATION LAMP	V	– VOLT METER	
MFM – MULTI FUNCTION METER	VT	– VOLTAGE TRANSFORMER	
kA – KILO AMPS	F	– FREQUENCY	
MOG – MAGNETIC OIL GAUGE	CB	– CIRCUIT BREAKER	
FA HSES – FAST ACTING HIGH SPEED EARTH SWITCH	KV	– KILO VOLT	
SAS – SUBSTATION AUTOMATION SYSTEM	AIS	– AIR INSULATED SUBSTATION	
TL – TRANSMISSION LINE	PRV	– PRESSURE RELIEF VALVE	
– MINIATURE CIRCUIT BREAKER	SPP	– SOLAR POWER PLANT	
CBCT – CORE BALANCE CURRENT TRANSFORMER	WPP	– WIND POWER PLANT	
– STATION SERVICE TRANSFORMER			

NOTES:-

01. SOLAR / WIND POWER DEVELOPER'S 33KV TRANSMISSION LINES TO BE TERMINATED AS PER ALLOCATED 33KV BAY AT PSS.
02. SPD/WPD SHALL PROVIDE SPACE PROVISION FOR INSTALLATION OF 33KV LINE DIFFERENTIAL PROTECTION SYSTEM AT GENERATION END.(INCLUDING BUT NOT LIMITED TO PS CLASS CT, DIFFERENTIAL RELAY ETC).
03. SOLAR PROJECT DEVELOPER (SPD) / WIND PROJECT DEVELOPER(WPD) SHALL PROVIDE 3Rx3Cx500 SQMM 33KV XLPE ARMOURED CABLES FOR EVACUATION OF EACH 50MW 33KV TRANSMISSION LINE FROM SPD/WPD PROJECTS UP TO PSS. THE SPD/WPD SCOPE INCLUDES BUT NOT LIMITED TO SUPPLY, ERECTION, COMMISSIONING, ALONG WITH SUPPLY OF END TERMINATION /JOINTING KITS, COMMUNICATION CABLES WITH REQUIRED ACCESSORIES ETC. THE DETAIL CABLE LAYING METHODOLOGY SHALL BE PRE-APPROVED FROM GIPCL.
04. SPD/WPD SHALL PROVIDE ONE NUMBER 3Cx500SQMM SPARE 33KV CABLE FOR EACH 100MW BLOCK.

FOR TENDER PURPOSE

REV.	DATE	DESCRIPTION	DRN.	STR.	MECH.	ELEC.	INST.
				APPROVED BY			
0	15.02.2023	ISSUED FOR TENDER	JVJ		KA		

FICHTNER
Consulting Engineers (India) Private Limited
Chennai, Bangaluru

GUJARAT INDUSTRIES POWER CO. LTD
2375 MW CAPACITY SOLAR/WIND/HYBRID
RENEWABLE ENERGY PARK AT GREAT RANN OF KUTCH AREA, GUJARAT

	SIGNATURE	DATE
DRAWN	JVJ	14.02.2023
DESIGNED	MC	14.02.2023
CHECKED	KA	14.02.2023
DEPT.HEAD	KA	14.02.2023
PROJ.MGR.	ENN	14.02.2023

TITLE
TENTATIVE OVERALL SINGLE LINE DIAGRAM OF 400/33 KV 1200MW PSS-2 SUBSTATION FOR TENDER PURPOSE

RELEASED FOR		
	PRELIMINARY	
	TENDER	✓
	ENGINEERING	
	CONSTRUCTION	

DEPT. ELECTRICAL | JOB NO. 1721125 | SCALE: NTS | REV.

DWG.NO. FCE-1721125-EL-DWG-SLD-2100-041 | 0

SIZE-A1