



ASSAM ELECTRICITY GRID CORPORATION LIMITED

OFFICE OF THE MANAGING DIRECTOR

Regd. Office: (FIRST FLOOR), BIJULEE BHAWAN, PALTANBAZAR, GUWAHATI - 781001

CIN: U40101AS2003SGC007238 GSTIN: 18AAFCA4973J9Z3

PHONE: 0361-2739520 Web: www.aegcl.co.in

MINUTES OF PREBID MEETING

Bid Identification No.:	AEGCL/MD/Tech-1142/TSAT/245kV GIS Extn./BID
NIT No.:	AEGCL/MD/Tech-1142/TSAT/245kV GIS Extn./NIT Dated 18.08.2026
Name of the Work	Turnkey Extension of Existing 245 kV GIS by Addition of 2 (Two) Nos. of 245 kV GIS Feeder Bays along with Associated Services at 400 kV Sonapur GIS Substation of AEGCL
Date of Pre-Bid Meeting	27/08/2026
Venue of Pre-Bid Meeting	Conference Room O/o the MD, AEGCL, 1st Floor, Bijulee Bhawan, Paltan Bazar, Guwahati-01

OPENING REMARKS:

Smt. Jayashree Devi, CGM (PP&D), AEGCL extended a warm welcome to all the prospective bidders and introduced his team.

Sri Arunav Gogoi GM (NEAP), AEGCL briefed on tender Turnkey Extension of Existing 245 kV GIS by Addition of 2 (Two) Nos. of 245 kV GIS Feeder Bays along with Associated Services at 400 kV Sonapur GIS Substation of AEGCL. It was assured to the prospective bidders that comprehensive reply/clarifications shall be prepared and uploaded in the AEGCL site as well as e-tender portal in response to their raised queries on the bid document.

NAMES OF THOSE PRESENT (Attendance Sheet enclosed herewith):

1. FROM EMPLOYER:

1. Smt. Jayashree Devi, CGM (PP&D), AEGCL
2. Sri Arunav Gogoi, GM (NEAP), AEGCL
3. Sri Rituparna Khargharia, GM (P&D), AEGCL
4. Sri Himangshu Raj Gogoi, DGM (P&D), AEGCL
5. Sri Rupjyoti Sarma, DGM (NEAP), AEGCL
6. Sri Dhriti Lochan Hazarika, AGM (BD), AEGCL



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2. FROM PROSPECTIVE BIDDERS:

A. BIDDERS THAT WERE PRESENT AT THE PRE-BID MEETING:

1. M/s Singhi Infrapower Projects Pvt Ltd.
2. M/s Siemens Energy Ltd. (Through VC)
3. M/s CG Power and Industrial Solutions (Through VC)
4. M/s Hemen Deka (Through VC)

MEMBERS OF THE PRE-BID COMMITTEE:

1. The CGM (PP&D), AEGCL
2. The CGM (O&M), LAR, AEGCL
3. The GM (P&D), AEGCL
4. The GM (NEAP), AEGCL
5. The GM (Civil), AEGCL
6. The DGM (F&A), AEGCL
7. The DGM (NEAP), AEGCL
8. The AGM (BD), AEGCL
9. The AGM (LAW), AEGCL

The queries submitted by the prospective bidders were discussed by the Pre-Bid Committee and the observations made are as follows in Table-1.

[Handwritten signatures and initials in blue ink]

Table-1

QUERIES ON BID DOCUMENT

Sl. No.	Clause of Specification	Queries on Specification.	Clarification from AEGCL
1	BOQ-1 - 1.01 (3) cores, ratio 1600–800/1-1-1 A (0.2S-PX-PX & PX-PX-PX) (as indicated in the approved Single Line Diagram),	We understand that CT ratio and parameters like Vk, Rct, Magnetixing current shall be as per existing GIS. Kindly confirm.	Confirm. However, any changes based on the CT Sizing calculation shall be accomodated by the Bidder without any price implication.
2	BOQ-1 - 1.03 Supply of 245 kV SF ₆ -to-Air Bushing Termination Module, 3150 A, 50 kA for 3 seconds, comprising three (3) Nos 1-phase SF ₆ -to-air bushings, complete termination module, support structures, corona shields, connectors, terminal pads, mounting accessories and all associated fittings for outdoor connection of the GIS to the 245 kV Line Bay.	We understand that 6 Nos 220kV Single Phase SF6-Air Bushings shall be quoted against this requirement. Kindly confirm.	Confirm.
3	BOQ-1 - 1.04 Supply of 245 kV Gas Insulated Bus Duct (GIB), 3150 A, 50 kA for 3 seconds, Single-phase encapsulated SF ₆ Gas Insulated Bus Duct (inside & outside GIS Hall), complete with bus duct sections, expansion joints, support structures, gas compartments, jointing elements, gas monitoring accessories, pressure switches, gas barriers, UHF Partial Discharge (PD) sensors and all associated fittings required for complete installation.	We understand that bus duct length of 300 Meters shall be considered from GIS Bay modules up to the SF6-Air terminations. Kindly confirm.	Confirm
4	BOQ-4 - 4.01 220 kV Horizontal Double Break Isolator with Double Earth switch	In specifications it is mentioned as Horizontal Center Break. Kindly confirm whether it is Horizontal Double Break or Horizontal Center Break.	As per BoQ
5	BOQ-3 - 3.02 220 kV Metering PT	Kindly provide technical specifications of 220kV IVT.	Provided along with this document as Annexure-I

6	Bid Volume-II Chapter-16 Clause No.: 16.4.3 The switchgear, which shall be of modular design, shall have complete phase isolation.	As mentioned in Table from Clause No 16.2.2 Set of 3-single(isolated) phase/ Three phase , 3150A, 50kA for 3 second, SF6 gas-insulated metal enclosed bus bar of 245kV, Hence, for 220kV GIS we are following three phase encapsulated busbar design. Other compartments of GIS shall be of isolated phase.	Confirm
7	Bid Volume-II Chapter-16 Clause No.: 16.4.9 Continuous bus lengths without gas segregation shall not be acceptable for any voltage level.	Please note that, proposed busbar design is passive. We meet the requirement of service continuity, maintenance & repair without provision of any barrier in busbar. In addition to that by putting additional gas compartment/ barrier in busbar we are indirectly increasing gas leakage points in GIS. This type of passive non segregated busbar design is type tested as per IEC 62271-203 and accepted by various state & central utilities. hence we request your acceptance on this design.	Accepted
8	Bid Volume-II Chapter-16 Clause No.: 16.4.7 100 micro-meter or smaller sintered stainless-steel particle filtered disc shall be provided in gas filling port.	Gas filling shall be done using particle filter, hence we do not envisage such filter. However separate filter unit can be used with supplied filling ports during gas handling in future.	Accepted
9	Bid Volume-II Chapter-16 Clause No.: 16.4.9 The devices shall provide continuous and online monitoring (Display at SAS) of the density of the gas.	Kindly confirm weather an output of 6-20mA from the Gas density monitors will be required for the monitoring requirement	Yes required
10	Bid Volume-II Chapter-16 Clause No.: 16.4.11 As minimum flexibility in the layout arrangement, it shall be possible to remove the circuit breaker with both bus bar remaining in service	We infer the requirement calls for withdrawal of CB Interrupters durig repair and maintainance, and not the circuit breaker enclosure as it is not subject to any faults	Agreed
11	Bid Volume-II Chapter-16 Clause No.: 16.4.12 The material and thickness of the enclosures shall be such as to withstand an internal flash over without burns through for a period of 300 ms at rated short time withstand current.	This value shall be in line with IEC 62271-203	As per Type Tested Design








12	Bid Volume-II Chapter-16 Clause No.: 16.4.14 Equipment. Inspection windows (View Ports) shall be provided for Disconnect Switch and both type of earth switches i.e. Maintenance and fast operating. Stroboscopic port shall also be provided.	View ports for DS & ES shall be provided. No stroboscopic port is available in market for GIS.	Confirm
13	Bid Volume-II Chapter-16 Clause No.: 16.4.17 In case the leakage under the specified conditions is found to be greater than 0.5% after one year of commissioning, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during the first year of operation after commissioning.	We infer that an additional 10% extra gas shall be required to be supplied as spare to meet out any contingency requirements	confirm
14	Bid Volume-II Chapter-16 Clause No.: 16.4.19 The switchgear when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations up to the permissible servicing intervals under 100% rated and fault conditions, shall not diminish the performance or significantly shorten the useful life of the switchgear.	The switchgear is equipped with all necessary arrangements for protection from any internal and external faults without deteriorating its performance below recommended level. However, it is requested to inform the manufacturer in the event of any abnormal condition during its operation, so that suitable solution can be given.	confirm
15	Bid Volume-II Chapter-16 Clause No.: 16.4.27 Manufacturer shall submit the study report of VFTO generated for GIS installation for 220 kV and above.	VFTO generally applies to GIS rated 400kV and above, thus a VFTO analysis report is not envisaged for present requirement.	Confirm
16	Bid Volume-II Chapter-16 Clause No.: 16.4.35 In addition to above suitable portable scissor lift shall be provided for access of distant portion of GIS installation.	All portions of supplied GIS shall be accesible using portable ladder, thus provision of portable scissor lift is not envisaged	Confirm

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17	Bid Volume-II Chapter-16 Clause No.: 3.1 GAS INSULATING SYSTEM: ii) Any other alarm necessary to indicate deterioration of the gas insulating system.	Not applicable for offered GIS	Confirm
18	Bid Volume-II Chapter-16 Clause No.: 16.4.43.4 The enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, current transformers, voltage transformers, cable terminals, surge arrestors, earth switches and at each end of the bus bars.	GIS shall meet earthing requirements as per relevant IEEE publication.	As per BID
19	Bid Volume-II Chapter-16 Clause No.: 16.4.43.6 - c EARTHING CONDUCTOR SHALL BE OF COPPER AND SIZE MAY VARY AS PER EARTHING CALCULATION AND THE SAME WILL BE DECIDED DURING DETAILED ENGINEERING.	Both copper and steel earthing conductor shall be proposed. During execution suitable material shall be selected.	Earthing Conductor shall be of COPPER only
20	Bid Volume-II Chapter-16 Clause No.: 16.4.49 Maximum weight of gas in a gas tight section of GIB shall not exceed 400 Kg (for 400 kV)/ 250 Kg (for 220 kV & 132 kV).	The Gas quantities shall be in line with manufacturer standard type tested design suitable form GIS operation at site	confirm
21	Bid Volume-II Chapter-16 Clause No.: 16.4.52 vi. DOCUMENTATION : vi. GIS Component Drawings	Being intellectual property, manufacturing drawings can not be shared.	As per BID

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22	Bid Volume-II Chapter-16 Clause No.: 16.5.1.7.4 The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 p.u. power frequency voltage across the breaker continuously)	The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 p.u. power frequency voltage across the breaker for a specified period of time)	As per BID
23	Bid Volume-II Chapter-16 Clause No.: 16.5.1.14.2.19 The mechanical endurance class shall be M2 as per IEC for 400kV, 220 kV and 132kV disconnectors. Electrical endurance class shall be E2.	Mechanical endurance class shall be M2. however, electrical endurance class E2 is not applicable for disconnector switch.	As per BID
24	Bid Volume-II Chapter-16 Clause No.: 16.5.1.14.2.22 The degree of protection for the Drive Mechanism box of disconnector shall be IP55.	Considering Indoor requirement, IP43 class shall be sufficient. Please accept the same.	As per BID
25	Bid Volume-II Chapter-16 Clause No.: 16.5.1.15.10 The safety grounding switches shall conform to the requirements of IEC- 62271- 102 and shall have electrical endurance class: E2 & shall have mechanical endurance class M2 for 400 kV/220/132 kV voltage level..	Mechanical endurance class shall be M2. however, electrical endurance class shall be E0 for maintenance earth switch in line with IEC and type test report.	As per BID
26	Bid Volume-II Chapter-16 Clause No.: 16.5.1.15.15 The degree of protection of the Drive Mechanism box of maintenance earth switch shall be IP55.	Considering Indoor requirement, IP43 class shall be sufficient. Please accept the same.	As per BID
27	Bid Volume-II Chapter-16 Clause No.: 16.5.1.13 HIGH SPEED MAKE PROOF GROUNDING SWITCHES These shall confirm to class F and electrical endurance class E2 and mechanical endurance class M2.	Electrical endurance class shall be E1 and mechanical endurance class M1 for high speed earth switch in line with IEC and type test report which is in line with tender GTP.	As per BID

28	Bid Volume-II Chapter-16 Clause No.: 16.5.1.22.2.1 Minimum degree of protection of enclosure of LCC shall be IP55	Considering Indoor requirement, IP43 class shall be sufficient. Please accept the same.	As per BID
29	Bid Volume-II Chapter-16 Clause No.: 16.5.1.23.1 The core insulation and outer sheath of cable shall be of halogen-free special polymer.	Request to accept FRLS cables for cabling of LCC panel and GIS equipments.	As per BID
30	Bid Volume-II Chapter-16 Clause No.: 16.10 All transport packages containing critical units viz Circuit breakers and Voltage transformers shall be provided with sufficient number of impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. In case of electronic impact recorder, the recording shall commence in the factory and must continue till the units reach site. The data of electronic impact recorders shall be downloaded at site and a soft copy of it shall be handed over to Engineer	GIS modules are rigidly build and does not gets affected by transportation vibrations. Large modules are shipped by splitting into small parts to reduce mechanical stress during transport. However, mechanical type shock indicators shall be provided for critical items like CB, CT, VT. Request your acceptance on same.	As per BID
31	Bid Volume-II Chapter-16 Clause No.: 16.13 Power frequency tests for the completed GIS at site shall be possible without removing the voltage transformers. The power frequency test voltage at site shall be 80% of the factory test voltage for 1 min at 100Hz.	Please note, during HV test at site voltage transformers shall be disconnected.	Confirm
32	Bid Volume-II Chapter-16 Training	Site Training shall be given by site engineer during ETC activity. No factory training is envisaged. Any expenses like food, lodging, boarding, travel of trainees etc are excluded from GIS OEM scope.	Only site training shall be required under this contract, and the same shall be arranged by the successful bidder.

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33	Bid Volume-I Scope of the Work Clause 11, Page 4 Contractor shall be responsible for reliable operation and performance of the entire extended 245 kV GIS including complete existing GIS bus up to expiry of DLP.	Existing GIS is already commissioned and operational. We understand Contractor's responsibility shall be limited to newly supplied equipment and modifications executed under present contract only and shall not extend to existing GIS equipment. Please confirm.	As per BID
34	Bid Volume-I Scope of the Work Clause 5, Page 3 Shutdown planning and execution in coordination with AEGCL.	Please provide tentative shutdowns available and duration of each shutdown for GIS extension works	After Award of Contract
35	Bid Volume-I Scope of the Work Clause 6, Page 3 Modification of existing SAS database wherever required.	Existing SAS is Hitachi make. We understand all updated database modifications, software and license along with sufficient tags are available for integration for new GIS.	Any upgradation work (if required) shall be under the scope of the Bidder for successful Integration with the existing SAS
36	Bid Volume-I Scope of the Work Clause 6, Page 3 Integration with existing HMI, Gateway, SCADA and Remote Control Centre.	Please provide complete details of existing Gateway, HMI and SCADA.	Hitachi make MicroSCADA SYS600 10.7
37	Bid Volume-I Scope of the Work Clause 6, Page 3 SAS integration works should be carried out in presence of authorized OEM representative of existing Hitachi SAS.	Noted, provided that existing system is healthy. We are not considering any upgradation of the system.	Any upgradation work (if required) shall be under the scope of the Bidder for successful Integration with the existing SAS
38	Bid Volume-I Scope of the Work Clause 8, Page 3 Integration with existing GIS, Protection, SAS, SCADA, Communication Network, AC/DC System and Earthing System.	Kindly define battery limits between existing systems and new extension works.	Existing System will cater

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39	Bid Volume-I Scope of the Work Clause 12, Page 4 Any item required for successful operation shall be deemed included.	Please clearly define scope limits for existing equipment modifications and third-party OEM involvement.	As per BoQ
40	Bid Volume-II Chapter-16 Clause 16.4.50.4, Page 376 Drawing of existing GIS interface/end piece module shall be provided by Employer	Kindly provide GIS OEM approved latest drawings and any revision history.	Shall be provided after award of the Contract.
41	Existing Interface Module Drawing Existing Siemens extension module details available.	Please confirm that no changes have been made to existing installed GIS from approved drawings.	Confirm
42	Existing Interface Module Drawing Extension designed through specific end modules.	Please confirm adequacy of existing extension interface for addition of two feeder bays.	As per Site Visit
43	Bid Volume-II Chapter-16 Clause 16.12, Pages 406-407 GIS hall cleanliness, erection requirements and working procedures specified.	Please provide available GIS erection area, storage area and temporary assembly area details.	Bidders are requested to visit the site.
44	Bid Volume-II Chapter-16 Clause 16.4.48, Page 374 UHF sensors and online PD monitoring required.	Please confirm existing system is having online PD monitoring. And existing online monitoring system is having tags available for integrating new bays. Please clarify.	Confirm
45	Bid Volume-II Chapter-16 Clause 16.14, Page 409 MANDATORY SPARS: Design, engineering, manufacture, testing, supply on FOR destination site basis including transportation & insurance, storage at site of Mandatory spares for the GIS. Standard list of Mandatory Spares shall be provided as per the BPS.	We request M/s. AEGCL to share the BPS as mentioned in the tender document, as there is no specified list of spares provided	As per Bid

46	BoQ1 2.01 (LA), 3.01 (MCT) & 3.02 (MPT)	As per the requirement, two line bay extension is the scope of work, accordingly, 6 nos LA only required, however no. of LA mentioned in the BOQ is 12 No. , we request M/s. AEGCL to specify the requirement of rest 6 Nos.	As per BoQ
47	SAS ARCHITECTURE-Rev04 Note-5, Page 3 Existing Sonapur data integrated through IEC61850.	We understand that we will get the latest CD files, CID files and SAS engineering database.	Confirm
48	SAS ARCHITECTURE-Rev04 Note-6, Page 3 Existing IEDs connected in HSR ring and integrated through HSR to PRP switches.	Please provide HSR ring architecture drawings and switch spare capacity details.	The IEDs under this project will be connected in PRP Architecture
49	SAS ARCHITECTURE-Rev04 Note-7, Page 3 Existing switch replacement may be required if switch is not healthy	We understand that upgradation or replacement of unhealthy existing switches components shall not be in bidder scope. Please confirm.	Any upgradation work (if required) shall be under the scope of the Bidder for successful Integration with the existing SAS
50	Bid Volume-II Chapter-15 Clause 15.24, Pages 280-281 BCU and SAS integration through IEC61850.	Please provide available spare BI/BO, IED capacity and SAS node availability for additional feeders.	Sufficient Tags available in the existing SAS for Integration of the Bays under this project. However, Any upgradation work (if required) shall be under the scope of the Bidder for successful Integration with the existing SAS
51	Bid Volume-II Chapter-15 Clause 15.25, Pages 304-305 Managed Ethernet communication infrastructure.	Please provide details of existing PRP switches, RedBoxes and spare communication ports.	As per the SAS Architecture
52	Bid Volume-II Chapter-15 Clause 15.12, Page 280 Gateway integration with SLDC and Remote Control Centre.	Kindly provide existing Gateway make, model, firmware version and license status.	Hitachi make MicroSCADA SYS600 10.7
53	220 KV BB PROTECTION- (1) Existing Busbar Protection Drawing Existing REB670 Busbar Protection System.	Please confirm sufficient spare CT inputs, spare bays and software capacity are available in existing BBP scheme.	Confirm

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54	220 KV BB PROTECTION- (1) Existing Future Bay Allocation Future bay provisions shown in drawings.	Kindly provide latest REB670 configuration files and busbar trip matrix.	After Award of Contract
55	Approved 220kV Line CRP Drawing Distance Relay Existing Line Protection Scheme Existing REL670, 7SA87, REC670 configuration.	Please confirm new feeder bay protection philosophy shall match existing Sonapur line bays.	Confirm
56	Technical Specification of PLCC & Line Trap Clause 19.8, Pages 592-600 Digital PLCC and Teleprotection required.	Please provide existing PLCC make, model and teleprotection scheme details.	M/s HITCHAI make ETL600
57	Technical Specification of Specification for Communication Equipments for Establishment of Fibre Optic Communication System Clause 29.6, Pages 841-845 SDH/FOTE integration required.	Please provide existing SDH architecture, STM loading and spare interface details.	Existing SDH: Tejas make TJ1400
58	Technical Specification of Samast Meter Chapter 30, Pages 891-920 SAMAST compliant metering and AMR integration.	Please provide existing meter make, DCU architecture and AMR integration details.	Only Meter shall be supplied under this project. Existing Meter: Secure make ProQ100. Existing DCU: Kalitech make SYNC3000
59	Technical specifications of Current transformer Clause 23.14, CT Data Sheet CT ratios and PX core requirements as per detailed engineering.	Please provide confirmed CT ratios and protection core utilization for both proposed feeder bays.	As BoQ
60	Technical Specification of IVT & CVT Clause 13.6.2, Pages 247-248 CVT suitable for carrier coupling.	Please confirm carrier coupling requirement for proposed feeder bays.	As per BID

61	Technical specifications for Earthing and DSLP Earthing System Design, Page 1 Earth mat resistance shall not exceed 1 Ohm.	Please provide latest earth resistance test report and approved earth mat layout.	Earth mat layout and design calculation provided along with this documents
62	Technical specifications for Earthing and DSLP DSLP Section, Pages 4-5 DSLP coverage through lightning masts and shield wires.	Kindly provide approved DSLP calculations and coverage drawings applicable for extension area.	DSLP Layout provided along with this documents
63	Scope of the Work Clause 3, Page 2 Earth mat extension, cable trenches and foundations included.	Please provide geotechnical investigation report, contour survey and underground utility drawings.	Geotechnical investigation report provided along with this documents
64	Approved Trench Drawing APPROVED-220 KV OUTDOOR CABLE TRENCH Existing trench layout available.	Please provide exact trench extension quantities and cable route layout applicable for new bays.	As per BoQ
65	Scope of the Work Clause 4, Page 2 Complete cable laying and termination included.	Please provide detailed cable source-destination and trench and tray route layout for estimation.	Layout provided along with this documents.
66	Technical Specification of Design & Fabrication of Substation Steel Structure Pages 792-799 Contractor to design equipment support structures.	Please confirm existing approved support structure drawings of Sonapur project may be adopted for present extension works.	As per Bid
67	Bid_Volume_I, Section 3.1.1, Pg 49-52 "This is a complete turnkey contract, and any equipment, material, accessory, software, interface, civil modification or service not explicitly mentioned but required for the safe, reliable and successful commissioning and operation of the two 245 kV GIS feeder bays shall be deemed to be included in the Contractor's scope without any additional cost to AEGCL."	Kindly define the boundaries of the Contractor's turnkey scope. Please confirm that any requirement arising from existing undocumented site conditions, latent defects, OEM restrictions, third-party systems, or changes mandated after contract award shall be treated as a scope variation and compensated separately.	As per Bid. Bidders are requested to visit the site.

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68	Scope of the Work, Clause 11 Defect Liability & Warranty "The Contractor shall be responsible for the safety, integrity and satisfactory performance of the existing 245 kV Siemens Make GIS during execution of the extension works."	Please confirm that the Contractor's responsibility shall be limited to the equipment supplied and portions of the existing GIS modified under this contract and shall exclude pre-existing defects or latent defects.	As per Bid
69	Scope of the Work, Clause 11 Defect Liability & Warranty "Upon successful commissioning and charging... Contractor shall be responsible for the reliable operation and performance of the entire extended 245 kV GIS, including the complete existing GIS bus."	Kindly clarify whether responsibility for the complete existing GIS bus is limited to the modified interface portions only.	As per BID
70	Bid_Volume_I, SCC 6.9.3, Pg 66 "The warranty shall remain valid for a period of sixty (60) months from the date of supply or 54 months from the date of commissioning of the project, whichever is later."	Kindly clarify the Defect Liability Period (DLP) applicable for this project and its relationship with the warranty period. The warranty for the GIS shall be valid for a period of sixty (60) months from the date of supply or 54 months from the date of commissioning of the project, whichever is earlier and for rest of items it shall be 24 months from date of supply or 18 months from date of commissioning which ever is earlier. Please provide your acceptance.	As per Bid
71	Bid_Volume_I, SCC 6.8.1, Pg 66 "The Supplier shall have to deposit to the extent of 10% (ten percent) of the total value of the order as performance security..."	Please confirm whether Performance Security can be reduced/released after commissioning and accepted performance.	As per Bid
72	Bid_Volume_I, ECQ Clause 2.5.1(V), Pg 24 "The Tenderer shall furnish performance guarantee for an amount of 20% of the ex-works cost of GIS equipment(s) for a period of five (5) years after completion of the defect liability period."	Kindly clarify BG format, validity start date, expiry conditions, invocation conditions and whether the same can be provided through OEM undertaking instead of additional BG.	As per Bid
73	Bid_Volume_I, SCC 6.16.2, Pg 69 "Supplier shall pay to the Purchaser liquidated damages at the rate of 1% of the total Contract Price per week."	Please confirm that LD shall be the sole and exclusive remedy for delay and no additional damages shall be levied.	As per Bid

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74	Bid_Volume_I, SCC, Entire Contract No clause limiting contractor's overall liability identified.	Kindly confirm Contractor's aggregate liability shall be limited to the total contract value excluding fraud and wilful misconduct.	As per Bid
75	Bid_Vol_I, SCC, Entire Contract No exclusion of indirect/consequential damages identified.	Please confirm that neither party shall be liable for consequential, indirect, special or loss of profit damages.	As per Bid
76	Bid_Vol_I, SCC 6.17.1, Pg 69 "Purchaser may black-list or bans the Supplier."	Kindly define show-cause process, opportunity of hearing and appeal mechanism prior to any blacklisting action.	As per Bid
77	Bid_Vol_I, SCC 6.14, Pg 68 Force Majeure clause provisions.	Kindly confirm pandemic impacts, import restrictions, OEM manufacturing disruptions and global supply chain interruptions are covered under Force Majeure.	As per Bid
78	Bid_Vol_I, SCC 6.7.2, Pg 64 "Payment would be made... subject to availability of fund."	Please remove the clause of 'subject to availability of fund'. Kindly clarify maximum payment timeline irrespective of fund availability.	The Clause Specification is as per AEGCL GCC & thus may not changed. However, please note that fund for this work/project is already secured/tied up. Payment timeline remains unchange from tender docs.
79	Bid_Vol_I, SCC 6.7.2, Pg 64 "80% payment of the total supply invoice value would be made."	Kindly consider release of 90% against receipt and acceptance of material.	As per Bid
80	Bid_Vol_I, SCC 6.7.2 & 6.7.3, Pg 64-65 Retention linked to Completion Certificate and Operational Acceptance Certificate.	Kindly specify the timeline within which Completion Certificate and Operational Acceptance Certificate shall be issued.	After successfully completion of the whole scope of the work.
81	Bid_Vol_I, SCC 6.7.5, Pg 66 "No advance payment is applicable for this contract."	Request consideration of mobilisation advance against BG considering long manufacturing cycle of GIS equipment.	As per Bid
82	Bid_Vol_I, ITB 1.3.7.5, Pg 9 "The prices quoted by the Bidder shall be fixed."	Please confirm statutory variation in GST, duties and taxes after bid submission shall be reimbursed separately.	As per Bid
83	Bid_Vol_I, Clause 3.1.3, Pg 53 "Quantities may vary to the extent of (+)20% to (-)20%."	Kindly clarify that delivery schedule and completion period shall be revised proportionately for quantity increase.	As per Bid
84	Bid_Vol_I, SCC 6.11.1, Pg 67 Purchaser may increase/decrease quantity by 20%.	Kindly clarify applicability of quantity variation to major GIS equipment and bay quantities.	As per Bid








85	Scope of the Work, Clause 5 "Shutdown planning and execution in coordination with AEGCL."	Kindly provide details of expected shutdowns, number of outages and planned outage durations.	Will be provided after award of contract.
86	Bid_Vol_I, Clause 3.8.10, Pg 56 "Employer has the right to use or replicate such designs."	Kindly confirm proprietary OEM designs, software, calculations and GIS know-how shall remain intellectual property of the OEM.	As per Bid
87	Bid_Vol_I, SCC 6.10.1, Pg 67 IP indemnity clause.	Kindly clarify that indemnity shall not apply to modifications performed by others or use outside intended purpose.	As per Bid
88	Bid_Vol_I, SCC 6.13.1, Pg 67 Insurance responsibility until receipt at destination.	Kindly confirm insurance responsibility shall cease after receipt and acceptance at site stores.	As per Bid
89	BoQ1 Item 1.04 "245 kV Gas Insulated Bus Duct (GIB) - 300 Running Meter."	Kindly confirm whether payment shall be based on actual approved engineering quantities.	Confirm
90	BoQ Item 6.02 "Integration of 245 kV Line CRP including all required signals from GIS modules to the existing SAS of Hitachi make."	Kindly clarify exact boundary of SAS integration scope and identify remote-end modifications, if any.	As per Bid
91	Bid_Vol_I, SCC 6.18, Pg 69-70 Arbitration provisions.	Kindly confirm Arbitration and Conciliation Act, 1996 (as amended from time to time) shall govern arbitration proceedings.	As per Bid
92	Bid_Vol_I, SCC 6.15, Pg 69 Extension of time provisions.	Kindly confirm delays attributable to owner approvals, outage unavailability, OEM dependencies and statutory permissions shall qualify for EOT without LD.	As per Bid











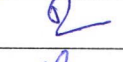
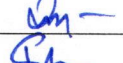
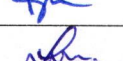
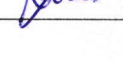


ATTENDANCE SHEET

Pre-Bid meeting / discussion regarding the tender for "Turnkey Extension of Existing 245 kV GIS by Addition of 2 (Two) Nos. of 245 kV GIS Feeder Bays along with Associated Services at 400 kV Sonapur GIS Substation of AEGCL"

Venue – AEGCL(HQ), Bijulee Bhawan

Date – 27.08.2025

SN	Name & Designation	Organization	Ph. Number	Email	Signature
1.	Jayashree Dew				
2.	Aruna Bora				
3.	Rituparna Khajuria				
4.	Himanshu Rijyappa	AEGCL	8638029189		
5.	Rupjyoti Sarma	AEGCL			
6.	D.L. Hazarika				
7.	Dhiraj Sarma (Manager)	SIPPL	9101641330	project.gty@sippl-group.com	
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CHAPTER 13: TECHNICAL SPECIFICATION FOR 33 KV, 132KV, 220KV & 400 KV CVT & IVT

13.1. SCOPE:

13.1.1. This specification provides for the design, manufacture, assembly inspection and testing at the manufacturer's works, packing and delivery at site, erection, testing and commissioning of outdoor mounted type, single phase, oil filled, self-cooled, single unit type Inductive voltage transformers for 33 KV, 132KV & 220KV systems, & Capacitive Voltage Transformers for, 132KV, 220kV & 400 KV system to be used for voltage indication, supply of potential to energy meters, relays for feeder protection in Grid Sub- stations of AEGCL, ASSAM.. In addition to the above functions the 400 KV, 220kV, 132KV CVT shall be suitable for carrier coupling.

13.1.2. The IVTs shall be complete in all respects with insulators, bimetallic connectors, fixing details etc. as described herein.

13.1.3. Bidders are required to quote for 0.2 accuracy class [metering winding] for 33 KV and 132KV IVTs & 132KV, 220kV, 400kV CVTs in the following manner.

(a) Guaranteed Technical Particulars.

(b) Technical literatures, brochures and drawings as per this specification.

(c) Type Test reports.

(d) List of orders, executed and Users' certificates with **minimum 5years of field proven experience** failing submission of the above particulars with the offer, the tender may not be considered for evaluation.

13.2. Following is the list of documents constituting this Specification:

(i) Technical Specification (TS).

(ii) Technical requirements.

13.3. STANDARDS:

13.3.1 The IVTs & CVTs shall conform in all respects to high standards of Engineering, design, workmanship and latest revisions of relevant standards at the time of offer and the Purchaser shall have the power to reject any work or material which in his judgement is not in full accordance therewith.

13.3.2. Except to the extent modified in the specifications, the IVTs & CVTs shall conform to the latest editions and the amendments of the standards listed hereunder:

Sl. No.	Standard Ref. No.	Title
01	IEC-44(4)	Instrument Transformer – measurement of PDS.
02	IEC-60	High voltage testing techniques.
03	IEC-171	Insulation co-ordination.
04	IEC-186	Voltage Transformers.
05	IEC-186(A)	Voltage Transformers (first supp. to IEC-186)
06	IEC-270	Partial discharge measurement.
07	IS-335	Insulating oil for transformers and switchgears.
08	IEC-8263	Method for RIV Test on high voltage insulators.

09	IS-2071	Method of high voltage testing.
10	IS-2099	High Voltage porcelain bushings.
11	IS-2147	Degree of protection provided by enclosures for low voltage switchgear and control.
12	IS-2165	Insulation co-ordination for equipments of 100KV and above.
13	IS-3156 (Part-I to IV).	Voltage transformers.
14	IS-3347	Dimensions of porcelain transformer bushings.
15	IS-4146	Application guide for voltage transformers.
16	IS-5547	Application guide for Capacitor Voltage Transformers.
17	IS-9348	Coupling Capacitor & Capacitor Devices.

13.3.3 All the above along with the amendments thereof shall be read and interpreted together. However, in case of a contradiction between the Technical Specification and any other volume, the provisions of this Technical Specification will prevail.

13.3.4. The voltage transformers with the requirements of other authoritative standards, which ensure equal or better quality than the standards, mentioned above shall also be acceptable. Where the equipments, offered by the supplier conform to other standards, salient points of difference between the standards shall be brought out in the offer. 4 (four) copies of the reference standards in English language shall be furnished along with the offer.

13.3.5. **The supplier is to furnish the standards as mentioned above from SI. 1 to 17 at their own cost, if required by the purchaser.**

13.3.6: Accuracy specified shall be maintained at 25% of rated burden.

13.4. CLIMATIC AND SERVICE CONDITIONS:

13.4.1 Earthquake Incidence:

The CVT/VT are to be designed to withstand earthquake of intensity, equivalent to **Minimum** 0.5g in the horizontal and 0.6g in the vertical direction.

13.5. INSTALLATION:

The **CVT/IVT** covered under this specification shall be suitable for outdoor installation without any protection from rain, dust, mist and direct rays of the sun.

13.6. GENERAL TECHNICAL REQUIREMENTS:

13.6.1. GENERAL TECHNICAL REQUIREMENTS FOR IVT:

13.6.1.1. Each IVT shall be supplied, filled with insulating oil and shall be hermetically sealed to prevent **atmospheric environment** in contact with oil, avoiding filtration and change of oil. Stainless steel diaphragm Bellow with bellow level indicator shall be provided.

13.6.1.2. Secondary Terminal Box:

13.6.1.2.1. The secondary terminals shall be brought out in a weatherproof terminal box with IP-55 **degree of protection enclosure**.

13.6.1.2.2 All secondary terminals shall be brought out in a compartment on one side of each IVT for easy access.

13.6.1.2.3. The exterior of this terminal box shall be hot dip galvanized.

13.6.1.2.4. The terminal box shall be provided with removable gland plate and glands suitable for 1100 volts grade. PVC insulated, PVC sheathed multi core of **2.5 sq.mm to 4 sq.mm** stranded copper conductor cable.

13.6.1.2.5. The terminal box shall be provided with a cover in front so as to have easy access of secondary terminals. The cover shall have a sealing/locking arrangement and shall be suitable to prevent penetration of moisture and rainwater.

13.6.1.2.6. The dimensions of the terminal box and its openings shall be adequate to enable easy access and sufficient working space for use of normal tools.

13.6.1.2.7. The terminal blocks shall be standard type and provided with ferrules indelibly marked or numbered and their identifications shall correspond to the designation on the relevant wiring diagram.

13.6.1.2.8. Secondary wiring terminal studs shall be provided with at least three nuts, plain and spring washers. The studs, nuts and washers shall be of brass, duly nickel plated. The minimum diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads.

13.6.1.2.9. Primary earthing link should be provided for measurement of capacitance & dielectric dissipation factor.

13.6.1.2.10 Polarity shall be indelibly marked on each primary and secondary terminal.

13.6.1.3 The IVT shall be vacuum filled with oil after processing and thereafter hermetically sealed to eliminate breathing and to prevent air and moisture from entering the tanks. The method adopted for hermetic sealing shall be described in the offer.

13.6.1.4. The castings of base, collar etc. shall be die cast and tested before assembly to detect cracks and voids, if any.

13.6.1.5. The characteristics of the IVTS shall be such as to provide satisfactory performance such as voltage error and phase displacement at rated frequency shall not exceed the values as per relevant standards at any voltage between 80% and 120% of rated voltage and with burdens of between 25% and 100% of rated burden at a power factor of 0.8 lagging. The error shall be determined at the terminals of the IVT and shall include the effects of any fuses or resistors as an integral part of the IVT.

13.6.1.6. Inductive voltage transformers shall be ferro-resonance proof and adequately designed to use in HT cable circuit wherever applicable.

13.6.1.10. Primary Winding:

Primary winding of the IVT will be connected phase to neutral with the neutral point solidly earthed. The arrangement for this shall be included in the scope of supply. The primary conductor shall be of adequate cross-section so that the maximum permissible current density shall not be exceeded even during short-circuit conditions. Primary Windings shall be made of Copper.

13.6.1.11. Secondary Winding:

Suitably insulated copper wire of electrolytic grade shall be used for secondary windings. The secondary conductor shall be of adequate cross section so that the maximum permissible current density shall not be exceeded even during short-circuit conditions. Secondary windings details, burden & accuracy class are mentioned in Appendix-I. Secondary windings shall be used for metering, relaying and synchronizing. Each winding shall comply requirements of both Part-II and III of up-to-date editions of IS-3156/IEC-186.

13.6.1.12. Core:

Core laminations shall be of cold rolled grain-oriented silicon steel to ensure 0.2 accuracy class at both normal and over voltage. The core material, thickness of lamination, the relevant graphs showing the characteristics of the core materials shall be submitted along with the offer.

13.6.1.13. Tank:

13.6.1.13.1. Both expansion chambers and tanks of the IVT shall be made of high-quality steel and shall be able to withstand full vacuum and pressure, and thermal and mechanical stresses resulting from maximum short circuit current during operation. The tanks along with all ferrous parts shall be hot-dip galvanized as per relevant standard.

13.6.1.13.2. The metal tanks shall have bare minimum number of welded joints so as to minimize possible locations of oil leakage. Welding in horizontal plane is to be avoided. Supplier has to obtain specific approval from the purchaser for any horizontal welding, used in the bottom tank

13.6.1.13.3. Paint inside the metallic housing shall be of anti-condensation type.

13.6.1.14. Porcelain Housing:

13.6.1.14.1. The housing shall be made up of homogeneous, vitreous porcelain of high mechanical and dielectric strength; glazing of porcelain shall be of uniform brown or dark brown colour with a smooth surface, arranged to shed away rainwater or condensed water particles (fog)

13.6.1.14.2. The bushings of the IVTS shall conform to latest edition of IS-2099. The hollow porcelain insulators shall conform to the latest edition of IS-5621

13.6.1.14.3. The insulators shall be cemented with Portland cement to the flanges resulting in high mechanical, tensile and breaking strength

13.6.1.14.4. The bushings shall have ample insulation, mechanical strength and rigidity for the condition under which they shall be used and shall be designed to prevent accumulation of explosive gases and provide adequate oil circulation to remove the internal heat.

13.6.1.14.5. Cast metal and caps for the bushings shall be of high strength hot dip galvanized malleable iron. They shall have smooth surface to prevent discharge taking place between the metal parts and porcelain as a result of ionisation.

13.6.1.14.6. End shields should be provided for distribution of stresses.

13.6.1.14.7. Corona shields for bushings, if required, should be provided.

13.6.1.15. Insulating Oil:

The quantity of insulating oil for the filling and the complete specification of the insulating oil shall comply in all respects with the provisions of the latest edition of IS-335. The IVTs shall be supplied filled with **new oil**.

13.6.1.16. Prevention of Oil Leakage and Entry of Moisture:

The supplier shall ensure that the sealing of the IVT is properly achieved. In this connection, the arrangement provided by the supplier at various locations including the following ones shall be described, supported by sectional drawings

- (a) Locations of emergence of primary & secondary terminals.
- (b) Interface between porcelain housing and metal tank(s).
- (c) Cover of the secondary terminal box.
- (d) Sealing around oil level indicator.

13.6.1.16.1. Nuts and bolts or screws used for fixation of the interfacing porcelain bushings for taking out terminals shall be provided on flanges, cemented to the bushings and not on the porcelain.

13.6.1.16.2. For gasketed joints, wherever used, **nitrite butyl rubber/Neoprene gaskets shall be used**. The gasket shall be fitted in properly machined groove with adequate space for accommodating the gasket under compression.

13.6.1.17. Fittings and Accessories:

Fittings and accessories listed below shall be supplied with each IVT. Any fitting required essential other than those listed below shall also be supplied along with each IVT.

- (a) Oil level gauge.
- (b) Oil filling hole and cap.
- (c) Pressure relieving device.
- (d) Lifting lugs.
- (e) Phase terminal connectors.
- (f) Tank earthing pads/terminals with necessary nuts and bolts and washers for connecting to Purchaser's strip.
- (g) Name/Rating plate.
- (h) H.R.C. fuse of Adequate rating
- i) Bellow

13.6.1.18. Provisions

13.6.1.18.1. Oil Level Gauge:

An oil level gauge shall be provided to indicate the oil level in the IVT. This gauge shall be mounted in such a way that the oil level can be seen from the ground level.

13.6.1.18.2. Pressure Relieving Device:

Each IVT shall be provided with a pressure relieving device so as to protect bushing of the IVT even under unfavourable conditions.

13.6.1.18.3. Oil Drain Cock:

An oil drain cock along with a stop cock shall be provided in the bottom flange so as to permit taking of oil samples for testing, if required.

13.6.1.18.4. Earthing: Metal tank of each IVT shall be provided with two separate earthing terminals for bolted connection to be provided by the Purchaser for connection to station earth-mat.

13.6.1.18.5. Lifting Arrangement:

The IVT shall be provided with suitable lifting arrangement to lift the entire unit. The lifting arrangement shall be clearly shown in the general arrangement drawing.

Lifting arrangement [Lifting eye] shall be positioned in such a way so as to avoid any damage to the porcelain housing or the tanks during lifting for installation/transport. Necessary string guides shall be offered which shall be of removable type.

13.6.1.18.6. Name Plate:

The IVT shall be provided with non-corrosive legible name plate with the information specified in relevant standards, duly engraved/punched on it.

13.6.1.18.7. Gasket Joint:

The manufacturer shall furnish the type of gasket used or setting methods.

13.6.1.18.8. Terminal Connectors:

All the IVTs shall be provided with bimetallic solder less clamp type, rigid type terminal connectors, suitable for ACSR Conductor as per site requirement. Each terminal connector shall be of universal type, suitable for both horizontal and vertical connections to the transmission line conductors/station bus bar.

13.6.1.18.8.1. Terminal Connectors shall be manufactured and tested as per IS:5561.

13.6.1.18.8.2. All castings shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

13.6.1.18.8.3. No part of a clamp shall be less than 12mm. thick.

13.6.1.18.8.4. All ferrous parts shall be hot dip galvanized conforming to IS-2633

13.6.1.18.8.5. All current carrying parts shall be designed and manufactured to have minimum contact resistance.

13.6.1.18.8.6. Connectors shall be designed to be corona free in accordance with the requirements, stipulated in IS-5561.

13.6.1.18.9. Secondary Wiring: The Secondary wiring shall be enclosed in conduits and shall be brought to a terminal block ready for external connections. The wiring shall be of adequate cross-section and not less than 2.5 sq.mm copper wire.

13.6.1.18.10. The supplier shall supply necessary hardwares, required for connection of phase side conductor to the line terminal and the grounding strip to the grounding terminal.

13.6.1.18.11. Necessary nuts and bolts for fixing the IVTS on the supporting structures shall be in tenderer's scope of supply.

13.6.2. GENERAL TECHNICAL REQUIREMENTS FOR 400KV, 220KV & 132KV CAPACITIVE VOLTAGE TRANSFORMER:

13.6.2.1. The CVT shall operate satisfactorily in system with high X/R ratio. (Tp=100 ms.).

13.6.2.2. The CVT transformer tanks along with top metallic shall be galvanized and painted to required shade.

13.6.2.3. Impregnation details along with tests and checks to ensure successful completion of impregnation cycle shall be furnished for purchaser's approval.

13.6.2.4. Bellows, if used to cater for expansion of insulating oil, shall be tested in accordance with relevant standards. The details shall be subject to the approval of the purchaser.

13.6.2.5. The CVT shall be capacitor voltage type with electromagnetic units and shall be suitable for carrier coupling.

13.6.2.6. All windings of voltage transformer secondaries shall be protected by HRC cartridge type fuses.. The secondary terminals of the CVTs shall be terminated to stud type non-disconnecting terminal blocks in the individual phase secondary boxes via the fuse. Fuse ratings shall be clearly mentioned.

13.6.2.7. CVTs shall be suitable for high frequency (HF) coupling, required for power line carrier communication. The carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor, suitable for effectively blocking the carrier signal over the entire carrier frequency range i.e. 40 to 500 KHZ. Details of the arrangement shall be furnished along with the bid. HF terminal of the CVT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling devices of the carrier communication equipment, when utilized. The bushing shall be fully protected against rain and vermin so as to avoid the possibility of short circuits to earth. An earthing link with fastener shall be provided for HF terminal. **Test tap for Tan-delta and capacitance shall be provided.**

13.6.2.8. The electromagnetic unit, comprising compensating reactor, intermediate transformer and protective and damping devices should have a separate terminal box with all secondary terminals, brought out.

13.6.2.9. The accuracy of the windings (0.2/3P/3P) shall be maintained throughout the entire burden range preferably in the frequency range of 48 HZ to 51.5 HZ on all the three windings without any adjustment during operation. Preference will be given to such bidders who can offer for maintaining the above accuracy class in the frequency range i.e. 48 HZ to 51.5 HZ up to the above specified burden values.

13.6.2.10. Constructional Features:

13.6.2.10.1. The 400KV, 220KV & 132KV CVT shall be suitable for mounting on support structure of lattice type structures.

13.6.2.10.2. Access to secondary terminals shall be possible without any danger of access to high voltage circuit.

13.6.2.10.3. CVTs shall be hermetically sealed units.

13.6.2.10.4. A protective surge Arrester/spark gap shall be provided to prevent break down of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning reactor/RF choke etc. due to short circuit in transformer secondaries. Surge arrester shall be provided in the secondary winding also.

13.6.2.10.5. The CVT secondary terminals shall be brought out into a weatherproof terminal box for ease of access. The terminal box shall have an IP rating of not less than IP 55. The terminal box shall be provided with a removable gland plate at the bottom and shall be suitable for accepting the required number of PVC insulated PVC sheathed, 10 core 2.5 mm² standard copper conductor cable.

13.6.2.10.6. All terminals shall be clearly marked to facilitate connection of secondary wiring.

13.6.2.10.7. Secondary fuses or MCBs shall be provided on or adjacent to each CVT, located such that they are accessible while the primary is live and shall be provided with labels indicating their function and their phase colours. CVT secondary circuits shall be complete in themselves and shall be earthed at one point only. A separate earth link shall be provided for each secondary winding and shall be situated at the CVT. Primary earthing links should be provided.

13.6.2.10.7. To prevent ferro resonance, suitable damping devices shall be provided for connection to the transformer secondaries.

13.6.2.10.8. CVTs shall meet the requirements, given in this section of the specification.

13.6.2.10.9. The creepage and flashover distances of the high voltage insulator shall be suitable for the outdoor service conditions, specified in the schedules.

13.6.2.10.10. The bidder in the offer is to state the suitable precautions/methods, adopted during design stage of the CVT to avoid the undesirable effects due to ferro resonance phenomena.

13.6.2.10.11. It should be stated in the bid offer regarding the steps taken in the design stage for elimination/minimization of the influence of the transient response on the behaviour of high-speed relays.

13.6.2.10.12. It shall be ensured by the bidder in the offer that the connection of carrier, frequency coupling device across the CVT will not affect the designated accuracy class of the CVT windings.

13.6.2.10.13. The capacitor divider unit shall comply to IS: 9348/1979.

13.6.2.10.14. It shall also be complied in the offer through a calculation sheet, proving that the designated accuracy class of the CVT (both metering and protection) are not affected by extreme temperatures, to be encountered in service conditions (Max. ambient temperature 50° C and minimum -0° C). The terminal connectors should be suitable for 'ACSR' Conductor as per site requirement.

13.7. TESTS:

13.7.1 Type Tests:

The offered 33 KV, 132KV, 220kV Inductive voltage transformer 400kV, 220kV, 132KV capacitive voltage transformer should have been subjected to the following type tests in a Government approved Test Laboratory. The bidder shall furnish four sets of type test reports along with the offer. These tests must not have been conducted earlier than five years from the date of opening of the bid. For any change in the design/type already type tested and to the design/type offered against this specification, the purchaser reserves the right to demand repetition of some or all type tests/special tests without any extra cost to AEGCL in the presence of purchaser's representative at the cost of the supplier.

For 33 KV, 132 KV, 220kV IVT:

- (a) Temperature rise test.
- (b) Lightning Impulse Test.
- (c) High Voltage power frequency wet withstand voltage tests.
- (d) Determination of errors.
- (e) IP-55 Test on secondary Terminal Box.

(f) RIV Test

(g) Creepage distance measurement test

N.B.: (i) The dielectric type tests should have been carried out on the **Same design and type of IVT.**

(ii) After the IVT was subjected to the dielectric tests, it should have been subjected to all routine tests as per relevant standards.

(iii) For Temperature Rise Test, the test must have been made with the appropriate rated burden, connected to each secondary winding.

For 400kV, 220kV & 132kV CVT.

Type Tests/Special Tests for 400kV, 220kV, 132kV CVT:

- a) Lightning Impulse voltage test on complete CVT unit.
- b) Power frequency over-voltage test on complete CVT unit.
- c) Partial discharge test.
- d) Radio interference voltage test.
- e) Corona extinction voltage test.
- f) Temperature rise test on complete CVT unit.
- g) Ferro resonance test on the complete C.V.T. unit.
- h) Transient response tests.
- i) Determination of Temperature Co-efficient test.
- j) High frequency capacitance and equivalent resistance measurement test (as per IEC-358)

- k) Stray capacitance and stray conductance test (as per IEC-358).
- l) Accuracy tests.
- m) Thermal stability test.
- n) Thermal Co-efficient test (as per IEC-358)
- o) Fast transient test.
- p) Seismic withstand test.
- q) IP-55 test on secondary Terminal Box.
- r) Magnetization and internal burden tests.
- s) Effectiveness of sealing tests.
- t) Mechanical Terminal load test on Bushing.
- u) Dielectric loss angle test (Tan Delta Test).
- v) Switching impulse withstand test
- w) Critical impulse withstand voltage of insulator housing.

N.B: 1. The dielectric type tests should have been carried out on the same CVT.

- 2. After the CVT was subjected to the dielectric tests, it should have been subjected to all routine tests as per relevant standards.
- 3. The ratio errors, phase displacements before, during and after the temperature rise test on complete CVT unit should have been determined with stipulated burdens and the same should comply with the designated accuracy class for each winding of the CVT.

13.7.2 Routine Tests:

The following routine tests shall be conducted on each VT in the presence of Purchaser's representative for which no charges will be payable by AEGCL. No sampling is allowed.

- (a) Verification of terminal markings.
- (b) Power frequency withstand tests on primary windings/capacitor voltage divider for CVT
- (c) Partial discharge measurement for 400kV, 220kV & 132kV CVT.
- (d) Power frequency withstand tests on secondary windings/Low voltage terminal of the capacitor divider for 400kV, 220kV & 132kV CVT.
- (e) Determination of errors on complete IVT/CVT.
- (f) Measurement of Insulation resistance.
- (g) Oil leakage test.
- (h) Measurement of capacitance and dielectric dissipation factor before and after dielectric tests (as per IEC-358)
- (j) Power frequency tests on electromagnetic unit for 400kV, 220kV & 132kV CVT.
- (j) Any other test as per relevant national & international standards.

(k) Creepage distance measurement test.

N.B.: Determination of errors shall be performed after the other tests. The standard reference VT to be used during testing for determination of ratio error and phase angle error should be of 0.05 accuracy class or better as per standard practice, presently adopted by AEGCL.

13.8. INSPECTION:

13.8.1. The Purchaser shall have access at all times to the works and all other places of manufacture, where the IVTs/CVTs are being manufactured and the supplier shall provide all facilities for unrestricted inspection of the supplier's works, raw materials, manufacturer of all the accessories and for conducting the necessary tests.

13.8.2. The Supplier shall keep the Purchaser informed in advance of the time of starting and of the progress of manufacture of equipment in its various stages so that arrangement could be made for inspection at the discretion of the Purchaser.

13.8.3. No material shall be dispatched from its manufacture unless the material has been satisfactorily inspected, tested and dispatch clearance issued. However, the Purchaser reserves the right to alter the despatch schedule attached to this Specification.

13.8.4. The acceptance of any quantity of equipment shall in no way relieve the supplier of his responsibility for meeting all the requirements of this Specification and shall not prevent subsequent rejection, if such equipments are found to be defective.

13.8.5. Clear 15 (Fifteen) days' notice shall be given to this office for deputing officer(s) for inspection. The Voltage Transformers shall be despatched only after the inspection is conducted by a representative of AEGCL and release order, issued from this office after approval of Routine Test Certificates. The shop routine test certificates in triplicate for all the Voltage Transformers along with the calibration certificates of all the meters and equipments to be used during testing (as per Annexure-B of the Specification) should be furnished along with the Inspection Offer. The Inspecting Officer will be authorised for inspection of the Voltage Transformers subject to the condition that the routine test certificates and calibration certificates of the testing equipments/meters will be found to be in order.

13.9. QUALITY ASSURANCE PLAN:

13.9.1. The Bidder shall invariably furnish following informations along with his offer.

- (i) Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards, according to which the raw materials are tested, list of tests, normally carried out on raw materials in presence of Bidder's representative, copies of test certificates.
- (ii) Information and copies of test certificates as in (i) above in respect of bought out items.
- (iii) List of manufacturing facilities available.
- (iv) Level of automation achieved and list of areas where manual processing exists.
- (v) List of areas in manufacturing process where stage inspections are normally carried out for quality control and details of such tests and inspection.
- (vi) Special features provided in the equipment to make it maintenance free.

(vii) List of testing equipments, meters and test plant limitation, if any, vis-à-vis the type, acceptance and routine tests, specified in the relevant standards. These limitations shall be very clearly brought out in the offer.

(viii) All the testing equipments, meters etc. should have been calibrated in a Government approved laboratory. The Bidder must submit the list of testing equipments and meters test as per the Technical Specification.

(ix) QAP shall include acceptance criteria against all parameters with relevant clause of standards

13.9.2. The Supplier shall within 30 days of placement of order submit the following information to the Purchaser.

(i) List of raw materials as well as bought out accessories and the names of the materials as well as bought out accessories and the name of Sub-suppliers selected from those, furnished along with the offer.

(ii) Type test certificates of the raw materials and bought out accessories.

(iii) Quality Assurance Plan (QAP) with hold points for the Purchaser's possible inspection. The QAP and hold points shall be discussed between the Purchaser and the Supplier before the QAP is finalised.

13.9.3. The Supplier shall submit the routine test certificates of bought out items and raw materials at the time of acceptance testing of the fully assembled equipment.

13.10. DOCUMENT:

The supplier shall furnish four sets of following drawings/documents along with his offer.

(a) General outline and assembly drawings of the Inductive Voltage Transformers/ Capacitive

Voltage Transformers.

(b) Sectional views showing:

i) General constructional features.

ii) Materials/gaskets/sealing used.

iii) The insulation of the winding arrangements, method of connection of primary/ secondary winding to the primary/secondary terminals etc.

(c) Schematic drawing.

(d) Rating & diagram plate as per relevant IEC/ISS

(e) Secondary Terminal Box.

(f) Assembly Sectional view of Primary terminal/capacitor voltage divider

(g) Assembly drawing for secondary terminal

(h) The detailed dimensional drawing of Porcelain Housing such as ID, OD, thickness and insulator details such as height, profile of petticoats, angle of inclination and gap between successive petticoats, total creepage distance etc.

(i) Sectional view of pressure release device.

- (j) Drawing showing details of Oil level.
- (k) All type test reports relating to the tests as specified in Clause-8.1 of the above.
- (l) Ratio and phase angle error curves for IVTS/ CVTS
- (m) Magnetization characteristic curves such as B-H curves and Sp. Loss vs. Flux density curves for core material, used for IVT & EMU unit of CVT.
- (n) Sectional view of EMU unit of 220KV&132KV CVT.
- (o) Schematic diagram showing the working of CVT in PLCC.

13.11. TEST REPORTS:

- (i) Four copies of type test/special test reports shall be furnished to the Purchaser with the tender offer.
- (ii) Copies of acceptance test reports and routine test reports shall be furnished to the Purchaser. One copy will be returned, duly certified by the Purchaser and only thereafter shall the materials be despatched.
- (iii) All records of routine test reports shall be maintained by the supplier at his works for periodic inspection by the Purchaser.
- (iv) All test reports of tests conducted during manufacture shall be maintained by the supplier. These shall be produced for verification as and when required for by the purchaser.
- (v) The necessary galvanized flanges, bolts etc. for the base of the Inductive/Capacitive Voltage Transformers shall be supplied without any extra cost to the purchaser.

13.12 APPENDIX – I.

TECHNICAL REQUIREMENTS FOR 33kV, 132kV & 220kV INDUCTIVE VOLTAGE TRANSFORMERS & 132kV, 220kV, 400kV CAPACITIVE VOLTAGE TRANSFORMER.

Sl. No	Particulars	33kV IVT	132kV IVT	220kV IVT	132kV CVT	400kV/220kV CVT
I	II	III	IV	V	VI	VI
1	Type	Single phase, 50Hz, oil filled, self-cooled, Hermetically sealed, outdoor porcelain type.	Single phase, 50Hz, oil filled, self-cooled, Hermetically sealed, outdoor porcelain type.	Single phase, 50Hz, oil filled, self-cooled, Hermetically sealed, outdoor porcelain type.	Single phase, 50Hz, oil Filled, self-cooled, Hermetically sealed, Outdoor porcelain type.	Single phase, 50Hz, oil Filled, self-cooled, Hermetically sealed, Outdoor porcelain type.
2	Nominal system voltage.	33kV	132kV	220kV	132kV	400 kV/220kV
3	Highest system voltage.	36kV	145kV.	245kV.	145kV	420kV/245kV
4	Frequency.	50Hz± 5%	50Hz± 5%	50Hz± 5%	50Hz ± 5%	50Hz± 5%
5	System earthing.	Effectively solidly earthed	Effectively solidly earthed	Effectively solidly earthed	Effectively solidly earthed.	Effectively solidly earthed.
6	Number of phases.	3 [single phase]	3 [single phase]	3 [single phase]	3 [single phase]	3 [single phase]
7	(i) Number of secondary windings. (ii) Purpose of windings.	3 [three] Protection & metering.	3 [three] Protection & metering.	3 [three] Protection & metering.	3 [three] Protection & metering.	3 [three] Protection & metering.
8	Rated primary voltage.	33/1.732kV	132/1.732kV	220/1.732 kV	132/1.732kV	400/1.732 kV 220/1.732 kV
9	Rated secondary voltage.	Winding-II &III- 110/1.732V (Protection) Winding-I- 110/1.732V (Metering)	Winding-II &III- 110/1.732V (Protection) Winding-I- 110/1.732V (Metering)	Winding-II &III- 110/1.732V (Protection) Winding-I- 110/1.732V (Metering)	Winding-I- 110/1.732V Winding-II- 110/1.732V Winding-III- 110/1.732V	Winding-I- 110/1.732V Winding-II- 110/1.732V Winding-III- 110/1.732V
10	Ratio	33kV/1.732: 110V/1.732 110V/1.732	132kV/1.732: 110V/1.732 110V/1.732	220kV/1.732: 110V/1.732 110V/1.732	132kV/1.732: 110V/1.732 110V/1.732	400kV/1.732: 110V/1.732, 110V/1.732 220kV/1.732: 110V/1.732 110V/1.732
11	Rated burden.	Winding-I(M)- 50VA Winding-II(P)- 50VA Winding-III(P)- 50VA	Winding-I(M)- 50VA Winding-II(P)- 50VA Winding-III(P)- 50VA	Winding-I(M)- 50VA Winding-II(P)- 50VA Winding-III(P)- 50VA	Winding-I (M)- 50VA Winding-II (P)- 50VA Winding-III(P)- 50VA	Winding-I (M)- 50VA Winding-II (P)- 50VA Winding-III(P)50VA
12	Accuracy class	0.2/3P/3P	0.2/3P/3P	0.2/3P/3P	0.2/3P/3P	0.2/3P/3P
13	Rated voltage factor at rated frequency.	1.2 continuous. 1.5 for 30second.	1.2 continuous. 1.5 for 30second.	1.2 continuous. 1.5 for 30second.	1.2 continuous. 1.5 for 30second.	1.2 continuous. 1.5 for 30second.

14	Temperature rise at 1.2 times the rated primary voltage, rated frequency & rated burdens.	As per IEC- 186.	As per IEC-186.	As per IEC-186.	As per IEC-186/61869	As per IEC-186/61869
15	Temperature rise at 1.5 times the rated primary voltage for 30 seconds, rated frequency & rated burden.	As per IEC- 186.	As per IEC-186.	As per IEC-186.	As per IEC-186/61869	As per IEC-186/61869
16	One-minute power frequency dry/wet withstands test voltage for primary winding.	70kV[rms]	275kV[rms]	460kV[rms]	275kV[rms]	650kV[rms](400kV)/ 460kV[rms](220kV)
17						
18	1.2/50 micro second impulse withstand test voltage for primary winding	170kV[peak]	650kV[peak]	1050kV[peak]	650kV[peak]	1425kV[peak] (400kV)/ 1050kV[peak] (220kV)
19 (i) (ii)	One-minute power frequency withstands test voltage for Secondary winding Between LV(HF) terminal & earth terminal	3kV[rms] -	3kV[rms] -	4kV[rms]	3kV[rms] 10kV[rms] for exposed terminals & 4kV[rms] for terminals, enclosed in a weatherproof box.	3kV[rms] 10kV[rms] for exposed terminals & 4kV[rms] for terminals, enclosed in a weatherproof box.
20	Class of insulation.	A	A	A	A	A
21	Material of the conductor of primary and secondary windings.	Copper.	Copper.	Copper.	Copper for EMU	Copper for EMU

22	Fault level	31.5kA [rms] for 3 second.	40 kA [rms] for 3 second.	50 kA [rms] for 3 second.	40 kA [rms] for 3 second.	50KA for 3 (220kV) / 63KA(400kV)[rms] for 3 second.
23	Minimum creepage distance.	1116mm	4495mm	7595mm	4495 mm	13020(400kV)/7595(220 kV) mm
24	Quality of oil.	EHV Grade As per IS-335.	EHV Grade As per IS-335.	EHV Grade As per IS-335.	EHV Grade As per IS- 335.	EHV Grade As per IS- 335.
25	Radio interference voltage at 1.1 times maximum rated voltage at 1.0 MHz.	-	500 micro volts.	500 micro volts.	500 micro volts.	500 micro volts.
26	Partial discharge level.	-	Less than 10 piccoulombs.	Less than 10 Piccoulombs.	Less than 10 Piccoulombs.	Less than 10 piccoulombs.
27	Seismic acceleration Horizontal – Vertical –	0.5g. 0.6g.	0.5g. 0.6g.	0.5g. 0.6g.	0.5g. 0.6g.	0.5g. 0.6g.
28	Accuracy class of standard V.T. to be used during testing towards determination of ratio errors and phase angle errors for metering windings.	0.05 or better.	0.05 or better.	0.05 or better.	0.05 or better.	0.05 or better.
29.	Capacitance (Pf)	-	-		4400 + 10%, -5%	4400 (for 220kV), 8800 (for 400kV) + 10%, -5%

Note:

- (i) For Station service bay equipments rated system voltage shall be 33kV and highest system voltage shall be 72.5kV.

REPORT ON
GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220
KV TRANSMISSION LINE AGAINST CONSTRUCTION OF
400/220 KV , 2X500MVA GIS AT SONAPUR (NEW) ALONG
WITH THE ASSOCIATED TRANSMISSION LINES
(PACKAGE-H(R))

:REPORT SUBMITTED TO:

THE ASSISTANT GENERAL MANAGER
ASSAM ELECTRICITY GRID CORPORATION LIMITED
132 KV EHV GRID, SUB STATION
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RELIANT FOUNDATIONS PVT LTD

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GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220 KV TRANSMISSION LINE AGAINST CONSTRUCTION OF 400/220 KV , 2X500MVA GIS AT SONAPUR (NEW) ALONG WITH THE ASSOCIATED TRANSMISSION LINES(PACKAGE)H®

1. INTRODUCTION: The work of soil Investigation was awarded to RELIANT FOUNDATIONS PVT. LTD & RELIANT ENGINEERS Sun-Polo Colony, Bye lane - Dipar Boro Path, Near Ayursundra Super Specialty Hospital, Ahomgaon, GARCHUK Guwahati-781035.

2. Soil investigation work by making boreholes:

2.1 The field and laboratory investigations carried out by us to access the nature of sub-strata and to evaluate the soil parameters required for design of foundations proposed to be constructed for proposed construction.

2.2 Client's help is gratefully acknowledged in providing bore hole locations, close supervision and checking during boring, sampling, various testing operations and cooperation and guidance during finalization of report.

2.3 This report is based upon the results of field, laboratory tests conducted on selected soil samples collected from borehole locations.

3. SCOPE OF WORK:

The scope of work provided to us for this project was limited to the following:-

3.1 Mobilizing necessary plant, equipments and personnel to the project site, setting up the equipment, carrying out the field investigations on land and demobilization on completion of work.

3.2 Making 150 mm nominal diameter bore holes at the site in all types of soil using suitable approved method of boring to be given at site by the Engineer-in-Charge. Refusal shall mean when SPT field 'N' value reaches 100 for 30 cm or less penetration of SPT sampler.

3.2.1 Conducting standard penetration tests in the bore holes at 1.50 m interval in depth as per specifications / instructions of Engineer-in-Charge.

3.2.2 Collecting undisturbed soil samples from bore holes at 3.0m interval or every change of strata, whichever is earlier as per specifications.

3.2.3 Collecting disturbed soil samples from bore hole at regular interval and at every identifiable change of strata to supplement the boring records.

3.2.4 Recording the depth of ground water table in all the bore hole if observed up to the depth of exploration during boring work as per specifications & withdrawing the casing pipe.

3.3 Conducting the following laboratory tests on selected disturbed / undisturbed soil samples collected from bore hole / test locations :-

(a) Bulk density and Moisture content

(b) Sieve analysis

(c) Hydrometer analysis

(d) Liquid limit & Plastic limits

(e) Specific gravity

(f) Shear test on undisturbed and remoulded saturated disturbed soil samples





GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220 KV TRANSMISSION LINE AGAINST CONSTRUCTION OF 400/220 KV , 2X500MVA GIS AT SONAPUR (NEW) ALONG WITH THE ASSOCIATED TRANSMISSION LINES(PACKAGE)H®

(g) Determination of void ratio.

3.4 Preparation and submission of report in three copies.

4.0 FIELD INVESTIGATIONS:

4.1 Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site.

4.2 Bore hole was bored at this site using Auger and wash boring method as per IS: 1892-1979. Casing or Bentonite has been used as required to retain the bore hole.

4.3.1 **Standard penetration** tests were conducted in the above bore hole at every 1.50 m interval & at change of strata as per specifications / instructions of Engineer-in-Charge. The bore was cleaned up to the desired depths. Standard split spoon sampler attached to lower end of 'A' drill rods was driven in the bore holes by means of standard hammer of 63.5 Kg. falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications & the numbers of blows required for each 15 cm penetration were recorded. The numbers of blows for the first 15 cm penetration were not taken into account. This was considered as seating drive. The numbers of blows for next 30 cm penetration were designated as SPT 'N' value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed soil samples obtained from standard split spoon sampler for all the above standard penetration tests were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to the laboratory for testing.

4.3.2 **Undisturbed** soil samples were collected from the bore hole at every 3.00 m interval in depth & at change of strata as per sampling specifications. These sampling tubes after retrieval from the bore hole was properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

4.3.3 **Disturbed soil** samples were also collected from the borehole at suitable depths/intervals to supplement the boring records. These samples were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.

4.3.4 The depth of ground water table was checked / measured in all boreholes.





GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220 KV TRANSMISSION LINE AGAINST CONSTRUCTION OF 400/220 KV , 2X500MVA GIS AT SONAPUR (NEW) ALONG WITH THE ASSOCIATED TRANSMISSION LINES(PACKAGE)H®

4.3.5 Summary of boreholes:

Sl. No	Borehole number	Location	Depth of borehole (M)	Depth of water table(M)
1	BH1	400kv Site	10.50	3.50M FROM EGL
2	BH2	220kv Site	10.50	3.50M FROM EGL

5.0 LABORATORY INVESTIGATIONS:

5.1 The following laboratory tests were conducted on selected soil samples recovered

From borehole / test locations: -

- (a) Bulk density and Moisture content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid limit & Plastic limits
- (e) Specific gravity
- (f) Shear test on remolded and saturated disturbed soil samples
- (g) Determination of void ratio.

All the above laboratory tests were carried out as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498-1970.

6.0 FINDING OF GEOTECHNICAL INVESTIGATION:

The study of bore logs/results of laboratory and other field tests are tabulated through different tables as annexure.

7.0 CALCULATION OF BEARING CAPACITY

Calculation of Net Safe Bearing Capacity based on shear Criteria

IS: 6403-1981 recommends the following equation to calculate the net Safe Bearing Capacity ' q_s ' based on Hansen's Bearing Capacity analysis:

$$q_s = 1/F \{ C N_c S_c d_c I_c + q (N_q - 1) S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma \times R_w \}$$

Where, C = Cohesion of soil.

γ = Saturated Density of soil

B = Width of footing

R_w = Water table correction factor depending upon position of water table with respect to founding level

Q = Effective surcharge at footing level = γD (D = depth of footing)





GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220 KV TRANSMISSION LINE AGAINST CONSTRUCTION OF 400/220 KV , 2X500MVA GIS AT SONAPUR (NEW) ALONG WITH THE ASSOCIATED TRANSMISSION LINES(PACKAGE)H@

N_c, N_q, N_γ = Bearing capacity factor

S_c, S_q, S_γ = Shape factor

d_c, d_q, d_γ = depth factor

i_c, i_q, i_γ = inclination factors

F = Factor of safety =3

B) Calculation of safe bearing pressure based on tolerable settlement.

The safe bearing pressure is to be found out from the elastic settlement consideration and is found from the following equation given I.S. 8009 (part-1) 1976

$$S_f = S_{ocd} = (H_t / (1 + e_o)) C_c \log_{10} (p_o + \Delta p) / p_o$$

S_f = Final settlement in mm

S_{ocd} = Settlement computed from one dimensional test

H_t = Thickness of soil layer in m

e_o = Initial void ratio at mid height of of layer

C_c = Compression Index

P_o = Initial effective pressure at mid height of layer

Δp = pressure increment

For the computation of settlement of foundation founded at certain depth, a correction should be applied to the calculated S_f in the form of a depth factor to be read from

Fig: 12 of I.S. 8009 (part-1) 1976.

Corrected settlement $S_{fd} = S_f \times \text{depth factor}$

Depth factor is dependent on the following

i. D= Depth of footing ii. L= Length of footing iii. B= Width of footing

For granular soil settlement is calculated from the *method Based on Dynamic Penetration Test as per IS 8009-Part-I, 1976, reaffirmed 1998*

— Settlement of a footing of width B under unit **intensity** of pressure resting on dry cohesion less deposit with known standard **penetration** resistance value N , (determined according to IS: 2131- 1963t), may be read from Fig. 9 (*IS 8009-Part-I*) . The settlement under any other pressure may be **computed** by assuming that the settlement is proportional to the intensity of pressure.





GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220 KV TRANSMISSION LINE AGAINST CONSTRUCTION OF 400/220 KV , 2X500MVA GIS AT SONAPUR (NEW) ALONG WITH THE ASSOCIATED TRANSMISSION LINES(PACKAGE)H®

8.0 RECOMMENDATION OF FOUNDATION

After obtaining the laboratory test results of the samples collected from the field and analyzing the subsoil parameters in a very careful manner, the net safe bearing capacities of isolated footing foundation at different depths are calculated and shown in table 1 & 2

Table 1: Safe Bearing Capacities of Footing Foundations:

Location	Depth of footing from FGL (M)	Footing size (M ²)	Net Safe Bearing Capacities (Metric Ton /Sqm.)
400KV SITE	1.00	1.5 X 1.5	8.45
		2.0 X 2.0	8.21
		2.5 X 2.5	8.06
		3.0 X 3.0	7.97
		3.5 X 3.5	7.92
		4.0 X 4.0	7.88
		4.5 X 4.5	7.83
	1.50	1.5 X 1.5	9.05
		2.0 X 2.0	8.68
		2.5 X 2.5	8.46
		3.0 X 3.0	8.31
		3.5 X 3.5	8.21
		4.0 X 4.0	8.14
		4.5 X 4.5	8.09

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Location	Depth of footing from FGL (M)	Footing size (M ²)	Net Safe Bearing Capacities (Metric Ton /Sqm.)
400KV SITE	2.00	1.5 X 1.5	12.21
		2.0 X 2.0	11.56
		2.5 X 2.5	11.18
		3.0 X 3.0	10.92
		3.5 X 3.5	10.75
		4.0 X 4.0	10.63
		4.5 X 4.5	10.52
	2.50	1.5 X 1.5	13.93
		2.0 X 2.0	13.05
		2.5 X 2.5	12.53
		3.0 X 3.0	12.19
		3.5 X 3.5	11.94
		4.0 X 4.0	11.76
		4.5 X 4.5	11.63


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Location	Depth of footing from FGL (M)	Footing size (M ²)	Net Safe Bearing Capacities (Metric Ton /Sqm.)
400KV SITE	3.00	1.5 X 1.5	14.72
		2.0 X 2.0	13.67
		2.5 X 2.5	13.04
		3.0 X 3.0	12.62
		3.5 X 3.5	12.33
		4.0 X 4.0	12.11
		4.5 X 4.5	11.95

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Table 2: Safe Bearing Capacities of Footing Foundations:

Location	Depth of footing from FGL (M)	Footing size (M ²)	Net Safe Bearing Capacities (Metric Ton /Sqm.)
220KV SITE	1.00	1.5 X 1.5	7.02
		2.0 X 2.0	6.82
		2.5 X 2.5	6.70
		3.0 X 3.0	6.63
		3.5 X 3.5	6.58
		4.0 X 4.0	6.54
		4.5 X 4.5	6.52
	1.50	1.5 X 1.5	7.53
		2.0 X 2.0	7.22
		2.5 X 2.5	7.04
		3.0 X 3.0	6.93
		3.5 X 3.5	6.85
		4.0 X 4.0	6.79
		4.5 X 4.5	6.75

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Location	Depth of footing from FGL (M)	Footing size (M ²)	Net Safe Bearing Capacities (Metric Ton /Sqm.)
220KV SITE	2.00	1.5 X 1.5	11.53
		2.0 X 2.0	10.92
		2.5 X 2.5	10.56
		3.0 X 3.0	10.32
		3.5 X 3.5	10.16
		4.0 X 4.0	10.03
		4.5 X 4.5	9.94
	2.50	1.5 X 1.5	12.72
		2.0 X 2.0	11.93
		2.5 X 2.5	11.45
		3.0 X 3.0	11.14
		3.5 X 3.5	10.92
		4.0 X 4.0	10.76
		4.5 X 4.5	10.64


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GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220 KV TRANSMISSION LINE AGAINST CONSTRUCTION OF 400/220 KV , 2X500MVA GIS AT SONAPUR (NEW) ALONG WITH THE ASSOCIATED TRANSMISSION LINES(PACKAGE)H®

Location	Depth of footing from FGL (M)	Footing size (M ²)	Net Safe Bearing Capacities (Metric Ton /Sqm.)
220KV SITE	3.00	1.5 X 1.5	13.45
		2.0 X 2.0	12.50
		2.5 X 2.5	11.93
		3.0 X 3.0	11.55
		3.5 X 3.5	11.29
		4.0 X 4.0	11.09
		4.5 X 4.5	10.94

9.0 CONCLUSION: Safe bearing capacities are shown in above Tables.

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Calculation of Net safe bearing capacity (Shear Criteria) :FOR 400KV SITE(BH01)

Depth of foundn , Df = 2.0 m

Width(B)M= 2 Length L = 2

Soil parameter

Cohesion, C= 0.51 kg/scm= 5.1 t/sqm

Saturated density , γ (Metric ton/m3) = 1.92

Submerged density , γ (Metric ton/m3) = 0.92

Angle of internal

friction, ϕ (deg)= 7 , shear condition Local

Angle of shearing resistance for local failure = $\phi_m = \tan^{-1} \frac{2}{3} \tan \phi$

Bearing capacity factor

ϕ	7	Nc	Nq	N γ
ϕ m	4	6.22	1.45	0.36

Shape, Depth and inclination factor

Shape factor		Depth factor		Inclination factor		Water table corection factor
Sc=	1.30	dc=	1.21	ic=	1	W' = 0.5
Sq=	1.20	dq=	1.00	iq=	1	
Sy =	0.80	dy =	1.00	iy =	1	

Ultimate bearing capacity (qd) (Local shear Condition)

$$q_d = \left\{ \frac{2}{3} c N_c s_c d_c i_c \right\} + \left\{ \gamma D (N_q - 1) s_q d_q i_q \right\} + \left\{ 0.5 \gamma B N_\gamma s_\gamma d_\gamma i_\gamma W' \right\}$$

$$q_d = \{ 0.67 \times 5.1 \times 6.22 \times 1.3 \times 1.21 \times 1 \} + \{ 0.92 \times 2 \times (1.45 - 1) \times 1.2 \times 1 \times 1 \} + \{ 0.5 \times 0.92 \times 2 \times 0.36 \times 0.8 \times 1 \times 1 \times 0.5 \}$$

$$q_d = 33.55 + 0.9936 + 0.1325 = 34.68 \text{ Metric tonne/sqm}$$

Net Safe bearing capacity , q_{ns} = $Q_d / F = 34.68 \text{ Metric tonne/sqm} / 3$

F= factor of safety = 3.0

q_{ns} =	11.56 Metric tonne/sqm
q_{ns} =	113.3 KN/sqm



Calculation of Net safe bearing capacity (Shear Criteria) : For 220 KV SITE(BH-02)

Depth of foundn , Df = 2.0 m

Width(B)M= 2 Length L = 2

Soil parameter

Cohesion, C= 0.48 kg/scm= 4.8 t/sqm Saturated density , γ (Metric ton/m³) = 1.96

Submerged density , γ (Metric ton/m³) = 0.96

Angle of internal

friction, ϕ (deg)= 7 , shear condition Local

Angle of shearing resistance for local failure = $\phi_m = \tan^{-1} \frac{2}{3} \tan \phi$

Bearing capacity factor

ϕ	7	Nc	Nq	N γ
ϕ m	4	6.22	1.45	0.36

Shape, Depth and inclination factor

Shape factor		Depth factor		Inclination factor		Water table corection factor
Sc=	1.30	dc=	1.21	ic=	1	W' = 0.5
Sq=	1.20	dq=	1.00	iq=	1	
Sy =	0.80	dy =	1.00	iy =	1	

Ultimate bearing capacity (qd) (Local shear Condition)

$$q_d = \left\{ \frac{2}{3} c N_c s_c d_c i_c \right\} + \left\{ \gamma D (N_q - 1) s_q d_q i_q \right\} + \left\{ 0.5 \gamma B N_\gamma s_\gamma d_\gamma i_\gamma W' \right\}$$

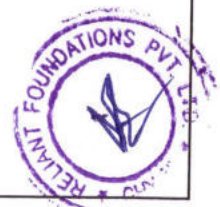
$$q_d = \{ 0.67 \times 4.8 \times 6.22 \times 1.3 \times 1.21 \times 1 \} + \{ 0.96 \times 2 \times (1.45 - 1) \times 1.2 \times 1 \times 1 \} + \{ 0.5 \times 0.96 \times 2 \times 0.36 \times 0.8 \times 1 \times 1 \times 0.5 \}$$

$$q_d = 31.58 + 1.0368 + 0.1382 = 32.75 \text{ Metric tonne/sqm}$$

Net Safe bearing capacity , Q_{ns} = $Q_d / F = 32.75 \text{ Metric tonne/sqm} / 3$

F= factor of safety = 3.0

Q_{ns} =	10.92 Metric tonne/sqm
Q_{ns} =	107 KN/sqm



Settlement Analysis as per IS 8009-1976: FOR 400 KV SITE(BH-01)

Total settlement , $St = Si + Sc$

St = Total settlement , Si = Immediate (elastic) settlement , Sc = Primary consolidation settlement

$$Si = \frac{pB(1-\mu^2)}{Es} I$$

$$Sc = Soed = \frac{Ht}{1+eo} Cc \log_{10} \frac{(po + \Delta p)}{po}$$

p = Load intensity , B = Width of foundation , μ = Poissons ratio

I = Influence factor , Es = Modulus of elasticity of soil

Ht = Thickness of soil layer , eo = Initial void ratio at mid height of of layer

Cc = Compression Index , Po = Initial effective pressure at mid height of layer

Δp = Average pressure increment due to foundation loading

1. Settlement of clay strata

A. Calculation of Immediate settlement (Si)

Depth of foundation D_f (M) =	2
LENGTH (L) in m =	2
BREATH (B) in m =	2
L/B =	1
INFLUNCE FACTOR (Ir)=	1.12
Load intensity (t/m ²)=	11.56

E (t/m ²)=	3060
μ =	0.50

Settlement (m), Si =	0.00635
Settlement (mm), Si =	6.35

B. Calculation of Primary consolidation settlement= Sc

Cc =	0.08
eo =	0.53
H (m)=	4
field density (t/m ³)=	1.92
P =	7.68
ΔP = (at $H/2$ m depth)	2.89
Settlement Sc (m)=	0.02901
Settlement Sc (mm)=	29.012

Total settlement $Sc = A+B =$ 35.359

Correction factors

i	Depth correction factor from Fig 12 of IS -8009 Pt1. $C.F$ =	0.72
ii	Rigidity factor (for raft foundation) cl 9.5.2	
iii	λ = (Pore pressure correction factor, Cl9.2.3 of IS 8009, Pt1)	0.80

Total Corrected settlement , $Sc =$ 25.46 mm

L/B =	1.00
$D/\sqrt{LB}$ =	1.00
$\sqrt{LB} / D$ =	1.00

<40MM Safe



Settlement Analysis as per IS 8009-1976: FOR 220 KV SITE(BH-02)

Total settlement , $S_t = S_i + S_c$

S_t = Total settlement , S_i = Immediate (elastic) settlement , S_c = Primary consolidation settlement

$$S_i = \frac{pB(1-\mu^2)}{E_s} I_f$$

$$S_c = \frac{H}{1+e_0} C_c \log_{10} \left(\frac{p_o + \Delta p}{p_o} \right)$$

p = Load intensity , B = Width of foundation , μ = Poissons ratio

I_f = Influence factor , E_s = Modulus of elasticity of soil

H_t = Thickness of soil layer , e_0 = Initial void ratio at mid height of of layer

C_c = Compression Index , P_o = Initial effective pressure at mid height of layer

Δp = Average pressure increment due to foundation loading

1. Settlement of clay strata

A. Calculation of Immediate settlement (S_i)

Depth of foundation D_f (M) =	2
LENGTH (L) in m =	2
BREATH (B) in m =	2
L/B =	1
INFLUNCE FACTOR (I_f)=	1.12
Load intensity (t/m ²)=	10.92

E (t/m ²)=	2880
μ =	0.50

Settlement (m), S_i =	0.00637
Settlement (mm), S_i =	6.37

B. Calculation of Primary consolidation settlement= S_c

C_c =	0.13
e_0 =	0.71
H (m)=	4
field density (t/m ³)=	1.96
P =	7.84
ΔP = (at $H/2$ m depth)	2.73
Settlement S_c (m)=	0.03946
Settlement S_c (mm)=	39.459

Total settlement $S_c = A+B =$ 45.829

Correction factors

i	Depth correction factor from Fig 12 of IS -8009 Pt1. $C.F$ =	0.72
ii	Rigidity factor (for raft foundation) cl 9.5.2	
iii	λ = (Pore pressure correction factor, Cl9.2.3 of IS 8009, Pt1)	0.80

Total Corrected settlement , $S_c =$ 33.00 mm

L/B =	1.00
$D/\sqrt{LB}$ =	1.00
$\sqrt{LB} / D$ =	1.00

<40MM Safe



BORE LOG CUM LABORATORY TEST RESULT																						
Name of Project: GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220 KV TRANSMISSION LINE AGAINST CONSTRUCTION OF 400/220 KV , 2X500MVA GIS AT SONAPUR (NEW) ALONG WITH THE ASSOCIATED TRANSMISSION LINES(PACKAGE)(H)®																						
Boring method: AUGER & WASH BORING					Location: 400 KV Site		Boring dia: 150mm			Date Commenced: 20-05-2025			Date completed: 20-05-2025			DEPTH OF WATER TABLE=3.50M FROM EGL						
BH: 01																						
Depth in meters below reference		Types of Sample	Observed N-Value	Corrected N-Value	Group Symbol	Visual description of soil	% Gravel > 4.75 mm	% Sand 4.75-0.075 mm	% Silt and Clay <0.075mm	Field density, gms/cm³	Dry density, gms/cm³	Specific Gravity	Void Ratio	Natural moisture content	Unconfined compressive Strength (kg/cm²)	Cohesion 'c' Kg/cm²	Angle of shearing resistance (Φ°)	Compression Index Cc	LL%	PL%	PI%	
0.50-0.95		P	6	6	CI	Grayish Silty Clay			100	1.84	1.46	2.66	0.83	26.31		0.40	7	0.17	40.32	26.10	14.22	
0.95-1.00-1.45		U		8					100	1.92	1.53	2.66	0.74	25.32		0.51	8	0.14	38.52	25.56	12.96	
1.45-1.50-1.95		U		9					100	1.94	1.60	2.66	0.66	21.40		0.55	8	0.12	36.58	24.97	11.61	
1.95-2.00-2.45		P	14	14					100	2.04	1.74	2.66	0.53	17.14		0.93	8	0.08				
2.45-2.50-2.95		P	17	17																		
2.95-3.00-3.45		U																				
3.45-3.50-3.95		P	11	11					100	1.98		2.66										
3.95-4.00-4.45		U		3					100	1.60		2.66					0.20		7			
4.45-4.50-4.95		U		2																		
4.95-5.00-5.45		P	13	13				4.70M			100	2.02		2.66								
5.00-5.45		U	26	21	SP	Whitish Fine to Medium SAND			90	2.00		2.66					33					
5.45-5.50-5.95		D																				
5.95-6.00-6.45		P	35	25																		
6.45-6.50-6.95		D		61					95	2.13		2.66							34			
6.95-7.00-7.45		P	69	42					100	2.17		2.66							35			
7.45-7.50-7.95		D		84																		
7.95-8.00-8.45		P	92	54				Whitish Medium To Coarse SAND											36			
8.45-8.50-8.95		D		95						100	2.21		2.66									
8.95-9.00-9.45		P	R	R																		
9.45-9.50-9.95		D								100	2.24		2.66									
9.95-10.00-10.45		P	R	R																		
10.45		D					100		2.27		2.66											

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U: Undisturbed Sample; D: Disturbed Sample; P: Standard Penetration test; EGL: Existing Ground Level :: R : Refusal N>100, NP: Non plastic

BORE LOG CUM LABORATORY TEST RESULT																					
Name of Project: GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220 KV TRANSMISSION LINE AGAINST CONSTRUCTION OF 400/220 KV , 2X500MV/A GIS AT SONAPUR (NEW) ALONG WITH THE ASSOCIATED TRANSMISSION LINES(PACKAGE)(H)®																					
Boring method: AUGER & WASH BORING				Location: 220 KV Site		Boring dia: 150mm		Date Commenced: 20-05-2025		Date completed: 20-05-2025		DEPTH OF WATER TABLE=3.50M FROM EGL									
BH: 02																					
Depth in meters below reference	Types of Sample	Observed N-Value	Corrected N-Value	Group Symbol	Visual description of soil	% Gravel > 4.75 mm	% Sand 4.75-0.075 mm	% Silt and Clay <0.075mm	Field density, gms/cm³	Dry density, gms/cm³	Specific Gravity	Void Ratio	Natural moisture content	Unconfined compressive Strength (Kg/cm²)	Cohesion 'c' Kg/cm²	Angle of shearing resistance (Φ°)	Compression Index Cc	LL%	PL%	PI%	
0.50-	P	5	5	CI	Grayish Silty Clay			100	1.80	1.43	2.66	0.87	26.31		0.33	7	0.18	39.54	25.86	13.68	
0.95	U																				
1.00-1.45	P	8	8						100	1.90	1.52	2.66	0.75	25.32		0.50	8	0.15	36.21	24.86	11.35
1.45	U																				
1.50-1.95	P	5	5						100	1.81	1.47	2.66	0.81	23.47		0.32	7	0.16	35.11	24.53	10.58
1.95	U																				
2.00-2.45	P	7	7						100	1.88	1.55	2.66	0.71	21.14		0.48	7	0.13			
2.45	U											2.66									
2.50-2.95	P	10	10						100	1.87		2.66									
2.95	U																				
3.00-3.45	P	7	7						100	1.76		2.66					0.27	7			
3.45	U																				
3.50-3.95	P	4	4																		
3.95	U																				
4.00-4.45	P	4	4																		
4.45	U																				
4.50-4.95	P	4	4																		
4.95	U																				
5.00-5.45	P	3	3																		
5.45	U																				
5.50-5.95	P	3	3																		
5.95	U																				
6.00-6.45	P	2	2		6.00M																
6.45	U				Grayish Silty Clay With Sand																
6.50-6.95	P	3	3					5	95	1.60	2.66										
6.95	U																				
7.00-7.45	P	16	16		7.00M																
7.45	D																				
7.50-7.95	P	40	28																		
7.95	D						100		2.12	2.66						35					
8.00-8.45	P	39	27																		
8.45	D																				
8.50-8.95	P	55	35		Whitish Medium To Coarse SAND																
8.95	D																				
9.00-9.45	P	87	51				100		2.15	2.66							36				
9.45	D																				
9.50-9.95	P	R	R																		
9.95	D																				
10.00-10.45	P	R	R			100		2.19	2.66												
10.45	D																				

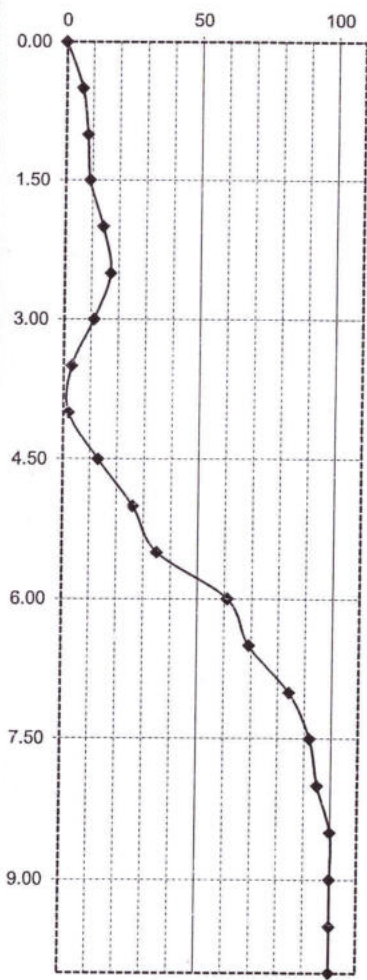




U: Undisturbed Sample; D: Disturbed Sample; P: Standard Penetration test; EGL: Existing Ground Level :: R : Refusal N>100, NP: Non plastic

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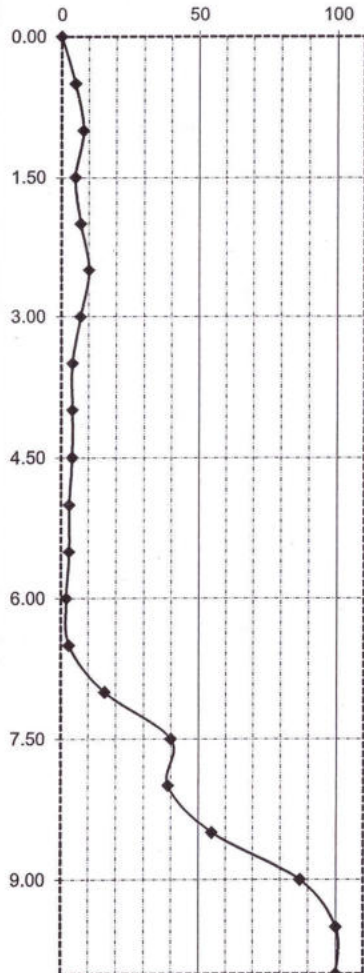
BORE LOG CHART

BORE HOLE NO: 1			DATE					GROUND WATER LEVEL	TYPE OF BORING				
			START		COMPLETE								
			20-05-2025		20-05-2025								
DEPTH (m)	TYPE OF SAMPLE	SPT			N-VALUE	VISUAL DESCRIPTION OF SOIL	LOG	GRAPHICAL REPRESENTATION OF N-VALUE					
		15 cm	15 cm	15 cm									
0.50-0.95	P	2	3	3	6	Grayish Silty Clay							
0.95	U												
1.00-1.45	P	3	5	3	8								
1.45	U												
1.50-1.95	P	2	4	5	9								
1.95	U												
2.00-2.45	P	6	6	8	14								
2.45	U												
2.50-2.95	P	6	8	9	17								
2.95	U												
3.00-3.45	P	4	5	6	11								
3.45	U												
3.50-3.95	P	1	1	2	3								
3.95	U												
4.00-4.45	P	1	1	1	2	Whitish Fine to Medium SAND							
4.45	U												
4.50-4.95	P	1	1	12	13								
4.95	U												
5.00-5.45	P	8	11	15	26								
5.45	D												
5.50-5.95	P	10	16	19	35								
5.95	D												
6.00-6.45	P	15	24	37	61								
6.45	D												
6.50-6.95	P	17	28	41	69								
6.95	D												
7.00-7.45	P	22	36	48	84								
7.45	D												
7.50-7.95	P	27	39	53	92	Whitish Medium To Coarse SAND							
7.95	D												
8.00-8.45	P	35	45	50	95								
8.45	D												
8.50-8.95	P	43	57	R	R								
8.95	D												
9.00-9.45	P	50	50	R	R								
9.45	D												
9.50-9.95	P	50	R	R	R								
9.95	D												
10.00-10.45	P	50	R	R	R								
10.45	D												
U:UDISTURBED SAMPLE										D: DISTURBED SAMPLE		P: STANDARD PENETRATION TEST	
EGL: EXISTING GROUND LEVEL										R:REFUSAL;N>100			



Name of Project: GEOTECHNICAL INVESTIGATION WORK FOR 440 AND 220 KV TRANSMISSION LINE AGAINST CONSTRUCTION OF 400/220 KV , 2X500MVA GIS AT SONAPUR (NEW) ALONG WITH THE ASSOCIATED TRANSMISSION LINES(PACKAGE)(H)®

BORE LOG CHART

BORE HOLE NO: 2		DATE					GROUND WATER LEVEL	TYPE OF BORING
		START		COMPLETE				
		20-05-2025		20-05-2025				
DEPTH (m)	TYPE OF SAMPLE	SPT			N-VALUE	VISUAL DESCRIPTION OF SOIL	LOG	GRAPHICAL REPRESENTATION OF N-VALUE
		15 cm	15 cm	15 cm				
0.50-0.95	P	2	2	3	5	Grayish Silty Clay		
0.95	U							
1.00-1.45	P	3	5	3	8			
1.45	U							
1.50-1.95	P	3	2	3	5			
1.95	U							
2.00-2.45	P	3	3	4	7			
2.45	U							
2.50-2.95	P	3	5	5	10			
2.95	U							
3.00-3.45	P	2	3	4	7			
3.45	U							
3.50-3.95	P	1	2	2	4			
3.95	U							
4.00-4.45	P	2	2	2	4			
4.45	U							
4.50-4.95	P	2	2	2	4			
4.95	U							
5.00-5.45	P	1	1	2	3	6.00M		
5.45	U							
5.50-5.95	P	1	1	2	3	Grayish Silty Clay With Sand		
5.95	U							
6.00-6.45	P	3	1	1	2	7.00M		
6.45	U							
6.50-6.95	P	1	1	2	3	Whitish Medium To Coarse SAND		
6.95	U							
7.00-7.45	P	4	7	9	16			
7.45	D							
7.50-7.95	P	10	15	25	40			
7.95	D							
8.00-8.45	P	10	16	23	39			
8.45	D							
8.50-8.95	P	15	24	31	55			
8.95	D							
9.00-9.45	P	28	39	48	87			
9.45	D							
9.50-9.95	P	50	R	R	R	10.50M		
9.95	D							
10.00-10.45	P	50	R	R	R			
10.45	D							
U:UDISTURBED SAMPLE						D: DISTURBED SAMPLE		
EGL: EXISTING GROUND LEVEL						R:REFUSAL;N>100		
						P: STANDARD PENETRATION TEST		



BH-01-400 KV SITE Depth : 0.95m

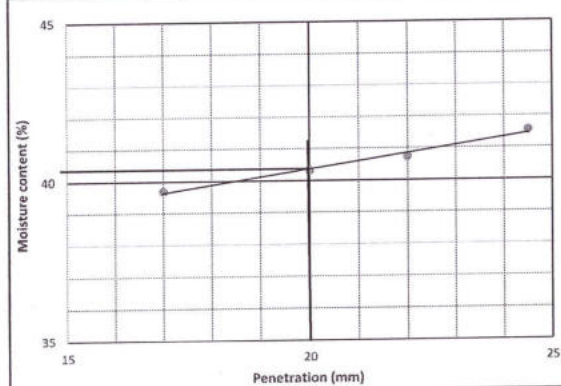
LIQUID AND PLASTIC LIMIT TEST (IS : 2720 (Part 5)-1985, Reaffirmed 2020)

Observations

Sl. No.	Description	Liquid Limit (%)				Plastic Limit (%)		Average
	Trail No.	1	2	3	4	1	2	
1	Container No.	C-23	C-24	C-25	C-26	C-17	C-18	26.10
2	Penetration (mm)	17.0	20.0	22.0	24.5	-	-	
3	Weight of Container, W1 g	12.45	12.62	12.45	13.45	13.66	13.48	
4	Weight of Container + Wet Soil, W2 g	44.65	63.51	62.89	65.65	35.4	37.05	
5	Weight of Container + Oven dried Soil, W3 g	35.5	48.63	48.29	50.33	30.92	32.15	
6	Water content, $w = [(W2-W3)/(W3-W1)] \times 100$ %	39.70	41.32	40.74	41.54	25.96	26.25	

Penetration (mm)	Moisture Content (%)
17	39.70
20.0	40.32
22.0	40.74
24.5	41.54

LIQUID LIMIT (%) - BY GRAPH	40.32
PLASTIC LIMIT (%)	26.10
PLASTICITY INDEX (%)	14.22



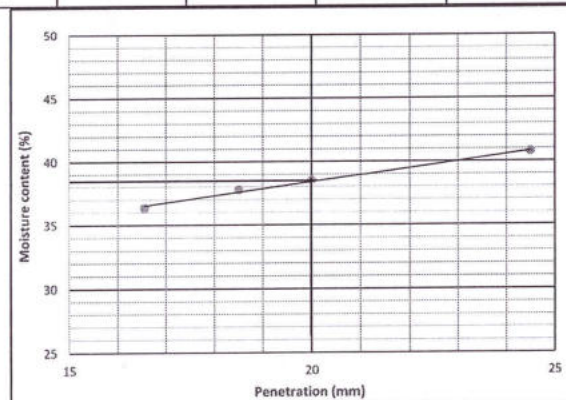
BH-01-400 KV SITE Depth : 1.45m

LIQUID AND PLASTIC LIMIT TEST (IS : 2720 (Part 5)-1985, Reaffirmed 2020)

Observations								
Sl. No.	Description	Liquid Limit (%)				Plastic Limit (%)		Average
	Trail No.	1	2	3	4	1	2	
1	Container No.	C-27	C-28	C-29	C-30	C-100	C-25	25.56
2	Penetration (mm)	16.56	18.5	20.0	24.5	-	-	
3	Weight of Container, W1 g	12.45	14.9	13.35	13.25	13.1	13.46	
4	Weight of Container + Wet Soil, W2 g	44.65	71.65	64.95	66.1	35.52	37.05	
5	Weight of Container + Oven dried Soil, W3 g	36.07	56.1	50.6	55.25	31.05	32.15	
6	Water content, $w = [(W2-W3)/(W3-W1)] \times 100 \%$	36.33	37.74	38.52	25.83	24.90	26.22	

Penetration (mm)	Moisture Content (%)
16.56	36.33
18.5	37.74
20.0	38.52
24.5	40.74

LIQUID LIMIT (%) - BY GRAPH	38.52
PLASTIC LIMIT (%)	25.56
PLASTICITY INDEX (%)	12.96



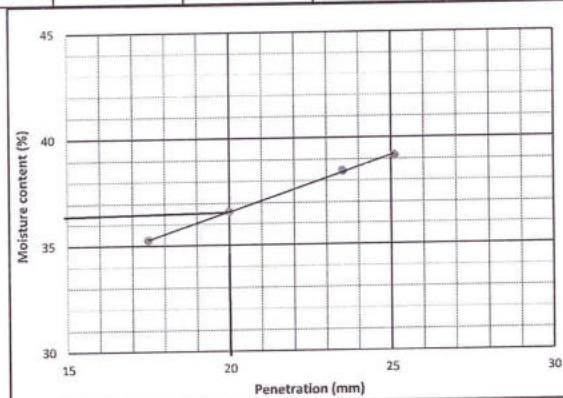
BH-01-400 KV SITE Depth : 1.95m

LIQUID AND PLASTIC LIMIT TEST (IS : 2720 (Part 5)-1985, Reaffirmed 2020)

Observations								
Sl. No.	Description	Liquid Limit (%)				Plastic Limit (%)		Average
	Trail No.	1	2	3	4	1	2	
1	Container No.	C-31	C-32	C-33	C-34	C-17	C-18	24.97
2	Penetration (mm)	17.5	20.0	23.5	25.1	-	-	
3	Weight of Container, W1 g	14	17.02	12.44	13.45	13.66	13.58	
4	Weight of Container + Wet Soil, W2 g	57.23	80.08	65.23	76.42	35.4	37.05	
5	Weight of Container + Oven dried Soil, W3 g	45.96	63.19	50.57	58.7	31.18	32.23	
6	Water content, $w = [(W2-W3)/(W1-W3)] \times 100\%$	35.26	36.58	38.45	39.16	24.09	25.84	

Penetration (mm)	Moisture Content (%)
17.5	35.26
20.0	36.58
23.5	38.45
25.1	39.16

LIQUID LIMIT (%) - BY GRAPH	36.58
PLASTIC LIMIT (%)	24.97
PLASTICITY INDEX (%)	11.61



BH-02-220 KV SITE Depth : 0.95m

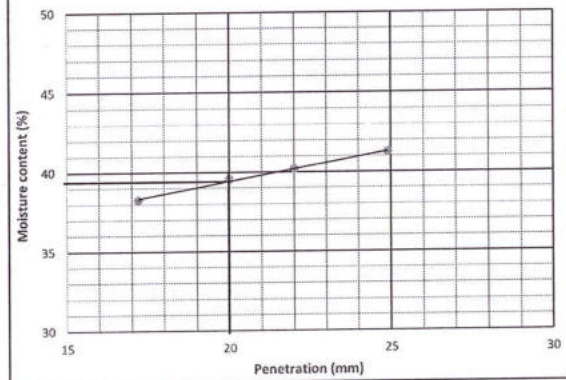
LIQUID AND PLASTIC LIMIT TEST (IS : 2720 (Part 5)-1985, Reaffirmed 2020)

Observations

Sl. No.	Description	Liquid Limit (%)				Plastic Limit (%)		Average
	Trail No.	1	2	3	4	1	2	
1	Container No.	C-19	C-20	C-21	C-22	C-30	C-101	25.86
2	Penetration (mm)	17.2	20.0	22.0	24.9	-	-	
3	Weight of Container, W1 g	12.4	13.5	13.24	13.45	13.43	13.96	
4	Weight of Container + Wet Soil, W2 g	37.56	59.45	63.45	58.61	35.4	37.05	
5	Weight of Container + Oven dried Soil, W3 g	30.6	46.43	49.04	45.42	30.93	32.26	
6	Water content, $w = [(W2-W3)/(W3-W1)] \times 100$ %	38.24	39.54	40.25	41.26	25.54	26.17	

Penetration (mm)	Moisture Content (%)
17.2	38.25
20.0	39.54
22.0	40.16
24.9	41.25

LIQUID LIMIT (%) - BY GRAPH	39.54
PLASTIC LIMIT (%)	25.86
PLASTICITY INDEX (%)	13.68



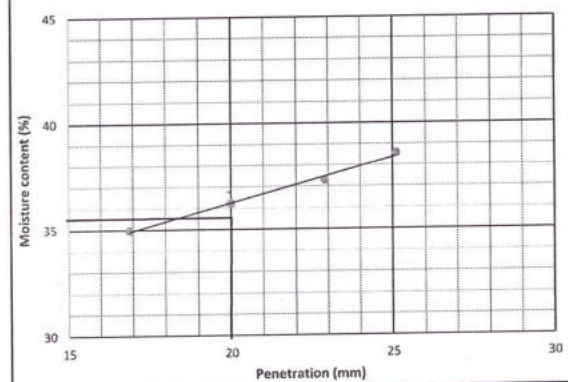
BH-02-220 KV SITE Depth : 1.45m

LIQUID AND PLASTIC LIMIT TEST (IS : 2720 (Part 5)-1985, Reaffirmed 2020)

Observations								
Sl. No.	Description	Liquid Limit (%)				Plastic Limit (%)		Average
	Trail No.	1	2	3	4	1	2	Average
1	Container No.	C-19	C-20	C-21	C-22	C-30	C-101	
2	Penetration (mm)	16.9	20.0	22.9	25.1	-	-	24.86
3	Weight of Container, W1 g	12.39	19.49	12.55	13.44	13.45	14.05	
4	Weight of Container + Wet Soil, W2 g	36.25	73.54	45.1	56.2	35.4	37.05	
5	Weight of Container + Oven dried Soil, W3 g	30.07	59.17	36.26	44.3	31.05	32.45	
6	Water content, $w = [(W2-W3)/(W3-W1)] \times 100 \%$	34.95	36.21	37.28	38.56	24.72	25.00	

Penetration (mm)	Moisture Content (%)
16.9	34.95
20.0	36.21
22.9	37.28
25.1	38.56

LIQUID LIMIT (%) - BY GRAPH	36.21
PLASTIC LIMIT (%)	24.86
PLASTICITY INDEX (%)	11.35



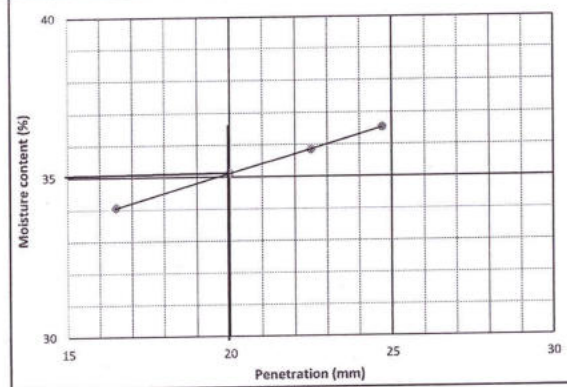
BH-02-220 KV SITE Depth : 1.95m

LIQUID AND PLASTIC LIMIT TEST (IS : 2720 (Part 5)-1985, Reaffirmed 2020)

Observations								
Sl. No.	Description	Liquid Limit (%)				Plastic Limit (%)		Average
	Trail No.	1	2	3	4	1	2	
1	Container No.	C-13	C-14	C-15	C-16	C-72	C-75	24.53
2	Penetration (mm)	16.9	20.0	21.0	24.7	-	-	
3	Weight of Container, W1 g	12.24	13.41	13.58	13.62	13.63	13.5	
4	Weight of Container + Wet Soil, W2 g	32.83	49.16	50.61	52.9	35.4	37.1	
5	Weight of Container + Oven dried Soil, W3 g	27.6	39.87	40.84	42.39	31.35	32.2	
6	Water content, $w = [(W2-W3)/(W3-W1)] \times 100 \%$	34.05	35.11	35.84	36.53	22.86	26.20	

Penetration (mm)	Moisture Content (%)
16.5	34.05
20.0	35.11
22.5	35.84
24.7	36.53

LIQUID LIMIT (%) - BY GRAPH	35.11
PLASTIC LIMIT (%)	24.53
PLASTICITY INDEX (%)	10.58



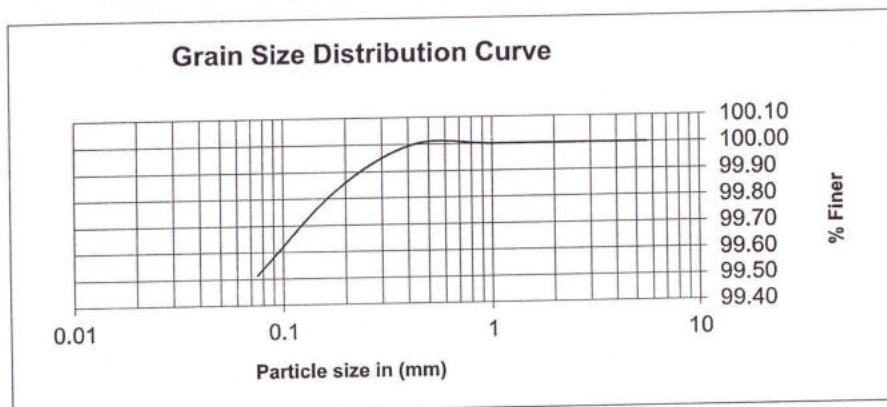
Location: 400 kv site ;BH-01

Depth :3.45M

Grain Size Analysis

IS Sieve Size(MM)	Aperture Size 'd'(MM)	Average Size (mm)	Weight of soil Retained (gm)	Percentage of Wt. Ret. (fi)	Cum. % material Retained	% Passing	Weighted diameter (fi * d)
5.6	5.6		0	0.00	0.00	100.00	0.00
4	4	4.8	0	0.00	0.00	100.00	0.00
2.8	2.80	3.400	0	0.00	0.00	100.00	0.00
1	1.000	1.900	0	0.00	0.00	100.00	0.00
0.425	0.425	0.713	0.0	0.00	0.00	100.00	0.00
0.18	0.180	0.303	1.14	0.17	0.17	99.83	0.05
0.075	0.075	0.128	2.14	0.32	0.49	99.51	0.04
PAN	0.075 and below	0.0375	670.014	99.51	100.00	0.00	3.73
			673.294			$\sum fi * d$	3.82

Weighted mean diameter , $dm = (\sum fi * d / 100) =$	0.038 mm
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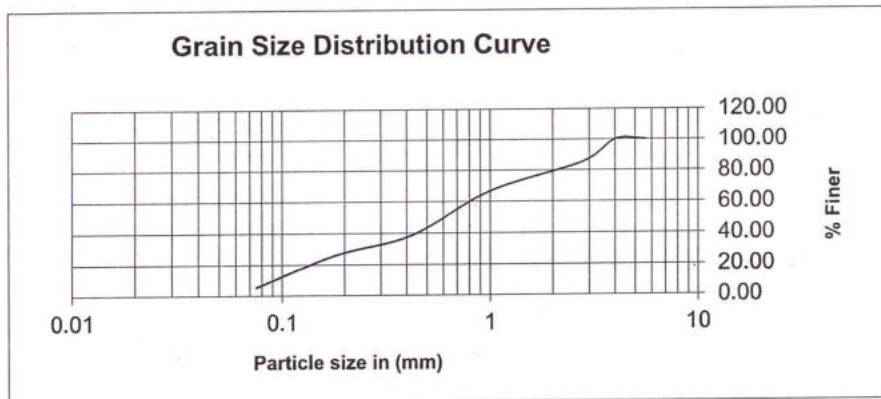
Location: 400 kv site ;BH-01

Depth :6.45M

1. Grain Size Analysis

IS Sieve Size(MM)	Aperture Size 'd'(MM)	Average Size (mm)	Weight of soil Retained (gm)	Percentage of Wt. Ret. (fi)	Cum. % material Retained	% Passing	Weighted diameter (fi * d)
5.6	5.6		0	0.00	0.00	100.00	0.00
4	4.00	4.8	0	0.00	0.00	100.00	0.00
2.8	2.80	3.400	28.14	14.44	14.44	85.56	49.09
1	1.000	1.900	36.21	18.58	33.02	66.98	35.30
0.425	0.425	0.713	55.1	28.29	61.31	38.69	20.16
0.18	0.180	0.303	25.14	12.90	74.21	25.79	3.90
0.075	0.075	0.128	40.11	20.58	94.80	5.20	2.62
PAN	0.075 and below	0.0314	10.14	5.20	100.00	0.00	0.16
			194.88			$\sum fi * d$	111.25

Weighted mean diameter , $d_m = (\sum fi * d / 100) =$	1.112 mm
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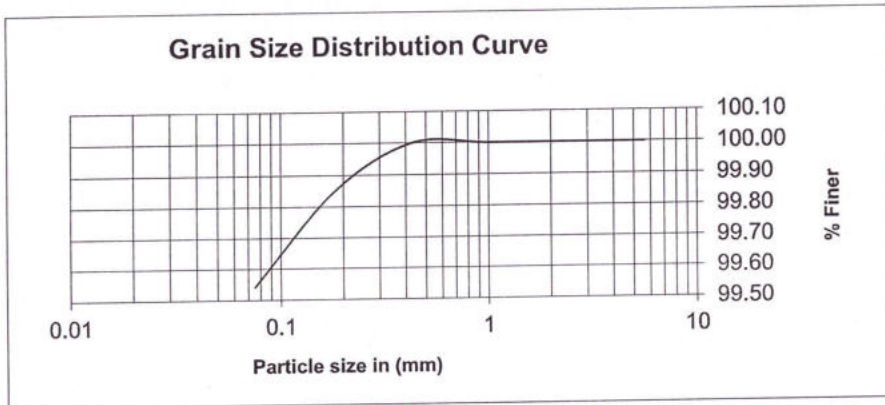
Location: 220 kv site ;BH-02

Depth :4.95M

. Grain Size Analysis

IS Sieve Size(MM)	Aperture Size 'd'(MM)	Average Size (mm)	Weight of soil Retained (gm)	Percentage of Wt. Ret. (fi)	Cum. % material Retained	% Passing	Weighted diameter (fi * d)
5.6	5.6		0	0.00	0.00	100.00	0.00
4	4	4.8	0	0.00	0.00	100.00	0.00
2.8	2.80	3.400	0	0.00	0.00	100.00	0.00
1	1.000	1.900	0	0.00	0.00	100.00	0.00
0.425	0.425	0.713	0.0	0.00	0.00	100.00	0.00
0.18	0.180	0.303	1.02	0.15	0.15	99.85	0.05
0.075	0.075	0.128	2.02	0.30	0.46	99.54	0.04
PAN	0.075 and below	0.0375	660.47	99.54	100.00	0.00	3.73
			663.51			$\sum fi * d$	3.82

Weighted mean diameter , $dm = (\sum fi * d / 100) =$	0.038 mm
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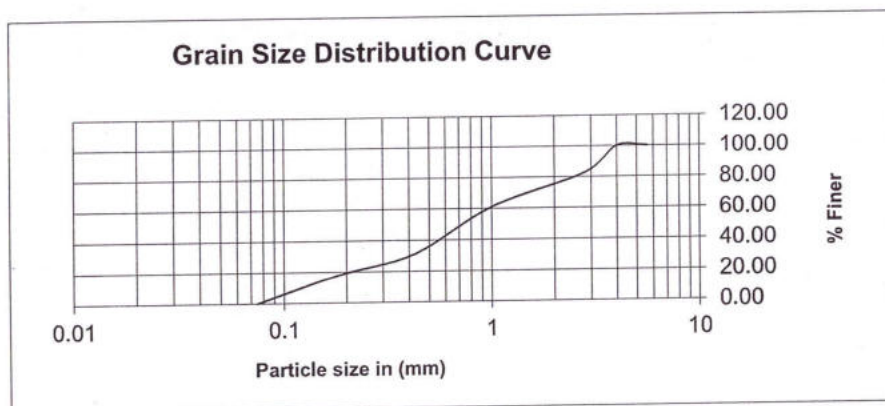
Location: 220 kv site ;BH-02

Depth :7.95M

1. Grain Size Analysis

IS Sieve Size(MM)	Aperture Size 'd'(MM)	Average Size (mm)	Weight of soil Retained (gm)	Percentage of Wt. Ret. (fi)	Cum. % material Retained	% Passing	Weighted diameter (fi * d)
5.6	5.6		0	0.00	0.00	100.00	0.00
4	4.00	4.8	0	0.00	0.00	100.00	0.00
2.8	2.80	3.400	29.63	17.18	17.18	82.82	58.40
1	1.000	1.900	37.21	21.57	38.75	61.25	40.98
0.425	0.425	0.713	52.1	30.22	68.97	31.03	21.53
0.18	0.180	0.303	23.14	13.41	82.38	17.62	4.06
0.075	0.075	0.128	30.14	17.47	99.86	0.14	2.23
PAN	0.075 and below	0.0314	0.25	0.14	100.00	0.00	0.00
			172.51			$\sum fi * d$	127.20

Weighted mean diameter , $d_m = (\sum fi * d / 100) =$	1.272 mm
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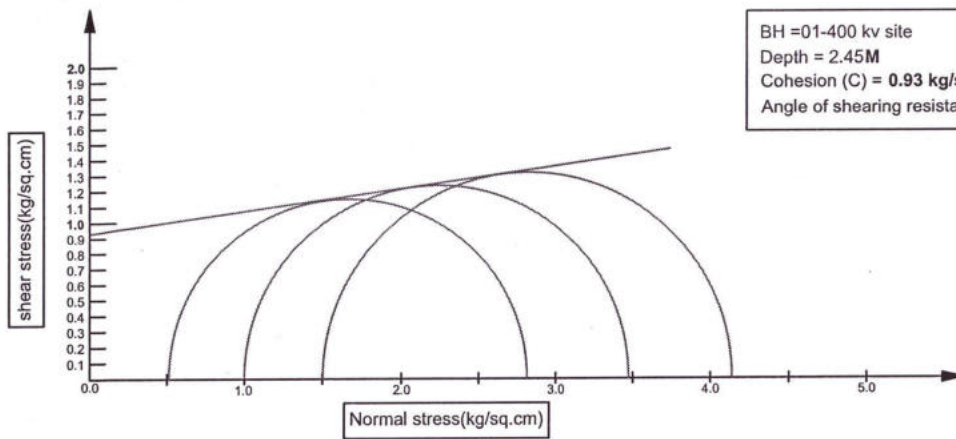
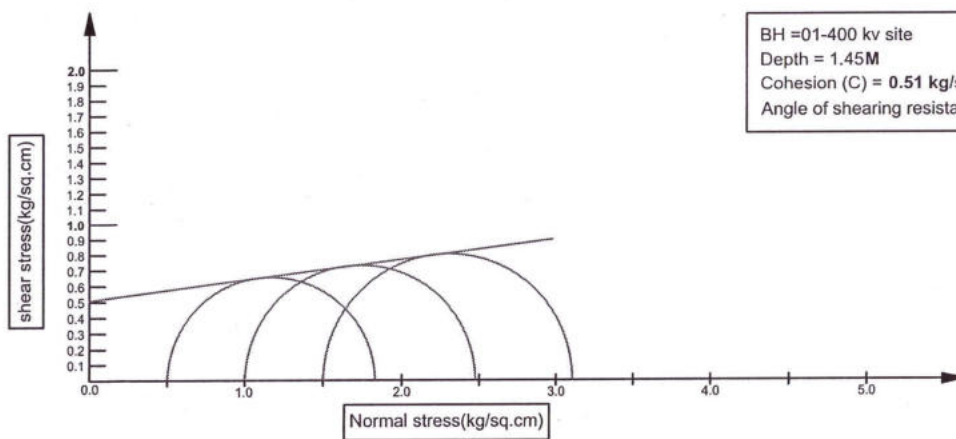


SHEAR TEST RESULT

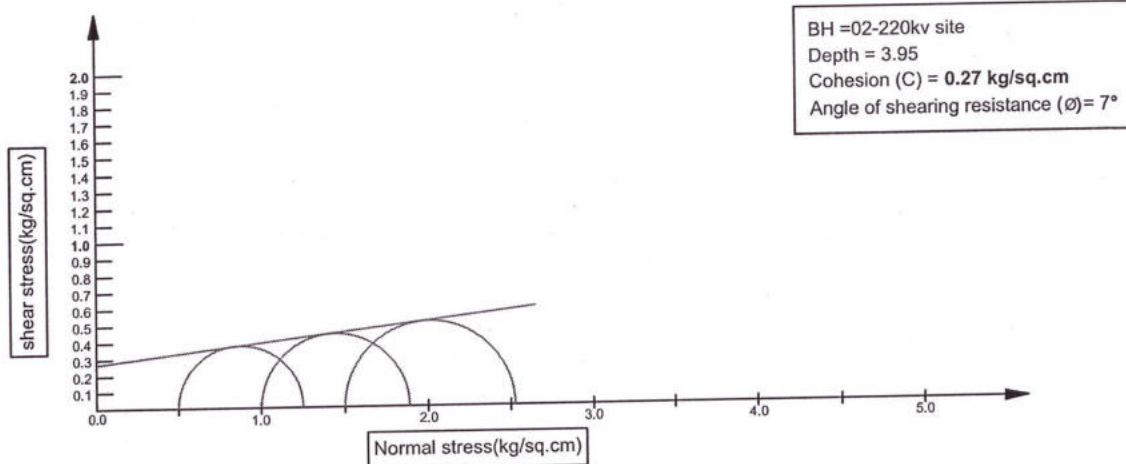
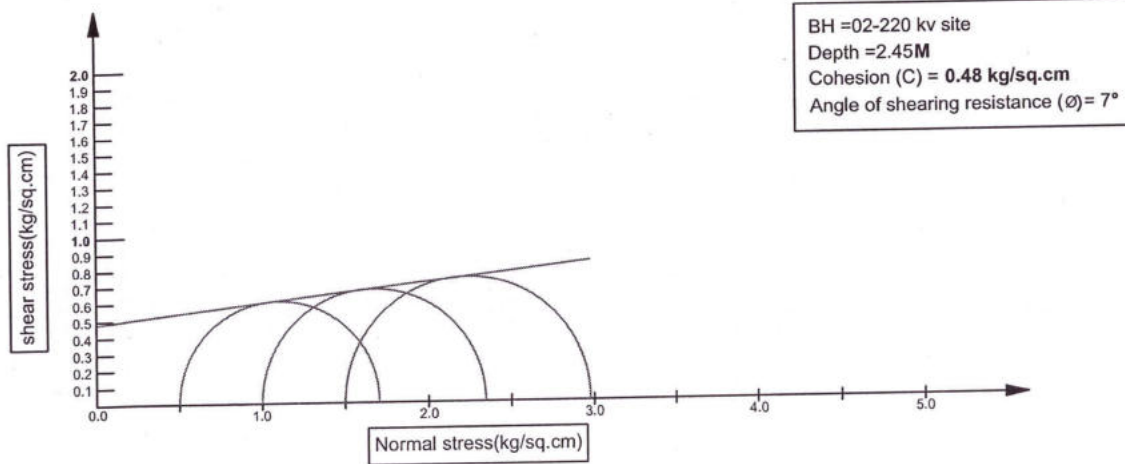
BH NO.	DEPTH(M)	COHESION 'C' kg/cm²	ANGLE OF INTERNAL FRICTION (Φ°)	TYPE OF TEST
BH01-400 kv site	1.45	0.51	8	Triaxial Shear Test(Unconsolidated Undrained test)
	2.45	0.93	8	
BH02-220 kv site	2.45	0.48	7	
	3.95	0.27	7	
BH01-400 kv site	5.45	0	33	Direct Shear Test
	6.95	0	35	
BH02-220 kv site	7.95	0	35	
	8.95	0	36	



TRIAXIAL SHEAR TEST



TRIAXIAL SHEAR TEST



SHEAR

Direct Shear test result

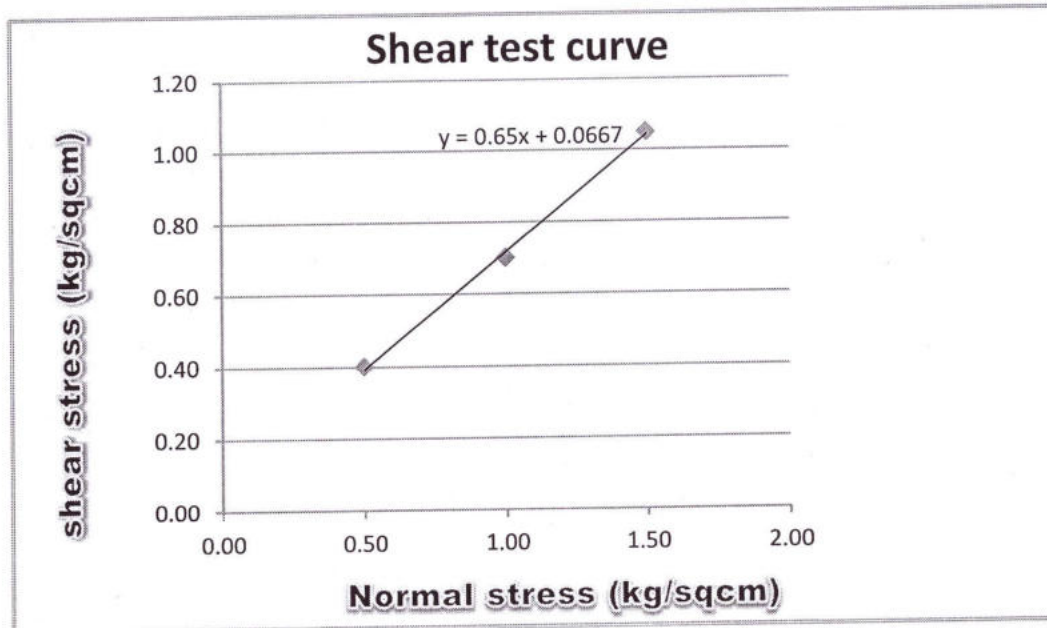
- 1 Dimension : 6 cm x 6 cm
2 Thickness : 2.5 cm
3 Test condition : Drained

BH-01-400kv site

Depth =5.45m

Shear Parameters determination

SI No	Normal stress(Kg/sqcm)	Shear stress (Kg/sqcm)
1.00	0.50	0.40
2.00	1.00	0.70
3.00	1.50	1.05



$$c=0.0\text{kg/sqcm}$$

$$\Phi = 33^\circ$$



SHEAR

Direct Shear test result

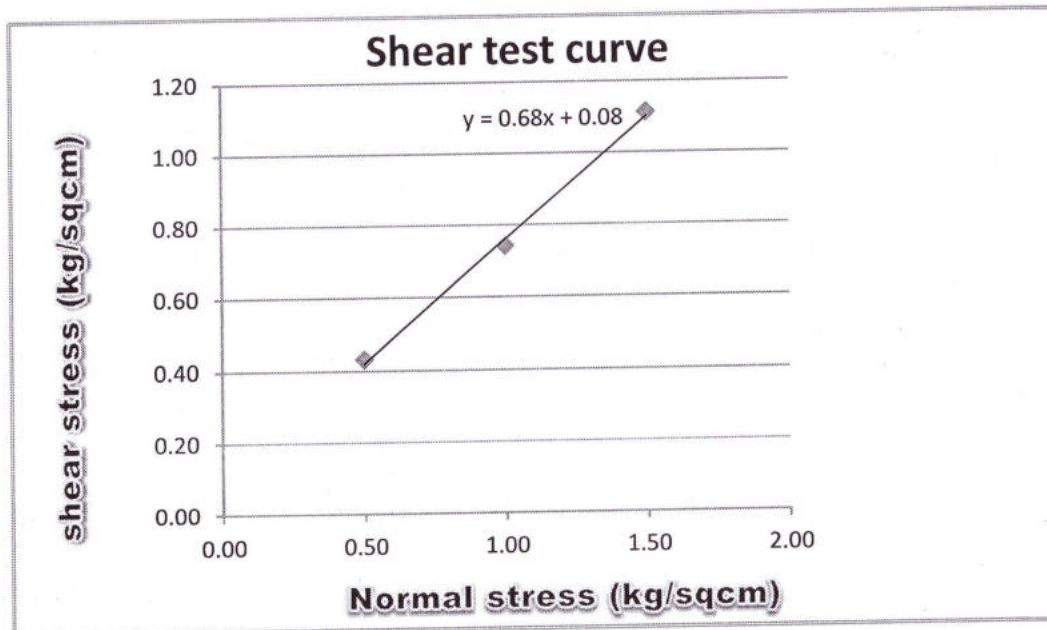
- 1 Dimension : 6 cm x 6 cm
2 Thickness : 2.5 cm
3 Test condition : Drained

BH-01-400kv site

Depth =6.95m

Shear Parameters determination

SI No	Normal stress(Kg/sqcm)	Shear stress (Kg/sqcm)
1.00	0.50	0.43
2.00	1.00	0.74
3.00	1.50	1.11



$$c=0.0\text{kg/sqcm}$$

$$\Phi = 35^\circ$$



SHEAR

Direct Shear test result

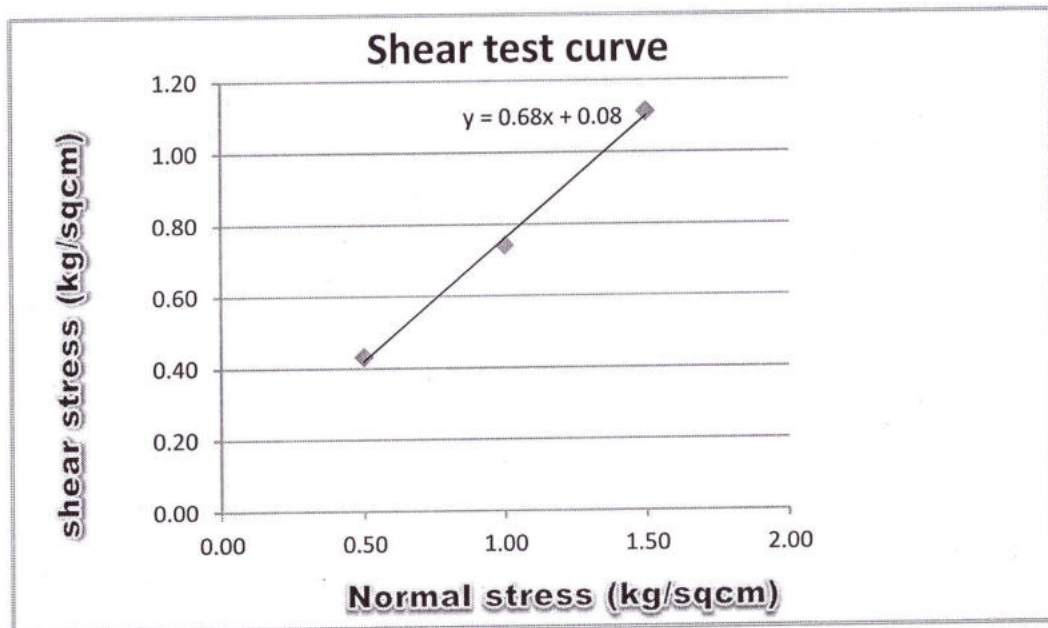
- 1 Dimension : 6 cm x 6 cm
- 2 Thickness : 2.5 cm
- 3 Test condition : Drained

BH-02-220kv site

Depth =7.95m

Shear Parameters determination

SI No	Normal stress(Kg/sqcm)	Shear stress (Kg/sqcm)
1.00	0.50	0.43
2.00	1.00	0.74
3.00	1.50	1.11



$c=0.0\text{kg/sqcm}$

$\Phi = 35^\circ$

SHEAR

Direct Shear test result

1 Dimension : 6 cm x 6 cm

2 Thickness : 2.5 cm

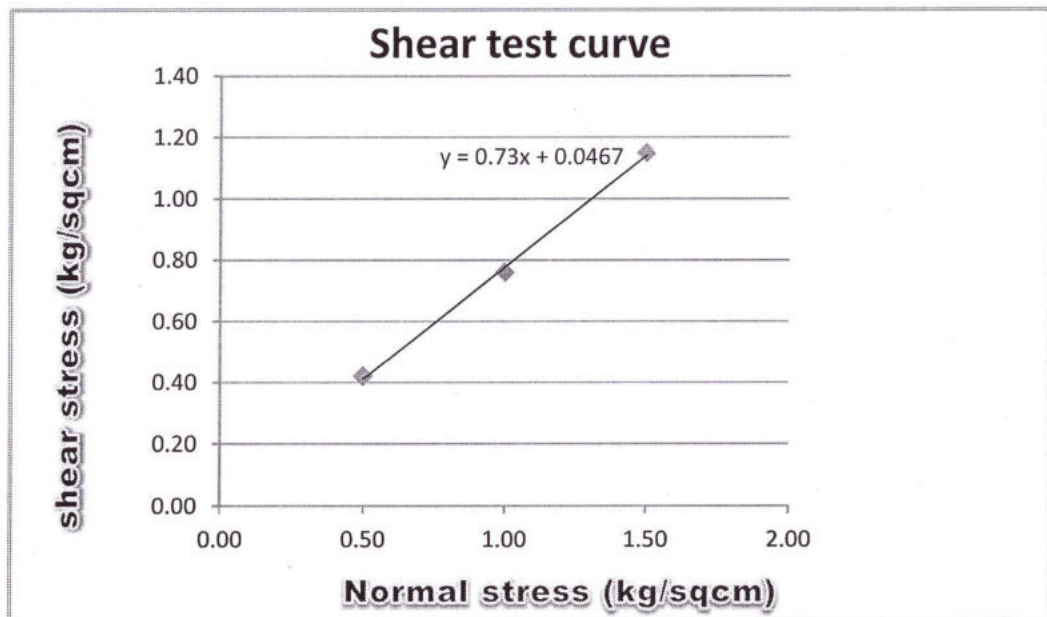
3 Test condition : Drained

BH-02-220kv site

Depth =8.95m

Shear Parameters determination

SI No	Normal stress(Kg/sqcm)	Shear stress (Kg/sqcm)
1.00	0.50	0.42
2.00	1.00	0.76
3.00	1.50	1.15



$$c=0.0\text{kg/sqcm}$$

$$\Phi = 36^\circ$$



SITE PHOTOGRAPHS



SOIL TEST BOREHOLE CHART
RELIANT FOUNDATION PVT. LTD.
 SUN POLO COLONY, DIPAR BORO PATH
 AHOMGAON, GARCHUK
 GUWAHATI-781035
 PHONE: +91 986020945

NAME OF PROJECT: 400Kv. Duct foundation
 at Sonapur Area

Client Name & PH. No. 7002964183

Lat:

Long:

BORING TYPE: Hand Wash Boring

START DATE: 20/05/25

BORE HOLE NO.: 01.

END DATE: 20/05/25

GROUND WATER LEVEL: 3.8 mt.

DEPTH (M)		SAMPLE TYPE	SPT			N VALUE	DESCRIPTION
FROM	TO		15cm	15cm	15cm		
0.50	0.95	DS	2	3	3	6	6.1 to 2.8 mt. Brownish gray silty clay filling soil.
1.00	1.45	DS	3	5	3	8	
1.50	1.95	DS	2	4	5	9	2.8 mt. to 3.5 mt. Brownish gray silty clay and some sand.
2.00	2.45	DS	6	6	8	14	
2.50	2.95	DS	6	8	9	17	3.5 mt. to 4.7 mt. Grayish silty clay.
3.00	3.45	DS	4	5	6	11	
3.50	3.95	DS	1	1	2	3	4.7 mt. to 6.5 mt. Whiteish medium sand.
4.00	4.45	DS	1	1	1	2	
4.50	4.95	DS	1	1	12	13	6.5 mt. to 10.00 mt. Whiteish medium to coarse sand.
5.00	5.45	DS	8	11	15	26	
5.50	5.95	DS	10	16	19	35	
6.00	6.45	DS	15	24	37	61	
6.50	6.95	DS	17	28	41	69	
7.00	7.45	DS	22	36	48	84	
7.50	7.95	DS	27	39	53	92	
8.00	8.45	DS	35	46	50	R	
8.50	8.95	DS	43	57	50	R	
9.00	9.45	DS	54	50	R	R	
9.50	9.95	DS	50	R	R	A	
10.00	10.45	DS	50	R	R	A	

Bellal Hussain
 Supervisor Signature
 Name and Mobile No.

Sanjay Das
 Visiting Officer's Signature
 Name and Designation

Visiting Officer's Signature
 Name and Designation

SOIL TEST BOREHOLE CHART
RELIANT FOUNDATION PVT. LTD.
SUN POLO COLONY, DIPAR BORO PATH
AHOMGAON, GARCHUK
GUWAHATI-781035
PHONE: +91 986020945

NAME OF PROJECT: 220kv. Duct foundation
 Area at Sonapur.

Client Name & PH. No: 7002964183

Lat:

Long:

BORING TYPE: Hand Wash Boring

START DATE: 20/05/25

BORE HOLE NO.: 02.

END DATE: 20/05/25

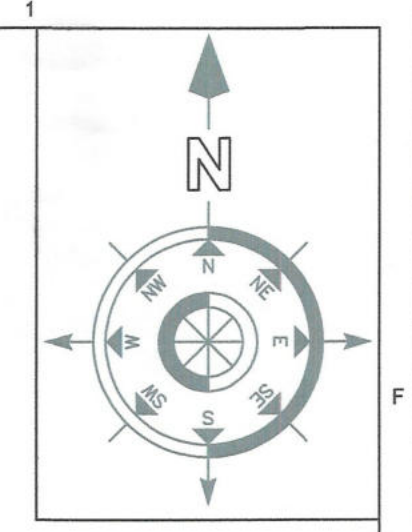
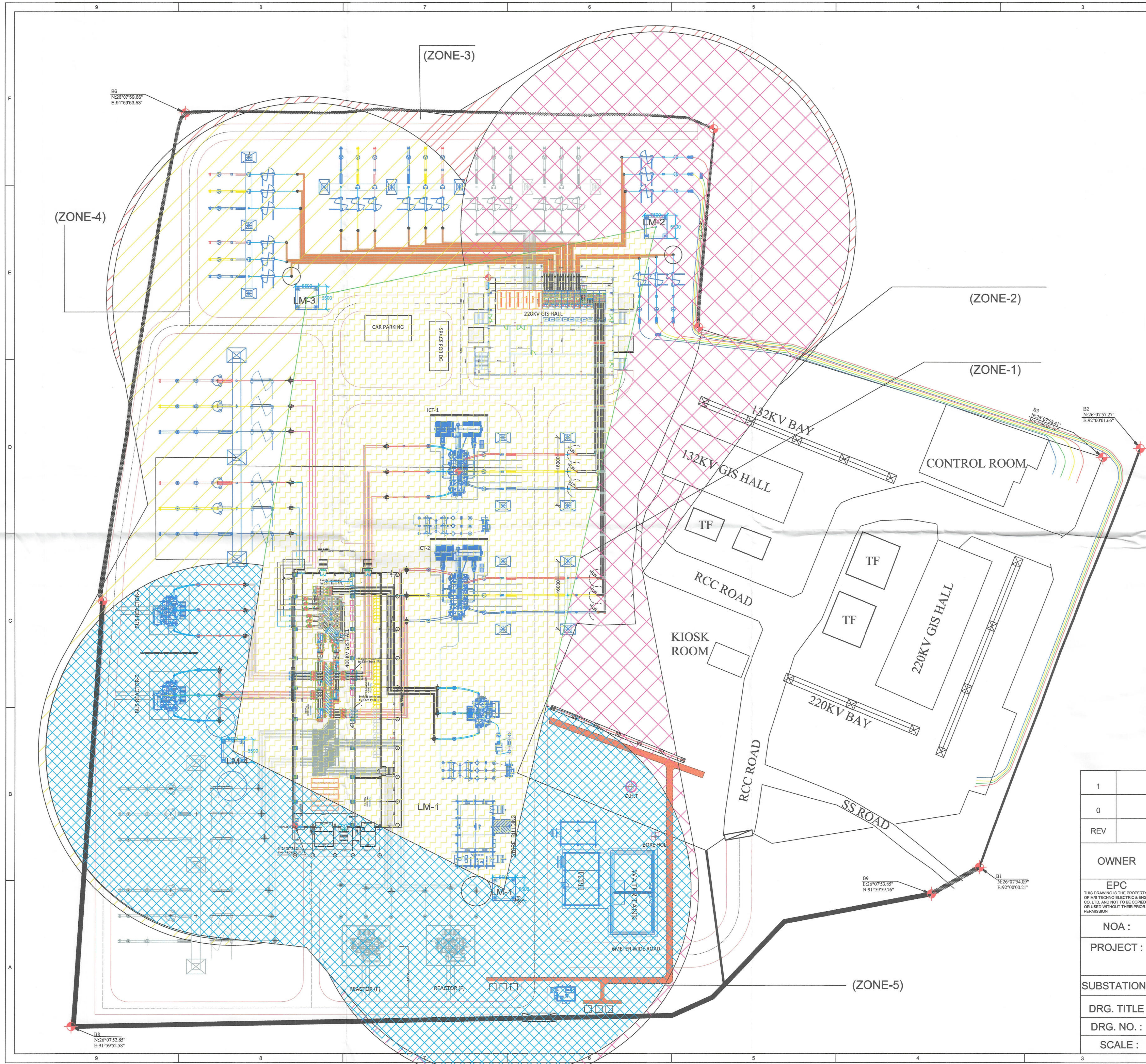
GROUND WATER LEVEL: 3.5 mt.

DEPTH (M)		SAMPLE TYPE	SPT			N VALUE	DESCRIPTION
FROM	TO		15cm	15cm	15cm		
0.50	0.95	DS	2	2	3	5	0.1 to 2.0 mt. Brownish gray silty clay filling soil.
1.00	1.45	DS	3	5	3	8	2.0 mt. to 3.0 mt. grayish brown silt clay filling soil.
1.50	1.95	DS	3	2	3	5	3.0 mt. to 4.0 mt. grayish silty clay.
2.00	2.45	DS	3	3	4	7	4.0 mt. to 6.0 mt. grayish silty clay.
2.50	2.95	DS	3	5	5	10	6.0 mt. to 7.0 mt. grayish silty clay and fine sand.
3.00	3.45	DS	2	3	4	7	7.0 mt. to 10.0 mt. white to light gray medium to coarse sand.
3.50	3.95	DS	1	2	2	4	
4.00	4.45	DS	2	2	2	4	
4.50	4.95	DS	2	2	2	4	
5.00	5.45	DS	1	1	2	3	
5.50	5.95	DS	1	1	2	3	
6.00	6.45	DS	3	1	1	2	
6.50	6.95	DS	1	1	2	3	
7.00	7.45	DS	4	7	9	16	
7.50	7.95	DS	10	15	25	40	
8.00	8.45	DS	10	16	23	39	
8.50	8.95	DS	15	24	31	55	
9.00	9.45	DS	28	39	48	87	
9.50	9.95	DS	40	53	50	R	
10.00	10.45	DS	47	50	R	R	

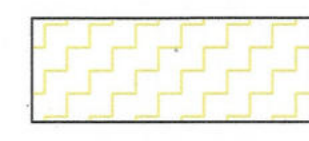
Supervisor Signature *Bellal Hussain*
 Name and Mobile No.

20/05/25
TEEC

Visiting Officer's Signature
 Name and Designation



LEGEND:

-  ZONE-1 PROTECTION AT 22.9 MTR BY 50+1 FOUR LM METHOD
-  ZONE-2 PROTECTION BY TWO LM METHOD. BY 50+1 M SPIKE REFER CALCULATION.
-  ZONE-3 PROTECTION BY TWO LM METHOD. BY 50+1 M SPIKE REFER CALCULATION.
-  ZONE-4 PROTECTION BY TWO LM METHOD. BY 50+1 M SPIKE REFER CALCULATION.
-  ZONE-5 PROTECTION BY TWO LM METHOD. BY 50+1 M SPIKE REFER CALCULATION.

LM QTY (50 MTR HEIGHT)

SL NO	ITEM DESCRIPTION	QTY (NOS)
1	50 MTR LM (WITH 50NB,2 MTR. SPIKE)	4

NOTES :

- ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED.
 - DIRECT STROKE LIGHTNING PROTECTION SHALL BE PROVIDED IN THE SUBSTATION BY LIGHTNING MAST. REFER "DSLPCALCULATION" FOR CALCULATION DETAILS.
 - LIGHTNING PROTECTION SYSTEM DOWN CONDUCTORS SHALL NOT BE CONNECTED TO OTHER CONDUCTOR ABOVE FGL.
 - THE LIGHTNING PROTECTION SYSTEM SHALL NOT BE DIRECT CONTACT WITH UNDERGROUND METALLIC SERVICE DUCTS.
 - LIGHTNING PROTECTION FOR GAS INSULATED BUSDUCT ARE NOT CHECKED AS THEY ARE METALLIC ENCLOSURE WITH PROPER EARTHING.
- REFERENCE :**
- ELECTRICAL LAYOUT PLAN : AEGCL-SONA-0816SN-ELE-ELAY-002
 - DSLPCALCULATION : AEGCL-SONA-0816SN-ELE-DSLPCAL-038

1	SECOND SUBMISSION	S.S.	S.S.	S.D.	03.05.25
0	FIRST SUBMISSION	S.S.	S.S.	S.D.	29.03.25
REV	DESCRIPTION	PREP.	CHKD.	APPD.	DATE
			SIGN.		
OWNER	ASSAM ELECTRICITY GRID CORPORATION LIMITED				
EPC	TECHNO ELECTRIC & ENGINEERING COMPANY LIMITED				
NOA :	AEGCL/MD/AIIB/400kv/Sonapur/Tender/PkgH/2023-24/Extn-2/71 Dtd: 13.09.2024				
PROJECT :	CONSTRUCTION OF 400/220kV, GIS AT SONAPUR AND ASSOCIATED TRANSMISSION LINES AND BAY EXTENSION WORKS AT EXISTING 220kV SONAPUR GIS INCLUDING BAY AUGMENTATION AT SARUSAJAI GSS				
SUBSTATION :	400/220kV GAS INSULATED SUBSTATION AT SONAPUR				
DRG. TITLE	SONAPUR SS - 400/220kV DSLP LAYOUT				
DRG. NO. :	AEGCL-SONA-0816SN-ELE-DSLPL-011				
SCALE :	1:1	JOB NO:	0816SN	SHEET	1 OF 1

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2 Approved By
GM (P&D)
2 Checked By
DSM (P&D)
0 Checked By
ACM (P&D)
A Checked By
DM (P&D)
A Checked By
AM (P&D)



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Earthmat Design Calculation

Reference Standard

: IEEE - 80 - 2013

Design Parameters

Resistivity Data

Avg. Soil Resistivity at ERT-2

$$\rho = 51.17 \Omega\text{-m}$$

(Soil Resistivity Test Report, attached)

Surface layer resistivity

$$\rho_s = 3000 \Omega\text{-m}$$

Surface layer thickness

$$h_s = 0.15 \text{ m}$$

Reflection factor between different resistivities

$$\begin{aligned} K &= (\rho - \rho_s) / (\rho + \rho_s) \\ &= (51.17 - 3000) / (51.17 + 3000) \\ &= -0.96646 \end{aligned}$$

Eq. 21

Surface layer derating factor

$$\begin{aligned} C_s &= 1 - (0.09 * (1 - \rho / \rho_s)) / (2 * h_s + 0.09) \\ &= 1 - (0.09 * (1 - 51.17 / 3000)) / (2 * 0.15 + 0.09) \\ &= 0.773 \end{aligned}$$

Eq. 27

System Data

Maximum System Fault Level
for conductor sizing

$$I_{sc} = 63000 \text{ A}$$

Fault current in substation

$$3I_0 = 63000 \text{ A}$$

Division factor for determining I_G
(400kV Transmission Line 4 nos. and 220kV
Transmission Line 6 nos.)

$$S_f = 0.6$$

- Reference 1

Maximum grid current that flows
between ground grid and surrounding
earth (including dc offset)

$$I_G = 37800 \text{ A}$$

Duration of shock for determining
allowable body current

$$t_s = 1 \text{ s}$$

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SUBSTATION	400/220KV SUBSTATION, SONAPUR		Sheet	7 OF 7	

Conductor Data

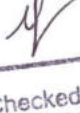
Specific heat of MS rod	Sh	=	0.114 Kcal/kg	(CBIP Manual on Substation -223)
Specific weight of MS rod	Sw	=	7.86 gm/cc	(CBIP Manual on Substation -223)
Co-efficient of linear expansion of MS rod	α_r	=	0.00377	(CBIP Manual on Substation -223)
Resistivity of MS Rod	Pr	=	15.9 micro ohm-m	(CBIP Manual on Substation -223)
Reference temperature	Tr	=	20 degree C	
Maximum temperature	Tm	=	1510 degree C	
Ambient temperature	Ta	=	50 degree C	

Grid Data (Refer Annexure II)

Total area enclosed by ground grid	A	=	26921.7 m ²
Eqv Diameter of grid conductor	d	=	0.04 m
Spacing between parallel conductors	D	=	12 m
Depth of ground grid conductors	h	=	0.7 m
Reference depth of grid	h ₀	=	1 m
Maximum distance between any two points on the grid	D _m	=	258 m
Total length of grid conductor	L _c	=	5256 m
Peripheral length of grid	L _p	=	747 m
Maximum length of grid conductors in x direction	L _x	=	122 m
Maximum length of grid conductors in y direction	L _y	=	212 m
Length of ground electrodes at each location	L _r	=	3 m
Number of electrodes placed in area A	n _R	=	215 Nos.

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Total length of ground Electrodes

$$\begin{aligned} L_R &= n_R \cdot L_r \\ &= 215 \cdot 3 \\ &= 645 \text{ m} \end{aligned}$$

Total effective length of grounding system conductor, including grid and electrodes

$$\begin{aligned} L_T &= L_c + L_R \\ &= 5256 + 645 \\ &= 5901 \text{ m} \end{aligned}$$

Calculation of effective length of $L_c + L_R$ for mesh voltage

Effective length of $L_c + L_R$ for mesh voltage

for grids with ground rods in the corners, as well as along the perimeter and throughout the grid, the effective buried length is

$$\begin{aligned} L_{M1} &= L_r / ((L_x^2 + L_y^2)^{0.5}) \\ &= 3 / ((122^2 + 212^2)^{0.5}) \\ &= 0.01227 \end{aligned}$$

$$\begin{aligned} L_M &= L_c + (1.55 + 1.22 \cdot L_{M1}) \cdot L_R \\ &= 5256 + (1.55 + 1.22 \cdot 0.01227) \cdot 645 \\ &= 6265.41 \text{ m} \end{aligned}$$

Eq. 91

Calculation of effective length of $L_c + L_R$ for step voltage

Effective length of $L_c + L_R$ for step voltage

$$\begin{aligned} L_S &= 0.75 \cdot L_c + 0.85 \cdot L_R \\ &= 0.75 \cdot 5256 + 0.85 \cdot 645 \\ &= 4490.25 \text{ m} \end{aligned}$$

Eq. 93

Calculation of different factors related to Grid Geometry

Geometry of Grid

= Irregular Grid

Geometric factor

$$\begin{aligned} n_a &= 2 \cdot L_c / L_p \\ &= 2 \cdot 5256 / 747 \\ &= 14.07 \end{aligned}$$

Eq. 85

$$\begin{aligned} n_b &= (L_p / (4 \cdot (A^{0.5})))^{0.5} \\ &= (747 / (4 \cdot (26921.7^{0.5})))^{0.5} \\ &= 1.07 \end{aligned}$$

Eq. 86

$$\begin{aligned} n_{c1} &= 0.7 \cdot A / (L_x \cdot L_y) \\ &= 0.7 \cdot 26921.7 / (122 \cdot 212) \\ &= 0.72863 \end{aligned}$$

Eq. 87

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$$\begin{aligned} n_c &= (L_x \cdot L_y / A)^{n_{c1}} \\ &= (122 \cdot 212 / 26921.7)^{0.72863} \\ &= 0.971 \end{aligned} \quad \text{Eq. 87}$$

$$\begin{aligned} n_d &= Dm / ((L_x^2 + L_y^2)^{0.5}) \\ &= 258 / ((122^2 + 212^2)^{0.5}) \\ &= 1.055 \end{aligned} \quad \text{Eq. 88}$$

Geometric factor composed of factors n_a , n_b , n_c and n_d

$$\begin{aligned} n &= n_a \cdot n_b \cdot n_c \cdot n_d \\ &= 14.07 \cdot 1.07 \cdot 0.971 \cdot 1.055 \\ &= 15.4223 \end{aligned} \quad \text{Eq. 84}$$

Factors for calculation of step and touch voltages

Corrective weighting factor that emphasizes the effects of grid depth, simplified method

$$\begin{aligned} K_h &= (1 + h/h_0)^{0.5} \\ &= (1 + 0.7/1)^{0.5} \\ &= 1.304 \end{aligned} \quad \text{Eq. 83}$$

Correction factor for grid geometry, simplified method

$$\begin{aligned} K_i &= 0.644 + 0.148 \cdot n \\ &= 0.644 + 0.148 \cdot 15.4223 \\ &= 2.927 \end{aligned} \quad \text{Eq. 89}$$

Corrective weighting factor that adjusts for the effects of inner conductors on the corner mesh, simplified method

For, grid with ground rods along the perimeter, or for grids with ground rods in the grid corners as well as both along the perimeter and throughout the grid area.

$$K_{ii} = 1$$

Spacing factor for step voltage, simplified method

$$\begin{aligned} K_{s1} &= 1/(2 \cdot h) \\ &= 1/(2 \cdot 0.7) \\ &= 0.71429 \end{aligned}$$

$$\begin{aligned} K_{s2} &= 1/(D + h) \\ &= 1/(12 + 0.7) \\ &= 0.07674 \end{aligned}$$

Eq. 94

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$$\begin{aligned}
 K_{s3} &= 1/D*(1-0.5^{(n-2)}) \\
 &= 1/12*(1-0.5^{(15.4223-2)}) \\
 &= 0.08333 \\
 K_s &= 1/\pi*(K_{s1}+K_{s2}+K_{s3}) \\
 &= 1/3.1416(0.71429+0.07874+0.08333) \\
 &= 0.28
 \end{aligned}$$

Eq. 94

Geometrical factor for mesh voltage simplified method

$$\begin{aligned}
 K_{m1} &= D^2/(16*h*d) \\
 &= 12^2/(16*0.7*0.04) \\
 &= 321.429 \\
 K_{m2} &= ((D+2*h)^2)/(8*D*d) \\
 &= ((12+2*0.7)^2)/(8*12*0.04) \\
 &= 46.7604 \\
 K_{m3} &= h/(4*d) \\
 &= 0.7/(4*0.04) \\
 &= 4.375 \\
 K_{m4} &= \ln(8/(\pi*(2^n-1))) \\
 &= \ln(8/(3.14159265358979*(2^{15.4223}-1))) \\
 &= -2.46 \\
 K_m &= 1/(2*\pi)*(\ln(K_{m1}+K_{m2}-K_{m3})+K_{m4}/K_h*K_{m4}) \\
 &= 1/(2*3.1416)*(\ln(321.4286+46.7604-4.375)+(1/1.304*-2.46)) \\
 &= 0.64
 \end{aligned}$$

Eq. 81

Resistance of grounding system

$$\begin{aligned}
 R_{g1} &= 1/L_T \\
 &= 1/5901 \\
 &= 0.00017 \\
 R_{g2} &= 1/((20*A)^{0.5}) \\
 &= 1/((20*26921.7)^{0.5}) \\
 &= 0.0014 \\
 R_{g3} &= 1+1/(1+h*(20/A)^{0.5}) \\
 &= 1+1/(1+0.7*(20/26921.7)^{0.5}) \\
 &= 1.9813 \\
 R_g &= \rho*(R_{g1}+R_{g2}*R_{g3}) \\
 &= 51.17*(0.00017+0.0014*1.9813) \\
 &= 0.1506
 \end{aligned}$$

Eq. 52

APPROVED subject to the condition that the review is done by the concerned person who has signed his name on the contract. The AEGCL's right to the contract is not affected by this approval.

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Grid Potential Rise

$$\begin{aligned} \text{GPR} &= I_G \cdot R_g \\ &= 37800 \cdot 0.15064 \\ &= 5694.19 \text{ Volts} \end{aligned}$$

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Allowable Step and Touch Voltage

Tolerable step voltage for human with 50 kg body weight

$$\begin{aligned} E_{\text{step}50} &= (1000 + 6 \cdot C_s \cdot \rho_s) \cdot (0.116 / (t_s^{0.5})) \\ &= (1000 + 6 \cdot 0.773 \cdot 3000) \cdot (0.116 / (1^{0.5})) \\ &= 1730.02 \text{ V} \end{aligned} \quad \text{Eq. 29}$$

Tolerable step voltage for human with 70 kg body weight

$$\begin{aligned} E_{\text{step}70} &= (1000 + 6 \cdot C_s \cdot \rho_s) \cdot (0.157 / (t_s^{0.5})) \\ &= (1000 + 6 \cdot 0.773 \cdot 3000) \cdot (0.157 / (1^{0.5})) \\ &= 2341.5 \text{ V} \end{aligned} \quad \text{Eq. 30}$$

Tolerable touch voltage for human with 50 kg body weight

$$\begin{aligned} E_{\text{touch}50} &= (1000 + 1.5 \cdot C_s \cdot \rho_s) \cdot (0.116 / (t_s^{0.5})) \\ &= (1000 + 1.5 \cdot 0.773 \cdot 3000) \cdot (0.116 / (1^{0.5})) \\ &= 519.506 \text{ V} \end{aligned} \quad \text{Eq. 32}$$

Tolerable touch voltage for human with 70 kg body weight

$$\begin{aligned} E_{\text{touch}70} &= (1000 + 1.5 \cdot C_s \cdot \rho_s) \cdot (0.157 / (t_s^{0.5})) \\ &= (1000 + 1.5 \cdot 0.773 \cdot 3000) \cdot (0.157 / (1^{0.5})) \\ &= 703.125 \text{ V} \end{aligned} \quad \text{Eq. 33}$$

Calculated Step and Touch Voltage

Mesh (Touch) voltage at the center of the corner mesh for the simplified method

$$\begin{aligned} E_m &= \rho \cdot K_m \cdot K_i \cdot I_G / L_M \\ &= 51.17 \cdot 0.64 \cdot 2.927 \cdot 37800 / 6265.405 \\ &= 578.31 \text{ V} \end{aligned} \quad \text{Eq. 80}$$

Step voltage between a point above the outer corner of the grid and a point 1 m diagonally outside the grid for the simplified method

$$\begin{aligned} E_s &= \rho \cdot K_s \cdot K_i \cdot I_G / L_s \\ &= 51.17 \cdot 0.28 \cdot 2.927 \cdot 37800 / 4490.25 \\ &= 353.035 \text{ V} \end{aligned} \quad \text{Eq. 92}$$

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Check for Conductor size adequacy

Adequacy Check for conductor size as per IEEE - 80 / CBIP Publication - 223 Page - 4

Conductor X-section in mm²

$$A = \frac{(I_{sc}/1000)}{\left\{ \frac{TCAP * 10^{-4}}{Ts * \alpha_r * Pr} * \ln \left(\frac{(Ko+Tm)}{(Ko+Ta)} \right) \right\}^{1/2}}$$

Where,

TCAP

= Thermal Capacity per unit volume from Table 1 in J / (cm³ . °C)K₀= (1 / α_r) - T_r in °CI_{sc}

= 63000 A

Thermal Capacity Factor

Tcap = 4.184 * Sh * Sw

= 3.74903 J / (cm³ . °C)

Ts

= 3

Ts * α_r * Pr = 0.17983k₀ = (1 / Alpha r) - T_r
= 245.252 °C

Ko + Tm = 1755.25 °C

Ko + Ta = 295.252 °C

So, Conductor X-section

A = 1033.45 mm²

Ageing Factor

F = 1.15 (Reference 2 attached)

So Gross Conductor X section Area

= 1188.47 mm²
= 38.9 mm Dia

Chosen Conductor Size

= 40 Dia MS Rod
1256.64 mm²

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Reference 1

IEEE Std 80-2013
IEEE Guide for Safety in AC Substation Grounding

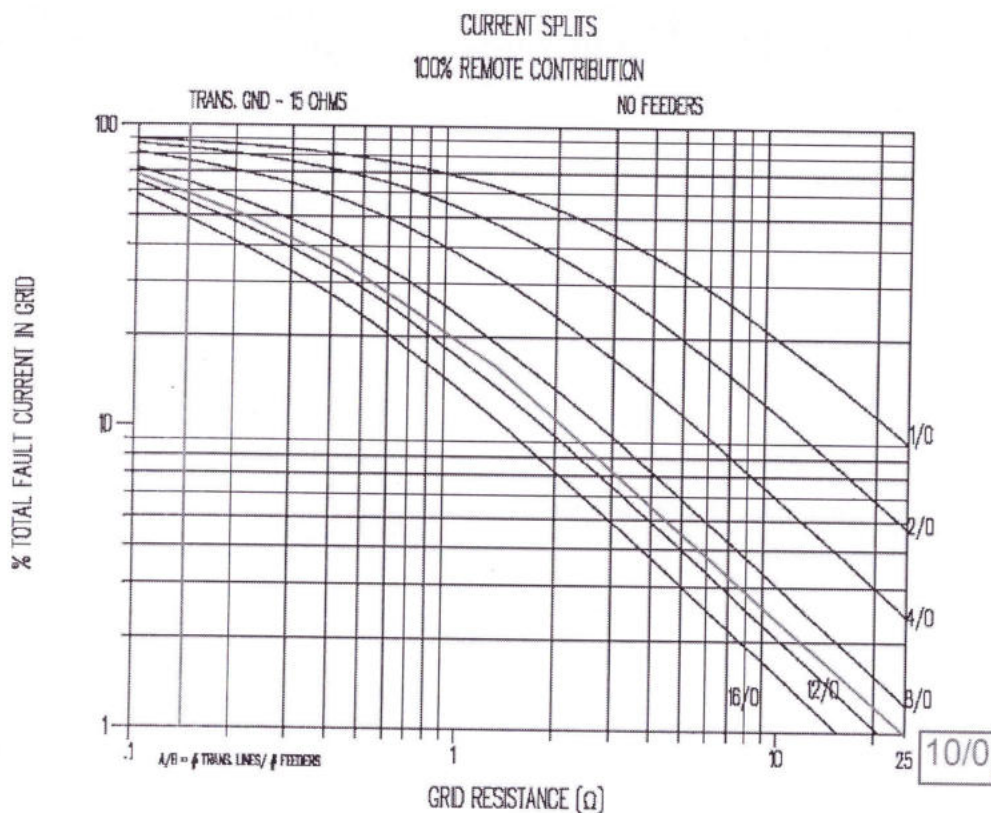
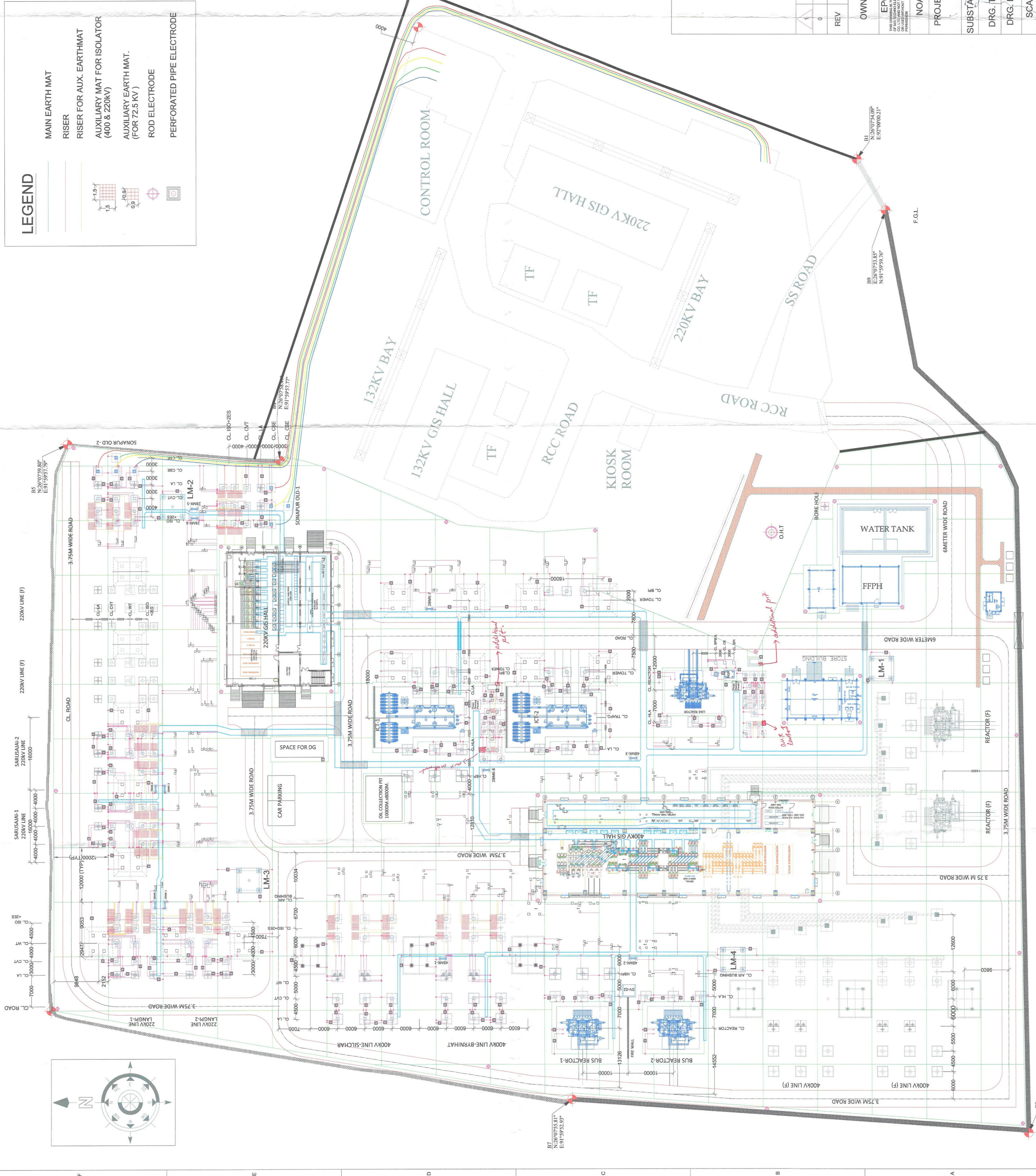


Figure C.13—Curves to approximate split factor S_f

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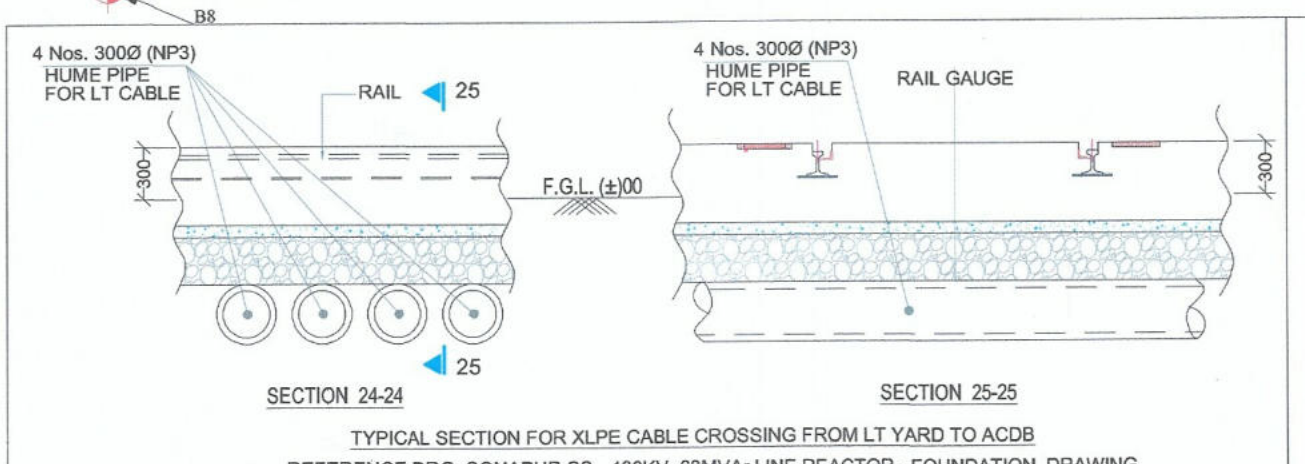
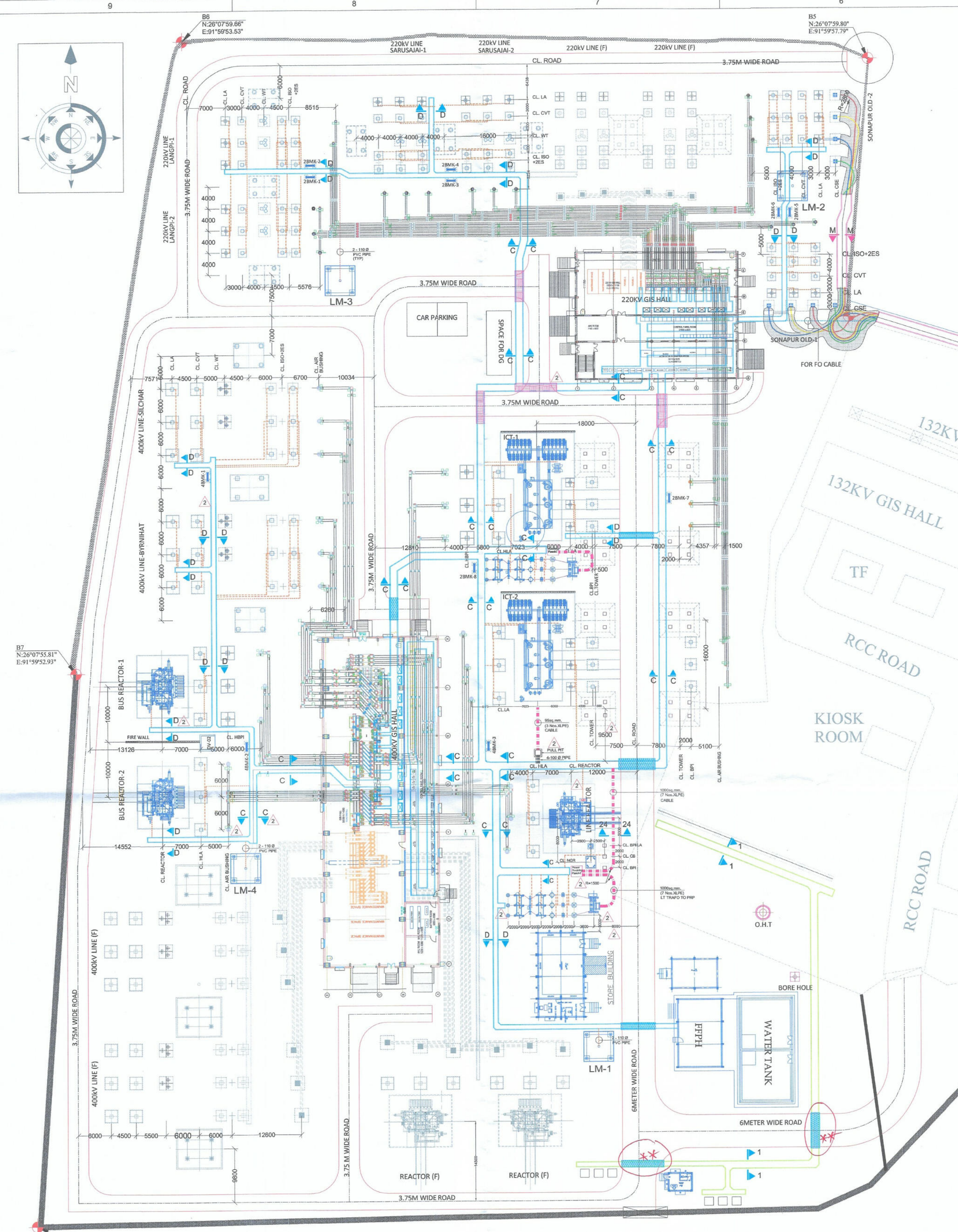
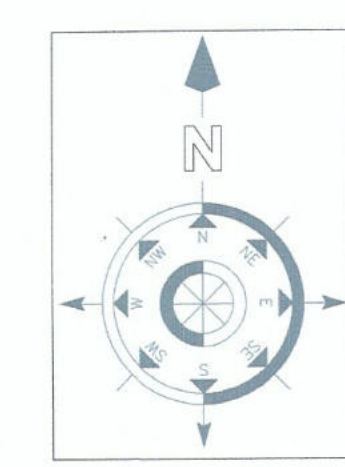
NOTES :-

* additional aux contract & treated pit as marked shall be provided.

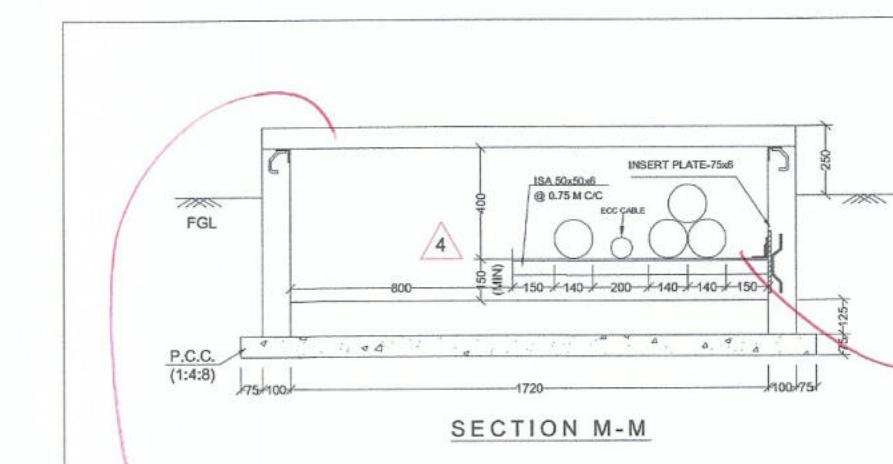
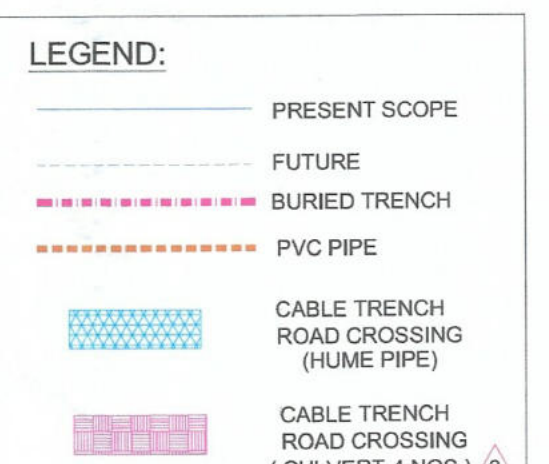
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1	SECOND SUBMISSION	P.M.	S.S.	S.D.	28.07.25
0	FIRST SUBMISSION	P.M.	S.S.	S.D.	09.08.25
REV	DESCRIPTION	PREP.	CHKD.	APPD.	DATE
			SIGN.		
OWNER	ASSAM ELECTRICITY GRID CORPORATION LIMITED				
EPIC					
PROJECT	TECHNO ELECTRIC & ENGINEERING COMPANY LIMITED				
NOA :	AEGCL/MD/AIIB/400kv/SonapurTender/PkgH/2023-24/Extn-2/71 Dtd: 13.09.2024				
SUBSTATION :	CONSTRUCTION OF 400/220kV, GIS AT SONAPUR AND ASSOCIATED TRANSMISSION LINES AND BAY EXTENSION WORKS AT EXISTING 220kV SONAPUR GIS INCLUDING BAY AUGMENTATION AT SARUSAJAI GSS				
DRG. TITLE	400/220kV GAS INSULATED SUBSTATION AT SONAPUR				
DRG. NO. :	SONAPUR S/S- 400/220kV EARTHMAT LAYOUT				
SCALE :	AEGCL-SONA-08/16SN-ELE-EARTHLAY-013				
	1:1	JOB NO:	08/16SN	SHEET	1 OF 1

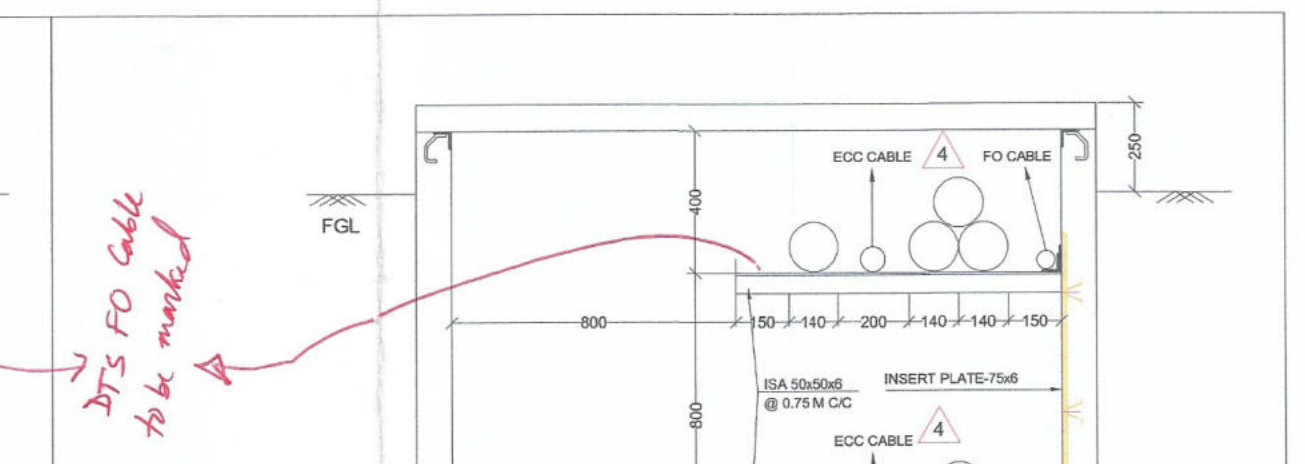
1	SECOND SUBMISSION	P.M.	S.S.	S.D.	28.07.25
0	FIRST SUBMISSION	P.M.	S.S.	S.D.	09.08.25
REV	DESCRIPTION	PREP.	CHKD.	APPD.	DATE
			SIGN.		
OWNER	ASSAM ELECTRICITY GRID CORPORATION LIMITED				
EPCC	TECHNO ELECTRIC & ENGINEERING COMPANY LIMITED				
NOA :	AEGCL/MD/AIIB/400kv/SonapurTender/PkgH/2023-24/Extn-2/71 Dtd: 13.09.2024				
PROJECT :	CONSTRUCTION OF 400/220kV, GIS AT SONAPUR AND ASSOCIATED TRANSMISSION LINES AND BAY EXTENSION WORKS AT EXISTING 220kV SONAPUR GIS INCLUDING BAY AUGMENTATION AT SARUSAJAI GSS				
SUBSTATION :	400/220kV GAS INSULATED SUBSTATION AT SONAPUR				
DRG. TITLE	SONAPUR S/S- 400/220kV EARTHMAT LAYOUT				
DRG. NO. :	AEGCL-SONA-08/16SN-ELE-EARTHLAY-013				
SCALE :	1:1	JOB NO:	08/16SN	SHEET	1 OF 1



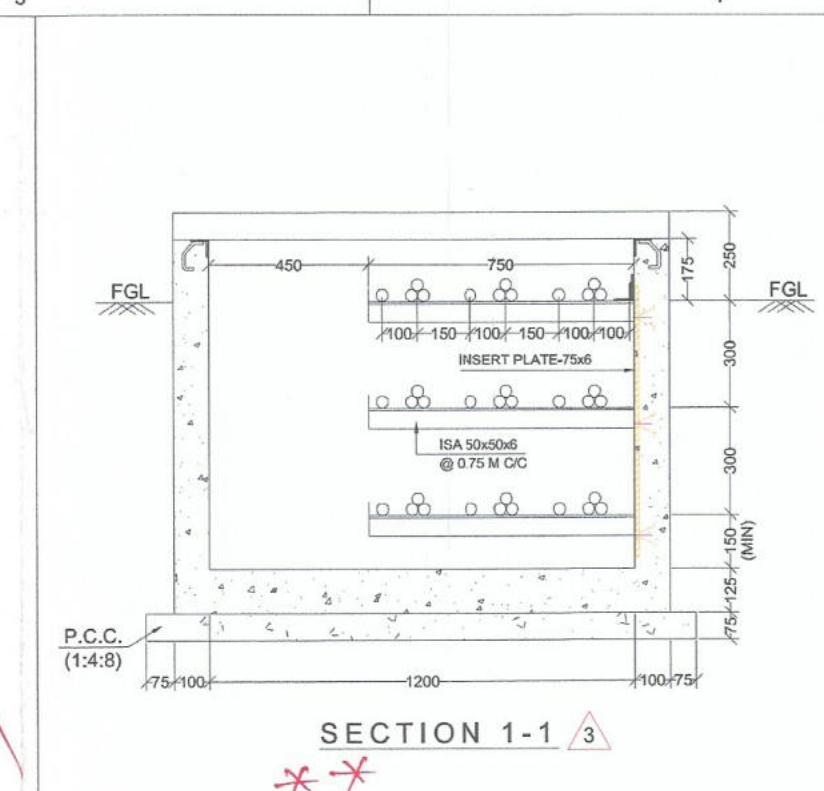
CABLE TRENCH LENGTH		LENGTH		LEGEND	REMARKS
		AS PER LOA	AS PER ENGINEERING		
28	CABLE TRENCH ALONG WITH ROAD CROSSING CULVERT FOR CABLES WHEREVER NECESSARY.				
28.01	TRENCH C-C	100 MTR.	385 MTR. (Approx.)		
28.02	TRENCH D-D	80 MTR.	332 MTR. (Approx.)		
28.03	CABLE TRENCH FOR 220 KV POWER CABLE WITH 1600 SQMM CORE CABLE FOR 2 CIRCUIT WITH 4 CABLES PER CIRCUIT.	300 MTR.	280 MTR. (Approx.)		
28.04	8 NO. 3.3KV OUTGOING BAY FROM EXISTING SWITCHYARD UPTO BOUNDARY WALL AS PER LAYOUT.	60 MTR.	154 MTR. (Approx.)		



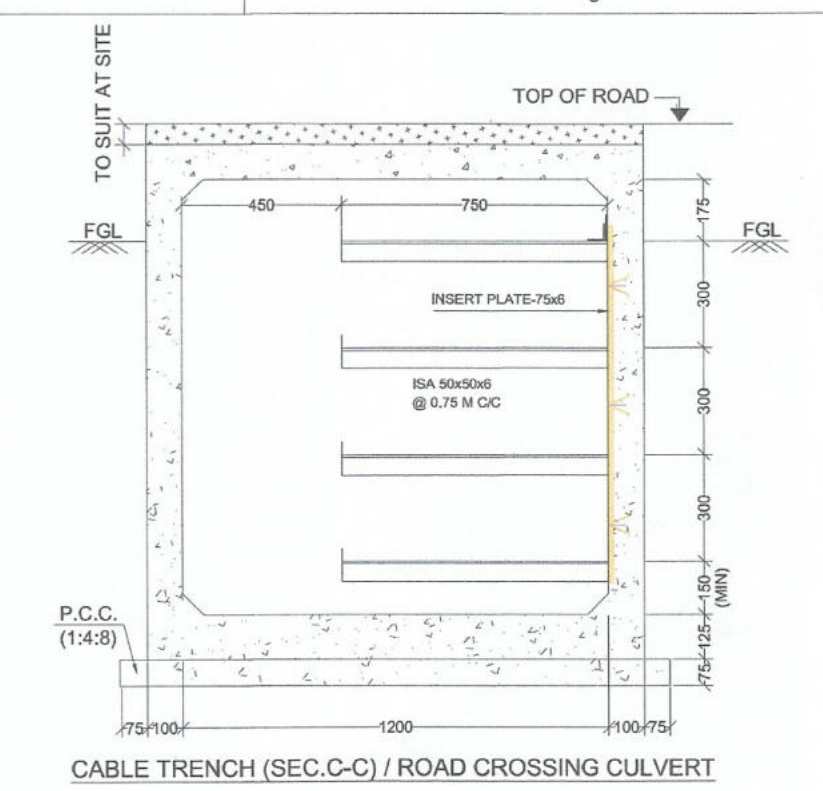
Top Cover Slab to be suitably Reinforced for the portion marked above



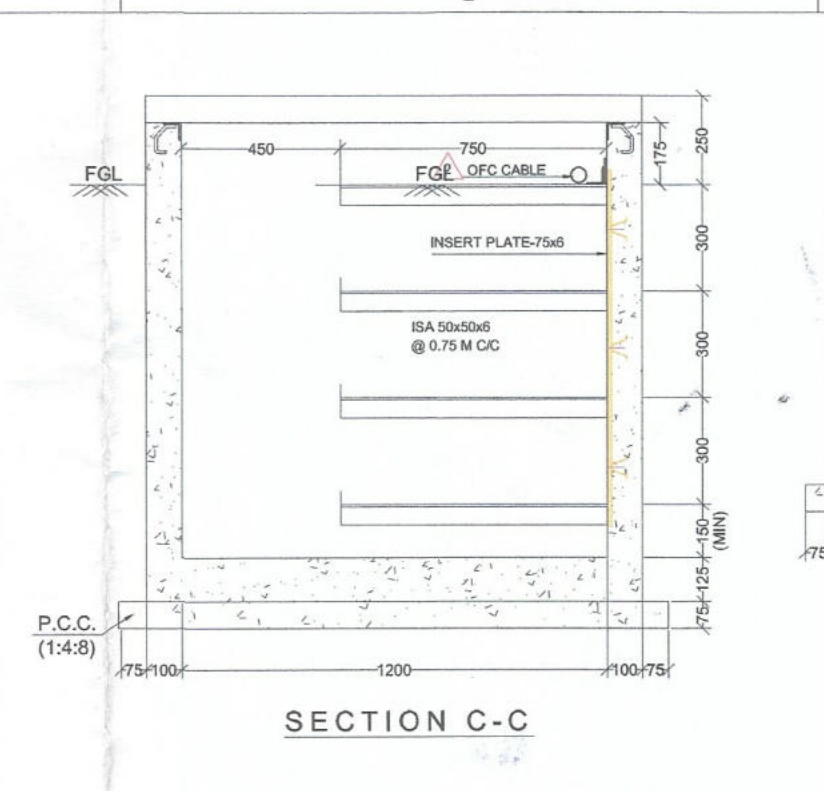
For FO Cable to be marked



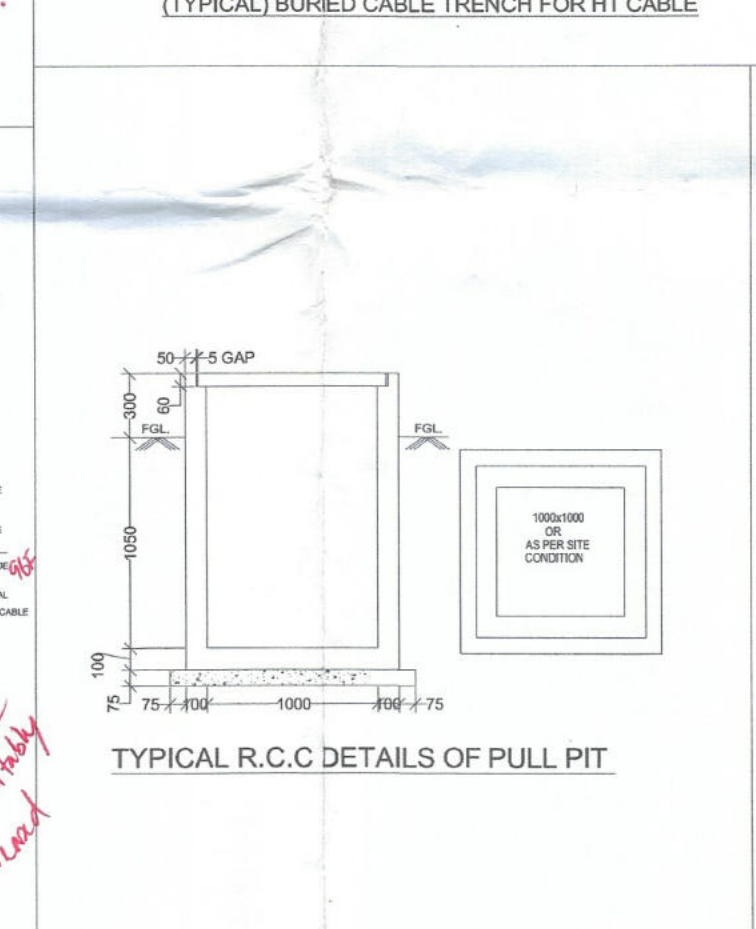
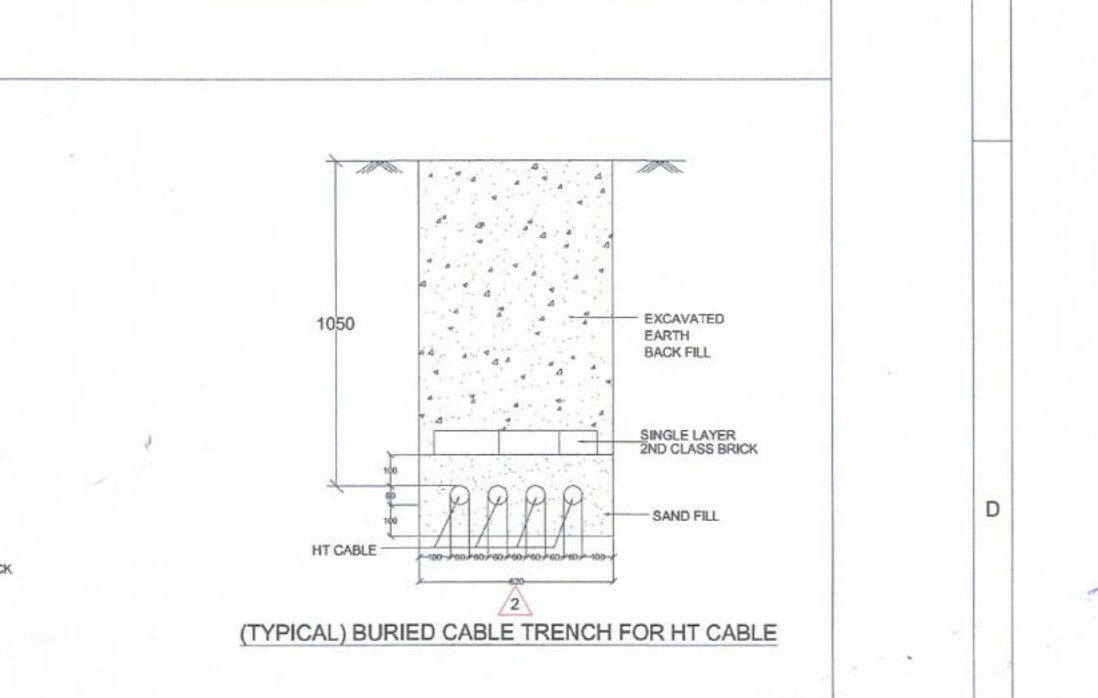
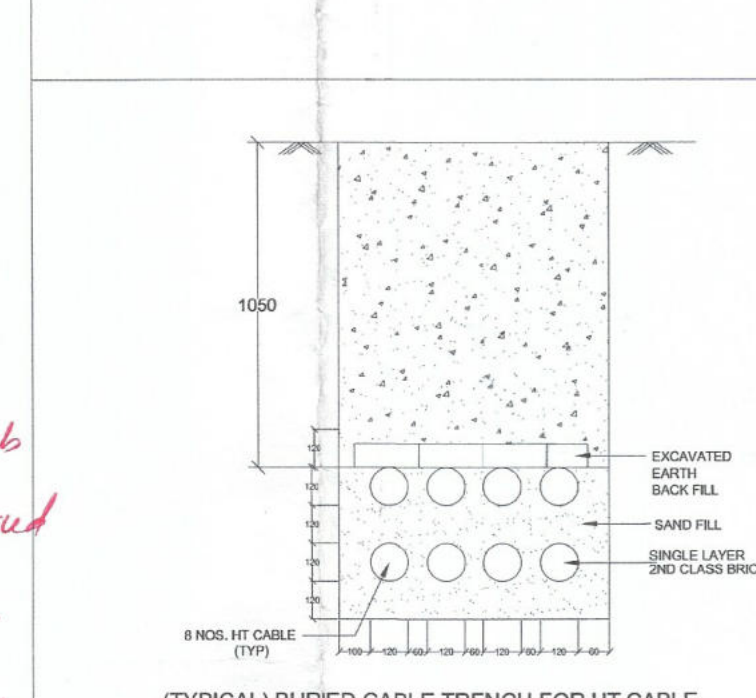
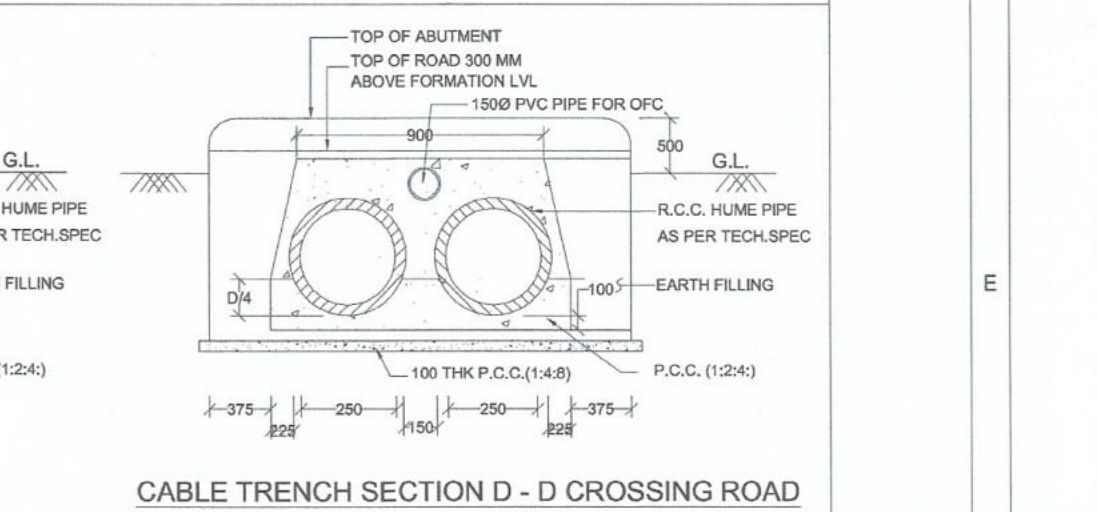
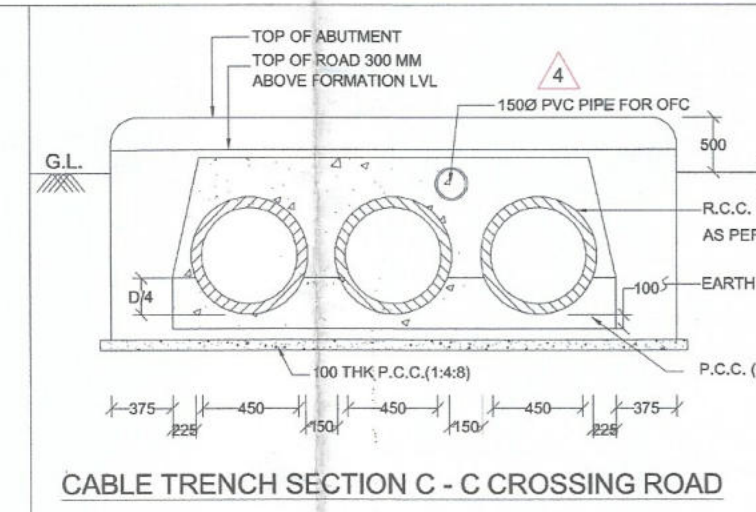
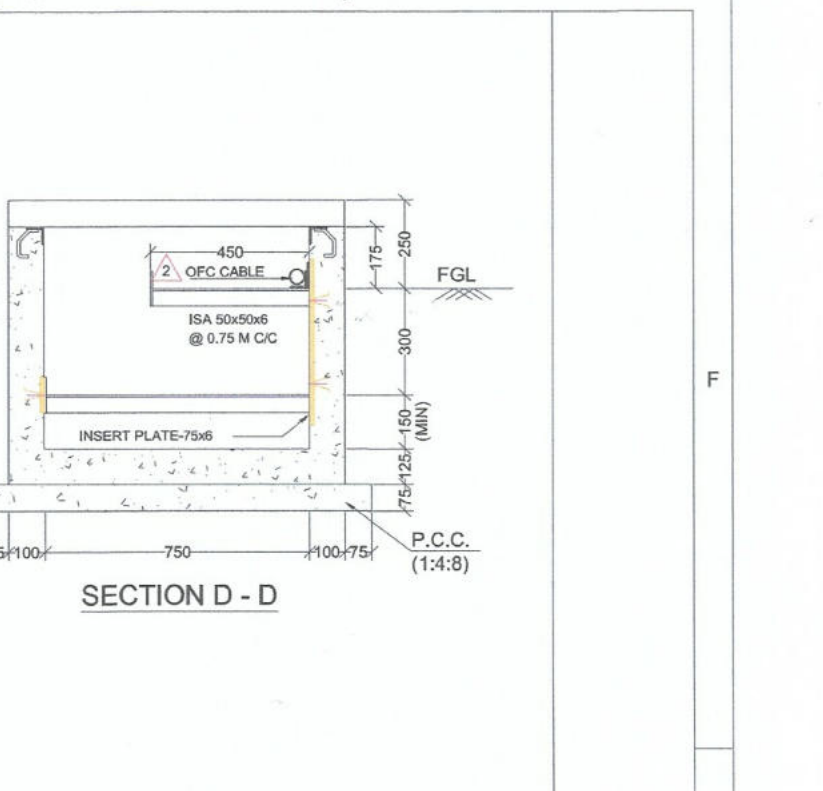
** For Road Crossing portion as marked, Typical Section similar to Section C-C with dimensions pertaining to Section 1-1 shall be used.



** This typical sectional layout for road crossing to be submitted

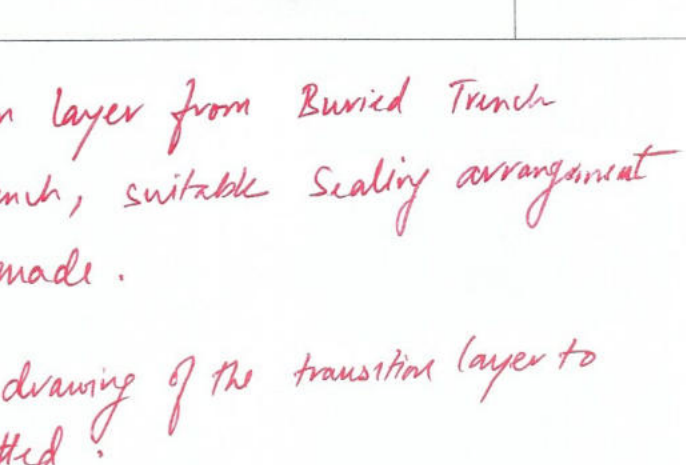


** For This Section marked, The Cover Slab shall be suitably Reinforced for movement of Hydran for maintenance works.



SL.	DESCRIPTION	LENGTH
1	50 Ø PVC PIPE	1152 M. (Approx)
2	110 Ø PVC PIPE	1540 M. (Approx)

TYPICAL PIPE SLEEVE DETAILS OF ISOLATOR WITH 2/ES



For transition layer from Buried Trench to Cable Trench, suitable Sealing arrangement shall be made.

* Sectional drawing of the transition layer to be submitted.

APPROVED, subject to the condition that the approval conveyed herein neither releases the contractor of his contractual obligations and his responsibilities, design details, performance particulars and conformity of the supplies with the Indian Statutory laws / IEC. Modifications as may be applicable, no date limit. AEGCL's right under the contract.

Checked By	Checked By	Checked By	Checked By	Approved By
AM (P&D)	DM (P&D)	AGM (P&D)	DGM (P&D)	GM (P&D)

4	FIFTH SUBMISSION	P.M.	S.S.	S.D.	18.12.25
3	FOURTH SUBMISSION	P.M.	S.S.	S.D.	11.11.25
2	THIRD SUBMISSION	P.M.	S.S.	S.D.	17.07.25
1	SECOND SUBMISSION	P.M.	S.S.	S.D.	02.06.25
0	FIRST SUBMISSION	P.M.	A.B.	S.D.	16.04.25
REV	DESCRIPTION	PREP.	CHKD.	APPD.	DATE
OWNER		ASSAM ELECTRICITY GRID CORPORATION LIMITED			
NOA :		AEGCL/MD/AIIB/400kv/Sonapur/Tender/PkgH/2023-24/Extn-2/71 Dtd: 13.09.2024			
PROJECT :		CONSTRUCTION OF 400/220KV, GIS AT SONAPUR AND ASSOCIATED TRANSMISSION LINES AND BAY EXTENSION WORKS AT EXISTING 220KV SONAPUR GIS			
SUBSTATION :		400/220KV GAS INSULATED SUBSTATION AT SONAPUR			
DRG. TITLE		SONAPUR S/S- 400/220KV OUTDOOR CABLE TRENCH LAYOUT			
DRG. NO. :		AEGCL-SONA-0816SN-ELE-CABTRELAY-006			
SCALE :		1:1	JOB NO. :	0816SN	SHEET 1 OF 1