28.08.2025

Name of Work : New horizontal belt filter and associated facilities in phosphoric acid plant at FACT-CD on LSTK basis, Ambalmedu, Kochi

E-Tender ID No. : 2025_FACT_869361_1

Corrigenda and Clarifications to prebid queries

The following documents/clarifications are issued as corrigendum:

i. **Pre-Bid Clarifications**
ii. **Soil Investigation Report**
iii. **Illustrative calculation of bill payment (Simple Calculation)**
iv. **Corrigendum Related to Site Clearance**

All other terms and conditions remains unchanged.

Anand S
DM(Mat)-F

FERTILISERS AND CHEMICALS TRAVANCORE LTD

Clarifications to Queries raised by bidders

Job No:	32771
Project Name:	New horizontal belt filter and associated facilities in phosphoric acid plant at FACT-CD on LSTK basis, Ambalmedu, Kochi

Pre Bid Queries

Sl. No.	Discipline	SUBJECT	Bidder CLARIFICATION / QUERY	FACT REPLY
1	Common	Battery Limits / Tie-in-points	Bidder requests to funrish the Tie-in points including Piping, Control Room, Storm Water Drain and Effulent Drain.	Piping tie-in points shall be located within one meter of the battery limit as indicated in the layout, primarily on the existing main plant building side. The subsequent routing and transfer of piping to the plant, with appropriate supporting arrangements, shall be within the bidder's scope. SW drain and Effluent drain tie in points are avaialble within 15m from battery limits. SW drain shall be connected to existing SW drain running along north side of battery limit. Effluents, if any, shall be suitably discharged to PAP equalisation tank/ Effluent drain suitably, as per detailed drain design. Bidder shall suitably consider the same.
2	Civil	Preliminary Soil Investigation Report	As per Tender Clause No. 32771-12-DA-002 R1, Preliminary Soil Investigation Report to be furnished to Bidder during pre-bid meeting for bidding reference. Kindly furnish the same.	Refer corrigendum Annexure A
3	Civil	Demolitions of Existing facilities	As per Tender Clause No. 1.0 32771-12-DA-002 R1 under Civil Departement, Demolitions under LSTK Bidder scope whereas as per pre-bid meeting we understand that all demolitions of the existing facilities (if any) will be done Owner "FACT" and incumbrance free land upto Finish Grade Level shall be furnished to LSTK Bidder for further consturction purpose.	Demolition of existing structures in the proposed area (as per dwg no: 32771-12-DG-00101 indicated in Annexure B of corrigendum) shall be in the scope of Owner. Any rerouting/demolition/ repair / modification for tie in to existing facilities or any additional modification requirement during detailed engineering shall be in Bidder's scope

4	Civil	Undergroung scanning	Undergroung scanning (if required) for existing facilities under battery limits will be done by LSTK Bidder. After scanning, if any obstruction/hindrance found will be taken care by Owner 'FACT'.	All rerouting of existing underground utilities/ structures inside battery limit shall be in the scope of owner as per the underground scanning performed by Owner. Any rerouting or any additional modification requirement during detailed engineering shall be in Bidder's scope
5	Civil	Protection Lining	Bidder requests that provide Type of Protection Lining wherever is required.	Protection lining for foundations shall be conforming to 32771-12-PS-001, Cl 2.3, page no: 644/726. If any other protective linings are specified in the soil investigation conducted during detailed engineering by Successful bidder, the same shall be provided as per Doc No: 32771-12-DA-002, Page 46 of 58 Cl 5.1.4.
6	Civil	Existing conveyor	Bidder requests to provide Existing Conveyor Gantry Drawing detailes at tie-in location of new gantry.	Dwg not available with the Owner
7	Civil	Pavement Scope	Bidder understand that pavement shall be done in only construction effected area.	Access roads to be provided as per the approved plot plan (as mentioned in Doc No: 32771-12-DA-001, Page 2 of 9, Cl. 1.0) and in areas where existing pavement is affected due to construction activities by bidder after award of work (as mentioned in Doc No: 32771-12-DA-002, Page 58 of 58, Cl. 6.4).
8	Civil	HBF Building	We have considered RCC upto crane level & after that we are considering Steel Structure Shed with side covering of Non-Asbestos Sheeting. No side covering is considered below the HB Filter floor where pumps and tanks will be installed.	Refer corrigendum in this regard.
9	Civil	Transfer Towers	We have considered RCC upto 3 m level from NGL & after that we are considering Steel Structure Floor & shed with FRP Grating Floor.	Refer corrigendum in this regard.
10	Civil	Conveyor Gantry	We have considered Steel Structure Gantry with covering of Non-asbestos sheeting.	Refer corrigendum in this regard.

11	Civil	HBF & MCC Building	Space provided for HBF Building is 15.2 x 42.2 , whereas Equipment length is coming 42.5 M (approx) so there is requirment of additional space for Equipment Fittment and Maintenance. FACT to confirm the availability of additional area requirement for Building i.e. 55M x 15.2M incl. MCC Room.	MCC room is considered in Ground floor of HBF building as per tender document. However final sizing shall be as per detailed engineering by successful bidder. Sufficient space is availabile inside battery limit to position building of size 55m x 15m.
12	Layout	Existing Control Room	Location of Existing Control Room and its tie in point location.	The existing control room is located on the second floor of the main plant building, at an approximate distance of 225 meters from the proposed MCC room. Cable routing and supporting arrangements shall be included in the bidder's scope
13	Process	VMS & PMS	Bidder request to provide PMS and VMS (incl. Valve Type specially for Plug Valve).	Minimum MOCs considered shall be as follows: **1.** DM WATER PIPE MOC - ASTM A312 TP 304 VALVE MOC - ASTM A182 F304/ ASTM A351 Gr. CF8 **2.** SULPHURIC ACID (98%) PIPE MOC - CS ASTM A106 Gr,.B VALVE MOC -Alloy 20 **3.** GYPSUM,PHOSPHORIC ACID, SLURRY PIPE MOC - A312 TP 904L,SMLS VALVE MOC -ALLOY 20 **4.** Phosphoric acid,Vapour/VAccum, Slurry,Process water, effluent water,cooling water Pipe MOC - Carbon Steel with 5mm thick rubber lining Valve MOC - ALloy 20 (Phosphoric acid,VApuor/Vaccum & Slurry) ,Stainless steel (Process/Effluent water), Carbon steel (Cooling water). **5.** Steam and Condensate Pipe MOC - ASTM A 106 Gr.B, SMLS IBR Valve MOC : A216 WCB with SS internals. **6.** Instrument Air Pipe - CArbon Steel Valve MOC : A216 WCB with SS internals. However, for ball and plug valves, regular/long pattern full bore valves shall be considered.

14	Electrical	3.3kV HT Panel	As per the tender requirements, the contractor is to carry out the necessary modification work in the 3.3kV HT panel. In this regard, we kindly request FEDO to provide the complete set of drawings and location, including the Single Line Diagram (SLD), schematic, and other relevant documentation for our reference.	Bidders can visit the site and collect required details.
15	Electrical	PAP MCC (Existing)	The contractor will be executing the panel extension on both sides of the AB section of the PAP MCC. Therefore, we request FEDO to share the existing PAP MCC room layout & Existing MCC Panel General Arrangement (GA) drawings, SLD, and schematic for the proposed extension.	Bidders can visit the site and collect required details.
16	Instrumentation	PLC	As per tender clause no. 5.2(c) of 32771-14-PS-001 SPL (INST), Bidder understand that only one(1) dedicated PLC shall be considered with the provision to communicate with other system through Modbus RS485/232, kindly confirm. In addition, kindly confirm if any External / Other IO's of Existing plant need to be considered. If yes, please provide the consolidated IO list.	Bidders understanding is correct that a dedicated PLC shall be considered with the provision to communicate with other system through serial communication (RS232/485), Modbus over Ethernet communication. No additional signals are envisaged from the existing plant at present. However, during detailed engineering any additional signals (like ESD, interlock) arise the same shall be addressed.
17	Instrumentation	Power Distribution Board	As per tender clause no. 10.14 of 32771-14-PS-001 SPL (INST), Bidder understand that the Power distribution board shall be used in the field to distribute the External UPS power supply for the instruments, whereas in Clause 10.15, Each consumer of instrument supply shall have individual isolation facility in Control Panel. Please confirm.	110 V AC UPS supply shall be connected to the control panel (PLC panel) located at the control room. Further110 V AC power distribution to instruments shall be from this panel and each consumer of instruments shall have individual isolation facility in the control panel. From this panel, either individual cables can be laid till each instrument or same shall be connected thorugh a field junction box.
19	Process	Instrument Air	As per tender Clause No. 5.7 of 32771-11-PS-001-DB R1, Instrument Air Pressure at Battery Limit is 4.5 Kg/cm2g (min.). Please check and confirm pressure can be increased to 6 kg/cm2g. (min.)	IA available at the battery limit is mentioned in tender Clause No. 5.7. Additional requirement, if any, shall be in bidder scope.

20	Process	Sulphuric Acid	As per tender Clause No. 4.4 of 32771-11-PS-001-SW R2, Please confirm the concentration of Sulphuric Acid at Battery Limit i.e. 5% or 98%). We assume that usage of Sulphuric Acid is only for line flushing as we don't have any requirement in HBF Package as OEM recommendation, kindly confirm.	The concentration of Sulphuric acid available at the battery limit is 98.4 %. Sulphuric acid is generally used for line flushing. Sulphuric acid dilution requirement, if any as per OEM shall be in bidder scope.
21	Process	Fume Gas Emission	As per tender Process Schematic Flow diagram Page No. 168 of 850, Fume Gas will be terminated at Battery Limit, therefore kindly provide us the terminal connection details at destintation with allowable pressure for fan design.	Refer to clause 5.3 of 32771-11-PS-001-SW, the bidder shall provide the details of fumes of fumes generated from the fume hood area, design/TPS of scrubber fan and circulating pumps. The existing scubber stack sketch is attached for reference
22	Process	Condesate Water	As per tender Clause No. 4.4 of 32771-11-PS-001-SW R2, condensate is to be used Cloth Wash, kindly confirm paramters of condensate at battery limits for e.g. Pressure, Temperature, Density, Viscosity, etc. We recommend to utilize the Return Wash Water incl. process drains in 3rd and Polish Cake Wash for HB Filter as part of ZLD.	Condensate properties are given below Head - 28mlc Temperature - 80 °C Density - 970 Kg/m3 Viscocity - 0.354 cP
23	Process	Condesate Tank & Pump	As per tender Clause No. 7.10 of 32771-11-PS-001-DB R1, Condensate Tank & Pump to be considered by LSTK Bidder. Since, our requirement of Condensate Water for Belt Wash is getting fulfilled as per available pressure at Battery Limit @ 28mlc as our requirement is 2 bar.	Noted. The condensate tank and pump will be in FACT CD Scope.

CORRIGENDUM FOR CIVIL AND STRUCTURAL WORK REQUIREMENTS FOR CONSTRUCTION OF NEW HORIZONTAL BELT FILTER & ASSOCIATED FACILITIES IN PHOSPHORIC ACID PLANT AT FACT – CD ON LSTK BASIS

1. *Document No. 32771-12-DA-001_R1, Page 8 of 9 Scope of work & deliverable list , Description under the heading – 6.2 - Deliverables after award of contract*

" BIDDER shall submit to FACT CD/FEDO soft copies of the design documents and drawings for approval and hardcopies of approved drawings after getting approval from FACT CD/ FEDO as detailed in the Technical specifications & Design basis of the work (8169-12-DA-002/003)."

The above mentioned paragraph have been modified as :

" BIDDER shall submit to FACT CD/FEDO soft copies of the design documents and drawings for approval and hardcopies of approved drawings after getting approval from FACT CD/ FEDO as detailed in the Technical specifications & Design basis of the work (32771-12-DA-002/003). "

2. *Document No. 32771-12-DA-002_R1, Page 26 of 58 Design basis – Civil & structural works , Description under the heading – 2.24 – Building components/ General structures*

The below mentioned item have been added as last entry to the table:

18	Acid spillage areas	Wherever chances of acid spills/ storage/ transport are expected/ designed, Underlying structures shall be suitably protected by providing acid proof tiling/ acid proof coating suitably. Addition of admixtures to concrete for developing acid resistance quality is also acceptable, provided suitable documents for satisfactory performance of executed work can be submitted by the Contractor.

3. *Document No. 32771-12-DA-002_R1, Page 26 of 58 Design basis – Civil & structural works , Description under the heading – 3.1.1 – HBF Building*

The below mentioned sentence have been added as starting of the paragraph:

" Main building shall be RCC framed structure (RCC slab/beam/column framing) with structural steel roofing. Roof sheeting shall be conforming to specifications. "

4. *Soil investigation report in the proposed area, which can be used as a guideline, is attached as Annexure A in this corrigendum.*
5. *Document No. 32771-12-DA-002 _R1, Page 50 of 58 Design basis – Civil & structural works , Description under the heading – 5.1.9 – Conveyor Gantries/Trestle*

" Transfer towers shall be RCC framed construction. Independent staircase shall be provided to all transfer points with landing facility at all floors. If the frame is designed using Structural steel, encasing against all adverse conditions shall be provided above 3 m from existing yard level and RCC framework shall be planned upto 3m."

The above-mentioned sentences have been modified as follows:

" Overhead conveyor shall be housed in a suitable enclosed gallery of structural steel with chequered plate flooring. Conveyor gallery shall be completely weather proof with walkways of minimum 750mm clear width on both sides. Provisions of maintenance platform, walkways, handrails, supports for miscellaneous items shall be conforming to specifications mentioned in 32771-01-PS-001, Cl 2.7: Belt conveyor system. Cable tray and other utilities are to be accommodated within the gantry space.
Trestles shall be provided as supporting structure to the main gantry at every kink point along conveyor. The height of trestles may vary. Trestles shall be provided with due consideration to stability and permissible vibration. The spacing of trestle for overhead conveyor gallery shall be suitably spaced. Adequate clearance and safety arrangement should be provided for trestles nearby roads and other infrastructures conforming to CEMA/ IS 11592/ Technical specifications as mentioned in tender document.
Transfer towers shall be RCC framed construction. Independent staircase shall be provided to all transfer points with landing facility at all floors. If the frame is designed using Structural steel, encasing against all adverse conditions shall be provided above 3 m from existing yard level and RCC framework shall be planned upto 3m.
The roof covering and side sheeting of conveyor gantry and transfer houses shall be with UPVC roofing sheet with suitable provisions for air and light through fixed type and openable type UPVC windows and ventilators. Openings for electric cable entry/ miscellaneous access points are to be planned and provided on all the floors suitably. Different floors of the transfer houses shall be made with minimum 6 mm thick chequered plate. "

6. *Document No. 32771-12-DA-002 _R1, Page 51of 58 Design basis – Civil & structural works , Description under the heading – 5.1.9 . i) – Conveyor Gantries/Trestle*

" i) For proper ventilation in conveyor gallery circular holes 300mm radius with Tilt & turn type or sliding type UPVC ventilator shall be provided"

The above-mentioned sentence have been deleted.

7. Document No. 32771-12-DA-003 _R1, Page 53 of 55 Technical Specifications of Civil works

The below mentioned clause have been added as Cl no: 2.15 :

" 2.15 SPECIFICATION FOR ROOFING SHEET

Roofing sheet shall be Trapezoidal wave profile coloured uPVC sheet 2mm tk. of DION make or equivalent and roofing sheet shall be crest fixed to the purlins with Hot dip galvanized self drilling fasteners of required diameter and length with integral EPDM washers as per manufacturer's specifications. Fasteners also to be provided on the side laps of sheet. Minimum sheet overlap at end laps shall be 150mm- For Roofing/cladding/louver. All accessories like flashing, capping, shall be made of the above specified material. All components shall be made of uPVC of standard width 220mm, standard depth 160mm and outlet dia of 110mm of thickness 2.5mm with adequate number inner drop, end drop, end cap, joint, joint drop, elbow, inner drop, bracket with or without GI extension etc as per requirement at site. "

8. Document No. 32771-12-DA-003 _R1, Page 51 of 55 Technical Specifications of Civil works , Description under the heading – 2.13.1 – Components

"Slats for rolling shutters shall be made from tested bright cold rolled, annealed M.S. strips, not less than 0.9 mm thick for shutters up to 4.5 M wide and not less than 2.25 mm thick for shutters 5.5 M wide and above, machine rolled at 75 mm rolling centers, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load. "

The above mentioned sentences have been modified as follows:

" Slats for rolling shutters shall be made from tested bright cold rolled, annealed M.S. strips, not less than 0.9 mm thick for shutters up to 3.5 m wide, not less than 1.2mm for shutters from 3.5m to 5.5m and not less than 2.25 mm thick for shutters 5.5 M wide and above, machine rolled at 75 mm rolling centers, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load. "

9. *Document No. 32771-12-DA-003 _R1, Page 50 of 55 Technical Specifications of Civil works , Description under the heading – 2.11 – SPECIFICATION FOR WATERPROOFING LIQUID RETAINING STRUCTURES*

The below mentioned paragraph have been added in the beginning of the clause

" Depending upon the specific requirements and exposure Rigid or flexible waterproofing system shall be provided. Rigid waterproofing system consists of Watertight concrete, mortar linings and epoxy linings. Flexible waterproofing system consists of crack bridging mortar linings, liquid applied membranes and sheet membranes. Addition of admixtures for making mother concrete watertight shall be subjected to approval from PMC. Epoxy/ mortar linings shall be provided by skilled applicators from the manufacturer's side. All flexible waterproofing membranes shall be associated with joint sealing products. FDA approved solvent free coatings/ waterstops/ membranes shall be used for lining potable water tanks/ reservoirs. "

10. *Document No. 32771-12-DA-003 _R1, Page 49 of 55 Technical Specifications of Civil works , Description under the heading – 2.9 – Specifications for epoxy flooring*

" The curing time should be at the maximum of 48 hrs. "

The above mentioned last sentence in the clause have been modified as follows:

" The curing time of flooring and further loading sequences shall be as per manufacturer's specifications. "

Annexure A

SOIL INVESTIGATION REPORT

Bridging vision with reality

SOIL INVESTIGATION REPORT

CLIENT

M/s. THE FERTILISERS & CHEMICALS TRAVANCORE LTD

COCHIN, KERALA

PROJECT LOCATION

AMBALAMUKAL, COCHIN

REPORT NO.: SI/KL/25/S 240/02

JUNE 2025

GEO FOUNDATIONS & STRUCTURES PVT LTD

GEO TECHNICAL DIVISION KOCHI

Email: kochioffice@geo.net.in, soil@geo.net.in

NAME OF PROJECT

GEOTECHNICAL INVESTIGATION FOR THE PROPOSED HORIZONTAL BELT FILTER IN PHOSPHORIC ACID PLANT AT FACT COCHIN DIVISION, KOCHI.

CLIENT

FACT
प्रगति के पथप्रदर्शक
PIONEERS IN PROGRESS

M/s. THE FERTILISERS & CHEMICALS TRAVANCORE LTD
COCHIN DIVISION, AMBALAMEDU,
KOCHI, KERALA - 682 303.

GEOTECHNICAL CONSULTANT

GEO FOUNDATIONS & STRUCTURES PVT LTD,
ALPHA PLAZA, 6TH FLOOR, K P VALLON ROAD,
KADAVANTHRA P.O., KOCHI – 682 020.

Project No.: S 240					
Rev. No.	**Date**	**Description**	**Created by**	**Verified by**	**Approved by**
FR/02	15.06.2025	REPORT	AJITHA KUMARI (QM)	A. SURESH KUMAR, M. Tech - (Geo technical)	DR. K. MUTHUKRISHNAIAH M. Tech., Ph.D.,
			Engineer	General Manager & Head	Chief Consultant

CONTENTS

APPENDIXES

★ ★ ★ ★ ★ ★ ★

SOIL INVESTIGATION REPORT

1.0 INTRODUCTION

1.1 The work of "Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT cochin Division, Kochi. " was entrusted to **M/s. Geo Foundations & Structures Pvt. Ltd., Kadavanthra**, **Kochi – 682 020**, by **M/s. The Fertilisers and Chemicals Travancore Ltd, Cochin Division, Ambalamedu, Kerala – 682 303.**

1.2 The soil Investigation works were carried out during **27th May 2025 to 7th June 2025**. This report summarizes the results of the soil investigation and presents recommendations for suitable type of foundations.

2.0 OBJECTIVE OF INVESTIGATION

2.1 The objective of soil investigation is to determine the nature and characteristics of sub-soil below the ground level for the proposed **Horizontal Belt Filter Structure**. The study includes identification of suitable type of foundations and assessment of safe capacities for the **Horizontal Belt Filter Structure**.

3.0 SCOPE OF WORK

The scope of work at this site comprises of the following:

3.1 Mobilization of boring rig with all necessary equipment and personnel.

3.2 Boring of **FIVE** bore holes of 150 mm diameter with Rotary drilling equipment through sand, silt, clay & up to 2 m into hard rock.

3.3 Conducting Standard Penetration Tests in the bore holes and collecting the disturbed but representative soil samples, including packing and transportation to laboratory.

3.4 To conduct the following laboratory tests on soil & rock samples, which are applicable to the type of soil & rock to be tested.

(a) Grain Size Analysis & Hydrometer analysis

(a) Index properties on clayey and silty soil samples

(i) Liquid limit

(ii) Plastic limit

(b) Natural Moisture content

(c) Bulk & Dry density

(d) Specific gravity

(e) Free Swell Index

(f) Consolidation Test

(g) Direct Shear Test

(h) Triaxial Test

(i) Unconfined Compressive Strength (UCS)

(j) Chemical Analysis of Water

(k) Chemical Analysis of Soil

3.1.5 To conduct the following laboratory tests on rock samples:

a) Unconfined Compressive Strength

3.1.6 Preparation and submission of detailed report of field and laboratory results with recommendations for foundations.

4.0 FIELD INVESTIGATIONS-GEO-TECHNICAL STUDIES

4.1 Boring rig, with all requisite equipment's and accessories, were mobilized at the worksite. A team of technical personnel with skilled laborers were also deputed.

4.2 **FIVE** bore holes of 150 mm diameter, which were bored to a maximum depth up to **24.6 m** below the existing ground level. The bore holes were made as per relevant Indian Standard IS: 1892. The borehole locations drawing are shown in **Fig. no. D1 (Appendix I).**

4.3 Representative soil samples were collected at every change of strata or about 1 m depth intervals, up to 10 m Depth and soil samples were collected at every 1.5m intervals up to the termination depth. The samples so collected were sealed and numbered with full particulars for identification and sent to the laboratory for conducting the required tests.

4.4 Standard Penetration tests were conducted in the bore holes at 1 m depth interval, up to 10 m Depth and soil samples were collected at every 1.5m intervals up to the termination depth, as per the relevant Indian Standard, IS: 2131. In this test, a standard split spoon sampler is driven into the ground at the required depth by means of standard hammer about 65 kg weight, falling from a height of 75 cm. Number of blows for the first 15 cm is not taken into consideration because of possible disturbances or presence of settled, suspended matters at the bottom of the bore- holes. The total number of blows for the next 30 cm depth of penetration is considered as SPT 'N' value as shown in **Figure Nos.1 to 5 (Appendix II).**

5.0 LABORATORY INVESTIGATION

The following laboratory tests were conducted on the selected soil collected from the bore holes:

(a) Grain size analysis& Hydrometer analysis

(b) Index properties on clayey and silty soil samples

  (i) Liquid limit

  (ii) Plastic limit

(c) Natural Moisture content

(d) Bulk & Dry density

(e) Specific gravity

(f) Direct Shear Test

(g) Unconfined Compressive Strength (UCS)

(h) Chemical Analysis of Water

(i) Chemical Analysis of Soil

All the above laboratory tests were carried out as per relevant Indian Standards.

All the soil samples were identified and classified as per relevant Indian Standard, IS: 1498.

The results are shown in **Table Nos. 1 to 5 (Appendix III).**

The results of the chemical analysis of ground water and soil samples were presented in **Table No.6 & 7 (Appendix IV).**

6.0 SOIL PROFILE

In borehole BH 1, medium stiff sandy clayey silt of medium plasticity occurs from existing ground level up to 2 m, followed by stiff sandy clayey silt of high plasticity up to 4 m, medium stiff sandy clayey silt with high plasticity up to 5 m, stiff sandy clayey silt of high plasticity up to 7 m, medium dense clayey sand up to 8 m , very stiff sandy clayey silt of medium plasticity up to 16 m, hard sandy clayey silt of medium plasticity up to 17.5 m, soft rock up to 19.2 m, followed by fractured hard rock up to **21.2 m,** at which depth the bore hole was terminated.

In borehole BH 2, very dense sandy gravel occurs from existing ground level up to 1.7 m, followed by lateritic rock up to 3 m, dense sandy gravel up to 4 m, dense gravelly silty sand up to 5 m, medium dense gravelly sand up to 7 m, medium dense silty sand up to 9 m, dense silty sand up to 10 m, medium dense silty sand up to 13 m, dense silty sand up to 14.5 m, very dense silty sand up to 21.6, soft rock up to 22.6m, followed by fractured hard rock up to **24.6 m,** at which depth the bore hole was terminated.

In borehole BH 3, medium dense silty gravelly sand occurs from existing ground level up to 2 m, followed by very dense sandy gravel up to 3 m, medium dense silty gravelly sand up to 3.6 m, lateritic rock up to 7 m, medium stiff sandy clayey silt of medium plasticity up to 8 m, stiff sandy clayey silt of medium plasticity up to 9 m, very stiff sandy clayey silt of medium plasticity up to 11.5 m, dense silty sand up to 15.5 m, soft rock up to 16.5 m, followed by fractured hard rock up to **18.5 m,** at which depth the bore hole was terminated.

In borehole BH 4, medium stiff sandy clayey silt of high plasticity occurs from existing ground level up to 3 m, followed by stiff sandy clayey silt of high plasticity up to 6 m, medium dense clayey sand up to 8 m, dense clayey sand up to 11.5 m, soft rock up to 12.45 m, followed by fractured hard rock up to **14.45 m,** at which depth the bore hole was terminated.

In borehole BH 5, loose clayey sand occurs from ground level up to 2 m, followed by medium dense clayey sand up to 3 m, stiff sandy clayey silt of medium plasticity up to 5 m, very stiff sandy clayey silt of medium plasticity up to 6 m, stiff sandy clayey silt of medium plasticity up to 9 m, medium dense silty sand up to 10 m, dense silty sand up to 13 m, very dense silty sand up to 13.5 m, followed by fractured hard rock up to **15.5 m,** at which depth the bore hole was terminated.

7.0 GROUND WATER TABLE

Ground water levels were met at a depth ranging from **2.2 m to 3 m** at the time of soil investigation in the 5 boreholes, during continuous boring on **27.05.2025 & 07.06.2025.**

8.0 DISCUSSION AND RECOMMENDATIONS ON RESULTS AND TYPE OF FOUNDATIONS:

Bore holes were made for soil investigation to assess the nature and strength of the subsoil strata for sustainability of the loads. This report gives the details of the soil strata, suitable type of foundation and safe bearing capacity. Based on the subsoil conditions described in Sl. No. 6, the following recommendations are made for suitable type of foundation for the proposed Horizontal Belt Filter structure.

8.1 Alternative I: Open Foundations(For Lightly Loaded Structures)

8.1.1 Open Foundations individual column footings or combined footings if there are two or more columns close to each other, or Strip Raft combining each row of columns, if each row of columns is close to each other when compared to the distance or span between the rows of columns, or raft foundation) are recommended.

8.1.2 Excavation shall be made up to the required depth below the existing ground level as given in the **Table No. A & B.**

8.1.3 After thorough compaction of the bottom of excavation, PCC for the foundations can then be laid at the depth below the ground level which existed at the time of soil investigation as given in the **Table No.: A & B.**

8.1.4 The recommended safe bearing capacities at different depths under the RCC foundation are given in the **Table No.: A & B.**

Table No.: A

INDIVIDUAL COLUMN FOOTING

Bore hole No.	Depth of Excavation for Foundation from EGL (m)	Width of Foundation (m)	Type of Soil	SPT 'N' Value	Corrected 'N' Value	Avg. 'N' Value Based on influence zone (considering depth of pressure bulb)	Recommended Safe Bearing Capacity for 50 mm Settlement (T/m^2)
BH 1	1	1 x 1	Sandy Clayey **SILT**	7	7	8	7
		1.5 x 1.5		7	7	7	6
	1.5	1 x 1	Sandy Clayey **SILT**	7	7	8	7.5
		1.5 x 1.5		7	7	8	8
	2	1 x 1	Sandy Clayey **SILT**	9	9	9	8
		1.5 x 1.5		9	9	8	8
	2.5	1 x 1	Sandy Clayey **SILT**	9	9	8	8
		1.5 x 1.5		9	9	8	8
	3	1 x 1	Sandy Clayey **SILT**	9	9	7	8
		1.5 x 1.5		9	9	8	8
BH 2	1	1 x 1	Sandy **GRAVEL**	86	100	93	20
		1.5 x 1.5		86	100	65	25
	1.5	1 x 1	Sandy **GRAVEL**	>100	60	76	20
		1.5 x 1.5		>100	60	57	25
	2	1 x 1	**Lateritic Rock**	>100	60	43	20
		1.5 x 1.5		>100	60	33	25
	2.5	1 x 1	**Lateritic Rock**	>100	60	37	20
		1.5 x 1.5		>100	60	26	25
	3	1 x 1	Sandy **GRAVEL**	43	34	37	20
		1.5 x 1.5		43	34	26	25

BH 3	1	1 x 1	Silty Gravelly **SAND**	11	16	55	10
		1.5 x 1.5		11	16	60	15
	1.5	1 x 1	Silty Gravelly **SAND**	11	16	44	10
		1.5 x 1.5		11	16	60	15
	2	1 x 1	Sandy **GRAVEL**	>100	60	60	20
		1.5 x 1.5		>100	60	60	20
	2.5	1 x 1	Sandy **GRAVEL**	>100	60	60	20
		1.5 x 1.5		>100	60	60	25
	3	1 x 1	Silty Gravelly **SAND**	22	22	60	20
		1.5 x 1.5		22	22	60	25
BH 4	1	1 x 1	Sandy Clayey **SILT**	7	11	11	17
		1.5 x 1.5		7	11	11	13
	1.5	1 x 1	Sandy Clayey **SILT**	7	11	11	17
		1.5 x 1.5		7	11	11	13
	2	1 x 1	Sandy Clayey **SILT**	9	12	11	17
		1.5 x 1.5		9	12	11	13
	2.5	1 x 1	Sandy Clayey **SILT**	9	12	10	13
		1.5 x 1.5		9	12	10	13
	3	1 x 1	Sandy Clayey **SILT**	9	11	9	12
		1.5 x 1.5		9	11	9	12
BH 5	1	1 x 1	Clayey **SAND**	9	14	11	12.5
		1.5 x 1.5		9	14	12	12.5
	1.5	1 x 1	Clayey **SAND**	9	14	11	12.5
		1.5 x 1.5		9	14	13	12.5
	2	1 x 1	Clayey **SAND**	13	17	12	12.5
		1.5 x 1.5		13	17	13	12.5
	2.5	1 x 1	Clayey **SAND**	13	17	13	12.5
		1.5 x 1.5		13	17	13	12.5
	3	1 x 1	Sandy Clayey **SILT**	11	13	13	12.5
		1.5 x 1.5		11	13	14	12.5

Table No.: B

STRIP FOOTING

Bore hole No.	Depth of Excavation for Foundation from EGL (m)	Width of Foundation (m)	Type of Soil	SPT 'N' Value	Corrected 'N' Value	Avg. 'N' Value Based on influence zone (considering depth of pressure bulb)	Recommended Safe Bearing Capacity for 50 mm Settlement (T/m^2)
BH 1	1	0.8	Sandy Clayey **SILT**	7	7	8	7.5
		1		7	7	8	8
	1.5	0.8	Sandy Clayey **SILT**	7	7	9	7.5
		1		7	7	8	8
	2	0.8	Sandy Clayey **SILT**	9	9	9	10
		1		9	9	9	10
	2.5	0.8	Sandy Clayey **SILT**	9	9	8	9
		1		9	9	8	9
	3	0.8	Sandy Clayey **SILT**	9	9	8	9
		1		9	9	7	9
BH 2	1	0.8	Sandy **GRAVEL**	86	100	93	20
		1		86	100	93	30
	1.5	0.8	Sandy **GRAVEL**	>100	60	93	20
		1		>100	60	76	30
	2	0.8	**Lateritic Rock**	>100	60	76	20
		1		>100	60	43	30
	2.5	0.8	**Lateritic Rock**	>100	60	37	20
		1		>100	60	37	30
	3	0.8	Sandy **GRAVEL**	43	34	33	20
		1		43	34	37	30

BH 3	1	0.8	Silty Gravelly **SAND**	11	16	55	20
		1		11	16	55	20
	1.5	0.8	Silty Gravelly **SAND**	11	16	44	25
		1		11	16	44	25
	2	0.8	Sandy **GRAVEL**	>100	60	44	20
		1		>100	60	74	25
	2.5	0.8	Sandy **GRAVEL**	>100	60	58	20
		1		>100	60	60	25
	3	0.8	Silty Gravelly **SAND**	22	22	58	20
		1		22	22	60	25
BH 4	1	0.8	Sandy Clayey **SILT**	7	11	11	15
		1		7	11	11	14
	1.5	0.8	Sandy Clayey **SILT**	7	11	11	16
		1		7	11	11	15
	2	0.8	Sandy Clayey **SILT**	9	12	11	17
		1		9	12	11	16
	2.5	0.8	Sandy Clayey **SILT**	9	12	10	14
		1		9	12	10	14
	3	0.8	Sandy Clayey **SILT**	9	11	9	13
		1		9	11	9	13
BH 5	1	0.8	Clayey **SAND**	9	14	11	10
		1		9	14	11	12.5
	1.5	0.8	Clayey **SAND**	9	14	11	12.5
		1		9	14	11	12.5
	2	0.8	Clayey **SAND**	13	17	12	10
		1		13	17	12	10
	2.5	0.8	Clayey **SAND**	13	17	12	12.5
		1		13	17	12	12.5
	3	0.8	Sandy Clayey **SILT**	11	13	13	12.5
		1		11	13	13	12.5

8.1.5 At the time of excavation for foundations, if ground water table occurs within the recommended depth of excavation, sumps may be made to an additional depth of 0.3 m at one or more corners of the foundation pits for column footings/combined footings or at desired locations along the periphery of excavation for strip raft/raft foundation, and the water collected in the sumps may be bailed out. At the time of laying the PCC, the bottom of excavation shall be relatively dry (not slushy). Dewatering shall be maintained until that part of the concrete in the foundations, which comes below the ground water table level, sets.

8.2 Alternative II: Pile Foundations(For proposed Heavy Loaded Structures)

8.2.1 Bored cast in situ concrete pile foundations are recommended.

8.2.2 The recommended safe load carrying capacity of bored cast in situ concrete piles are considered as per IS 2911 (Part 1/Sec2): 2010 (Reaffirmed 2020).

8.2.3 The pile bore may be terminated at a depth of minimum three times diameter of the pile in to hard strata (where four consecutive SPT 'N' values of more than 100 are obtained in each test at depth intervals of one pile diameter) or one diameter of the pile into hard rock.

8.2.4 To satisfy the above criterion, the pile length may be varying from **21 to 23 m** from the existing ground level for boreholes no. - BH 1 & BH 2. As BH 2 is taken as representative for both boreholes BH 2 & BH 3.

8.2.5 In terms of concrete used for the piles, to provide the required factor of safety of **3.0** for stress in the pile concrete, we recommend minimum M 30 Grade Concrete.

8.2.6 According to the structural strength of concrete determined for different pile diameters, assuming 5 grades less to allow for underwater concreting, consider M 25 grade concrete instead of M 30 grade concrete.

8.2.7 The recommended safe load carrying capacity of bored cast in situ concrete piles as per IS 2911 (Part 1/Sec2): 2010 (Reaffirmed 2020) for different pile diameters are presented in **Table C.**

Table No.: C

Reference Borehole No. & Proposed Structure	Length of pile from E.G.L (m)	Dia. (mm)	Recommended Safe Vertical Capacity (T)	Recommended Safe Uplift Capacity (T)	Recommended Safe Lateral Capacity (T)	Recommended Depth of Fixity (m)
BH 2 (Conveyor gantries /junction towers of approx. 10-15m height)	**23 m** (3 x dia. in hard strata N>100) or (1 x dia. in hard rock)	450	70	30	4	5.5
		500	100	40	5	6.5
		600	140	50	7	7.5
		750	200	70	10	9
		900	300	85	14	10
BH 1 (Conveyor junction towers of approx. 15 m height)	**21 m** (3 x dia. in hard strata N>100) or (1 x dia. in hard rock)	500	100	25	4	6
		600	140	35	5	7.5
		750	200	40	6	9
		900	300	50	7	10

8.3.1 R.C.C. BORED CAST IN SITU PILES

Safe capacity of RCC Bored cast-in-situ pile can be computed by using the formula given in IS: 2911 (Part-1/Sec-2):2010 (Reaffirmed 2020)

Ultimate bearing capacity Qu of piles in Cohesion less soil:

$$Qu = A_p(0.5.D.\gamma.N\gamma + P_D.N_q) + \sum_{I=1}^{I=n} K .P_{Di}.\tan \delta.A_{si}$$

Where, A_p = Cross sectional area of pile toe in cm²

D= Stem dia. in cm

γ= Effective unit weight of soil at pile toe in kg /cm³

P_D = Effective overburden pressure in kg / cm²

$N\gamma$ and Nq = Bearing capacity factors depending upon the angle of internal friction Ø at toe

$\sum_{i=1}^{i=n}$ = Summation of N layers in which pile is installed

K = Coefficient of earth pressure

P_{Di} = Effective overburden pressure in kg /cm² for the i^{th} layer where i varies from 1 to n.

δ = Angle of wall friction between pile and soil in degrees (may be taken equal to Ø)

A_{si} = Surface area of pile stem in cm² in the i^{th} layer where i varies from 1 to n.

For cohesive soil:-

Safe capacity of pile = $1/f \{A_P. Nc. Cp+\alpha. C.A_S\}$

Where,

A_p- c/s area of pile toe in cm²

Nc- Bearing capacity factor

Cp- Average cohesion at pile tip in kg/cm²

α - Reduction factor

C – Average cohesion throughout the length of pile in kg/cm²

A_S- Surface area of pile shaft in cm^2

f - Factor of safety.

9.0 CHEMICAL COMPOSITION OF GROUND WATER

The results of chemical analysis of the ground water samples were collected from the boreholes, presented in **Appendix – IV** show that:

9.1 Since the pH value is more than 6, the ground water, in terms of pH value, is suitable for mixing concrete as per Clause 5.4.2 of Indian Standard: 456-2000, (Reaffirmed 2021), plain and reinforced concrete – code of practice (Fourth Revision).

9.2 The chloride content is less than the permissible upper limit of 500 mg/l. for use of ground water for mixing in concrete for RCC, as per IS: 456-2000, (Reaffirmed 2021). Therefore, in terms of chloride content in the ground water, the ground water is suitable for mixing concrete for RCC, and also for PCC.

9.3 The sulphate content (expressed as SO_3) is nil and less than the permissible upper limit of 400 mg/l for use of ground water for mixing in concrete, as per IS: 456-2000 (Reaffirmed 2021). Therefore, in terms of sulphate content, the ground water is suitable for mixing concrete for RCC. The sulphate content (expressed as SO_3) is less than 300 mg/l which comes under Class 1 of "Requirements for concrete exposed to sulphate attack", as per IS:456-2000 (Reaffirmed 2021), Table 4. For this Class, the requirements are: Ordinary Portland cement or Portland slag cement or Portland pozzolana cement can be used with a minimum cement content of 280 kg/ m^3 of concrete and with a maximum water: cement ratio of 0.55"

9.4 Hence, the ground water is suitable for mixing concrete for Construction purpose.

10.0 LIQUEFACTION POTENTIAL:

- As per the IS 1893 (Part 1): 2016 (Sixth Revision) Criteria for earthquake Resistant design of structures part 1: General Provisions and Buildings, ANNEX F (Clauses 3.12 and 6.3.5.3) in soil deposits consisting of submerged loose sands and soils falling under classification SP with corrected SPT N , less than 15 in seismic Zone III, IV and V, and less than 10 in seismic zone II,

the factor of safety less than 1, the shaking caused by earthquake ground motion may cause liquefaction or excessive total and differential settlements.

- From the evaluation of liquefaction potential in the boreholes, the susceptibility against liquefaction for all five boreholes are mentioned in the **Table D** below.

Table D

Borehole No.	Susceptibility against Liquefaction
BH - 1	Not susceptible to liquefaction
BH - 2	Not susceptible to liquefaction
BH - 3	Not susceptible to liquefaction
BH - 4	Not susceptible to liquefaction
BH - 5	Not susceptible to liquefaction

- The calculated Factor of Safety against liquefaction was found to be greater than 1.0 at all evaluated depth in all boreholes.
- Hence, the soil strata at the site are not susceptible to liquefaction under the design seismic conditions, and no reduction in bearing capacity or pile skin friction is required due to liquefaction effects.
- For BH-1, BH-4, the soil strata up to a depth of 6–7 m and for BH-5 up to 2 m were initially considered potentially susceptible to liquefaction. This was based on a conservative interpretation of corrected SPT N-values (less than 15) in Seismic Zone III, in accordance with IS 1893 (Part 1):2016, specifically Clause 6.3.5.3 and Note 4 of Table 1. The mention of liquefaction susceptibility was included as a precautionary measure to align with codal guidance and ensure a conservative and safe design approach.

- In response to the request for detailed assessment, liquefaction analyses were carried out in accordance with relevant codal provisions. The results confirmed that the factor of safety against liquefaction is greater than 1.0 across all boreholes, indicating that the soil is not susceptible to liquefaction. The initial assumption was made purely as a precautionary measure to ensure a safe and conservative design approach.
- Previous references to liquefaction potential have been reviewed and updated based on finalized calculations. As per the revised analysis, none of the boreholes exhibit liquefaction susceptibility.

11.0 The results and recommendations provided in this report are based on the soil investigation conducted at the site. All design parameters and geotechnical recommendations have been derived through careful interpretation of the available borehole data, standard penetration test (SPT) N-value profiles, and laboratory test results. It is to be noted that laboratory test data was not available for all strata; therefore, for layers lacking direct results, the required design parameters have been interpolated using relevant provisions from IS 2911 (Part 1/Section 2):2010 (Figures 2 and 3) and IS 6403:1981 (Figure 1), in accordance with standard engineering practice. In the event that any variations are observed during actual execution, it is advised to consult the geotechnical engineer or design consultant for further guidance and necessary modifications, if required.

For GEO FOUNDATIONS & STRUCTURES PVT.LTD.

A. Suresh Kumar, M.Tech(Geo technical), **M.B.A** (T.M)
General Manager & Head

ANNEXURE – I

SAMPLE CALCULATIONS

GEO FOUNDATIONS & STRUCTURES PRIVATE LIMITED

Project No:	**S 240**
Project Name:	**Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.**

CALCULATION OF SETTLEMENT AS PER IS: 8009- PART 1- FIG. 9

Foundation size : **1.0 m x 1.0 m**

Foundation depth : **2.5 m from NGL**

Average N value below the founding stratum & within the depth of pressure bulb, N = 13

Corrected Average N value below the founding & Mid of the pressure bulb = 13

The settlement in meter/ unit pressure, i.e., for 1kg/cm^2 or for 10t/m^2 read from **Fig. 9 of IS: 8009- Part 1, corresponding to the average N value** = 15.0 mm (From the graph- m is converted to mm by multiplying it with 1000)

Correction factor for water = 0.5 = 30.0 mm

Depth factor = 0.750

Corrected settlement after depth factor correction = = 22.5 mm

Hence, the pressure corresponding to 50 mm settlement is given by = $\frac{1 \times 50}{22.5}$ kg/cm^2

= 2.22 kg/cm^2

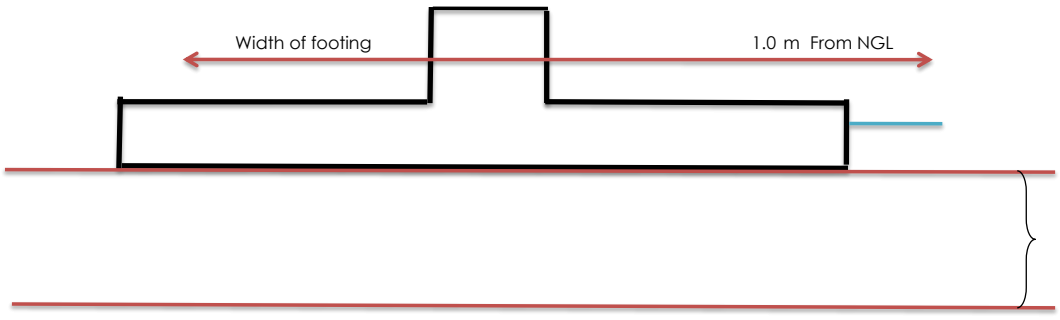
= 22.2 T/sq.m

Hence the Safe Bearing Capacity is = 22.2 T/sq.m

Note:

For averaging of corrected N value taken from Borelog is : 13

Reference Bore Hole No. : BH 5 **Depth : 2.5 m**



Note- The safe bearing capacity is considered to be least of the shear and settlement calculations.

GEO FOUNDATIONS & STRUCTURES PRIVATE LIMITED

Project No: S 240

Project Name :Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

DETERMINATION OF BEARING CAPACITY OF SHALLOW FOUNDATIONS
[Based On IS : 6403-1981, Clause 5.2.1] For C & ϕ Soils

Clayey Soil	Sandy Soil	
$Q_d = C N_c * s_c * d_c * i_c +$	$q (Nq-1) s_q d_q i_q +$	$0.5 B \gamma N_\gamma s_\gamma d_\gamma i_\gamma W$
Reference Borehole		**BH 5**
SBC Calculations:		
Average SPT N Value is considered up to Zone of influence (1.5 times the width of the foundation)		**13**
Angle of internal friction from Fig.1 of IS 6403 with reference to SPT N value		**0**

Data and Calculations for Shallow Foundation

Foundation strata:		
Width of foundation, m	B	1.00
Thickness of overburden soil, m	D	2.50
SPT value of the soil in the zone of influence	N	13
Angle of Internal friction, Degrees	ϕ	0
Unit weight of over-burden soil, kN/Cu.m.	γ_d	15.76
Length of foundation, m	L	1.00
Shear strength of soil, kN/Sq.m.	C	60.00
Bearing capacity factor Nc	N_C	5.14
Bearing capacity factor Nq	N_q	1.00
Bearing capacity factor Ny	N_γ	0.00
Depth factor, dc	d_c	1.50
Depth factor, dq	d_q	1.25
Depth factor, dy	d_γ	1.25
Shape Factor, sc	s_c	1.30
Shape Factor, sq	s_q	1.20
Shape Factor, sy	s_γ	0.80
Inclination Factor, ic	i_c	1.00
Inclination Factor, iq	i_q	1.00
Inclinaton Factor, iy	i_γ	1.00
Water Table Correction Factor, w	W	0.50
Effective surcharge at the base of foundation, kN/Sq.m.	q	14.40
Ultimate Bearing Capacity, UBC1, kN/Sq.m.	$C N_c * s_c * d_c * i_c$	601.38
Ultimate Bearing Capacity, UBC2, kN/sq.m.	$q (N_q-1) s_q d_q i_q$	0.00
Ultimate Bearing Capacity, UBC3, kN/Sq.m.	$0.5 B \gamma N_\gamma s_\gamma d_\gamma i_\gamma W$	0.00
Ultimate Bearing Capacity, UBC, kN/Sq.m.	(UBC 1+ UBC 2 + UBC 3)	601.38
Factor of Safety		3
Safe Bearing Capacity, kN/Sq.m.		200.46
Safe Bearing Capacity, t/Sq.m.		**20.05**

Note- The safe bearing capacity is considered to be least of the shear and settlement calculations.

PILE CAPACITY CALCULATIONS

Project No:	**S 240**		
Project Name:	**Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.**		
Reference Borehole	**BH 2**	**No. of layers**	**8**
		500	**mm dia**

Annex B (Clauses 6.3.1.1 and 6.3.2) of(IS 2911 part1/section 2) :2010

The Ultimate load capacity (Qu) of piles,in KN,in granlar soils is given by the following formula:

Piles in Granular and cohesive Soils

Qu = Ap((CUNC)+(1/2 D Y NY + PD Nq)) +((Σni-1 Ki P Di tan δi)+ (α*cu)) Asi

The first term gives end-bearing resistance and the second term gives skin friction resistance. Where

Ap = Cross-sectional area of pile tip ,in m^2;

D =Diameter of pile shaft, in m;

Y= Effective unit weight of the sol at pile tip, in kN/m3;

NY and Nq = Bearing capacity factors depending upon the angle of internal friction,Ø at pile tip;

$^{\delta}$i = Angle of wall friction between pile and soil for the ith layer;

PD = Effective overburden pressure at pile tip, in kN/m2;

Σni=1 =Summation for layers 1 to n in which pile is installed and which contribute to positive skin friction;

Ki = Coefficient of earth pressure applicable for the ith layer;

PDi = Effective overburden pressure for the ith layer, in kN/m2;

Asi = Surface area of pile shaft in the ith layer , in m2;

Let

Area of the Pile	Ap= Π/4 X D2	**0.1964**	**m^2**
Diameter of Pile	D =	**0.50**	**m**
Effective unit weight of the soil at pile tip, in kN/m3;	Y'=	**10.01**	**kN/m^3**
Shearing angle (Degrees)	Ø=	**40.0**	**at pile tip**
the angle of internal friction, f at pile tip;	Nq=	**120.0**	
bearing capacity factors	NY =	**109.41**	
Effective overburden pressure at pile tip, in kN/m2	PD =	**75.075**	**kN/m^2**

I Average Design Soil Profile

Layer No.	Description of Layer	From (m)	To (m)	Layer Thickness (m)	Avg. SPT Value	Shearing angle (Degrees)	Average Cohesion (kN/Sq.m.)	Wall Friction
1	Sandy GRAVEL & Laterite Rock	0.000	-2.00	2.00	93	35.0	0.0	35.0
2	Sandy GRAVEL	-2.000	-4.00	2.00	43	32.0	0.0	32.0
3	Gravelly	-4.000	-7.00	3.00	24	32.0	0.0	32.0
4	Silty SAND	-7.000	-10.00	3.00	21	32.0	0.0	32.0
5	Silty SAND	-10.000	-14.50	4.50	31	32.0	0.0	32.0
6	Silty SAND	-14.500	-21.00	6.50	64	35.0	0.0	35.0
7	Silty SAND	-21.000	-22.995	2.00	100	40.0	0.0	40.0
8	Rock	-22.995	-23.00	0.005	100	40.0	0.0	40.0

II Details of proposed piles

1	Diameter of pile, d	**500**	**mm**
2	Pile Cut off Level	-2.000	m
3	Pile Cut off Level	-2.000	m
4	Area of cross section, phi/4*(dia*dia)	0.1964	Sq.m.
5	Surface area/RM dia*phi	1.5714	Sq.m.
6	Pile termination level for GL	-23.00	m
6	Length of resistance in layer no. 1	2.00	RM
7	Length of resistance in layer no. 2	2.00	RM
8	Length of resistance in layer no. 3	3.00	RM
9	Length of resistance in layer no. 4	3.00	RM
10	Length of resistance in layer no. 5	4.50	RM
11	Length of resistance in layer no.6	6.50	RM
12	Length of resistance in layer no. 7	2.00	RM
13	Termination Depth of Pile from EGL//BL	23.00	RM
14	Total length of Pile Shaft	21.00	m

Bored Cast in-situ piles

Consistancy	N value	a
Soft to very soft clay	< 4	0.7
Medium soft	4 to 8	0.5
Stiff clay	8 to 15	0.4
Stiff to hard clay	> 15	0.3

III Design Soil Data:

S.No.	Layer No	Layer Thickness (m)	Ave. SPT Value	Unit weight (kN/m^3)	Shearing angle (Degrees)	Wall Friction (Degrees)	Average Cohesion (kN/Sq.m.)
1	1	2.00	93	16.43	35	35.0	0.0
2	2	2.00	43	16.28	32.0	32.0	0.0
3	3	3.00	24	17.18	32	32.0	0.0
4	4	3.00	21	17.81	32	32.0	0.0
5	5	4.50	31	18.14	32	32.0	0.0
6	6	6.50	64	20.01	35	35.0	0.0
7	7	2.00	100	20.01	40	40.0	0.0
8	8	0.005	100	20.01	40	40.0	0.0

Note:

1 Inclination of Pile with respect to vertical is zero degrees

2 IS:2911 (Part I/Sec 2) - 2010 indicates taking of d (Angle of wall friction) = f, the same is considered.

3 Submerged Unit Weight of Soil Mass is considered in Capacity Calculations

IV Estimation of skin friction Resistance:

For Layer No. 1:	
Adhesive Factor	0.00
Skin Friction due to cohesion, kN	0.00
Over Burden Pressure, kN/Sq.m.	6.43
Skin Friction Due to shearing angle, kN	14.15

For Layer No. 2	
Adhesive Factor	0.00
Skin Friction due to cohesion, kN	0.00
Over Burden Pressure, kN/Sq.m.	19.14
Skin Friction Due to shearing angle, kN	37.60

For Layer No. 3	
Adhesive Factor	0.00
Skin Friction due to cohesion, kN	0.00
Over Burden Pressure, kN/Sq.m.	36.19
Skin Friction Due to shearing angle, kN	106.66

For Layer No. 4:	
Adhesive Factor	0.00
Skin Friction due to cohesion, kN	0.00
Over Burden Pressure, kN/Sq.m.	58.68
Skin Friction Due to shearing angle, kN	172.94

For Layer No. 5	
Adhesive Factor	0.00
Skin Friction due to cohesion, kN	0.00
Over Burden Pressure, kN/Sq.m.	75.08
Skin Friction Due to shearing angle, kN	331.90

For Layer No. 6:	
Adhesive Factor	0.00
Skin Friction due to cohesion, kN	0.00
Over Burden Pressure, kN/Sq.m.	75.08
Skin Friction Due to shearing angle, kN	537.23

For Layer No. 7:	
Adhesive Factor	0.00
Skin Friction due to cohesion, kN	0.00
Over Burden Pressure, kN/Sq.m.	75.08
Skin Friction Due to shearing angle, kN	197.60

Ultimate Skin Friction resistance, kN	Σ^{n}_{i-1} Ki P Di tan δi Asi
Ultimate Skin Friction resistance, kN	**1384 kN**

V Estimation of End Bearing Resistance:

Nc	9.00	
Ap (Sq.m.)	0.1964	
Cp (kN/Sq.m.)	0.0	
D (m)	0.50	
g (kN/Cu.m.)	10.01	
Shearing Angle	40	
N_g	109.41	
P_d (kN/Sq.m.)	192.05695	or
15 times dia of pile shaft	75.075	
Nq	120.0	
Part 1 (Due to Cohesion)	0	kN
Part 2 (Due to Shear)	1823	kN
Total End bearing resistance	**1823**	**kN**

VI Estimation of Self Weight

Length of Pile	21.00	m
Cross Sectional Area	0.1964	Sq.m.
Density of Concrete	25	kN/Cu.m.
Sub-merged Density	15	kN/Cu.m.
Wt. Of Pile at tip	61.88	kN

VII Estimation of Bearing Capacity of piles

Ultimate Skin Friction Resistance, kN	1384
Ultimate End Bearing Resistance, kN	1823
Self Weight of Pile	62
Total Ultimate pile carrying capacity, kN	**3207**
Factor of safety	**3.0**
Capacity of pile, T	**100.7**

Uplift Capacity,T	**52.32**

STRUCTURAL DESIGN OF PILES - LATERAL CAPACITY

Project No:	**S 240**
Project Name:	**Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.**

Reference Bore Hole	**BH 2**		
Dia of the Pile	**450**	**mm**	
Avg. 'N' Value	**20**		**Avg Corrected N Value up to depth of fixity**
Grade of Concrete	**25**		
Deflection(y)	**5**	**mm**	
Cantilever	**0**	**m**	

For Fixed Head Pile :

Deflection, Y= $\frac{H(e+zf)^3 \times 10^3}{12EI}$

H = Lateral Load, in kN

y = Deflection of pile head, in mm — **5 mm**

E = Young's Modulus of pile material, in kN/m² — **25000000 kN/m²**

I = moment of inertia of the pile cross-section in m^4 — **0.002012889 m^4**

zf = Depth to point of fixity, in m — **m**

e = Cantilever length above ground/bed to the point of load application, in m — **0 m**

E	25000	N/mm²	5000 √ fck
E	25000000.0	kN/m²	
E	25000	MN/m^2	

For Piles in **Sand** and **Normally Loaded Clays** :

for N value 20 — **nh = 4.5**

Stiff ness factor T, in m — **T =** $\sqrt[5]{EI/\eta h}$ — ηh from IS 2911:Part 1(Sec 2) ANNEX C Table 3 = 4.5 MN/m^3

T= 1.620725524

ηh = modulus of subgrade reaction , in MN/m²

K = k_1/0.5 X 0.3/B, in MN/m3 — 0.720322455 MN/m^3

B = Width of the pile shaft (diameter in case of circular pile) — 0.45 m

1) **L_1 (or) e = 0 m**

2) **R (or) T = 1.620725524 m**

3) **L_1/R (or) L_1/T = 0.00**

4) **Lf/R (or) Lf/T = 2.2** **From FIG:4 of IS:2911 Part1 (Sec 2) ANNEX C** for 0.00

5) **Lf (or) Zf = 2.2 1.620725524 3.565596153 m**

Lf= zf Depth of Fixity

Y= $\frac{H(e+Zf)^3 \times 10^3}{12EI}$ **For Fixed Head Pile**

H= $\frac{Y*12EI}{(e+zf)^3 \times 10^3}$

Lateral Load, in kN — **H = 66.60620122 kN**

6.660620122 T

PILE CAPACITY CALCULATIONS

Project No:	**S 240**		
Project Name:	**Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.**		
Reference Borehole	**BH 4**	**No. of layers**	**8**
		600	**mm dia**

Annex B (Clauses 6.3.1.1 and 6.3.2) of(IS 2911 part1/section 2) :2010

The Ultimate load capacity (Qu) of piles,in KN,in granlar soils is given by the following formula:

Piles in Granular and cohesive Soils

Qu = Ap((CUNC)+(1/2 D Ɣ NƳ + PD Nq)) +((Σni-1 Ki P Di tan δi)+ (α*cu)) Asi

The first term gives end-bearing resistance and the second term gives skin friction resistance. Where

Ap = Cross-sectional area of pile tip ,in m^2;

D =Diameter of pile shaft, in m;

Ɣ= Effective unit weight of the sol at pile tip, in kN/m3;

NƳ and Nq = Bearing capacity factors depending upon the angle of internal friction,Ø at pile tip;

$^{\delta}$i = Angle of wall friction between pile and soil for the ith layer;

PD = Effective overburden pressure at pile tip, in kN/m2;

Σni=1 =Summation for layers 1 to n in which pile is installed and which contribute to positive skin friction;

Ki = Coefficient of earth pressure applicable for the ith layer;

PDi = Effective overburden pressure for the ith layer, in kN/m2;

Asi = Surface area of pile shaft in the ith layer , in m2;

Let

Area of the Pile	Ap= Π/4 X D2	**0.2829**	**m^2**
Diameter of Pile	D =	**0.60**	**m**
Effective unit weight of the soil at pile tip, in kN/m3;	Ɣ'=	**10**	**kN/m^3**
Shearing angle (Degrees)	Ø=	**35.0**	**at pile tip**
the angle of internal friction, f at pile tip;	Nq=	**50.0**	
bearing capacity factors	NƳ =	**48.03**	
Effective overburden pressure at pile tip, in kN/m2	PD =	**90**	**kN/m^2**

I Average Design Soil Profile

Layer No.	Description of Layer	From (m)	To (m)	Layer Thickness (m)	Avg. SPT Value	Shearing angle (Degrees)	Average Cohesion (kN/Sq.m.)	Wall Friction
1	Sandy Clayey SILT	0.000	-2.00	2.00	6	0.0	18.0	0.0
2	Sandy Clayey SILT	-2.000	-3.00	1.00	8	0.0	18.0	0.0
3	Sandy Clayey SILT	-3.000	-6.00	3.00	10	0.0	18.0	0.0
4	Clayey SAND	-6.000	-8.00	2.00	27	27.0	17.0	27.0
5	Clayey SAND	-8.000	-11.50	3.50	34	27.0	17.0	27.0
6	Soft Rock	-11.500	-12.45	0.95	100	35.0	0.0	35.0
7	Fractured Hard Rock	-12.450	-13.995	1.55	100	35.0	0.0	35.0
8	Fractured Hard Rock	-13.995	-14.00	0.005	100	35.0	0.0	35.0

II Details of proposed piles

1	Diameter of pile, d	**600**	**mm**
2	Pile Cut off Level	-2.000	m
3	Pile Cut off Level	-2.000	m
4	Area of cross section, phi/4*(dia*dia)	0.2829	Sq.m.
5	Surface area/RM dia*phi	1.8857	Sq.m.
6	Pile termination level for GL	-14.00	m
6	Length of resistance in layer no. 1	2.00	RM
7	Length of resistance in layer no. 2	1.00	RM
8	Length of resistance in layer no. 3	3.00	RM
9	Length of resistance in layer no. 4	2.00	RM
10	Length of resistance in layer no. 5	3.50	RM
11	Length of resistance in layer no.6	0.95	RM
12	Length of resistance in layer no. 7	1.55	RM
13	Termination Depth of Pile from EGL//BL	14.00	RM
14	Total length of Pile Shaft	12.00	m

Bored Cast in-situ piles

Consistancy	N value	a
Soft to very soft clay	< 4	0.7
Medium soft	4 to 8	0.5
Stiff clay	8 to 15	0.4
Stiff to hard clay	> 15	0.3

III Design Soil Data:

S.No.	Layer No	Layer Thickness (m)	Ave. SPT Value	Unit weight (kN/m^3)	Shearing angle (Degrees)	Wall Friction (Degrees)	Average Cohesion (kN/Sq.m.)
1	1	2.00	6	19.24	0	0.0	18.0
2	2	1.00	8	18.85	0.0	0.0	18.0
3	3	3.00	10	17.97	0	0.0	18.0
4	4	2.00	27	15.60	27	27.0	17.0
5	5	3.50	34	15.51	27	27.0	17.0
6	6	0.95	100	20.00	35	35.0	0.0
7	7	1.55	100	20.00	35	35.0	0.0
8	8	0.005	100	20.00	35	35.0	0.0

Note:

1 Inclination of Pile with respect to vertical is zero degrees

2 IS:2911 (Part I/Sec 2) - 2010 indicates taking of d (Angle of wall friction) = f, the same is considered.

3 Submerged Unit Weight of Soil Mass is considered in Capacity Calculations

IV Estimation of skin friction Resistance:

For Layer No. 1:	
Adhesive Factor	1.00
Skin Friction due to cohesion, kN	67.89
Over Burden Pressure, kN/Sq.m.	9.24
Skin Friction Due to shearing angle, kN	0.00

For Layer No. 2	
Adhesive Factor	1.00
Skin Friction due to cohesion, kN	33.94
Over Burden Pressure, kN/Sq.m.	22.91
Skin Friction Due to shearing angle, kN	0.00

For Layer No. 3	
Adhesive Factor	1.00
Skin Friction due to cohesion, kN	101.83
Over Burden Pressure, kN/Sq.m.	39.29
Skin Friction Due to shearing angle, kN	0.00

For Layer No. 4:	
Adhesive Factor	1.00
Skin Friction due to cohesion, kN	64.11
Over Burden Pressure, kN/Sq.m.	56.84
Skin Friction Due to shearing angle, kN	109.28

For Layer No. 5	
Adhesive Factor	1.00
Skin Friction due to cohesion, kN	112.20
Over Burden Pressure, kN/Sq.m.	72.08
Skin Friction Due to shearing angle, kN	242.52

For Layer No. 6:	
Adhesive Factor	0.00
Skin Friction due to cohesion, kN	0.00
Over Burden Pressure, kN/Sq.m.	86.48
Skin Friction Due to shearing angle, kN	108.53

For Layer No. 7:	
Adhesive Factor	0.00
Skin Friction due to cohesion, kN	0.00
Over Burden Pressure, kN/Sq.m.	90.00
Skin Friction Due to shearing angle, kN	183.70

Ultimate Skin Friction resistance, kN	Σ^{n}_{i-1} Ki P Di tan δi Asi
Ultimate Skin Friction resistance, kN	**956 kN**

V Estimation of End Bearing Resistance:

Nc	9.00	
Ap (Sq.m.)	0.2829	
Cp (kN/Sq.m.)	0.0	
D (m)	0.60	
g (kN/Cu.m.)	10	
Shearing Angle	35	
N_g	48.03	
P_d (kN/Sq.m.)	106.675	or
15 times dia of pile shaft	90	
Nq	50.0	
Part 1 (Due to Cohesion)	0	kN
Part 2 (Due to Shear)	1314	kN
Total End bearing resistance	**1314**	**kN**

VI Estimation of Self Weight

Length of Pile	12.00	m
Cross Sectional Area	0.2829	Sq.m.
Density of Concrete	25	kN/Cu.m.
Sub-merged Density	15	kN/Cu.m.
Wt. Of Pile at tip	50.91	kN

VII Estimation of Bearing Capacity of piles

Ultimate Skin Friction Resistance, kN	956
Ultimate End Bearing Resistance, kN	1314
Self Weight of Pile	51
Total Ultimate pile carrying capacity, kN	**2270**
Factor of safety	**3.0**
Capacity of pile, T	**70.6**

Uplift Capacity,T	**36.96**

STRUCTURAL DESIGN OF PILES - LATERAL CAPACITY

Project No:	**S 240**
Project Name:	**Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.**

Reference Bore Hole	**BH 4**		
Dia of the Pile	**600**	**mm**	
Avg. 'N' Value	**8**		**Avg Corrected N Value up to depth of fixity**
Grade of Concrete	**25**		
Deflection(y)	**5**	**mm**	
Cantilever	**0**	**m**	

For Fixed Head Pile :

Deflection, Y= $\frac{H(e+zf)^3 \times 10^3}{12EI}$

H =	**Lateral Load, in kN**		
y =	**Deflection of pile head, in mm**	**5**	**mm**
E =	**Young's Modulus of pile material, in kN/m²**	**25000000**	**kN/m²**
I =	**moment of inertia of the pile cross-section in m^4**	**0.006361724**	**m^4**
zf =	**Depth to point of fixity, in m**		**m**
e =	**Cantilever length above ground/bed to the point of load application, in m**	**0**	**m**

E	25000	N/mm²	5000 √ fck
E	25000000.0	kN/m²	
E	25000	MN/m^2	

For piles in **Preloaded Clays**

for N value 8 **k1 = 18**

Stiff ness factor R, in m **R = 4√EI/ KB** k1 from IS 2911:Part 1(Sec 2) ANNEX C Table 4 = 18 MN/m^3

R= 2.578119712

ηh = modulus of subgrade reaction , in MN/m²

K = k_1/1.5 X 0.3/B, in MN/m3 6 MN/m^3

B = Width of the pile shaft (diameter in case of circular pile) 0.6 m

1) **L_1 (or) e = 0 m**

2) **R (or) T = 2.578119712 m**

3) **L_1/R (or) L_1/T = 0.00**

4) **Lf/R (or) Lf/T = 2.2** **From FIG:4 of IS:2911 Part1 (Sec 2) ANNEX C** for 0.00

5) **Lf (or) Zf = 2.2 2.578119712 5.671863366 m**

Lf= zf Depth of Fixity

Y= $\frac{H(e+Zf)^3 \times 10^3}{12EI}$ **For Fixed Head Pile**

H= $\frac{Y*12EI}{(e+zf)^3 \times 10^3}$

Lateral Load, in kN **H = 52.29844645 kN**

5.229844645 T

	Project: Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.	Bore Hole No. BH - 1

$$FS = \frac{CRR}{CSR},$$

$$CRR = CRR_{7.5}(MSF)K_{\sigma}K_{a},$$

$$CSR = 0.65\left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{vo}}{\sigma'_{vo}}\right)r_{d},$$

No of layers	Soil Description	From(m)	To(m)	g_d	N_{avg}	Overburden Pressure (Pa)	Atmospheric Pressure (Pa)
Layer No.1	Sandy Clayey SILT	0.00	-2.00	17.08	7	14160	101200
Layer No.2	Sandy Clayey SILT	-2.00	-4.00	17.50	9	30000	101200
Layer No. 3	Sandy Clayey SILT	-4.00	-5.00	17.69	6	38450	101200
Layer No. 4	Sandy Clayey SILT	-5.00	-7.00	16.88	11	48160	101200

CRR (Cyclic Resistance Ratio) Calculations

$$CRR = CRR_{7.5}(MSF)K_{\sigma}K_{a},$$

$$CRR_{7.5} = \frac{1}{34-(N_1)_{60CS}} + \frac{(N_1)_{60CS}}{135} + \frac{1}{\left[10\times(N_1)_{60CS}+45\right]^2} - \frac{1}{200}$$

$$(N_1)_{60CS} = \alpha + \beta\,(N_1)_{60},$$

$$(N_1)_{60} = C_N N_{60},$$

$$C_N = \sqrt{\frac{P_a}{\sigma'_{vo}}} \le 1.7,$$

$$N_{60} = NC_{60},$$

$$C_{60} = C_{HT}C_{HW}C_{SS}C_{RL}C_{BD}.$$

C_{60} =	C_{HT} * C_{HW} * C_{SS} * C_{RL} * C_{BD}		Ht. of Fall (mm) =		750	Hammer wt. (kg) =	63.5
Depth	**N_{avg}**	**C_{HT}**	**C_{HW}**	**C_{SS}**	**C_{RL}**	**C_{BD}**	**C_{60} =**
2.00	7	0.75	0.98	1.1	0.75	1.05	0.639
4.00	9	0.75	0.98	1.1	0.85	1.05	2.761
5.00	6	0.75	0.98	1.1	0.85	1.05	3.451
7.00	11	0.75	0.98	1.1	0.95	1.05	5.400

N1 60 CS Calculations:

Layer	C 60	N_{60}	Overburden pressure (Pa)	CN	N1 60	Fines Content	ALPHA	BETA	N1 60 CS
Layer No.1	0.639	4.48	14160	1.70	7.61	57	5.00	1.20	14.13
Layer No.2	2.761	24.85	30000	1.70	42.24	63	5.00	1.20	55.69
Layer No. 3	3.451	20.71	38450	1.62	33.59	67	5.00	1.20	45.31
Layer No. 4	5.400	59.40	48160	1.45	86.10	64	5.00	1.20	108.32

A $\frac{1}{34-(N_1)_{60CS}}+$ B $\frac{(N_1)_{60CS}}{135}+$ C $\frac{}{\left[10\times(N_1)_{60CS}+45\right]^2}$ D $-\frac{1}{200}$

$$K_{\sigma} = \left(\sigma'_{vo}/P_a\right)^{(f-1)}$$

$CRR_{7.5}$ VALUES				
A	**B**	**C**	**D**	**$CRR_{7.5}$**
0.0503	0.1047	0.0014	0.005	0.15
-0.0461	0.4125	0.0001	0.005	0.36
-0.0884	0.3356	0.0002	0.005	0.24
-0.0135	0.8024	0.0000	0.005	0.78

K Sigma Calculations	(f-1)	-0.3
σ'_{vo}	**P_a**	**K sigma**
14160	101200	1.80
30000	101200	1.44
38450	101200	1.34
48160	101200	1.25

CRR (Cyclic Resistance Ratio) Calculations:

Layers	CRR7.5	K sigma	MSF	Ka	CRR
Layer No.1	0.151	1.8040	0.9996	1.0000	0.2731
Layer No.2	0.362	1.4402	0.9996	1.0000	0.5205
Layer No. 3	0.242	1.3369	0.9996	1.0000	0.3240
Layer No. 4	0.784	1.2495	0.9996	1.0000	0.9793

$$CRR = CRR_{7.5}(MSF)K_{\sigma}K_{a},$$

CSR (Cyclic Stress Ratio) Calculations:

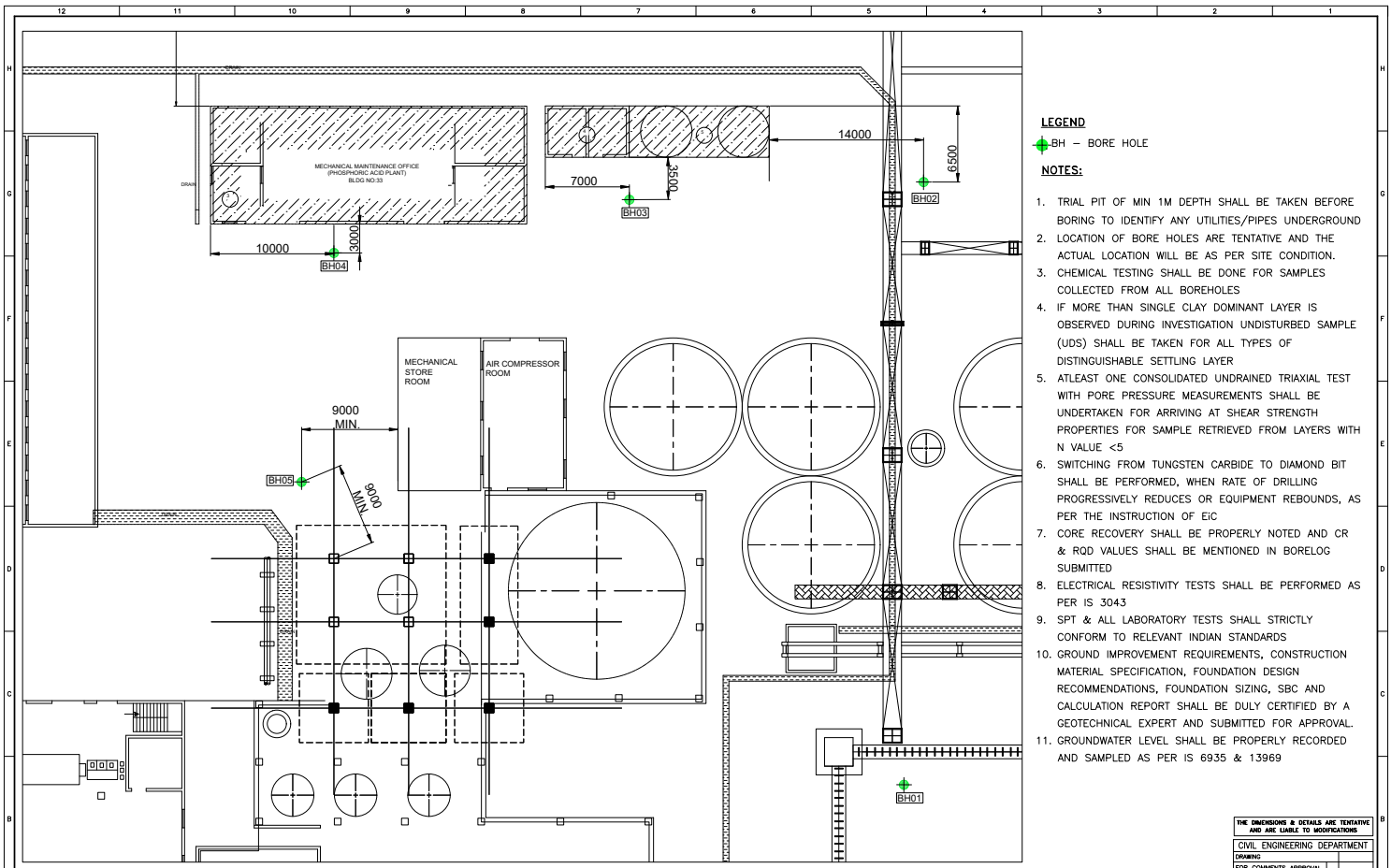
Layers	amax/g	σ_{vo}	σ'_{vo}	Y_d	CSR
Layer No.1	0.16	34.16	14.16	0.98	0.25
Layer No.2	0.16	70.00	30.00	0.97	0.24
Layer No. 3	0.16	88.45	38.45	0.96	0.23
Layer No. 4	0.16	118.16	48.16	0.95	0.24

$$CSR = 0.65\left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{vo}}{\sigma'_{vo}}\right)r_{d},$$

Bore Hole No. BH - 1	Depth (m)	FOS	Susceptibility against liquefaction
	2.00	1.11	Not Susceptible to liquefaction
	4.00	2.21	Not Susceptible to liquefaction
	5.00	1.41	Not Susceptible to liquefaction
	7.00	4.05	Not Susceptible to liquefaction

APPENDIX-I

BOREHOLE LOCATIONS DRAWING



LOCATION PLAN SHOWING BORE HOLES

LEGEND

BH – BORE HOLE

NOTES:

1. TRIAL PIT OF MIN 1M DEPTH SHALL BE TAKEN BEFORE BORING TO IDENTIFY ANY UTILITIES/PIPES UNDERGROUND
2. LOCATION OF BORE HOLES ARE TENTATIVE AND THE ACTUAL LOCATION WILL BE AS PER SITE CONDITION.
3. CHEMICAL TESTING SHALL BE DONE FOR SAMPLES COLLECTED FROM ALL BOREHOLES
4. IF MORE THAN SINGLE CLAY DOMINANT LAYER IS OBSERVED DURING INVESTIGATION UNDISTURBED SAMPLE (UDS) SHALL BE TAKEN FOR ALL TYPES OF DISTINGUISHABLE SETTLING LAYER
5. ATLEAST ONE CONSOLIDATED UNDRAINED TRIAXIAL TEST WITH PORE PRESSURE MEASUREMENTS SHALL BE UNDERTAKEN FOR ARRIVING AT SHEAR STRENGTH PROPERTIES FOR SAMPLE RETRIEVED FROM LAYERS WITH N VALUE <5
6. SWITCHING FROM TUNGSTEN CARBIDE TO DIAMOND BIT SHALL BE PERFORMED, WHEN RATE OF DRILLING PROGRESSIVELY REDUCES OR EQUIPMENT REBOUNDS, AS PER THE INSTRUCTION OF EIC
7. CORE RECOVERY SHALL BE PROPERLY NOTED AND CR & RQD VALUES SHALL BE MENTIONED IN BORELOG SUBMITTED
8. ELECTRICAL RESISTIVITY TESTS SHALL BE PERFORMED AS PER IS 3043
9. SPT & ALL LABORATORY TESTS SHALL STRICTLY CONFORM TO RELEVANT INDIAN STANDARDS
10. GROUND IMPROVEMENT REQUIREMENTS, CONSTRUCTION MATERIAL SPECIFICATION, FOUNDATION DESIGN RECOMMENDATIONS, FOUNDATION SIZING, SBC AND CALCULATION REPORT SHALL BE DULY CERTIFIED BY A GEOTECHNICAL EXPERT AND SUBMITTED FOR APPROVAL.
11. GROUNDWATER LEVEL SHALL BE PROPERLY RECORDED AND SAMPLED AS PER IS 6935 & 13969

THE DIMENSIONS & DETAILS ARE TENTATIVE AND ARE LIABLE TO MODIFICATIONS

CIVIL ENGINEERING DEPARTMENT

DRAWING	
FOR COMMENTS APPROVAL	
FOR TENDER PURPOSE ONLY	✓ 25.04.2025
PRELIMINARY ADVANCE COPY	
GOOD FOR CONSTRUCTION	

CLIENT M/s. FACT CD

DRAWING NO. | TITLE | REFERENCE DRAWING | NO | ZONE | PARTICULARS | REVISED | CHECKED | APPROVED | DATE | REVISION

SCALE	NTS
DATE	23.04.2025
DRAWN	AVR
CHECKED	NAV
DESIGNED	AVR
CHECKED	NJ
APPROVED	NJ

FACT ENGINEERING & DESIGN ORGANISATION
THE FERTILISERS AND CHEMICALS TRAVANCORE LTD
UDYOGAMANDAL KERALA

FEDO

PROJECT NAME: CONSTRUCTION OF NEW HBF IN FACT CD | PROJECT NO: 32771

TITLE: PROPOSED LOCATION OF BOREHOLES FOR GEOTECHNICAL INVESTIGATION

SHEET 1 OF 1 | DRG. NO. 32771-12-DG-00100 | REV. 0

APPENDIX-II

BORELOGS

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	**: BH 1**	**Drilling Hole Record-BH 1**	
Location	**: FACT, Ambalamugal**	**Fig No. 01**	
Type of Boring	**: Rotary**	**Reduced Level**	**:**
Ground Water Level	**: 2.30 m from E.G.L on 07.06.2025**	**Start Date**	**: 06.06.2025**
UTM Co-ordinate	**: E 649332, N 1103157**	**End Date**	**: 07.06.2025**
Termination Depth	**: 21.20 m**		

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT 'N' Blows/300mm	C.R (%)	R.Q.D(%)	REMARKS
Sandy Clayey **SILT** (Cl)	Brown/Yellow	Medium Stiff, Layered	2.00			SPT-1	SS	1.00	1.00-1.45	2	2	5	7			
						SPT-2	SS	2.00	2.00-2.45	2	3	6	9			G.W.L
Sandy Clayey **SILT** (CH)	Red / Yellow	Stiff, Layered	4.00			SPT-3	SS	3.00	3.00-3.45	3	4	5	9			
						SPT-4	SS	4.00	4.00-4.45	1	2	4	6			
Red / Yellowish, Medium Stiff, Sandy Clayey **SILT** (CH)			5.00			SPT-5	SS	5.00	5.00-5.45	2	3	6	9			
Sandy Clayey **SILT** (CH)	Red / Yellow	Stiff, Layered	7.00			SPT-6	SS	6.00	6.00-6.45	2	4	6	10			
						SPT-7	SS	7.00	7.00-7.45	3	7	8	15			
White / Browinsh, Medium Dense, Clayey **SAND** (SC)			8.00			SPT-8	SS	8.00	8.00-8.45	4	9	13	22			
						SPT-9	SS	9.00	9.00-9.45	6	11	13	24			
Sandy Clayey **SILT** (Cl)	Brown/Red	Very Stiff, Layered				SPT-10	SS	10.00	10.00-10.45	5	9	12	21			
						SPT-11	SS	11.50	11.50-11.95	7	12	12	24			

SPT 'N' PROFILE: 20 | 40 | 60 | 80 | 100

G.W.L: 2.30 m from E.G.L on 07.06.2025	No. of SPT : 16 Nos.	No. of UDS : Nil.	No. of CR : 3 Nos.	**Remarks**

Note: SPT-Standard Peneration Test
SS-Split Spoon Sample
OT- Open Tube

UDS-Un Disturbed Sample
CS-Core Sample

CR-Core Recovery
RQD-Rock Quality Designation

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	**: BH 1**	**Drilling Hole Record-BH 1**	
Location	**: FACT, Ambalamugal**	**Fig No. 01**	
Type of Boring	**: Rotary**	**Reduced Level**	**:**
Ground Water Level	**: 2.30 m from E.G.L on 07.06.2025**	**Start Date**	**: 06.06.2025**
UTM Co-ordinate	**: E 649332, N 1103157**	**End Date**	**: 07.06.2025**
Termination Depth	**: 21.20 m**		

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT 'N' Blows/300mm	C.R (%)	R.Q.D(%)	REMARKS
Sandy Clayey **SILT** (Cl)	Br./Red	Very Stiff, Layered				SPT-12	SS	13.00	13.00-13.45	9	12	14	26			
	Brown / Yellow					SPT-13	SS	14.50	14.50-14.95	9	15	16	31			
			16.00			SPT-14	SS	16.00	16.00-16.45	11	19	28	47			
		Hard, Layered	17.50			SPT-15	SS	17.50	17.50-17.56	>50	-	-	>100			50/6 cm Penetration
Soft Rock						SPT-16	SS									
			19.20			CR-1	CS	18.8	18.80-18.80 18.80-19.20	>50	-	-	>100			Rebound
Fractured Hard Rock						CR-2	CS	19.20	19.20-20.20	-	-	-	-	94	58	8 Nos. of pieces (9+8+14+6+8+28+5+16 in cm)
						CR-3	CS	20.2	20.20-21.20	-	-	-	-	28	28	1 No. of piece (28 cm)
			21.20													

SPT 'N' PROFILE: 20 | 40 | 60 | 80 | 100

G.W.L: 2.30 m from E.G.L on 07.06.2025	No. of SPT : 16 Nos.	No. of UDS : Nil.	No. of CR : 3 Nos.	**Remarks**

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	: BH 2
Location	: FACT, Ambalamugal
Type of Boring	: Rotary
Ground Water Level	: 2.2 m from E.G.L on 06.06.2025
UTM Co-ordinate	: E 649320, N 1103207
Termination Depth	: 24.60 m

Drilling Hole Record-BH 2

Fig No. 02

Reduced Level	:	
Start Date	:	04.06.2025
End Date	:	05.06.2025

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT 'N' Blows/300mm	SPT 'N' PROFILE	C.R (%)	R.Q.D(%)	REMARKS
Sandy **GRAVEL** (GM)	Red & Brown	Very Dense, Granular				SPT-1	SS	1.00	1.00-1.45	19	36	50	86				
			1.70			SPT-2	SS	1.70	1.70-1.70	>50	-	-	>100				Rebound G.W.L
Lateritic Rock						CR-1	CS		1.70-2.10	-	-	-	-				
			3.00			SPT-3	SS	3.00	3.00-3.45	16	19	24	43				
Red/Brownish, Dense, Sandy **GRAVEL** (GM)			4.00			SPT-4	SS	4.00	4.00-4.45	11	14	17	31				
Red/Brownish, Dense, Gravelly Silty **SAND** (SM)			5.00			SPT-5	SS	5.00	5.00-5.45	6	12	15	27				
Gravelly **SAND** (SM)	White/Brown	Medium Dense, Granular	7.00			SPT-6	SS	6.00	6.00-6.45	2	6	8	14				
						SPT-7	SS	7.00	7.00-7.45	3	8	8	16				
Silty **SAND** (SM)	Yellow	Medium Dense, Granular	9.00			SPT-8	SS	8.00	8.00-8.45	4	7	18	15				
		Dense, Granular	10.00			SPT-9	SS	9.00	9.00-9.45	4	12	21	33				
	Yellow / White	Medium Dense, Granular				SPT-10	SS	10.00	10.00-10.45	5	16	14	30				
						SPT-11	SS	11.50	11.50-11.95	9	11	18	29				

SPT 'N' PROFILE scale: 20, 40, 60, 80, 100

G.W.L: 2.2 m from E.G.L on 06.06.2025	No. of SPT : 17 Nos.	No. of UDS : Nil.	No. of CR : 4 Nos.	Remarks

Note: SPT-Standard Peneration Test
SS-Split Spoon Sample
OT- Open Tube

UDS-Un Disturbed Sample
CS-Core Sample

CR-Core Recovery
RQD-Rock Quality Designation

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	**: BH 2**	**Drilling Hole Record-BH 2**	
Location	**: FACT, Ambalamugal**	**Fig No. 02**	
Type of Boring	**: Rotary**	**Reduced Level**	**:**
Ground Water Level	**: 2.2 m from E.G.L on 06.06.2025**	**Start Date**	**: 04.06.2025**
UTM Co-ordinate	**: E 649320, N 1103207**	**End Date**	**: 05.06.2025**
Termination Depth	**: 24.60 m**		

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT 'N' Blows/300mm	C.R (%)	R.Q.D(%)	REMARKS
Yellow/White, Medium Dense, Silty **SAND** (SM)			13.00			SPT-12	SS	13.00	13.00-13.45	10	16	18	34			
Silty **SAND** (SM)	White	Dense, Granular	14.50			SPT-13	SS	14.50	14.50-14.95	11	24	30	54			
	Red & Brown	Very Dense, Granular				SPT-14	SS	16.00	16.00-16.45	14	26	32	58			
	White/Yellow					SPT-15	SS	17.50	17.50-17.95	17	29	36	65			
						SPT-16	SS	19.00	19.00-19.45	21	34	47	81			
			21.60			SPT-17	SS		21.50-21.60	>50	-	-	>100			50/10 cm Penetration
Soft Rock			22.60			CR-2	CS	21.50	21.60-22.60	-	-	-	-	8	Nil	1 No.of piece (8 cm)
Fractured Hard Rock			24.60			CR-3	CS	22.60	22.60-23.60	-	-	-	-	11	Nil	4 Nos. of Pieces (4+3+2+2)
						CR-4	CS	23.60	23.60-24.60	-	-	-	-	15	Nil	4 Nos. of Pieces (3+5+4+3)

SPT 'N' PROFILE: 20 | 40 | 60 | 80 | 100

G.W.L: 2.2 m from E.G.L on 06.06.2025	No. of SPT : 17 Nos.	No. of UDS : Nil.	No. of CR : 4 Nos.

Remarks

Note: SPT-Standard Peneration Test
SS-Split Spoon Sample
OT- Open Tube

UDS-Un Disturbed Sample
CS-Core Sample

CR-Core Recovery
RQD-Rock Quality Designation

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	**: BH 3**	**Drilling Hole Record-BH 3**	
Location	**: FACT, Ambalamugal**	**Fig No. 03**	
Type of Boring	**: Rotary**	**Reduced Level**	**:**
Ground Water Level	**: 3.0 m from E.G.L on 04.06.2025**	**Start Date**	**: 02.06.2025**
UTM Co-ordinate	**: E 649302, N 1103199**	**End Date**	**: 03.06.2025**
Termination Depth	**: 18.50 m**		

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT 'N' Blows/300mm	SPT 'N' PROFILE	C.R (%)	R.Q.D(%)	REMARKS
Silty Gravelly **SAND** (SM)	Pale Red	Medium Dense, Granular				SPT-1	SS	1.00	1.00-1.45	9	5	6	11				
			2.00			SPT-2	SS	2.00	2.00-2.40	39	46	>50	>100				50/10 cm Penetration
Grey / Brownish, Very Dense, Sandy **GRAVEL** (GM)																	G.W.L
			3.00			SPT-3	SS	3.00	3.00-3.45	21	12	10	22				
Gr,/ Brown, Medium Dense, Silty Gravelly **SAND** (SM)			3.60			SPT-4	SS	3.60	3.60-3.60	>50	-	-	>100				Rebound
						CR-1	CS		3.60-4.60								
						SPT-5	SS	4.60	4.60-4.60	>50	-	-	>100				Rebound
						CR-2	CS		4.60-5.60	-	-	-	-				
Lateritic Rock						SPT-5	SS	5.60	5.60-5.60	>50	-	-	>100				Rebound
						CR-3	CS		5.60-6.20	-	-	-	-				
																	Layer Change @ 6.20 m
			7.00			SPT-7	SS	7.00	7.00-7.45	2	2	5	7				
Sandy Clayey **SILT** (Cl)	Pale Yellow	Medium Stiff,	8.00			SPT-8	SS	8.00	8.00-8.45	3	6	6	12				
		Stiff, Layered	9.00			SPT-9	SS	9.00	9.00-9.45	2	7	9	16				
		Very Stiff, Layered				SPT-10	SS	10.00	10.00-10.45	4	9	9	18				
			11.50			SPT-11	SS	11.50	11.50-11.95	9	14	19	33				
Y/Brownish, Dense, Silty **SAND** (SM)																	

G.W.L: 3.0 m from E.G.L on 04.06.2025 | No. of SPT : 14 Nos. | No. of UDS : Nil. | No. of CR : 6 Nos. | **Remarks**

Note: SPT-Standard Peneration Test
SS-Split Spoon Sample
OT- Open Tube

UDS-Un Disturbed Sample
CS-Core Sample

CR-Core Recovery
RQD-Rock Quality Designation

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	**: BH 3**	**Drilling Hole Record-BH 3**	
Location	**: FACT, Ambalamugal**	**Fig No. 03**	
Type of Boring	**: Rotary**	**Reduced Level**	**:**
Ground Water Level	**: 3.0 m from E.G.L on 04.06.2025**	**Start Date**	**: 02.06.2025**
UTM Co-ordinate	**: E 649302, N 1103199**	**End Date**	**: 03.06.2025**
Termination Depth	**: 18.50 m**		

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT 'N' Blows/300mm	SPT 'N' PROFILE 20 40 60 80 100	C.R (%)	R.Q.D(%)	REMARKS
Silty **SAND** (SM)	Yellow/ Brown	Dense, Granular				SPT-12	SS	13.00	13.00-13.45	12	17	20	37				
	W/Yellow					SPT-13	SS	14.50	14.50-14.95	9	16	25	41				
			15.50			SPT-14	SS		15.50-15.50	>50	-	-	>100				
Soft Rock						CR-4	CS	15.50	15.50-16.50	-	-	-	-				
			16.50			CR-5	CS	16.50	16.50-17.50	-	-	-	-		87	60	7 Nos. of Pieces (10+9+11+10+9+9+29)
Fractured Hard Rock						CR-6	CS	17.50	17.50-18.50	-	-	-	-		68	46	6 Nos. of Pieces (4+4+9+5+11+35)
			18.50														

G.W.L: 3.0 m from E.G.L on 04.06.2025	No. of SPT : 14 Nos.	No. of UDS : Nil.	No. of CR : 6 Nos.	**Remarks**

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	**: BH 4**	**Drilling Hole Record-BH 4**	
Location	**: FACT, Ambalamugal**	**Fig No. 04**	
Type of Boring	**: Rotary**	**Reduced Level**	**:**
Ground Water Level	**: 3.0 m from E.G.L on 30.05.2025**	**Start Date**	**: 28.05.2025**
UTM Co-ordinate	**: E 649279, N 1103183**	**End Date**	**: 29.05.2025**
Termination Depth	**: 14.45 m**		

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT 'N' Blows/300mm	C.R (%)	R.Q.D(%)	REMARKS
Sandy Clayey **SILT** (CH)	Red	Medium Stiff, Layered				SPT-1	SS	1.00	1.00-1.45	2	3	3	6			
						SPT-2	SS	2.00	2.00-2.45	4	4	4	8			
			3.00			SPT-3	SS	3.00	3.00-3.45	3	4	6	10			G.W.L
		Stiff, Layered				SPT-4	SS	4.00	4.00-4.45	3	4	5	9			
						SPT-5	SS	5.00	5.00-5.45	4	5	6	11			
			6.00			SPT-6	SS	6.00	6.00-6.45	9	10	15	25			
Clayey **SAND** (SC)	White / Yellow	Medium Dense, Granular				SPT-7	SS	7.00	7.00-7.45	10	14	15	29			
			8.00			SPT-8	SS	8.00	8.00-8.45	10	16	16	32			
		Dense, Granular				SPT-9	SS	9.00	9.00-9.45	11	14	19	33			
						SPT-10	SS	10.00	10.00-10.45	15	18	20	38			
			11.50			SPT-11	SS	11.50	11.50-11.52	>50	-	-	>100			50/2 cm Penetration
Soft Rock						CR-1	CS		11.60-12.45	-	-	-	-			

SPT 'N' PROFILE: 20 | 40 | 60 | 80 | 100

G.W.L: 3.0 m from E.G.L on 30.05.2025	No. of SPT : 11 Nos.	No. of UDS : Nil.	No. of CR : 3 Nos.	**Remarks**

Note: SPT-Standard Peneration Test
SS-Split Spoon Sample
OT- Open Tube

UDS-Un Disturbed Sample
CS-Core Sample

CR-Core Recovery
RQD-Rock Quality Designation

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	**: BH 4**	**Drilling Hole Record-BH 4**	
Location	**: FACT, Ambalamugal**	**Fig No. 04**	
Type of Boring	**: Rotary**	**Reduced Level**	**:**
Ground Water Level	**: 3.0 m from E.G.L on 30.05.2025**	**Start Date**	**: 28.05.2025**
UTM Co-ordinate	**: E 649279, N 1103183**	**End Date**	**: 29.05.2025**
Termination Depth	**: 14.45 m**		

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT 'N' Blows/300mm	SPT 'N' PROFILE 20	40	60	80	100	C.R (%)	R.Q.D(%)	REMARKS
Soft Rock			12.45			CR-2	CS	12.45	12.45-13.45	-	-	-	-						69	33	8 Nos. of Pieces (12+7+6+8+8+7+10+11)
Fractured Hard Rock			14.45			CR-3	CS	13.45	13.45-14.45	-	-	-	-						63	16	12 Nos. of Pieces (9+2+2+2+2+2+4+5+7+4+16+8)

G.W.L: 3.0 m from E.G.L on 30.05.2025	No. of SPT : 11 Nos.	No. of UDS : Nil.	No. of CR : 3 Nos.	**Remarks**
---	---	---	---	---

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	**: BH 5**	**Drilling Hole Record-BH 5**	
Location	**: FACT, Ambalamugal**	**Fig No. 05**	
Type of Boring	**: Rotary**	**Reduced Level**	**:**
Ground Water Level	**: 3.0 m from E.G.L on 29.05.2025**	**Start Date**	**: 27.05.2025**
UTM Co-ordinate	**: E 649276, N 1103163**	**End Date**	**: 28.05.2025**
Termination Depth	**: 15.50 m**		

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT'N' Blows/300mm	SPT 'N' PROFILE	C.R (%)	R.Q.D(%)	REMARKS
Clayey **SAND** (SC)	Pale Red	Loose, Granular				SPT-1	SS	1.00	1.00-1.45	5	5	4	9				
			2.00			SPT-2	SS	2.00	2.00-2.45	5	6	7	13				
Pale Red, Medium Dense, Clayey **SAND** (SC)			3.00			SPT-3	SS	3.00	3.00-3.45	2	4	7	11				G.W.L
Sandy Clayey **SILT** (Cl)	Brown / Yellow	Stiff, Layered				SPT-4	SS	4.00	4.00-4.45	3	6	9	15				
			5.00			SPT-5	SS	5.00	5.00-5.45	4	6	12	18				
		Very Stiff, Layered	6.00			SPT-6	SS	6.00	6.00-6.45	3	6	8	14				
		Stiff, Layered				SPT-7	SS	7.00	7.00-7.45	2	5	8	13				
						SPT-8	SS	8.00	8.00-8.45	7	7	8	15				
			9.00			SPT-9	SS	9.00	9.00-9.45	4	8	9	17				
Pale Yellow, Medium Dense, Silty **SAND** (SM)			10.00			SPT-10	SS	10.00	10.00-10.45	7	15	18	33				
Silty **SAND** (SM)	Pale Yellow	Dense, Granular				SPT-11	SS	11.50	11.50-11.95	11	17	21	38				

SPT 'N' PROFILE scale: 20, 40, 60, 80, 100

G.W.L: 3.0 m from E.G.L on 29.05.2025	No. of SPT : 13 Nos.	No. of UDS : Nil.	No. of CR : 2 Nos.	**Remarks**

Note: SPT-Standard Peneration Test
SS-Split Spoon Sample
OT- Open Tube

UDS-Un Disturbed Sample
CS-Core Sample

CR-Core Recovery
RQD-Rock Quality Designation

Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Bore Hole No	**: BH 5**	**Drilling Hole Record-BH 5**	
Location	**: FACT, Ambalamugal**	**Fig No. 05**	
Type of Boring	**: Rotary**	**Reduced Level**	**:**
Ground Water Level	**: 3.0 m from E.G.L on 29.05.2025**	**Start Date**	**: 27.05.2025**
UTM Co-ordinate	**: E 649276, N 1103163**	**End Date**	**: 28.05.2025**
Termination Depth	**: 15.50 m**		

SOIL DESCRIPTION	COLOUR	STRUCTURE	DEPTH BELOW GROUND LEVEL (m)	REDUCED LEVEL (m)	LEGEND	TEST NO	SAMPLE TYPE	DEPTH BELOW GROUND LEVEL (m)	TEST DEPTH	PENETRATION VALUES 15cm	30cm	45cm	SPT 'N' Blows/300mm	SPT 'N' PROFILE 20 40 60 80 100	C.R (%)	R.Q.D(%)	REMARKS
Silty **SAND** (SM)	Pale Yellow	Dense, Granular	13.00														
Pale Yellow, Very Dense, Silty **SAND** (SM)			13.50			SPT-12	SS	13.00	13.00-13.45	19	27	39	66				Rebound
Fractured Hard Rock			15.50			SPT-13	SS	13.50	13.50-13.50	>50	-	-	>100		82	64	10 Nos. of Pieces (15+5+3+10+2+2+15+10+14+6) cm
						CR-1	CS		13.50-14.50								
						CR-2	CS	14.50	14.50-15.50	-	-	-	-		87	77	6 Nos. of Pieces (29+15+2+2+6+20+13) cm

G.W.L: 3.0 m from E.G.L on 29.05.2025	No. of SPT : 13 Nos.	No. of UDS : Nil.	No. of CR : 2 Nos.

Remarks

APPENDIX-III

LABORATORY TEST RESULTS

GEO FOUNDATIONS & STRUCTURES PVT LTD	Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.	Boring Start : 06.06.2025	Table No.: 1
		Boring End : 07.06.2025	Bore-Hole No. : BH 1
LABORATORY TEST RESULTS		Location	G.W.T: 2.30 m
ULR-TC1281224000001240F		Ambalamugal	Termination Depth : 21.2 m

Site Recorded N Value	DEPTH (m)	SAMPLE	SOIL DESCRIPTION	IS. CLASSIFICATION	GRAIN SIZE ANALYSIS(%) IS 2720(Part5):1985				ATTERBERG'S LIMIT(%) IS 2720(Part-5): 1985			SHRINKAGE LIMIT (%) IS 2720(Part6): 1972	DRY DENSITY, gm/cc	WET DENSITY, gm/cc	WATER CONTENT, % IS 2720 (Part2):1973	SPECIFIC GRAVITY IS 2720(Part-3/sec1):1980	FREE SWELL INDEX (%) IS 2720 (Part40):1977	SHEAR PARAMETERS		
					GRAVEL, %	SAND, %	SILT %	CLAY %	LIQUID LIMIT,%	PLASTIC LIMIT,%	PLASTICITY INDEX							TEST METHOD	C in Kg/cm²	Φ in degrees
7	1.00	SPT-1	Sandy Clayey **SILT** (Br./yellow)	Cl	2	41	41	16	43	21	22		1.22	1.71	40	2.44		UCS	0.13	
9	2.00	SPT-2	Sandy Clayey **SILT** (R/yellow)	CH	5	32	41	22	62	26	36				45					
9	3.00	SPT-3		CH											43					
6	4.00	SPT-4		CH	3	30	43	24	65	28	37				45					
9	5.00	SPT-5		CH									1.22	1.76	44	2.41	21	UCS	0.15	
10	6.00	SPT-6		CH	5	31	39	25							40					
15	7.00	SPT-7	Clayey **SAND** (W/brown)	SC	0	53	34	13	36	18	18		1.18	1.54	31			DST	0.14	25
22	8.00	SPT-8	Sandy Clayey **SILT** (Br./red)	Cl	3	42	39	16	41	20	21				30					
24	9.00	SPT-9		Cl											28	2.43		UCS	0.64	
21	10.0	SPT-10		Cl	5	41	37	17	42	21	21				26					
24	11.5	SPT-11		Cl											28					
26	13.0	SPT-12	Sandy Clayey **SILT** (Br./yellow)	Cl	7	42	37	14	40	19	21				27					
31	14.5	SPT-13		Cl									1.47	1.82	24	2.44	18	UCS	1.15	
47	16.0	SPT-14		Cl	5	41	39	15												
>100	17.50 - 17.56	SPT-15		Cl	2	41	41	16	42	20	22					2.43				
>100	18.80-18.80	SPT-16	**Soft Rock**	Sample not sufficient for tests																
-	18.80 - 19.20	CR-1																		
-	19.20 - 20.20	CR-2	**Fractured Hard Rock**	Core Recovery - 28% ; RQD - 28%									UCS - 305 kg/cm²							
-	20.20 - 21.20	CR-3		Core Recovery - 28% ; RQD - 28%									UCS - 376 kg/cm²							

NOTE: Type of Sample
SPT- Standard Penetration Test UDS- Un Disturbed Sample

GEO FOUNDATIONS & STRUCTURES PVT LTD	Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.	Boring Start : 04.06.2025	Table No.: 2
		Boring End : 05.06.2025	Bore-Hole No. : BH 2
LABORATORY TEST RESULTS		Location	G.W.T: 2.20 m
ULR-TC1281224000001240F		Ambalamugal	Termination Depth : 24.6 m

Site Recorded N Value	DEPTH (m)	SAMPLE	SOIL DESCRIPTION	IS. CLASSIFICATION	GRAIN SIZE ANALYSIS(%) IS 2720(Part5):1985				ATTERBERG'S LIMIT(%) IS 2720(Part-5): 1985			SHRINKAGE LIMIT (%) IS 2720(Part6): 1972	DRY DENSITY, gm/cc	WET DENSITY, gm/cc	WATER CONTENT, % IS 2720 (Part2):1973	SPECIFIC GRAVITY IS 2720(Part-3/sec1):1980	FREE SWELL INDEX (%) IS 2720 (Part40):1977	SHEAR PARAMETERS		
					GRAVEL, %	SAND, %	SILT %	CLAY %	LIQUID LIMIT,%	PLASTIC LIMIT,%	PLASTICITY INDEX							TEST METHOD	C in Kg/cm²	Φ in degrees
86	1.00	SPT-1	Sandy **GRAVEL** (R/Brown)	GM	86	14	0	0	No Limit						11					
>100	1.70-1.70	SPT-2	**Lateritic Rock**																	
-	1.70 - 2.10	CR-1																		
43	3.00	SPT-2	Sandy **GRAVEL** (R/Brown)	GM	70	30	0	0	No Limit						10					
31	4.00	SPT-3	Gravelly Silty **SAND** (R/brown)	SM	24	52	24	0	No Limit						7					
27	5.00	SPT-4	Gravelly **SAND** (W/brown)	SM	30	62	8	0	No Limit				1.48	1.91	29	2.62		DST	0	32
14	6.00	SPT-5		SM											25					
16	7.00	SPT-6	Silty **SAND** (Yellow)	SM	0	64	31	5	No Limit						20					
15	8.00	SPT-7		SM									1.43	1.73	21	2.59		DST	0.04	27
33	9.00	SPT-8		SM											20					
30	10.0	SPT-9	Silty **SAND** (Y/White)	SM	0	59	41	0	No Limit				1.45	1.81	25	2.63		DST	0	30
29	11.5	SPT-10		SM	0	51	49	0	No Limit						22					
34	13.0	SPT-11	Silty **SAND** (White)	SM											21					
54	14.5	SPT-12	Silty **SAND** (R/Brown)	SM	1	59	40	0	No Limit				1.56	1.94	24	2.62		DST	0	33
58	16.0	SPT-13	Silty **SAND** (W/yellow)	SM											26					
65	17.5	SPT-14		SM	0	64	32	4	No Limit						30					
81	19.0	SPT-15		SM	0	55	45	0	No Limit				1.52	2.19	44	2.61		DST	0.04	35
>100	21.50 - 21.60	SPT-16		SM																
-	21.60 - 22.60	CR-2	**Soft Rock**	Sample not sufficient for tests																
-	22.60 - 23.60	CR-3	**Fractured Hard Rock**	Core Recovery - 11% ; RQD - Nil																
-	23.60 - 24.60	CR-4		Core Recovery - 15% ; RQD - Nil																

NOTE: Type of Sample
SPT- Standard Penetration Test UDS- Un Disturbed Sample

GEO FOUNDATIONS & STRUCTURES PVT LTD	Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.	Boring Start : 02.06.2025	Table No.: 3
		Boring End : 03.06.2025	Bore-Hole No. : BH 3
LABORATORY TEST RESULTS		Location	G.W.T: 3.00 m
ULR-TC1281224000001240F		Ambalamugal	Termination Depth : 18.5 m

Site Recorded N Value	DEPTH (m)	SAMPLE	SOIL DESCRIPTION	IS. CLASSIFICATION	GRAIN SIZE ANALYSIS(%) IS 2720(Part5):1985				ATTERBERG'S LIMIT(%) IS 2720(Part-5): 1985			SHRINKAGE LIMIT (%) IS 2720(Part6): 1972	DRY DENSITY, gm/cc	WET DENSITY, gm/cc	WATER CONTENT, % IS 2720 (Part2):1973	SPECIFIC GRAVITY IS 2720(Part-3/sec1):1980	FREE SWELL INDEX (%) IS 2720 (Part40):1977	SHEAR PARAMETERS		
					GRAVEL, %	SAND, %	SILT %	CLAY %	LIQUID LIMIT,%	PLASTIC LIMIT,%	PLASTICITY INDEX							TEST METHOD	C in Kg/cm²	Φ in degrees
11	1.00	SPT-1	Silty Gravelly **SAND** (Pale Red)	SM	34	53	13	0	No Limit						22	2.64				
>100	2.00 - 2.40	SPT-2	Sandy **GRAVEL** (Gr./brown)	GM	70	27	3	0	No Limit						20					
22	3.00	SPT-3	Silty Gravelly **SAND** (Gr./ brown)	SM	32	54	11	3	No Limit						43					
>100	3.60 - 4.60	CR-1	**Lateritic Rock**																	
>100	4.60 - 5.60	CR-2																		
>100	5.60 - 6.20	CR-3																		
7	7.00	SPT-4	Sandy Clayey **SILT** (Pale Yellow)	Cl	0	43	38	19	44	26	18		1.40	1.81	29	2.47	19	UCS	0.28	
12	8.00	SPT-5		Cl											30					
16	9.00	SPT-6		Cl	0	41	39	20	45	24	21				28	2.45		UCS	0.58	
18	10.0	SPT-7		Cl											26					
33	11.5	SPT-8	Silty **SAND** (Y/Brown)	SM	0	59	41	0	No Limit				1.62	1.91	18	2.60		DST		32
37	13.0	SPT-9		SM											18					
41	14.5	SPT-10	Silty **SAND** (W/Yellow)	SM	0	68	32		No Limit				1.63	1.94	19			DST		34
>100	15.50-15.50	SPT-11	**Soft Rock**	Sample not sufficient for tests																
-	15.50 - 16.50	CR-4																		
-	16.50 - 17.50	CR-5	**Fractured Hard Rock**	Core Recovery - 87% ; RQD - 60%									UCS - 282 kg/cm²							
-	17.50 - 18.50	CR-6		Core Recovery - 68% ; RQD - 46%																

NOTE: Type of Sample
SPT- Standard Penetration Test UDS- Un Disturbed Sample

GEO FOUNDATIONS & STRUCTURES PVT LTD	Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.	Boring Start : 28.05.2025	Table No.: 4
		Boring End : 29.05.2025	Bore-Hole No. : BH 4
LABORATORY TEST RESULTS		Location	G.W.T: 3.00 m
ULR-TC1281224000001240F		Ambalamugal	Termination Depth : 14.45 m

Site Recorded N Value	DEPTH (m)	SAMPLE	SOIL DESCRIPTION	IS. CLASSIFICATION	GRAIN SIZE ANALYSIS(%) IS 2720(Part5):1985				ATTERBERG'S LIMIT(%) IS 2720(Part-5): 1985			SHRINKAGE LIMIT (%) IS 2720(Part6): 1972	DRY DENSITY, gm/cc	WET DENSITY, gm/cc	WATER CONTENT, % IS 2720 (Part2):1973	SPECIFIC GRAVITY IS 2720(Part-3/sec1):1980	FREE SWELL INDEX (%) IS 2720 (Part40):1977	SHEAR PARAMETERS		
					GRAVEL, %	SAND, %	SILT %	CLAY %	LIQUID LIMIT,%	PLASTIC LIMIT,%	PLASTICITY INDEX							TEST METHOD	C in Kg/cm^2	Φ in degrees
6	1.00	SPT-1	Sandy Clayey **SILT** (Red)	CH	0	21	47	32	54	27	27		1.14	1.68	48			UCS	0.15	
8	2.00	SPT-2		CH	0	24	41	35	57	26	31				45					
10	3.00	SPT-3		CH											46					
9	4.00	SPT-4		CH	0	20	48	32	55	28	27		1.30	1.74	34	2.42	23	UCS	0.18	
11	5.00	SPT-5		CH											35					
25	6.00	SPT-6	Clayey **SAND** (W/yellow)	SC	0	60	24	16	40	18	22				36					
29	7.00	SPT-7		SC	0	59	23	18					1.18	1.57	33	2.54		DST	0.15	26
32	8.00	SPT-8		SC											34					
33	9.00	SPT-9		SC	0	55	28	17	41	20	21		1.19	1.60	35			DST	0.14	27
38	10.00	SPT-10		SC											32					
>100	11.50 - 11.52	SPT-11		SC	0	58	24	18	40	20	20		1.29	1.68	30	2.53		DST	0.14	29
-	11.60 - 12.45	CR-1	**Soft Rock**	Sample not sufficient for tests																
-	12.45 - 13.45	CR-2	**Fractured Hard Rock**	Core Recovery - 69% ; RQD - 33%									UCS - 271 kg/cm^2							
-	13.45 - 14.45	CR-3		Core Recovery - 63% ; RQD - 16%																

NOTE: Type of Sample
SPT- Standard Penetration Test UDS- Un Disturbed Sample

GEO FOUNDATIONS & STRUCTURES PVT LTD	Project : Geotechnical Investigation for the Proposed Horizontal Belt Filter in Phosphoric Acid Plant at FACT Cochin Division, Kochi.	Boring Start : 27.05.2025	Table No.: 5
		Boring End : 28.05.2025	Bore-Hole No.: BH5
LABORATORY TEST RESULTS		Location	G.W.T: 3.00 m
ULR-TC1281224000001240F		Ambalamugal	Termination Depth : 15.5 m

Site Recorded N Value	DEPTH (m)	SAMPLE	SOIL DESCRIPTION	IS. CLASSIFICATION	GRAIN SIZE ANALYSIS(%) IS 2720(Part5):1985				ATTERBERG'S LIMIT(%) IS 2720(Part-5): 1985			SHRINKAGE LIMIT (%) IS 2720(Part6): 1972	DRY DENSITY, gm/cc	WET DENSITY, gm/cc	WATER CONTENT, % IS 2720 (Part2):1973	SPECIFIC GRAVITY IS 2720(Part-3/sec1):1980	FREE SWELL INDEX (%) IS 2720 (Part40):1977	SHEAR PARAMETERS		
					GRAVEL, %	SAND, %	SILT %	CLAY %	LIQUID LIMIT,%	PLASTIC LIMIT,%	PLASTICITY INDEX							TEST METHOD	C in Kg/cm²	Φ in degrees
9	1.00	SPT-1	Clayey **SAND** (Pale red)	SC	1	55	28	16	35	18	17				28					
13	2.00	SPT-2		SC											26					
11	3.00	SPT-3	Sandy Clayey **SILT** (Br./yellow)	CI	2	41	42	15	38	20	18		1.33	1.82	37	2.47		UCS	0.31	
15	4.00	SPT-4		CI	4	41	38	17							35					
18	5.00	SPT-5		CI											36					
14	6.00	SPT-6		CI	3	42	39	16	38	18	20				34					
13	7.00	SPT-7		CI	0	44	37	19	40	19	21		1.42	1.84	30	2.46		UCS	0.35	
15	8.00	SPT-8		CI											32					
17	9.00	SPT-9	Silty **SAND** (Pale Yellow)	SM	0	62	34	4	No Limit				1.34	1.63	22			DST	0.05	26
33	10.00	SPT-10		SM	0	65	32	3	No Limit						20					
38	11.50	SPT-11		SM									1.70	2.06	21	2.62		DST	0.03	35
66	13.00	SPT-12		SM	0	65	30	5	No Limit						20					
>100	13.50 - 13.50	SPT-13	**Fractured Hard Rock**	Core Recovery - 82% ; RQD - 64%									UCS - 256 kg/cm²							
-	13.50 - 14.50	CR-1																		
-	14.50 - 15.50	CR-2		Core Recovery - 87% ; RQD - 77%									UCS - 360 kg/cm²							

NOTE: Type of Sample
SPT- Standard Penetration Test UDS- Un Disturbed Sample

APPENDIX-IV

CHEMICAL ANALYSIS OF SOIL & GROUND WATER

Illustrative Calculation of Bill Payment (Sample Calculation)

	Reference		Amount	Remarks
CONTRACT VALUE (for example)			**10,00,00,000**	
Mobilisation Advance (10% of PO Value)	**Note 1**		1,00,00,000	As per Section 13(2) of CGST Act, GST is payable on advance received. Contractor shall treat mobilisation advance as inclusive of GST and discharge tax liability accordingly.
Less: TDS u/s 194C @ 2% of Taxable Value			1,69,492	Taxable Value- Rs.84,74,576
GST TDS @2% of Taxable Value			1,69,492	Add: GST@18%-Rs.15,25,424 ---------- Total Advance- Rs.1,00,00,000
Net Mobilisation Advance payable			**96,61,016**	
RA BILL (for example)				
Basic invoice value- As per 52.6 of SCC			10,00,000	
GST@18%	**Note 2**		1,80,000	
Total Invoice Value (A)			**11,80,000**	
Less Deductions:-				
Recovery of Mobilisation Advance(15% of invoice value)		1,50,000		
GST TDS @2% on (Invoice Value less Mobilisation Advance Recovery)		17,000		
Income Tax TDS u/s 194 C @2% on (Invoice Value less Mobilisation Advance		17,000		
Labour Cess@1% (If applicable) on baisc invoice value		10,000		
Retention @5% on Basic invoice value		50,000		
Interest on Mobilisation advance@10%	**Note 3**	83,333		
Total Deductions (B)			**3,27,333**	
Net Payable against RA bill- C= (A-B)			**8,52,667**	
Less: Other Recoveries				
Mutually agreed damages for delay (MAD) as applicable	**Note 4**	xxxx		
Cost of materials issued/Electricity charges/hire charges if any		xxxx		
Any other statutory deductions/ recovery (as applicable)		xxxx		
Other Recoveries- Total- D			**(xxxx)**	
Final Amount Payable E = C-D			**=8,52,667-xxxx**	

Notes:

1. Mobilisation advance shall be paid in two instalments as detailed in the tender document
2. Payment towards GST portion of RA bills shall be released only after uploading of invoice details by the supplier/service provider and the same is reflected in the GSTR2B statement of the owner.
3. The interest on mobilization advance as shown above is calculated for an estimated period of one month. Interest shall be calculated @10% on the principal amount outstanding, for the period as applicable.
4. Mutually agreed damages for delay (MAD) to be calculated as per Clause 11 of the 'Special Conditions of the contract'
5. Please note that the above table is only an illustration of the pattern of RA bill payment. Owner is at liberty to make further changes in the above structure on account of changes in any statute/ internal policies/contract amendments etc
6. Contractor should submit utilisation certificate for full Mobilisation Advance received

CORRIGENDUM RELATED TO SITE CLEARANCE

Job No : 32771

Project Name: For Construction of New Horizontal Belt Filter & Associated Facilities in Phosphoric Acid Plant at FACT–CD on LSTK Basis

The time period for the work is 17 months from the zero date specified in the Work to Proceed Notice.

The site will be cleared and handed over for construction activities no later than 60 days from the Zero Date specified in the Work to Proceed Notice.