HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

(A Joint Venture of Government of Haryana and Ministry of Railways)

BID DOCUMENT
For

TPC-01: Third Party Consultancy for checking of Detailed Design and Drawings of Twin NATM and Cut & Cover Tunnels from Km 24.850 to Km 29.580 including associated structures and Third Party Consultant's association during construction of NATM and Cut & Cover Tunnels for Haryana Orbital Rail Corridor (HORC) Project in the State of Haryana.

Bid No	:	HORC/HRIDC/TPC-01/2023
Contract title	:	Third Party Consultancy for checking of Detailed Design of NATM and Cut & Cover Tunnels and associated structures for Haryana Orbital Rail Corridor (HORC).
Project	:	Haryana Orbital Rail Corridor Project
Employer	:	Haryana Orbital Rail Corporation Limited (HORCL)
Country	:	INDIA
Issued on	:	23.11.2023

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Section 1
Instructions to Consultants (ITC)

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Section 1: Instructions to Consultants (ITC)

A. General

1. Introduction and Scope of Bid

1.1. Haryana Rail Infrastructure Development Corporation Limited (HRIDC), invites National Competitive Bids (NCB) on behalf of Haryana Orbital Rail Corridor Limited (HORCL) hereinafter called “the Employer” to provide the services of “Third Party Consultancy for Detailed Design and Drawings of Twin NATM and Cut & Cover Tunnels from Km 24.850 to Km 29.580 including associated structures and Third Party Consultant’s association during construction of NATM and Cut & Cover Tunnels for HORC project in the State of Haryana”. The detailed Scope of the Services are specified in Section 5: Employer’s Requirements (Scope of Services) of this Bidding Document. Consultants must meet the Eligibility Criteria Specified in ITC Clause 4 and Section 3, EQC.

1.2. The Bid number is as specified in **BDS**.

1.3. Haryana Rail Infrastructure Development Corporation LTD (HRIDC) having its office at Plot No. 143, 5th Floor, RailTel Tower, Sector-44, Gurugram, Haryana-122003 has been appointed as the implementing agency of the HORC project by HORCL.

1.4. M/s RITES-SMEC Pty consortium have been appointed as the General Consultant (GC) for the HORC project.

1.5. Rail Vikas Nigam Limited (RVNL) have been appointed as the Contractor for the execution of the Works of twin NATM and Cut & Cover tunnels on EPC basis. The Time for Completion of the Works Contract by RVNL is 1460 days.

1.6. Throughout these Bidding Documents:

a) the term “in writing” means communicated in written form (e.g., by mail, e-mail, fax, including, if specified in the **BDS**, distributed or received through electronic-procurement system used by the Employer) with proof of receipt.

b) except where the context requires otherwise, words indicating the singular also include the plural and words indicating the plural also include the singular.

c) “day” means calendar day.

d) “The word “tender” is synonymous with “bid” or “proposal”, the word tenderer with “bidder” or “proposer” or “Consultant”, the words “tender documents” with “bidding documents” and “request for bids documents” with “request for proposal documents”, as applicable.”

2. Source of Funds

2.1 Unless otherwise specified in the BDS, the required funds will be provided by HORCL.

3. Corrupt Practices

3.1 The Employer requires that Consultants observe the highest standard of ethics during the procurement and execution of such contracts. In pursuance of this policy, the Employer

a) defines, for the purposes of this provision, the terms set forth below as follows:

(i) "coercive practice" means impairing or harming, or threatening to impair or harm, directly or indirectly, any party or the property of the party to influence improperly the actions of a party;

(ii) "collusive practice" means an arrangement between two or more parties designed to achieve an improper purpose, including to influence improperly the actions of another party;

(iii) "corrupt practice" means the offering, giving, receiving or soliciting, directly or indirectly, of anything of value to influence improperly the actions of another party;

(iv) "fraudulent practice" means any act or omission, including a misrepresentation, that knowingly or recklessly misleads, or attempts to mislead, a party to obtain a financial or other benefit or to avoid an obligation.

(v) "theft" means the misappropriation of property belonging to another party

b) will reject a bid for award if it determines that the Consultant recommended for award has, directly or through an agent, engaged in corrupt, fraudulent, collusive, or coercive practices in competing for the Contract; and

c) will sanction a party or its successor, including declaring ineligible, either indefinitely or for a stated period of time, to participate in Employer’s activities, if it at any time determines that the firm has, directly or through an agent, engaged in corrupt, fraudulent, collusive, or coercive practices in competing for, or in executing a contract of the Employer.

4. Eligible Consultants

4.1

a) Only firms that are Registered or Incorporated in India are eligible to take part in the above Bid.

b) The Consultant may be an Individual or a Partnership Firm or a Company registered under the relevant applicable laws.

c) In case of Foreign Company, it should be registered in India under relevant legislation or company shall have required approval / permissions from RBI/FEMA for carrying out business in India. The proof of registration/approval/permission should be enclosed.

4.2 Joint Venture (JV)/Consortium

Joint Venture/Consortium is NOT permitted to take Part in the above Bid.

4.3 A Consultant shall not have conflict of interest. All Consultants found to have a conflict of interest shall be disqualified. A Consultant may be considered to be in conflict of interest with one or more parties (i.e. Consultants participating in the Bid, the General Consultant (GC), HRIDC, HORCL and RVNL) in this bidding process, if, including but not limited to:

a) they have controlling shareholders in common; or

b) they receive or have received any direct or indirect subsidy from any of them; or

c) they have the same legal representative for purposes of this bid;or

d) they have a relationship with each other, directly or through common third parties, that puts them in a position to have access to information about or influence on the Bid of another Consultant, or

e) a consultant participates in more than one bid in this bidding process. Participation by a Consultant in more than one Bid shall result in the disqualification of all Bids in which the party is involved; or

f) It should be noted that the 'Consultant' shall not combine itself with those of a Construction contractor and designer of construction Contractor and shall furnish an undertaking to the effect that the 'Third Party Consultant' agrees to limit its role to that of a consultant and to disassociate itself, its associates/affiliates from work in any other capacity (including Biding relating to any goods or services for any part of the work) on this work other than that of consultant; or

g) If, in connection with the performance of the consulting services, any Consultant intends to borrow, hire temporarily, personnel from other consultants, the Consultant must include in their bid all relevant information about such personnel. In such case, the Bid will be acceptable only if those consultants disassociate themselves from this work (including Bidding relating to any goods or services for any other part of this work) other than that of consultant.

4.4 The Consultant shall be disqualified if:

a) The Consultant or any of its constituents has been blacklisted/ banned business dealings by any Government Department, Government Agency or public sector undertaking at any time, except in cases where such blacklisting/banning has been withdrawn by Competent Authority or ceased on the deadline for submission of the bid, for which satisfactory evidence is to be produced.

b) Any previous contract of the Consultant or any of its constituents had been terminated/rescinded for Consultant's failure by Haryana Rail Infrastructure Development Corporation Limited (HRIDC) during the period of last 2 years before the deadline for submission of bid;

Provided, however, there is no stay order or declaration by any Court against such termination or rescission of the Contract by the Haryana Rail Infrastructure Development

Corporation Limited.

c) The Consultant or any of its constituents has suffered bankruptcy/insolvency or it is in the process of winding-up or there is a case of insolvency pending before any Court on the deadline of submission of bid.

d) The Consultant is found ineligible by the Employer in accordance with ITC 3.

e) The Consultant or its constituent has been found by HRIDC to be poor performer in any earlier contract.

f) The Consultant or any of its constituent has been issued a show cause notice for poor performance/banning/blacklisting of business or order for suspension of business by Competent Authority of HRIDC. However, if the Consultant is exonerated of the default before completion of the technical evaluation of bids, his bid will be considered for evaluation.

g) The Consultant or any of its constituents have changed their name or created a new business entity as covered by the definition of "Allied Firm" * consequent to having been banned business dealings or suspended business dealings.

***Allied Firm:** All concerns which come within the sphere of effective influence of the banned/suspended firms shall be treated as allied firms. In determining this, the following factors may be taken into consideration:

(i) Whether the management is common;

(ii) Whether majority interest in the management is held by the Partners or Directors of the banned/suspended firm;

(iii) Whether substantial or majority shares are owned by the banned/suspended firm and by virtue of this, it has a controlling voice; and

(iv) The Consultant or its constituents is having more than 10 litigations cases in the last 05 years prior to deadline for submission of bids.

The Consultant shall submit an affidavit stating that they are not liable to be disqualified as per this sub clause using the **Form: PS-1** given in Section 4. Non submission of an affidavit by the Consultant shall result in summary rejection of his bid

5. Eligible Software and Services

Design calculations done to check the Contractor's design shall be submitted by the Third Party Consultant in MS-Excel for cross checking/verification by the Engineer. Input files of design software (licensed version) used shall also be submitted to the Engineer. The Consultant shall make latest licensed software available to the Engineer for facilitating design checking for the duration of the Contract.

B. Contents of Bidding Document

6. Sections of Bidding Document

6.1 The Bidding Document consists of following Sections indicated below and should be read in conjunction with any Addenda/Corrigenda issued in accordance with ITC 8.

Section 1: Instructions to Consultants (ITC)

Section 2: Bid Data Sheet (BDS)

Section 3: Evaluation and Qualification Criteria (EQC)

Section 4: Bidding Forms (BDF)

Section 5: Employer's Requirements (Scope of Services)

Section 6: Bid Drawings and Documents

Section 7: General Conditions of Contract (GCC)

Section 8: Special Conditions of Contract (SCC)

Section 9: Contract Forms (COF)

6.2 The Invitation for Bids (IFB) issued by the Employer shall be part of the Bidding Document.

6.3 The Employer is not responsible for the completeness of the Bidding Document and their Addenda/Corrigenda, if they were not obtained directly from the source stated by the Employer in the BDS.

6.4 The Consultant is expected to examine all instructions, forms, terms, and specifications in the Bidding Document. Failure to furnish all information or documentation required by the Bidding Document may result in the rejection of the Bid.

7. Clarification of Bidding Document, Site Visit, Pre-Bid Meeting

7.1 While all efforts have been made to avoid errors in the drafting of the Bidding Document, the Consultant is advised to check the same and seek clarifications within the period stated in **BDS**. No claim on account of any errors detected in the Bidding Document shall be entertained. A prospective Consultant requiring any clarification of the Bidding Document shall contact the Employer in writing at the Employer's address indicated in the **BDS**. The Employer will respond in writing to any request for clarification, provided that such request is received within schedule period sated in **BDS**. Should the Employer deem it necessary to amend the Bidding Document as a result of a request for clarification, it shall do so following the procedure under ITC 8 and ITC 22.2.

7.2 The Consultant is advised to visit and examine the site of Works and its surroundings and obtain for itself, on its own responsibility, all information that may be necessary for preparing the Bid and entering into a contract for consultancy services. The costs of visiting the Site shall be at the Consultant's own expense. No Site Visit will be arranged by the Employer.

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

7.4 The Consultant's designated representative is invited to attend a pre-bid meeting, if provided for in the **BDS**.

7.5 The Consultant is requested to submit any queries in writing, to reach the Employer as specified in **BDS**.

7.6 Minutes of the Pre-Bid Meeting, including the text of the queries raised, without identifying the source, and the responses given, together with any responses prepared after the meeting, will be uploaded on HRIDC website www.hridc.co.in . Any modification to the Bidding Document, that may become necessary as a result of the Pre-Bid Meeting, shall be made by the Employer exclusively through the issue of an addendum/Corrigendum pursuant to ITC 8.

7.7 Non-attendance at the Pre-Bid Meeting will not be a cause for disqualification of a consultant.

8 Amendment of Bidding Document

8.1 At any time prior to the deadline for submission of bids, the Employer may amend the Bidding Document by issuing addenda/Corrigenda.

8.2 Any addendum/Corrigendum issued shall be part of the Bidding Document and shall be communicated in writing as specified in the **BDS**. The onus is on the Consultants to see the addenda/Corrigenda.

8.3 To give prospective Consultants reasonable time in which to take an addendum/Corrigendum into account in preparing their bids, the Employer may, at its discretion, extend the deadline for the submission of bids, pursuant to ITC 22.2

C. Preparation of Bids

9 Cost of Bidding

9.1 The Consultant shall bear all costs associated with the preparation and submission of its Bid and the Employer shall not be responsible or liable for those costs, regardless of the conduct or outcome of the bidding process.

10 Language of Bid

10.1 The Bid, as well as all correspondence and documents relating bid exchanged by the Consultant and the Employer, shall be written in English language. Supporting documents and printed literature that are part of the Bid and provided in another language provided should be accompanied by an accurate translation of the relevant passages in English in which case, for purposes of interpretation of the Bid, such translation shall govern.

11 Documents Comprising the Bid

11.1 The Bid shall comprise two parts submitted simultaneously, one called the Technical Bid containing the documents listed in ITC 11.4 and the other the Financial Bid containing the documents listed in ITC 11.5.

The Consultant is not required to sign and submit entire Bid document issued by the Employer (i.e. Section 1, Section 2, Section 3, Section 4, Section 5, Section 6, Section 7, Section 8 and Section 9) with any Addenda/Corrigenda issued in accordance with ITC 8 in its submission on eProcurement portal. The master copy of Bid Document published on Procurement portal shall be available with HRIDC which shall be final and binding. The Consultant shall submit their Bid as mentioned in ITC 21.

11.2 Technical Bid shall be opened at the address, date and time specified in ITC Sub-Clause 25.1 for the Bids accompanied by an enforceable and compliant Bid security as per ITC Clause 19. The Technical Bid shall only be evaluated by the Employer. No amendments or changes to the Technical Bid are permitted after submission of Bids. The Financial Bid shall be evaluated in accordance with ITC 35.

11.3 Deleted.

11.4 The Consultant shall submit all the documents in its Technical Bid as per the Checklist (Form CL) given in Section 4: Bidding Forms.

11.5 The Consultant shall submit all the documents in its Financial Bid as per the Checklist (Form CL) given in Section 4: Bidding Forms.

12 Letter of Bid and Price Schedules

12.1 The Consultant shall submit the Letter of Technical Bid using the appropriate forms furnished in Section 4: Bidding Forms. These forms must be completed without any alterations to their format, text and no substitutes shall be accepted. All blank spaces shall be filled with the information requested.

12.2 The Consultant shall submit, as part of the Financial Bid, the Letter of Financial Bid, the Schedules including the completed Price Schedules uploaded on eProcurement portal.

13 Alternative Bids

13.1 Unless otherwise indicated in the **BDS**, alternative bids shall not be accepted.

13.2 When alternative times for completion are explicitly invited, a statement to that effect will be included in the **BDS**, as will the method of evaluating different periods for completion

14 Bid Prices

14.1 The prices shall quoted by the Consultant in the Financial Bid only.

14.2 In the Price Schedule, Consultant shall quote lumpsum price in Indian Rupees (INR) only.

14.3 The price to be quoted in the Financial Bid shall be the total price of the Bid.

14.4 All duties, taxes [including Goods and Service Taxes (GST)] and other levies payable by the Consultant under the Contract, or for any other cause, as on the Base Date (i.e. 28 days prior to the deadline for submission of bids) shall be included in the total Bid Price submitted by the Consultant.

15 Currencies of Bid and Payment

15.1 The currency of the Bid and the payment currency shall be INR only. The Consultant shall quote the entire lumpsum price in Indian Rupees (INR) only.

16 Documents Comprising the Technical Bid

16.1 The Consultant shall furnish a commitment in Letter of Technical Bid for deployment of Key Personnel as stipulated in Section 5: Employer's Requirements.

16.2 Documents stipulated in ITC 11.4

17 Documents Establishing the Qualifications of the Consultant

17.1 To establish Consultant eligibility in accordance with ITC 4, Tenderers shall complete the Letter of Technical Bid and Form PS-1.

17.2 To establish its qualifications to perform the Contract, the Consultant shall provide the information requested in the corresponding information sheets included in Section 4, Bidding Forms.

18 Period of Validity of Bids

18.1 Bids shall remain valid for a period of **90 days** after the bid submission deadline date prescribed by the Employer. A bid valid for a shorter period shall be rejected by the employer as non-responsive.

18.2 In exceptional circumstances, prior to the expiration of the Bid validity period, the Employer may request Consultants to extend the period of validity of their bids. The request and the responses shall be made in writing. A Consultant may refuse the request without forfeiting its Bid security. A Consultant granting the request shall not be required or permitted to modify its Bid.

19 Bid Security

19.1 Unless otherwise specified in the BDS, the Consultant shall furnish as part of its bid, a Bid Security in the amount of Indian Rupees as specified in the **BDS**. (No interest shall be payable by the Employer on the Bid Security Amount).

19.2 The Bid Security amount shall be paid as specified in the **BDS**.

19.3 Any bid not accompanied by an enforceable and compliant Bid Security shall be considered as non-responsive.

19.4 The Bid Security of unsuccessful Consultants shall be returned as promptly as possible upon the successful Consultant's furnishing of the Performance Security pursuant to ITC 41.

19.5 The Bid Security of the successful Consultant shall be returned as promptly as possible once the successful Consultant has signed the Contract and furnished the required Performance Security pursuant to ITC 41.

19.6 The Bid Security may be forfeited:

a) If a Consultant withdraws its Bid during the period of Bid validity specified by the Consultant on the Letter of Bids, except as provided in ITC 18.2 or

b) If a Consultant misrepresents or omits the facts in order to influence the procurement process;

c) If the successful Consultant fails to:

   (i) sign the Contract in accordance with ITC 40;

   (ii) furnish a Performance Security in accordance with ITC 41;

   (iii) accept the correction of its Bid Price pursuant to ITC 32.

20 Format and Signing of Bid

20.1 The Technical Bid (comprising of documents specified in ITC 11.4) and Financial Bid (comprising of documents specified in ITC 11.5) shall be submitted in accordance with the requirements of the Bid Documents as mentioned in ITC 21.1.

20.2 The Bid Document shall be signed by a person duly authorized to sign on behalf of the Consultant. This authorization shall consist of a written confirmation as specified below using Form ELI-1.2 given in Section 4, Bidding Forms. The name and position held by each person signing the authorization must be typed or printed below the signature. All pages of the Bid, except for un-amended printed literature, shall be signed or initialed by the person signing the Bid.

The written confirmation of authorization (POA) to sign on behalf of the Consultant shall consist of:

a) In case of Private/Public Companies or Limited Liability Partnership (LLP) firms, a Power of Attorney from the Director of the Company who has been authorized by the Board of Directors through resolution to sign on behalf of the Company. Copy of Board Resolution shall also be submitted.

b) In case of Proprietory Consultant, Notary certified copy of Proprietorship Affidavit.

c) In case of Partnership firms, Power of Attorney duly signed by all the Partners and Notary certified copy of the Partnership Deed.

d) In case of Limited Liability Partnership (LLP) firms, a Power of Attorney issued by the LLP in favour of the individual to sign the Bid on behalf of the LLP and create liability against the LLP.

20.3 Any interlineations, erasures, or overwriting shall be valid only if they are signed or initialed by the person signing the Bid.

20.4 If during technical evaluation stage, POA submitted by the Consultant is not found in the correct format, Employer will send written (Courier/email with PDF attachment) request to the Authorized Representative for rectification of POA in accordance with format prescribed in Section 4, Bidding Forms, specifying the deadline for receipt of POA in correct form. If a Consultant does not provide the Power of Attorney in correct form within the stated date and time set in the Employer’s request for correction of POA, its Bid is liable to be rejected.

D. Submission and Opening of Bids

21 Sealing and Marking of Bids

21.1 The Consultant shall upload their Bids online as specified in the **BDS.**

21.2 Bids sent telegraphically or through any other means of transmission except as mentioned above shall be treated as invalid and shall stand rejected.

21.3 Deleted.

22 Deadline for Submission of Bids

22.1 The Bid submission is through the eProcurement portal only as specified in ITC 21.1.

The Consultant shall submit its Bid before expiry of the date and time for Bid submission indicated in the **BDS**.

22.2 The Employer may, at its discretion, extend the deadline for the submission of Bids by amending the Bidding Document in accordance with ITC 8, in which case all rights and obligations of the Employer and Consultants previously subject to the deadline shall thereafter be subject to the deadline as extended.

23 Late Bids

23.1 Submission of Bids shall be closed on eProcurement portal on the date & time of submission as prescribed in ITC 22.1 after which no Bid can be uploaded.

24 Withdrawal, Substitution, and Modification of Bids

24.1 The Bidder may modify, substitute or withdraw its e-Bid after submission prior to the deadline for submission of Bids. For modification of e-Bid, Bidder has to detach its old Bid from eProcurement portal and upload/ resubmit digitally signed modified Bid. For withdrawal of a bid, Bidder has to click on withdrawal icon at eProcurement portal and can withdraw its e-Bid. Before withdrawal of a bid, it may specifically be noted that after withdrawal of a bid for any reason, Bidder cannot re-submit its e-Bid again.

24.2 No Bid may be withdrawn, substituted, or modified in the interval between the deadline for submission of Bids and the expiration of the period of Bid validity period specified on the Letter of Bid or any extension thereof.

25 Technical Bid Opening

25.1 The Employer shall conduct the electronic opening of Bids on e-Procurement portal on the date, time and place as specified in the **BDS.**

The opening of the Bids and subsequent details can be viewed by the Consultant by logging on the e-Procurement portal. Alternatively, any Consultant who wish to attend the Bid opening can be present during the opening. The Consultant’s Representatives who are present shall be requested to mark their attendance on the format available with the Employer.

25.2 “FINANCIAL BID” submitted online on eProcurement portal shall remain unopened in the eProcurement portal until the date and time of opening of Financial Bid. The date and time of the opening of the Financial Part will be notified to all the Consultants on eProcurement portal whose Bid is found to be substantially responsive and qualified in technical evaluation as specified in ITC 29.

25.3 At the time of opening of the Technical Bid, the following shall be read out and recorded:

a) the name of the Consultant;

b) the presence or absence of a Bid Security; and

c) any other details as the Employer may consider appropriate.

25.4 The Employer shall prepare a record of the opening of Technical Bid that shall include, as a minimum, the name of the Consultant, the presence or absence of Bid.

25.5 At the Bid opening the Employer shall neither discuss the merits of any Bid nor reject any

Bid.

E. Evaluation and Comparison of Bids

26 Confidentiality

26.1 Information relating to the examination, evaluation & comparison, qualification of Bids and recommendation of contract award, shall not be disclosed to Consultants or any other persons not officially concerned with such process until information on Contract award is communicated to all Consultants.

26.2 Any attempt by a Consultant to influence the Employer in the examination, evaluation & comparison and qualification of the Bids or Contract award decisions may result in the rejection of its Bid.

26.3 Notwithstanding ITC Sub-Clause 26.2, from the time of opening the Bid to the time of Contract award, if any Consultant wishes to contact the Employer on any matter related to the bidding process, it should do so in writing.

27 Clarification of Bids

27.1 To assist in the examination, evaluation & comparison and qualification of the Bids, the Employer may, at its discretion, ask any Consultant for a clarification of its Bid. Any clarification submitted by a Consultant that is not in response to a request by the Employer shall not be considered. The Employer's request for clarification and the response shall be in writing. No change in the prices or substance of the Bid shall be sought, offered, or permitted, except to confirm the correction of arithmetic errors discovered by the Employer in the evaluation of the Financial Bid, in accordance with ITC 32.

27.2 If a Consultant does not provide clarifications of its Bid by the date and time set in the Employer's request for clarification, their Bid shall be evaluated as per the available information in the submitted Bid.

28 Deviations, Reservations, and Omissions

28.1 During the evaluation of bids, the following definitions apply:

a) "Deviation" is a departure from the requirements specified in the Bidding Document;

b) "Reservation" is the setting of limiting conditions or withholding from complete acceptance of the requirements specified in the Bidding Document; and

c) "Omission" is the failure to submit part or all of the information or documentation required in the Bidding Document.

29 Determination of Responsiveness

29.1 The Employer's determination of a Bid's responsiveness is to be based on the contents of the Bid itself, as defined in ITC 11.

29.2 A substantially responsive bid is one that meets the requirements of the Bidding Document without material deviation, reservation, or omission.

A material deviation, reservation, or omission is one that,

a) if accepted, would:

  (i) affect in any substantial way the scope, quality, or performance of the Services specified in the Contract; or

  (ii) limit in any substantial way, inconsistent with the Bidding Document, the Employer's rights or the Consultant's obligations under the proposed Contract; or

b) if rectified, would unfairly affect the competitive position of other Consultants presenting substantially responsive bids.

29.3 The Employer shall examine the technical aspects of the Bid submitted in accordance with ITC 11, ITC 16 and ITC 17 in particular, to confirm that all requirements of Bid Document have been met without any material deviation or reservation or omission.

29.4 If a bid is not substantially responsive to the requirements of the Bidding Document, it shall be rejected by the Employer and may not subsequently be made responsive by correction of the material deviation, reservation, or omission.

30 Nonconformities, Errors, and Omissions

30.1 Provided that a bid is substantially responsive, the Employer may waive any nonconformities in the bid that do not constitute a material deviation, reservation or omission.

30.2 Provided that a bid is substantially responsive, the Employer may request that the Consultant submit the necessary information or documentation, within a reasonable period of time, to rectify nonmaterial nonconformities in the bid related to documentation requirements. Requesting information or documentation on such nonconformities shall not be related to any aspect of the price of the Bid. Failure of the Consultant to comply with the request may result in the rejection of its Bid.

31 Financial Bid Opening.

31.1 Following the completion of the evaluation of the Technical Bids of the Consultants, the Employer shall notify in writing those Consultants whose Technical Bids were considered non-responsive to the requirements of Bid Document or failed to meet the Qualification Criteria, advising them of the following information:

(a) the grounds on which Technical Bid of Consultant failed to meet the requirements of the Bid Document; and
(b) their "FINANCIAL BID" shall remain unopened on the eProcurement portal; and
(c) notify them of the date, time and location of the public opening of "FINANCIAL BID"

31.2 The Employer shall, simultaneously, notify in writing those Consultants whose Technical Bids have been evaluated as substantially responsive to the Bid Document and met all Qualifying Criteria, advising them of the following information:

(a) their technical Bid has been evaluated as substantially responsive to the requirement of Bid Document and met the Qualification Criteria;

(c) their "FINANCIAL BID" on eProcurement portal will be opened at the public opening of the Financial Bids; and

(d) notify them of the date, time and location of the public opening of the envelopes marked "FINANCIAL BID".

31.3 The "FINANCIAL BID" of Consultants who met the Qualification Criteria and whose Bids were evaluated as substantially responsive, will be opened on eProcurement portal. The Employer shall read out the names of each Consultants, and the total Tender prices, including any discounts and any other details as the Employer may consider appropriate.

31.4 The Employer shall neither discuss with Consultant's Representative present, if any, the merits of any Bid nor reject any "FINANCIAL Bid"

31.5 The Employer shall prepare a record of the Financial Bid opening that shall include, as a minimum:

(a) the name of the Consultant whose Financial Bid was opened; and

(b) the Bid price;

A copy of the record (i.e. summary of rates quoted) can be viewed by all Consultant's on eProcurement portal after opening of the Financial Bid.

32 Correction of Arithmetical Errors

32.1 Provided that the Bid is substantially responsive, the Employer shall correct arithmetical errors in the Financial Bid on the following basis:

a) if there is a discrepancy between words and figures, the amount in words shall prevail, unless the amount expressed in words is related to an arithmetic error, in which case the amount in figures shall prevail subject to (a) and (b) above.

32.2 If the Consultant that submitted the lowest evaluated bid does not accept the correction of errors, its bid shall be disqualified and its Bid Security shall be forfeited.

33 Conversion to Single Currency

33.1 For evaluation and comparison purposes the currency of the Bid Price shall be **Indian Rupees (INR) only** .

34 Purchase Preference

34.1 Purchase Preference shall not apply.

34.2 Domestic Preference shall not apply.

35 Evaluation of Financial Bids

35.1 The Employer shall evaluate Financial Bid of each Bid for which the Technical Bids have been determined to be substantially responsive.

35.2 To evaluate the Financial Bid, the Employer shall consider the following:

a) the Bid price;

b) price adjustment for correction of arithmetic errors inaccordance with ITC 32.1;

35.3 Price adjustment provisions of the Conditions of Contract, applied over the period of execution of the Contract, shall not be taken into account in bid evaluation.

36 Comparison of Bids

36.1 The Employer shall compare all substantially responsive bids to determine the lowest evaluated bid, in accordance with ITC 32, ITC 33, ITC 34 and ITC 35.

37 Employer’s Right to Accept Any Bid, and to Reject Any or All Bids

37.1 The Employer reserves the right to accept or reject any bid, and to annul the bidding process and reject all bids at any time prior to contract award, without thereby incurring any liability to Consultants. In case of annulment, Bid Securities, shall be returned to the Consultants as per HORC policies.

F. Award of Contract

38 Award Criteria

38.1 The Employer shall award the Contract to the Successful Consultant. The successful Consultant is the Consultant whose Bid is determined to be substantially responsive to the Bidding document and the lowest evaluated bid.

39 Letter of Acceptance (LOA)

39.1 Prior to the expiration of the period of Bid validity, the Employer shall notify the successful Consultant, in writing, that its Bid has been accepted through “Letter of Acceptance” (LOA). “Letter of Acceptance” shall specify the sum that the Employer will pay the Consultant in consideration of the of the Services (hereinafter and in the Conditions of Contract and Contract Forms called “the Contract Price”) and the requirement for the Consultant to remedy any defects therein as prescribed by the Contract.

39.2 Until a formal contract is prepared and executed, the “Letter of Acceptance” shall constitute a binding Contract.

40 Signing of Contract

40.1 Promptly after notification, the Employer shall send the successful Consultant the Contract Agreement.

40.2 The Parties shall sign a Contract Agreement within 35 days after the Consultant is issued the Letter of Acceptance and submission of Performance Security in accordance with the Bidding Document read with the Contract, unless the Conditions of Contract establish otherwise.

41 Performance Security

41.1 Within twenty-eight (28) days of the issue of Letter of Acceptance from the Employer, the successful Consultant shall furnish:

(a) The Performance Security in accordance with Sub-Clause 3.2 of Conditions of Contract, using for that purpose the Performance Security Form included in Section 9: Contract Forms, or another form acceptable to the Employer.

(b) Failure of the successful Consultant to submit the above-mentioned Performance Security or to sign the Contract Agreement shall constitute sufficient grounds for the annulment of the award and forfeiture of the Bid Security.

42 Procurement related Complaint

The procedures for making a Procurement related Complaint is specified below:

The procedures for making a Procurement related Complaint are as specified in the **BDS**.

43 Jurisdiction of Court

Jurisdiction of Court in case of dispute or differences arising on account of this Bid:
Any suit or application, arising out of any dispute or differences on account of this Bid shall be filed in court at Gurugram, Haryana.

****

Section 2

Bid Data Sheet (BDS)

Section 2: Bid Data Sheet

This section consists of provisions that are specific to each procurement and supplement the information or requirements included in Section:1-Instructions to Consultants.

A. Introduction

ITC 1.2	**Bid No: HORC/HRIDC/TPC-01/2023, dated: 23.11.2023**
ITC 1.6(a)	**Electronic – Procurement System** The Employer shall use the following electronic-procurement system to manage this Tendering process: **eProcurement portal of Govt. of Haryana (https://etenders.hry.nic.in)**

B. Bidding Documents

ITC 6.3	**Replace ITC 6.3 with the following:** The complete Bid Document can be viewed/ downloaded by the Tenderer from eProcurement portal of Govt. of Haryana https://etenders.hry.nic.in. The Employer is not responsible for the completeness of the Tender Document and their addenda/Corrigenda, if they were not obtained directly from eProcurement portal of Govt. of Haryana https://etenders.hry.nic.in .
ITC 7.1	For **Clarification of Bid purposes** only, the Employer's address is: **Attention:** Sh. Rajiv Ranjan Kumar **Designation:** Chief Project Manager/West **Street address:** Haryana Rail Infrastructure Development Corporation Limited (HRIDC), Plot no.143, Railtel Tower, Sector-44 **Floor:** 5th floor **City:** Gurugram **ZIP code:** 122003 **Country:** India **Telephone:** +91 9310812157 **E-mail:** horc.etendering@gmail.com Last date for seeking clarifications from the Employer shall be as specified in ITC 7.5.
ITC 7.4	**Replace the entire Sub-Clause 7.4 with the following:** There shall be no Pre-Tender Meeting.

ITC 7.5	The Consultant is requested to submit any queries in writing, to reach the Employer not later than **30.11.2023 by 1800 hrs IST**. No further queries shall be entertained by the employer beyond the period mentioned above. The prospective Consultants shall send their queries through email along with an editable soft copy (MS Word) of the queries raised by them on the email id (i.e. horc.etendering@gmail.com). The Consultant should use the following format for any Pre-Tender queries: The Consultants should use the following format for any Bid queries:

Query No.	Reference to Bid Document (Clause/ Para No. & Page No.)	Brief Description of Clause/ Para No.	Query Raised
1.			
2.			
3.			
4.			
5.			
etc.			

ITC 7.6	**Replace ITC 7.6 with the following:** Replies to Pre-Bid Queries including the text of the questions raised, without identifying the source, and the responses given, together with any responses prepared after the meeting, will be uploaded on will be uploaded on HRIDC website www.hridc.co.in. Any modification to the Bid Document that may in the sole discretion of the Employer become necessary as a result of the replies to Pre Bid queries shall be made by the Employer exclusively through the use of an Addendum/Corrigendum pursuant to ITC 8.
ITC 8.2	Any addendum/Corrigendum issued shall be part of the Bid Document and shall be uploaded on eProcurement portal, https://etenders.hry.nic.in.

C. Preparation of Bids

ITC 11.1	**Add the following to ITC 11.1:** The Consultant shall submit their Bid online on eProcurement portal (https://etenders.hry.nic.in) as mentioned in para ITC 21.

ITC 19.1	The Consultant shall furnish a Bid Security for an amount of **INR 2,25,000.00** (Indian Rupees Two lakhs and Twenty Five Thousand Only).
ITC 19.2	The amount for Bid Security will only be paid online by eligible Consultants on eProcurement Portal of Government of Haryana (https://etenders.hry.nic.in**)** in favour of Haryana Rail Infrastructure

	Development Corporation Limited using the electronic payment gateway service.

D. Submission and Opening of Bids

ITC 20.1	**Replace ITC 20.1 with the following:** The Technical Bid (comprising of documents specified in ITC 11.4) and Financial Bid (comprising of documents specified in ITC 11.5) shall be submitted online on eProcurement portal of Government of Haryana (https://etenders.hry.nic.in**)** only in accordance with the requirements of the Bid Documents.
ITC 21	**Replace ITC 21 with the following:** 21.1 Consultants shall upload their Bid submission online on eProcurement portal (i.e. https://etenders.hry.nic.in) within the stipulated date and time as mentioned in ITC 22.1. The Consultants shall ensure that they retain a copy of the receipt/ acknowledgement of their Bid submission which is generated by the system upon successful submission of Bid online. 21.2 Bids sent telegraphically or through any other means of transmission except as mentioned above shall be treated as invalid and shall stand rejected. 21.3 No details about Financial Bid shall be submitted/ disclosed directly or indirectly in the Technical Bid failing which the Employer has the right to reject the Bid. 21.4 **Instructions for Online Bid Submission** The Consultants are required to submit soft copies of their Bids electronically on the eProcurement portal of Government of Haryana i.e., https://etenders.hry.nic.in, using valid Digital Signature Certificates. The instructions given below are meant to assist the Consultants in registering on the eProcurement Portal, prepare their Bids in accordance with the requirements and submitting their Bids online on the eProcurement Portal. **Registration:** i) Consultants are required to enroll on the above-mentioned eProcurement portal by clicking on the link “**Online Bidder Enrollment**” on the Portal which is free of charge. ii) As part of the enrolment process, the Consultants will be required to choose a unique username and assign a password for their accounts. iii) Consultants are advised to register their valid email address and mobile numbers as part of the registration process. These would be used for any communication from the eProcurement Portal. **A. Obtaining a Digital Certificate:** **i.** The Bids submitted online should be encrypted and signed electronically with a Digital Certificate to establish the identity of the Consultant online. These Digital Certificates are issued by an

Approved Certifying Authority, by the Controller of Certifying Authorities, Government of India.

ii. A Digital Certificate is issued upon receipt of mandatory identity (i.e. Applicant’s PAN Card) and Address proofs and verification form duly attested by the Bank Manager / Postmaster / Gazetted Officer. Only upon the receipt of the required documents, a digital certificate can be issued. For more details please visit the website – https://etenders.hry.nic.in

iii. The Consultants may obtain Class-II or III digital signature certificate from any Certifying Authority or Sub-certifying Authority authorized by the Controller of Certifying Authorities or may obtain information, application format and documents required for the issue of digital certificate.

iv. The Consultant must ensure that he/she comply by the online available important guidelines at the portal https://etenders.hry.nic.in for Digital Signature Certificate (DSC) including the e-Token carrying DSCs.

For any queries related to e-tendering process (registration, online e-bid submission/withdrawal, uploading of documents), Consultant may contact the below representative of NIC:

Mr. Anuj Mahajan
E - mail: amahajan@nic.in, eprocnichry@yahoo.com
Help Desk: 0120-4001002, 0120-4200462, 0120-4001005, 0120-6277787, 0172-2700275.

v. Bid for a particular bid must be submitted online using the digital certificate (Encryption & Signing), which is used to encrypt and sign the data during the stage of Bid preparation. In case, during the process of a particular Bid, the user loses his digital certificate (due to virus attack, hardware problem, operating system or any other problem) he will not be able to submit the Bid online.

Hence, the users are advised **to keep a backup of the certificate** and also keep the copies at safe place under proper security (for its use in case of emergencies).

vi. In case of online Bidding, if the digital certificate issued to the authorized user of a firm is used for signing and submitting a Bid, it will be considered equivalent to a no-objection certificate/power of attorney/lawful authorization to that User only for accessing eProcurement portal for online Bid submission on the portal. The firm has to authorize a specific individual through an authorization certificate signed by all partners to use the digital certificate as per Indian Information Technology Act 2000. Unless the certificates are revoked, it will be assumed to represent adequate authority of the user to Bid on behalf of the firm in the department bids as per Information Technology Act 2000. The digital signature of this authorized user will be binding on the firm.

vii. In case of any change in the authorization, it shall be the responsibility of management/ partners of the firm to inform the certifying authority about the change and to obtain the digital signatures of the new person/ user on behalf of the firm/ company. The procedure for application of a digital certificate however will remain the same for the new user.

viii. The same procedure holds true for the authorized users in a private/Public limited company. In this case, the authorization certificate will have to be signed by the directors of the company.

B. Purchase of Bid Document - Online

Bid Document can be downloaded free of cost from the eProcurement portal https://etenders.hry.nic.in . However, Consultants are required to pay **INR 10,000.00** including GST as cost of Bid Document online on eProcurement portal prior to submission of their Bid.

C. Pre-requisites for online Bidding:

In order to operate on the electronic Bid management system, a user's machine is required to be set up. A help file on system setup/Pre-requisite can be obtained from National Informatics Center or downloaded from the home page of the website - https://etenders.hry.nic.in the link for downloading required java applet & DC setup are also available on the Home page of the eProcurement Portal.

D. Online Viewing of Invitation for Bids (IFB):

The Consultants can view the IFB and the time schedule (Key Dates) through the single portal eProcurement system on the Home Page at https://etenders.hry.nic.in

E. Downloading of Bid Documents:

The detailed Bid Document can be downloaded free of cost from the eProcurement portal https://etenders.hry.nic.in from **23.11.2023 (17:00 Hrs. IST) to 19.12.2023 (15:00 Hrs. IST.)**

F. Key Dates:

The Consultants are strictly advised to follow dates and times as indicated in the online Invitation for Bids. The date and time shall be binding on all Consultants. All online activities are time tracked and the system enforces time locks that ensure that no activity or transaction can take place outside the start and end dates and the time of the stage as defined in the online Invitation for Bids.

G. Online Payment of E-Service Fee & Tender Security:

The online payment for E-Service Fee and Tender Security in INR shall

	be made using the secure electronic payment gateway by Consultants online directly through Debit Cards & Internet Banking accounts. The secure electronic payments gateway is an online interface between Contractors and Debit card/online payment authorization networks. For online payments guidelines, please refer to the Home page under tab "**Guidelines for hassle free Bid Submission**" of the eProcurement Portal of Government of Haryana, https://etenders.hry.nic.in H. **Preparation & Submission of online Applications/Bids:** a) Tender shall mandatorily be submitted online following the instruction appearing on the screen. b) **Scan copy of Documents to be submitted/uploaded for Technical Part under online PQQ/ Technical Envelope:** All documents shall be prepared and scanned in file formats PDF /JPEG/MS WORD format such that file size does not exceed 10 MB) and uploaded during the online submission of PQQ or Technical Envelope. **c) FINANCIAL Bid (MS-Excel File for quoting price and Pdf file for Letter of Financial Bid, Preamble, Price Schedule) shall be submitted mandatorily online under Commercial Envelope and original not to be submitted manually.** ***NOTES:*** ***(A) Consultants participating in online Bids shall check the validity of his/her Digital Signature Certificate before participating in the online Bids at the portal*** https://etenders.hry.nic.in**.** ***(B) For help manual, please refer to the 'Home Page' of the*** **eProcurement** ***website at*** https://etenders.hry.nic.in.
ITC 22.1	**The start date for Bid submission is:** **Date: 12.12.2023** Time: 1100 hrs IST **The deadline for Bid submission is:** **Date: 19.12.2023** **Time: 1500 hrs IST**
ITC 24.1	**Replace ITC 24.1 with the following:** The Consultant may modify, substitute or withdraw its e-Bid after submission prior to the deadline for submission of Bids. For modification

	of e-Bid, Consultant has to detach its old Bid from eProcurement portal (https://etenders.hry.nic.in) and upload/ resubmit digitally signed modified tender. For withdrawal of Bid, Consultant has to click on withdrawal icon at eProcurement portal and can withdraw its e-Bid. Before withdrawal of a Bid, it may specifically be noted that after withdrawal of a Bid for any reason, Consultant cannot re-submit e-Bid again.
ITC 25.1	Haryana Rail Infrastructure Development Corporation Limited (HRIDC), Plot No.143, RailTel Tower, Sector-44. **Floor/ Room Number:** 5th floor **City:** Gurugram **Zip code:** 122003 **Country:** INDIA Date: **19.12.2023** Time: **1530 hrs. IST**

F. Award of Contract	
ITC 42	Consultant may make a Complaint in writing, to: **For the attention**: Sh. Rajiv Ranjan Kumar **Title/position**: Chief Project Manager/West **Employer**: Haryana Orbital Rail Corporation Limited (HORCL) **Email address:** horc.etendering@gmail.com

Section 3

Evaluation & Qualification Criteria (EQC)

Contents

SECTION 3

EVALUATION AND QUALIFICATION CRITERIA (EQC)

1. General Provisions

1.1 Evaluation Sequence

(a) Bids will be evaluated through the following three stages:

(i) Stage 1: Evaluation of Administrative Requirements

(ii) Stage 2: Evaluation of Qualification Requirements

(iii) Stage 3: Financial Evaluation

1.2 Clarification of Bids

The Employer may request clarification of any Bid in accordance with the provisions of the Bid Documents (Part 1, Section-I: Instructions to Consultant, Clause 27).

1.3 Bidding Forms

(a) Consultants should note that the information required to be inserted into the Bidding Forms shall be comprehensive and detailed. The technical information shall be furnished in line with the requirements of the Bid Documents.

(b) All Forms contained in the Bid Documents must be fully and properly completed and all the forms must be returned, as they will be reviewed exactly as submitted and errors or omissions may count against the Consultant.

(c) Any Consultant who is found to have intentionally submitted false or inaccurate statements/information shall be disqualified from the Biding process.

1.4 Joint venture/Consortium

Joint venture/Consortium is **not permitted** to participate in this Bid.

2. Stage 1: Evaluation of Administrative Requirements

(a) The Stage 1 Evaluation will consist of checking the Bids to confirm whether they are substantially responsive to the administrative requirements of the Biding Documents.

(b) The following items will be checked:

  (i) Whether the Technical Bid submission is in accordance with ITC 11.4

  (ii) Whether the Power of Attorney (POA) for the Authorized signatory is in the correct form [Ref. ITC 20.3 and ITC 20.4]. If during technical evaluation stage, POA submitted by the Consultant is not found in the correct format, Employer will send written (Courier/email with PDF attachment) request to the Authorized Representative for rectification of POA in accordance with format prescribed in Section 4, Bidding Forms, specifying the deadline for receipt of Power of Attorney in correct form. If a consultant does not provide the Power of Attorney in correct form within the stated date and time set in the Employer's request for correction of Power of Attorney, its Bid is liable to be rejected.

3. Stage 2: Evaluation of Qualification Requirements

3.1 Eligibility

No.	Subject	Requirement	Documents Submission Requirements
3.1.1	**Nationality**	Nationality in accordance with ITC Sub-Clause 4.1	Form ELI-1.1
3.1.2	**Conflict of Interest**	No Conflict of interest in accordance with ITC Sub-Clause 4.3	Letter of Technical Bid
3.1.3	**Disqualification of Bidder**	Not Disqualified under Clause 4.4 of ITC.	Form PS-1

3.2 Financial Situation and Performance

No.	Subject	Requirement	Documents Submission Requirements
3.2.1	**Historical Financial Performance**	The Consultant must demonstrate the current soundness of the Consultant's financial position and indicate its prospective long-term profitability. a) Minimum Average Net Worth (Total Assets -Total Liabilities) during the last three (03) financial years 2020-21, 2021-22 and 2022-23 shall be **positive**, and **b)** Net Worth (Total Assets - Total Liabilities) during the last financial year 2022-23 shall be **positive**.	Form FIN – 1
3.2.2	**Average Annual Consultancy Turnover**	Minimum average annual Consultancy turnover must be **INR 56 lacs** calculated as total certified payments received for contracts in progress or completed within the last three financial years i.e. (2020-21, 2021-22 and 2022-23).	Form FIN – 2

3.3 Specific Consultancy Experience

No.	Subject	Requirement	Documents Submission requirements
3.3.1	**Specific Consultancy Experience**	The Consultant must have successfully/substantially completed any of the following during last 10 (ten) years ending last day of month previous to the one in which Bid is invited: (i) One "Similar work" costing not less than the amount equal to **INR 85.00 lacs**. The above work must involve design/proof checking of minimum **1.0 km** length of tunnel by New Austrian Tunnelling Method (NATM) or **1 (one)** building by NATM. **OR** (ii) Two "Similar works" each costing not less than the amount equal to **INR 56.00 lacs**. Both the above works combined together must involve design/proof checking of minimum **1.0 km** length of tunnel by New Austrian Tunnelling Method (NATM) **or 1 (one)** building by NATM. **Where,** (a) **'Similar Work'** means "Design/Proof checking of tunnel/building by New Austrian Tunnelling Method (NATM)" in Rail/Road projects. (b) **'Substantial completion'** shall be based on 80% or more of the original value of works completed under the contract.	Form EXP - 1

Notes:

1. ***Exchange Rate for Qualification Criteria***

Wherever a Form in Section 4, Bidding Forms, requires a Consultant to state a monetary amount, Consultant shall indicate the INR equivalent as indicated in the respective form using the rate of exchange determined as follows:

(i) For Consultancy turnover or financial data required for each year – Exchange rate prevailing on the last day of the respective financial year.

(ii) Value of single contract - Exchange rate prevailing on the date of the Contract Award i.e. the date of issue of Letter of Acceptance.

(ii) *Exchange rates shall be taken from reference rate published by the Reserve Bank of India (RBI) on its website https://www.rbi.org.in. In case the exchange rate of particular currency on given date is not available on RBI web site, it will be as per the web site https://www.fbil.org.in of Financial Benchmark India Private Limited (FBIL). Any error in determining the exchange rates may be corrected by the Employer. In the case, where a Consultant is required to convert a monetary amount from a currency other than those currencies for which the RBI/FBIL reference rate is not published, the INR equivalent shall be worked out using the rate of exchange as published by the central bank of the country issuing the said currency. In case the exchange rate of that currency is not directly available in INR on the website of the central bank of the country issuing the said currency then the currency will be first converted to USD as per that web site and then converted from USD to INR as Per RBI or FBIL reference rates.*

4. Stage 3: Financial Evaluation

The activities in this Stage 3 will be in two (2) parts.

A. Evaluation of Compliance and Responsiveness

(a) Under this Stage the following items will be checked:

(i) Whether the Letter of Financial Bid is compliant (i.e. does not include any alteration to the basic terms and does not constitute an alternative offer).

(ii) Whether all Forms and Price Schedules (words and figures) have not been altered and are correctly completed and signed.

B. Detailed Financial Evaluation

After passing the above requirements, the Bid will then proceed for Financial Part evaluation in accordance with ITC 35.

C. Award of Contract

Consultant with the lowest Bid price from above shall move to next stage as per ITC "F. Award of Contract".

Section 4

Bidding Forms (BDF)

Table of Contents

Letter of Technical Bid

Date: ……………………….

Bid No.: HORC/HRIDC/TPC-01/2023

To:

Chief Project Manager/West,
Haryana Rail Infrastructure Development Corporation Limited (HRIDC),
Plot no.143, 5th floor, RailTel Tower, Sector-44
Gurugram – 122003
Tel: +91 9310812157
We, the undersigned, declare that:

We have examined and have no reservations to the Bidding Document, including Addenda/Corrigenda issued in accordance with Instructions to Consultants (ITC) 8;

(a) We offer to provide the services in conformity with the Bidding Document;

(b) Our Bid shall be valid for a period of **90 days** after the date fixed for the bid submission deadline in accordance with the Bidding Document, and it shall remain binding upon us and may be accepted at any time before the expiration of that period;

(c) If our bid is accepted, we commit to submit a Performance Security in accordance with the Bidding Document;

(d) If our bid is accepted, we commit to deploy Consultant's Representative, Key Personnel and other personnel consistent with the requirements stipulated Section 5: Employer's Requirements of Bidding Document;

(e) We, including any subcontractors or suppliers for any part of the Contract, do not have any conflict of interest in accordance with ITC 4.3;

(f) We are not participating, as a Consultant, in more than one bid in this bidding process in accordance with ITC 4.3.;

(g) We declare that we are not liable to be disqualified in accordance with ITC 4.4, and we are enclosing the affidavit for the same as per the FORM PS-1 given in Section 4: Bidding Forms.

(h) We understand that this bid, together with your written acceptance thereof included in your notification of award (Letter of Acceptance), shall constitute a binding contract between us, until a formal contract is prepared and executed; and

(i) We have not made any deviations from the requirement of the Bidding Document and we have also not made any tampering or changes in the Bidding Document on which the bid is being submitted and if any tampering or changes are detected at any stage, we understand the bid will invite summary rejection and forfeiture of Bid Security/the contract will be liable to be terminated along with forfeiture of Performance Security, even if LOA has been issued.

(j) We declare and certify that we have not made any misleading or false representation in the forms, statements and attachments in proof of the qualification requirements.

(k) We declare that the information and documents submitted along with the Bid by us are correct and we are fully responsible for the correctness of the information and documents, submitted by us.

(l) [Select the appropriate option and delete whichever is not applicable]

[We declare and certify that financial data as per the balance sheets for last three financial years including that for the latest concluded financial year are being submitted]

OR

[We declare and certify that balance sheet for the latest concluded financial year has not been finalized till date and that is why we are furnishing financial data for last three financial years ignoring the latest concluded financial year.]

(m) We agree to limit our role to that of a Consultant and to disassociate ourselves, our associates/affiliates from work in any other capacity (including Bidding relating to any goods or services for any part of the Works) on this work other than that of Consultant.

(n) We understand that you are not bound to accept the Bid with lowest Bid price or any other bid that you may receive.

(o) We certify that we are not associated with the Contractor of C-4 Package as Detailed Design Consultant (DDC) or in any other way.

(p) We declare that in case the Third Party Consultancy is awarded to us, we will not associate in the DDC or in any other capacity with Contractor of C-4 Package.

Name of the Consultant:

....

Name of the person duly authorized to sign the Bid on the behalf of the Consultant:

In the capacity of

....

Signature of the person named above

....

Date Signed ....

Company stamp: ……………..…..

FORM: PS- 1

Format for affidavit to be submitted by Consultant along with the Bid

(Ref. Sub-Clause: ITC 4.4)

*(To be executed in presence of Public Notary on non-judicial stamp paper of INR 100. The stamp paper has to be in the name of the Consultant)***

I ……. ***(Name and designation) **……*** appointed as the attorney/authorized signatory of the Consultant (including its constituents), M/s._(hereinafter called the Consultant) for the purpose of the Bid for " **TPC-01**: Third Party Consultancy for checking of Detailed Design and Drawings of Twin NATM and Cut & Cover Tunnels from Km 24.850 to Km 29.580 including associated structures and Third Party Consultant's association during construction of NATM and Cut & Cover Tunnels for Haryana Orbital Rail Corridor (HORC) Project in the State of Haryana" as per the Bid No.: HORC/HRIDC/TPC-01/2023 of HRIDC, do hereby solemnly affirm and state on behalf of the Consultant including its constituents as under:

*1. That the Consultant or any of its constituents has not been Blacklisted/ banned for business dealings for all Government Departments or by Ministry of Railways or by HRIDC at any time and / or no such blacklisting is in force as on the deadline for submission of bids.

*2. That none of the previous contracts of the Consultant or any of its constituents had been terminated/rescinded for Consultant's failure by HRIDC during the period of last 2 years before the deadline for submission of bids.

3. That the Consultant or any of its constituents is neither Bankrupt/Insolvent nor is in the process of winding-up nor such a case is pending before any Court on the deadline of submission of the bid.

4. That the name of the Consultant or any of its constituents is not on the list of "Poor Performer" of HRIDC as on the deadline for submission of bid.

5. We declare that the Consultants or any of its constituents have not either changed their name or created a new business entity as covered by the definition of "Allied Firm" defined under ITC 4.4, consequent to having been banned business dealings for specified period which is not over or suspended business dealings or having been declared as poor performer.

6. We declare and certify that we have not made any misleading or false

representation in the forms, statements and attachments in proof of the qualification requirements.

7. We declare that the information and documents submitted along with the Bid by us are correct and we are fully responsible for the correctness of the information and documents, submitted by us.

8. We understand that in case we cease to fulfil the requirements of qualifying and eligibility criteria at any time after opening of bids and till finalization of bids, it will be our bounden duty to inform the Employer of our changed status immediately and in case of our failure to do so, our bid shall be rejected and Bid Security shall be forfeited. We shall also be liable for banning of business dealings upto a period of five years.

9. We understand that if the contents of the affidavit are found to be false at any stage during bid evaluation, it will lead to rejection of our bid and forfeiture of the Bid Security. Further, we [insert name of the Consultant]** and all our constituents understand that we shall be liable for banning of business dealings upto a period of five years.

10. We also understand that if the contents of the affidavit are found to be false at any time after the award of the contract it will lead to termination of the contract, forfeiture of Bid Security and/or Performance Security and banning of business dealings for a period of upto five years.

Verification:

Verified on__________________________day of _____ at_________that the contents of the above mentioned affidavit is true and correct and nothing material has been concealed there from.

SEAL AND SIGNATURE OF THE CONSULTANT

**Modify the contents wherever necessary, in terms of sub-clause 4.4 ITC.*

*** The contents in Italics are only for guidance purpose and details as appropriate, are to be filled in suitably by Consultant.*

Attestation before Magistrate/Public Notary.

Consultant’s Qualification

To establish its qualifications to perform the Contract, the Consultant shall provide the information requested in the corresponding Information Sheets included hereunder.

Form ELI – 1.1:

Consultant’s Information Form

(Ref. Sub-Clause: ITC 4.1)

Date: __________________
Bid No. and title: __________________
Page__________of ________________pages

Consultant’s name
Consultant’s actual or intended country of registration: *[indicate country of Constitution]*
Consultant’s actual or intended year of incorporation:
Consultant’s legal address [in country of registration]:
Consultant’s legal address for Communication:
Consultant’s authorized representative information Name: ______________________________________ Address: _____________________________________ Telephone/Fax numbers: ________________________ Mobile number: ________________________________ E-mail address: ________________________________
1. Attached are copies of original documents of ☐ Articles of Incorporation (or equivalent documents of constitution or association), and/or documents of registration of the legal entity named above, in accordance with ITC 4.1. 2. Authorization to represent the firm named in above, in accordance with ITC 20.2.

SIGNATURE OF AUTHORIZED SIGNATORY
ON BEHALF OF CONSULTANT

Company stamp: ……………..…..

Form: ELI - 1.2

Format for Power of Attorney for Authorised Signatory of Consultant

(Ref. Sub-Clause: ITC 20.2)

POWER OF ATTORNEY*

(*To be executed on non-judicial stamp paper of the appropriate value in accordance with relevant stamp Act. The stamp paper to be in the name of the company who is issuing the Power of Attorney*)

Know all men by these presents, we…..……………….. (name and address of the registered office) do hereby constitute, appoint and authorise Mr/Ms.………………….. (name and residential address) who is presently employed with us and holding the position of …………………………..as our attorney, to do in our name and on our behalf, all such acts, deeds and things necessary in connection with or incidental to our Bid for "**TPC-01**: Third Party Consultancy for checking of Detailed Design and Drawings of Twin NATM and Cut & Cover Tunnels from Km 24.850 to Km 29.580 including associated structures and Third Party Consultant's association during construction of NATM and Cut & Cover Tunnels for Haryana Orbital Rail Corridor (HORC) Project in the State of Haryana", including signing and submission of all documents and providing information/ responses to Haryana Rail Infrastructure Development Corporation Ltd (HRIDC), representing us in all matters before HRIDC, and generally dealing with HRIDC in all matters in connection with our Bid for the said project.

We hereby agree to ratify all acts, deeds and things lawfully done by our said attorney pursuant to this Power of Attorney and that all acts, deeds and things done by our aforesaid attorney shall and shall always be deemed to have been done by us.

…………………………………. (Signature)

(Name, Title and address) of the **Person Accepting the POA.**

…………………………………. (Signature)

(Name, Title and address) of the **Person issuing the POA**

Notes:

i. The Consultant should submit the notarised Power of Attorney.
ii. The mode of execution of the Power of Attorney should be in accordance with the procedure, if any, laid down by the applicable law and the charter documents of the executant(s) and when it is so required the same should be under common seal affixed in accordance with the required procedure.

iii. The Consultant should submit following additional document in support of the POA as case to case basis:

a) Notary certified copy of Proprietorship Affidavit in case of Proprietary Consultant.
b) Notary certified copy of Partnership Deed in case of Partnership Firms.
c) Board Resolution in case of a Public/Private limited company/LLP.
d) Incorporation Certificate and Memorandum & Article of Association in case of a Public/Private limited company.
e) Incorporation Certificate and Limited Liability Membership Agreement in case of Limited Liability Membership firms.

Form FIN-1

Financial Situation and Performance

[Ref. ITC Sub-Clause 17.2 & EQC Sub-Clause 3.2.1]
[The following table shall be filled in for the Consultant]

Bid No.: HORC/HRIDC/TPC-01/2023

Consultant's Name: ________________

Page _______________of ______________pages

(All amounts in Lacs)

Type of Financial information	**Historic information for Financial Years, (Amount in INR)**		
	Year 1: 2020-21	**Year 2: 2021-22**	**Year 3: 2022-23**
	Statement of Financial Position (Information from Balance Sheet)		
Total Assets (TA)			
Total Liabilities (TL)			
Total Equity/Net Worth (NW) = TA-TL			

Notes:

1. *(i) In case, the Financial Year is the same as the Calendar Year, the turnover for the year 2020, 2021 and 2022 shall be furnished.*
2. *(ii) The Consultant is not required to submit any document as documentary evidence along with the Tender Documents. All information furnished in this Form shall be certified by a Chartered Accountant/Company Auditor/Statutory Auditor.*
3. *(iii) The Form duly certified by a Chartered Accountant/Company Auditor/Statutory Auditor shall also be signed by Consultant's Authorized representative.*
4. *(iv) The above documents shall reflect the financial situation of the legal entity or entities comprising the Consultant and not the Consultant's parent companies, subsidiaries, or affiliates.*
5. *(v) In the event that the audited accounts for the latest concluded Financial Year are not available, the Consultant shall furnish information pertaining to the last three financial years after ignoring the latest concluded financial year. In case, the Consultant submits audited financial information for the last four or more years, only the figures for the latest three years shall be considered for evaluation.*

(vi) *In case audited balance sheet of the last financial year is not available with the Consultant, he will declare the same vide item (I) prescribed in the Letter of Technical Bid.*

(vii) *If the value of Net Worth is not submitted for any of the last three years, the Tender shall be considered nonresponsive and shall be summarily rejected.*

Consultant's Authorized Representative

Signature: ……………………..
Date: ……………………..……..
Company stamp: ……………..…..

Chartered Accountant/Company Auditor/Statutory Auditor

Certified that the information furnished above is correct as per the audited balance sheets of the entity.

Signature: ………………………..
Name:
Position:
Date:
Company:
Company stamp:
Membership No:
Address:
Contact No:
Email ID:

Form FIN-2

Average Annual Consultancy Turnover

[Ref. ITC Sub-Clause 17.2 & EQC Sub-Clause 3.2.2]

[The following table shall be filled in for the Consultant]

Bid No.: HORC/HRIDC/TPC-01/2023

Consultant's Name: ________________

Page _______________of ______________pages

(All amounts in Lacs)

Annual Turnover Data for the Last Three (03) Financial Years (Consultancy Only)			
Year	**Amount Currency**	***Exchange Rate**	**INR Equivalent**
2020-21	*[insert amount and indicate currency]*		
2021-22			
2022-23			
Average Annual Consultancy Turnover			

Notes:

(i) *In case, the Financial Year is the same as the Calendar Year, the turnover for the year 2020, 2021 and 2022 shall be furnished.*

(ii) *The Average Annual Consultancy Turnover shall be calculated by adding the turnover amount of last three financial years divided by three.*

(iii) *The Consultant is not required to submit any document as documentary evidence along with the Tender Documents. All information furnished in this Form shall be certified by a Chartered Accountant/Company Auditor/Statutory Auditor.*

(iv) *The Form duly certified by a Chartered Accountant/Company Auditor/Statutory Auditor shall also be signed by Consultant's Authorized representative.*

(v) *The above documents shall reflect the financial situation of the legal entity or entities comprising the Consultant and not the Consultant's parent companies, subsidiaries, or affiliates.*

(vi) *In the event that the audited accounts for the latest concluded Financial Year are not available, the Consultant shall furnish information pertaining to the last three financial years after ignoring the latest concluded financial year. In case, the Consultant submits audited financial information for the last four or more years, only the figures for the latest three years shall be considered for evaluation.*

(vii) *In case audited balance sheet of the last financial year is not available with the Consultant, he will declare the same vide item (I) prescribed in the Letter of Technical Bid.*

(viii) *If the value of Annual Consultancy Turnover is not submitted for any of the last three years prescribed in Financial Data, the Bid shall be evaluated by considering "NIL" Turnover for that year(s).*

Consultant's Authorized Representative

Signature: ……………………..
Date: …………………..……..
Company stamp: ……………..…..

Chartered Accountant/Company Auditor/Statutory Auditor

Certified that the information furnished above is correct as per the audited balance sheets of the entity.

Signature: ………………………..
Name:
Position:
Date:
Company:
Company stamp:
Membership No:
Address:
Contact No:
Email ID:

Form EXP-1

Specific Consultancy Experience

[Ref. ITC Sub-Clause 17.2 and EQC Sub-Clause 3.3.1]

[The following table shall be filled in for the Consultant]

Bid No.: HORC/HRIDC/TPC-01/2023

Consultant's Name: ________________

Page _______________of ______________pages

Similar Contract No.	**Information**		
Contract Identification			
Award date			
Completion date			
Role in Contract as Design Consultant OR Proof Checking Consultant	*[insert the role in Contract]*		
Total Contract Amount	*[insert Contract amount(s) and currency(ies)]*		INR [insert *exchange rate and total Contract amount in INR equivalent]
If member in a JV, specify participation in total Contract amount	*[insert Percentage participation]*	*[insert amount(s) and currency) of participation]*	*INR [insert exchange rate(i) and amount of participation in INR equivalent]*
Employer's Name			
Address: Mobile: Telephone/fax number: E-mail:			
Description of the similarity in accordance with Sub-Clause 4.5.1 of Section 1:			
1. Amount (in INR)			
2. Length of NATM tunnel designed/proof checked (Km) **OR**			
3. No. of Buildings designed/proof checked by NATM			

Consultant's Authorized Representative

Signature: ……………………….
Date: …………………………….
Company stamp: ………………

Notes:

(i) Value of completed work done by a Consultant in an earlier JV shall be reckoned only to the extent of the Consultant's share in that JV for purpose of satisfying their experience criteria mentioned in Sub-Clause 3.3.1 of Section 3, EQC.

(ii) The Consultant shall submit copy of Completion Certificate issued by the Employer / Concessionaire as documentary proof clearly indicating the similarity of the work as per Sub-Clause 3.3.1 of Section 3, EQC, actual completion cost, actual completion date. Bids submitted without this documentary proof shall not be evaluated.

Bid Security

The amount for Bid Security will only be paid online by eligible Tenderers on eProcurement Portal of Government of Haryana (https://etenders.hry.nic.in).

FORM CL

Checklist of submission of Documents/Forms online, duly filled

(Reference to ITC 11.4 & 11.5)

Bid No: HORC/HRIDC/TPC-01/2023

Name of Work:

A. TECHNICAL BID

S. No.	Requirement of Bid Document	Ref. Clause of Bid Document	Consultant's Name:	
			Whether submitted (Yes/No/NA)	Ref. Pg. No. in the Technical Bid
1.	Letter of Technical Bid	ITC 11.4 and Section 4		
2.	Technical Bid signed by authorized representative of Consultant	ITC 20.2		
3.	Bid Security/Online Bid Security payment Receipt (copy of online payment receipt on ePortal)	ITC 19.1		
4.	Cost of Bid Document (copy of online payment receipt on ePortal)			
5.	Form PS-1: Affidavit to be submitted by Consultant	ITC 4.4 and Section 4		
6.	Form ELI – 1.1: Consultant's Information Form	ITC 4.1 and Section 4		
7.	Form ELI-1.2: Power of Attorney (POA) for submitting Bid	ITC 20.2 and Section 4		
8.	Board Resolution in case of a Public/Private limited company/LLP	ITC 20.2 and Form ELI 1.2		
9.	Incorporation Certificate and Memorandum and Articles of Association (MOA & AOA) (in case of Private/Public Limited Company)	Note (iii) (d) of Form ELI 1.2		
10.	Incorporation Certificate and Limited Liability Membership Agreement in case of Limited Liability Membership firms.	Note (iii) (e) of Form ELI 1.2		
11.	Notarised Copy of Proprietorship Affidavit (in case the Consultant is Proprietorship Consultant)	Note (iii) (a) of Form ELI 1.2		
12.	Notarised copy of Partnership Deed (in case the Consultant is Partnership Firm)	Note (iii) (b) of Form ELI 1.2		
13.	Form FIN-1: Financial Situation and Performance	ITC 17.2 and EQC 3.2.1		

S. No.	Requirement of Bid Document	Ref. Clause of Bid Document	Consultant's Name:	
			Whether submitted (Yes/No/NA)	Ref. Pg. No. in the Technical Bid
14.	Form FIN-2: Average Annual Consultancy Turnover	ITC 17.2 and EQC 3.2.2		
15.	Form EXP-1: Specific Consultancy Experience	ITC 17.2 and EQC 3.3.1		

Notes:

(i) **The check list is indicative and not exhaustive. The Consultant must go through the complete Bid documents and submit the required document accordingly.**

(ii) **If any of the above form or criteria is not applicable to the Consultant, then they can simply indicate N.A. against the relevant column**

B. FINANCIAL BID

The Financial Bid is provided in the Bid Document. The lumpsum price shall be quoted at the prescribed place in the Price Schedule (MS-Excel Sheet) provided with the Bid Document. These prices should include all costs associated with the contract including GST. The lumpsum price shall not be offered/quoted elsewhere in the Technical Bid submission/Bid submission. The Consultant shall download the MS-EXCEL file and after quoting their Contract Price, upload the completed MS-EXCEL file along with duly signed PDF documents of Financial Bid mentioned in (a) below on eProcurement portal. The quoted Contract Price shall not be offered/quoted elsewhere in the Technical Bid submission/ Tender submission. These prices shall include all costs associated with the contract including GST. The Consultant shall complete the Financial Bid in accordance with the instructions given in the Financial Bid.

a) Following duly signed documents are required to be submitted by the Consultant in their Financial Bid**:**

(i) Letter of Financial Bid,
(ii) Preamble,
(iii) Cost Centres for lump sum cost of services under Price Schedule,
(iv) Stage of payments for Cost Centres and
(v) Price Schedule with quoted lumpsum Price (MS-Excel File)

I hereby confirm that:

(i) I have checked the above list with our submittal. I am also aware that if our Bid is not containing the above documents, the Employer has the right to reject our Bid.

(ii) All the pages of Bid submission are properly signed, indexed and numbered.

Seal:

Date:

(Signature of Authorized Representative of the Consultant)

Letter of Financial Bid

Date: ……………….

Bid No.: HORC/HRIDC/TPC-01/2023.

To:
Chief Project Manager/West,
Haryana Rail Infrastructure Development Corporation Limited (HRIDC),
Plot no.143, 5th floor,
Railtel Tower, Sector-44
Gurugram – 122003
Tel: +91 9310812157

We, the undersigned, declare that:

(i) We have examined and have no reservations to the Bidding Document, including Addenda/Corrigenda issued in accordance with Instructions to Consultants (ITC) 8.

(ii) We offer to provide the Services in conformity with the Bidding Document.

(iii) Our bid shall be valid for a period of **90 days** after the date fixed for the bid submission deadline in accordance with the Bidding Documents, and it shall remain binding upon us and may be accepted at any time before the expiration of that period.

(iv) The total price of our Bid is INR ……………………………………………………………………………

(v) We understand that this bid, together with your written acceptance Letter of Acceptance (LOA) thereof included in your notification of award, shall constitute a binding contract between us, until a formal contract is prepared and executed; and

(vi) We have not made any deviations from the requirement of the bidding document and we have also not made any tampering or changes in the bidding documents on which the bid is being submitted and if any tampering or changes are detected at any stage, we understand the bid will invite summary rejection and forfeiture of Bid Security/the contract will be liable to be terminated along with forfeiture of performance security, even if LOA has been issued.

(vii) We understand that you are not bound to accept the bid with lowest bid price or any other bid that you may receive.

Name of the Consultant:

....

Name of the person duly authorized to sign the Bid on the behalf of the Consultant:

In the capacity of

....

Signature of the person named above

....

Date Signed ....

PREAMBLE

1. The Price Schedule shall be read in conjunction with the Instructions to Consultants, Conditions of Contract, Employer’s Requirements (Scope of Work, Design Basis Report, Specifications and Drawings), Addendum/Corrigendum and any other document forming part of Bid Document.

2. The Contract is to be carried out on a fixed lumpsum price basis in which payment to the Consultant will be made in accordance with payment stages unless otherwise specified in the Contract.

3. The Schedules and Schedules of stage payments may not generally give a full description of the designs to be checked under each item. Consultant shall be deemed to have read the Employer’s Requirements and the other sections of the Bidding Document and reviewed the Drawings to ascertain the full scope of the work included in each item prior to filling the rates and prices.

4. The rates and prices quoted in the Price Schedule shall include all costs associated with the assignment. These normally cover all checking of design and drawings, remuneration for staff (foreign and local, in the field and at headquarters), accommodation (per diem, housing), include all checking of design, Consultant’s equipment, transportation, mobilization, demobilization of equipment, machinery, tools & plants, labour, supervision, materials; and equipment (vehicles, office equipment, furniture and supplies), printing of documents, surveys, remedy of any defects during the Defects Notification Period etc., Consultant’s profit, all taxes including GST, insurance, royalties, duties, cess, octroi, other levies and other charges together with all general risks, liabilities and obligations set out or implied in the Contract

5. The Consultant will be free to avail input tax credits under GST as per the prevailing rules and input tax credit shall be deemed to have been considered in the Quoted Price in the Price Schedules.

6. The Consultant should quote lumpsum price in Indian Rupees (INR) only.

7. The whole cost of complying with the provisions of the Contract shall be included in the items provided in the Price Schedule, and where related items is not part of Schedule but can be identified commonly as a part of professional grade work of a comparative nature, the cost shall be deemed to be included in the lumpsum price entered against the Schedules.

8. To the extent acceptable to the Employer for the purpose of making payments or partial payments, valuing variations or evaluating claims, or for such other purposes as the Employer may reasonably require, the Consultant may provide the Employer with a breakdown of any composite or lump sum items included in the Schedules.

9. The Employer shall make interim payments to the Consultant in accordance with the provisions of the General Conditions of Contract and as certified by the Engineer on the proportionate basis of the progress achieved for the items of works/stages of the works vis-à-vis the total scope of the work in each item.

10. Format for the Consultant’s application for payment shall be agreed between the Engineer and the Consultant.

11. The Consultant shall prepare his application for payment in the agreed format in four hard copies and one soft copy. All hard copies shall bear the original signatures of the Consultant’s Representative and be submitted to the Engineer.

12. If these are found in order, then the Engineer shall forward two certified copies of the application along with certified supplementary details to the Employer, with his recommendation for payment.

13. Fee against ‘Part-A’ of scope of Services i.e. “Third Party checking of Detailed Design and drawings of Twin NATM and Cut & Cover Tunnels from km 24.850 to km 29.580 including associated structures” shall be paid on the completion of sub cost-centre.

14. Consultant’s association during execution of works i.e. ‘Part-B’ of scope of work shall be paid quarterly on pro rata basis. First quarter shall start after the completion of design period (Part-A) or 6 month from the date of issue of LOA whichever comes earlier.

15. The price quoted shall be adjusted only as per Clause 19 of Section 7, GCC during the period of completion of the work.

Signature of the Consultant

Company Stamp

1 Price Schedule:

1.1. Breakup of lump sum cost of services under various cost centres shall be as follows:

Cost Centre		**Weightage percentage (%) of the quoted lump sum cost, LS***	**No. of Milestones**	**Total cost of each Cost Centre**
1	**2**	**3**	**4**	**5**
P	Third Party Checking	70	9	P= 0.70xLS*
C	Consultant's Association during construction	30	Payment to be made as per Sub-Clause 1.1.2	P= 0.30xLS*

LS*: Total lumpsum cost of Services.

The percentage figures as filled in column (3) by the Employer for the approximation of the contract price for completion of the services corresponding to various cost centers are fixed and payment will be released for different cost centers as per above percentage breakup of contract price.

1.1.1. Stage of payment i.e. Milestone of Cost centre 'P' Third Party Checking

Weightages of Various Milestones for Payment under Cost centre, P- Third Party Checking

Milestone	Item of Work	Description of Milestone	Weightage (X)
1	2	3	4
P1	Third Party checking of design & drawings of Cut & Cover Tunnel submitted by the C-4 Contractor	Third Party checking and approval of final design & Good for Construction (GFC) drawings submitted by the C-4 Contractor	13
P2	Third Party checking of design & drawings of NATM Tunnel (Soil) submitted by the C-4 Contractor	Third Party checking and approval of final design & Good for Construction (GFC) drawings submitted by the C-4 Contractor	20
P3	Third Party checking of design & drawings of NATM Tunnel (Rock) submitted by the C-4 Contractor	Third Party checking and approval of final design & Good for Construction (GFC) drawings submitted by the C-4 Contractor	15
P4	Third Party checking of design & drawings of permanent ventilation shafts and other associated structures submitted by the C-4 Contractor	Third Party checking and approval of final design & Good for Construction (GFC) drawings submitted by the C-4 Contractor	10
P5	Third Party checking of design & drawings of construction cum utility shaft and other associated structures including cross passages submitted by the C-4 Contractor	Third Party checking and approval of final design & Good for Construction (GFC) drawings submitted by the C-4 Contractor	10
P6	Third Party checking of design & drawings of cross passages along the length including fire stop doors submitted by the C-4 Contractor	Third Party checking and approval of final design & Good for Construction (GFC) drawings submitted by the C-4 Contractor	10
P7	Third Party checking of design & drawings of Portal P-2 including	Third Party checking and approval of final design & Good	7

Milestone	**Item of Work**	**Description of Milestone**	**Weightage (X)**
1	**2**	**3**	**4**
	drainage arrangement submitted by the C-4 Contractor	for Construction (GFC) drawings submitted by the C-4 Contractor	
P8	Third Party checking of design & drawings of Portal P-1 including slope stability of rock, boulder fall and protection arrangements submitted by the C-4 Contractor	Third Party checking and approval of final design & Good for Construction (GFC) drawings submitted by the C-4 Contractor	8
P9	Third Party checking of design & drawings of drainage arrangement near portal P-1 and its integration with drainage system of DFC submitted by the C-4 Contractor.	Third Party checking and approval of final design & Good for Construction (GFC) drawings submitted by the C-4 Contractor	7
Total Weightages of Sub Cost Centre "P1" to "P9"			**100%**

Note:

1. The value of each Milestone will be 70% of total lump sum accepted cost of services for Schedule 'A' (LS) multiplied by X.

   For example, the value of Milestone P1 will be =0.7xLSxX=0.7x LSx0.13.

3. Payment will be made on completion of each Milestones as per weightage defined.

1.1.2. Payment for cost centre ‘C’ (Consultant Association during Construction)

Consultant’s association during execution of works (Part-B of Completion Period) shall be paid quarterly on pro rata basis.

If additional visits beyond 48 visits are required as per instructions of the Engineer/Employer, each visit shall be paid @ half the lumpsum quoted price of the Consultant multiplied by 0.3 and divided by 48 (i.e., 0.5 x Lump sum Quoted Price x 0.3/ 48).

Sample Price Schedule for Quoting lumpsum rates
(Please refer MS-Excel Sheet for quoting Lumpsum Price)

Tender Inviting Authority: Haryana Rail Infrastructure Development Corporation Ltd

Name of Work: Third Party Consultancy for checking of Detailed Design and Drawings of Twin NATM and Cut & Cover Tunnels from Km 24.850 to Km 29.580 including associated structures and Third Party Consultant's association during construction of NATM and Cut & Cover Tunnels for Haryana Orbital Rail Corridor (HORC) Project in the State of Haryana.

Contract No: HORC/HRIDC/TPC-01/2023

Name of the Bidder/ Bidding Firm / Company :						
PRICE SCHEDULE **(This BOQ template must not be modified/replaced by the bidder and the same should be uploaded after filling the rele[illegible]se the bidder is liable to be rejected for this tender. Bidders are allowed to enter the Bidder Name and V[illegible]**						
NUMBER #	**TEXT #**	**NUMBER #**	**TEXT #**	**NUMBER**[illegible]	[illegible]**ER #**	**TEXT #**
Sl. No.	**Item Description**	**Quantity**	**Units**	**BASI**[illegible] **in** [illegible] **P**	[illegible]**AL AMOUNT With Taxes in Rs. P**	**TOTAL AMOUNT In Words**
1	**2**	[illegible]	[illegible]	**13**	**54**	**55**
1.01	Third Party Consultancy for checking of Detailed Design and Drawings of Twin NATM and Cut & Cover Tunne[illegible] from Km 24.850 to Km 29.580 including associa[illegible] structures and Third Party Consultant's asso[illegible] construction of NATM and Cut & Cover [illegible] Haryana Orbital Rail Corridor (HOR[illegible] State of Haryana		[illegible]umpsum		**0.00**	INR Zero Only
Total in Figures					**0.00**	INR Zero Only
Quoted Rate in Words		**INR Zero Only**				

▭ **Consultant is only required to fill the information in the boxes highlighted with cyan colour in Price Schedule (Excel sheet)*

Section 5

Employer’s Requirements
(Scope of Services)

Contents

Section 5: Employer's Requirements

1. Project Profile and Background

The state of Haryana is strategically located bordering the National capital of Delhi. NCT, Delhi shares three fourth of its border with Haryana alone and remaining with Uttar Pradesh. The development of the Haryana region, bordering Delhi is very important for balanced growth of NCR as it acts as buffer zone against rampant migration and other support infrastructure. At present on account of growth of Metro network in Delhi & NCR, there is radial movement of commuters to and from, Delhi being in centre. This "Hub and Spoke" traffic planning has resulted in rapid growth of Noida, Greater Noida, Faridabad and Gurugram. However, for hub and spoke concept to sustain it is necessary to link the ends of spoke by ring connectivity. There will be natural demand for commuter movement within these towns like Gurugram, Faridabad, Ballabhgarh, Palwal, Sohna, Manesar etc. Peripheral roads have been commissioned recently, linking these towns around Delhi but Rail link provides economical, sustainable, eco-friendly, and bulk freight transport option. The peripheral Rail link will also help in growth of other cities within the same distance from Delhi like Sonipat, Panipat, and Rohtak. This will also help in easing the pressure on the transport network of Delhi as some of the commuter traffic moving on the radials will get shifted to HORC. Western DFC originating from Dadri station passes through Asaoti Station on Delhi- Mathura route, providing connectivity to Haryana Orbital Rail Corridor (HORC).

Apart from passenger traffic, a substantial amount of freight traffic, which is entering the Delhi area of rail network but is not meant to be consumed in Delhi, will also get diverted via this corridor. Apart from this, there are major goods sheds in the heart of Delhi causing endless avoidable traffic jams. The goods sheds in west Delhi are Azadpur, Shakurbasti, Dayabasti, Sabzi Mandi which are located on prime commercial land and are black spots of the urban planning. Previously moving out commercial activity to other states had interstate taxation issues but now with GST in place, there is no reason for not shifting these activities to the peripheral region. In any case, if freight traffic movement through Delhi is restricted, then these goods sheds or alternatives will be serviced via the proposed HORC.

Haryana Orbital Rail Corridor (HORC) from Palwal to Sonipat Via Sohna, Manesar, Kharkhoda and Harsana Kalan is to be constructed as an Electrified (2X25 kV AC-50Hz) double line track, capable of operating at a maximum train speed of 160 kmph.

2. Objective of Services

HORC project crosses Aravalli Range between Sohna and Dhulawat stations through a tunnel, to be constructed in C-4 Package from Ch.24850 m to Ch.29580 m. The tunnelling is required to be done in rock as well as in soil. It involves tunnelling by NATM method and Cut & Cover method. Two separate tunnels are to be constructed - **one for the UP Line and one for Down Line.** The tunnel is to be provided with Ballastless track (BLT). NATM work is proposed to be carried out from fourteen faces as shown in Bid drawings. The tunnel has got four permanent ventilation shafts and one construction cum utility shaft.

The objective of the services is to ensure safe design of the tunnel, shafts and other related structures fulfilling all the functional requirements and proper commissioning of the works by the EPC tunnel Contractor (including without limitation, the design, installation, and removal of the Temporary Works) with minimum life cycle cost and maintenance. In full recognition of these objectives, and with full acceptance of the obligations, liabilities and risks which may be involved, the Third Party Checking Consultant shall undertake the checking of design of the Works.

The Services to be provided under this contract is of Third Party checking of the detailed design and drawing of tunnel and other associated structures submitted by the EPC tunnel Contractor and association of the Third Party Checking consultant during construction of civil works of tunnel.

Preliminary site information as available with the Employer are given in Section 6, Bid Drawings and Documents for only general appreciation of the Works. All site data and other information considered in the design of the work, shall be provided by EPC tunnel Contractor.

The Third Party Consultant shall ensure that the Permanent Works are designed and constructed to the highest standards available using proven up-to-date good Engineering practices. The construction procedures established by the Contractor shall be reviewed by the Third Party Consultant and Quality Assurance and Quality Control plan shall be approved by the Third Party Consultant.

3. Scope of Services

The scope of the Services is divided in two parts: -

- **Part-A:** Third Party Consultancy for verification of Detailed design and drawings (including construction methodology) of Tunnel and other associated structures
- **Part-B:** Third Party Consultant’s association during execution of the Works

Part-A:

3.1 Third Part Consultancy for verification of Detailed Design & drawings (including construction methodology) of Twin Tunnel and associated structures involves the following, but not limited to:

3.1.1 Third Part Consultancy for design & drawings of Cut & Cover Tunnels from Ch. 28480 m to Ch. 29580 m including drainage arrangements for catering to surface run off from open cutting of about 1340 m length as shown in Bid drawings.

3.1.2 Third Part Consultancy for design & drawing of NATM twin Tunnels from Ch. 24850 m to Ch. 28480 for UP line and Ch. 24853 m to Ch. 28480 m for DN line in all types of strata (rock and soil) including drainage arrangements for catering to surface run off from open cutting as shown in Bid drawings.

3.1.3 Third Part Consultancy for design & drawing of four (02x02) Nos. of permanent ventilation shafts and other associated structures including roofing system and stairs as specified in Bid drawings.

3.1.4 Third Part Consultancy for design & drawing of one (01) No. construction cum utility shaft and other associated structures including roofing system and stairs area. Cross passage between two tunnels at the location of construction cum utility shaft as shown in Bid drawings.

3.1.5 Third Part Consultancy for design & drawing of cross passages between the two tubes along the length including fire stop doors at both ends as shown in the Tender drawings.

3.1.6 Third Part Consultancy for design & drawing of Portal P-2 for both UP & DN lines including drainage arrangement at the interface of Portal P2 and Cut & Cover tunnel for catering to surface runoff from the cutting.

3.1.7 Third Part Consultancy for design & drawing of Portal P-1 for both UP & DN lines including slope stability of rock, boulder fall and protection arrangements.

3.1.8 Third Part Consultancy for design & drawing of drainage system at Palwal end approach of Portal P-1 for both UP & DN lines for disposal of storm water coming out of the tunnel and from adjoining open area and integrating the drainage system with the drainage scheme of DFC.

3.1.9 Third Part Consultancy for the design and drawings of the construction methodology of all the above structures and temporary structures.

The construction methodology shall include all safety precautions during construction and shall be adequate to ensure safety of DFC viaduct and its safety during construction (especially during blasting operations and rock cutting) near proposed Portal P-1.

3.2 TASKS TO BE PERFORMED

The broad tasks/activities to be performed by the Third Part Consultancy for Consultant in the Contract are as follows:

3.2.1 Study/Review of the data like topographical survey, lithological survey, Geotechnical data, GIR and Design Basis Note

(i) EPC tunnel Contractor shall conduct detailed Geotechnical & Geological investigations and prepare Geotechnical interpretative report (GIR). Third Part Consultant shall review the reports of various investigations conducted by EPC tunnel Contractor and shall ensure that required investigations have been conducted in sufficient details and parameters used in the designs are reasonably selected.

(ii) Third Party Consultant shall review the design basis note, design quality assurance plan & any other technical documents submitted by the EPC tunnel Contractor.

3.2.2 Approval of Preliminary Design and drawings

Drawings of tunnel and other structures shall be prepared by the EPC tunnel Contractor based on preliminary design and feasible – construction methodology and submitted to the Third Party Consultant along with the preliminary design calculations and drawings. This needs to be reviewed and finally approved by the Third Party Consultant. The Third Party Consultant shall attend any meeting/presentation/joint site visit with the Engineer/the Contractor’s designer, as per the requirement. Any meeting or site visit will be deemed to be inclusive in the Scope of Work and nothing extra shall be paid on this account.

3.2.3 Detailed Design and Drawings

The Third Party Consultant shall review the detail design and drawings submitted by the Contractor’s designer and convey his comments for incorporating in the final design and Good for Construction drawings. However, the Third Party Consultant shall also carry out independent Design checks of the tunnel and other structures. A copy of all correspondence/clarifications between Third Party Consultant and design consultant of EPC tunnel contractor shall be marked to the Engineer and the Employer for information.

Design calculations done to check the Contractor's design shall be submitted by the Third Party Consultant in MS-Excel for cross checking/verification by the Engineer. Input files of design software (licensed version) used shall also be submitted to the Engineer. The Consultant shall make latest licensed software available to the Engineer for facilitating design checking for the duration of the Contract.

All the designs and drawings shall be approved by the Third Party Consultant within three weeks after submission of design documents by the EPC Contractor.

It is anticipated that approval of all the major design works, submitted by the EPC Contractor, including investigation for tunnel works shall be completed within six months duration. However, any design or drawing submitted by the EPC Contractor after six months duration shall also be approved within three weeks of its submission.

Part-B:

4. Consultant's Association During Execution

The Consultant shall be associated during construction with the Engineer and shall offer support/guidance on Detailed Designs & Drawings during execution of the Works. The Consultant shall provide necessary design support and technical assistance during the construction stages for successful and timely completion of the works.

In cases of change in site conditions, site constraints or the Employer's /stakeholder's requirements during execution, the Contractor's designer will provide amended/revised/modified designs and drawings. The Consultant shall visit site as per the requirement & approve the modified design & drawings.

The Consultant can extend/provide these services from their home office. However, the Consultant (Team leader and Key Personnel as per requirement) will be required to visit project area minimum once in a month (i.e., 48 times in the period of 4 years) as decided by Engineer/Employer. For each visit designer(s) may have to spend more than one day as per the requirement at the site and as directed by the Engineer. The actual date of visit may be decided by the Engineer/Employer as per the site requirements in consultation with the Consultant. The cost of visits shall be in-built in the lump sum rate quoted by the Consultant. Any additional unavoidable site visit, if required, will be paid as per Sub-Clause 1.1.2 of the Price Schedule, Section 2.

5. Duration of work

Total Consultancy assignment duration of this project shall be 48 months from the Effective Date. The Contract for Package C-4 has already been awarded. Out of 48 months, first 6 months (approx) will be the design phase. However, the Third Party Consultant shall also be associated during the construction phase for support during construction.

In case the project completion is extended beyond a period of 48 months and if association of the Third Party Consultant is considered necessary, payment will be made for each additional month beyond 48 months, as per pro rata basis based on the rate quoted for 48 months.

6. Consultant's Representative and Key Personnel

6.1 The Consultant shall deploy suitably qualified Consultant's Representative and suitably qualified Key Personnel as described in the table below.

Table-1: Consultant's Representative and Key Personnel

S. No.	Designation	Qualification	Experience
1.	Consultant's Representative /Team Leader	Graduate in Civil Engineering	Graduate degree in Civil Engineering having experience not less than 10 years and would have handled minimum 02 projects involving design/proof checking of tunnel by NATM as Team Leader.
2.	Tunnel Design Expert (NATM)	Graduate in Civil Engineering	Graduate degree in Civil Engineering with total experience of 08 years and minimum 4 years of relevant experience in design/proof checking of tunnel or underground metro stations by NATM.
3.	Tunnel Design Expert (Cut & Cover)	Graduate in Civil Engineering	Graduate degree in Civil Engineering with total experience of 08 years and minimum 4 years of relevant experience in design/proof checking of Cut & Cover tunnel or Cut & Cover metro stations.
4.	Geologist	Master's degree in Geology	Minimum total experience of 08 years out of which minimum 04 years in tunnel projects.
5.	Geotechnical Engineer	Graduate in Civil Engineering	Minimum total experience of 08 years out of which minimum 04 years in infrastructure projects

6.2 Before deployment of Consultant's Representative and the Key Personnel, the Engineer's approval shall be obtained by the Consultant. The Consultant shall require the Engineer's consent to substitute or replace the Consultant's Representative (reference Conditions of Contract Clause 8, 9 and 10 and notes below).

6.3 Relaxation in qualifications/Experience can be given by the Engineer in exceptional cases where candidates have got high level of professional competency. The decision of the Engineer in such cases shall be final and binding.

6.4 The performance of Key Personnel deployed will be monitored by the Engineer during the Contract period. In case the performance of any of the Consultant's Personnel is not satisfactory, the Consultant shall replace them with good personnel immediately as per directions of the Engineer.

6.5 Notwithstanding the above, the substitution of Key Personnel during Contract execution may be considered only based on the Consultant's written request and due to circumstances outside the reasonable control of the Consultant, including but not limited to death or medical incapacity. In such case, the Consultant shall forthwith provide as a replacement, a person of equivalent or better qualifications and experience, meet eligibility requirements.

6.6 The associated non-key personnel, if required any, shall be considered by the consultants in their estimation.

6.7 The above Key Personnel shall be required for full duration during checking of the design of the tunnel and other related structures. During the construction stage, the Third Party Consultants are required to provide necessary support and to visit site along with experts (if needed as per site requirement) every month or as per requirement whichever is less. However, maximum site visits shall be limited to 14 in a year.

Section 6
Bid Drawings and Documents

A- Bid Drawings
B- Documents

Section 6
A: Bid Drawings
List of Drawings

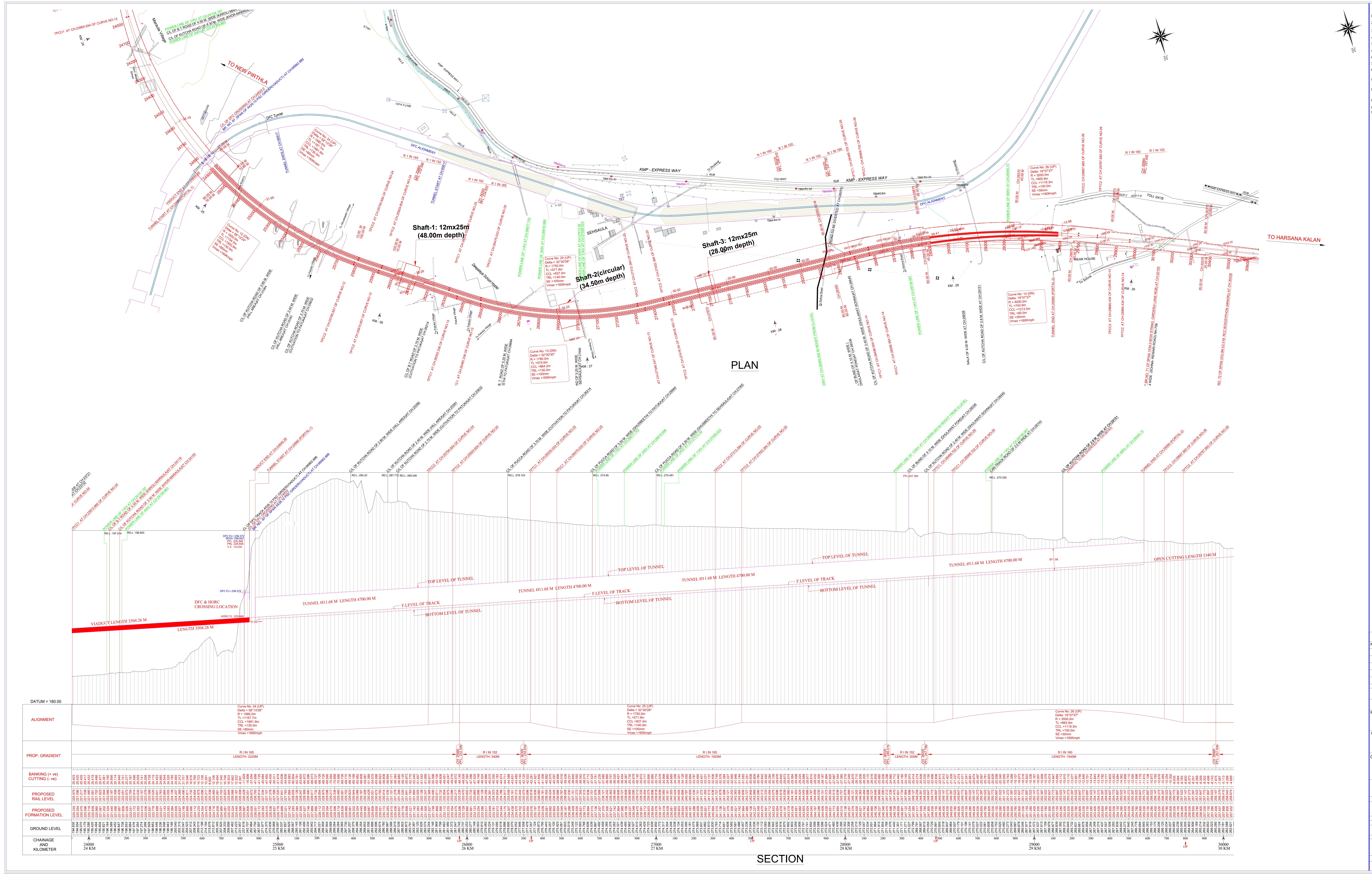
S. No	TITLE	DRAWING NO.
1	**ALIGNMENT PLAN & L-SECTION:**	
1.	Conceptual plan and longitudinal section from chainage 24.0KM to chainage 30.0KM (tunnel)	GC-HRIDC-ALL-DRW-ALN-P&P-24-30KM_A1
2	**TUNNEL**	
1.	Conceptual drawing for Single track tunnel cross section (Rock)	GC-HRIDC-C4-DRW-TTL-CLT-01001_A1
2.	Conceptual drawing for Single track tunnel cross section (Soil)	GC-HRIDC-C4-DRW-TTL-CLT-01002_A1
3.	Conceptual drawing for Support class III from CH: 24940 to CH: 26000	GC-HRIDC-C4-DRW-TTL-CLT-01003_A0
4.	Conceptual drawing for Support class IV from CH: 24880 to CH: 24940	GC-HRIDC-C4-DRW-TTL-CLT-01004_A0
5.	Conceptual drawing for Support class VI (i) from CH: 26000 to CH: 28420	GC-HRIDC-C4-DRW-TTL-CLT-01005_A0
6.	Conceptual drawing for Support class VI(ii) from CH: 28420 to CH: 28480	GC-HRIDC-C4-DRW-TTL-CLT-01006_A0
7.	Conceptual drawing for Tunnel typical detail of lattice girder	GC-HRIDC-C4-DRW-TTL-CLT-01007_A0
8.	Conceptual drawing for Cut & cover section of tunnel	GC-HRIDC-C4-DRW-TTL-CLT-01008_A1
9.	Conceptual drawing for Cross passage junction with main tunnel	GC-HRIDC-C4-DRW-TTL-CLT-01009_A1
10.	Conceptual drawing for Permanent Ventilation shaft junction with main tunnel	GC-HRIDC-C4-DRW-TTL-CLT-01010_A2 (Sheet 1 of 3)
		GC-HRIDC-C4-DRW-TTL-CLT-01010_A2 (Sheet 2 of 3)
		GC-HRIDC-C4-DRW-TTL-CLT-01010_A2 (Sheet 3 of 3)
11.	Conceptual drawing for Construction cum utility shaft	GC-HRIDC-C4-DRW-TTL-CLT-01011_A2
12.	Conceptual drawing for Portal-1 & Abutment A2 of Proposed HORC Viaduct	GC-HRIDC-C4-DRW-TTL-CLT-01012_A0
13.	Conceptual drawing for Portal-2 & open cutting area with 100m ballastless track	GC-HRIDC-C4-DRW-TTL-CLT-01013_A1
3	**MISCELLANEOUS DRAWINGS (CONCEPTUAL PLANS)**	
1.	Schematic diagram of HORC tunnel	GC-HRIDC-C4-SK-TUNNEL-001_A1

Section 6
B: Documents

List of Documents

S. No	Documents title
1.	Design Basis Report
2.	Geotechnical Investigation Reports for Tunnel
	i. Geotechnical Investigation Report
	ii. Geological Interpretive Report
	iii. Geotechnical Investigation Report Old Ch. 27+620 to Old Ch. 28+900KM

1. Alignment Plan & L-Section



NOTES :-

1. EXISTING WORK SHOWN IN BLACK.
2. PROPOSED WORK SHOWN IN RED.
3. ALL DIMENSIONS ARE IN METER UNLESS OTHERWISE SPECIFIED.
4, CHAINAGE IS RECKONED 0.00 FROM C.L. OF NEW PRITHLA STATION BUILDING .
5. RAIL LEVEL SHOULD BE 0.742m ABOVE FORMATION LEVEL FOR TRACK STRUCTURE 60KG NEW RAIL ON PSC SLEEPER (1660/KM) WITH 350mm BALLAST CUSHION.
6. RULLING GRADIENT IS 1 IN 150 OF THIS SECTION.(COMPENSATED)
7. VERTICAL CURVE WILL BE PROVIDED AS PER IRPWM PARA 419.
8. CROSS / LONGITUDINAL DRAINAGE ARRANGEMENT BET.TRACK SHOULD BE PROVIDED WHEREVER REQUIRED .
9. TROLLY REFUDGE IN BANKING / CUTTING SHALL BE PROVIDED AS PER PROVISION OF IRPWM.
10. CRS. SANCTION WILL BE OBTAINED BEFORE EXECUTION OF WORK FALLING UNDER PARA 1302(2) OF IRPWM.
11. STANRDARD OF LOADING (FOR PROP. LINE):- 32.5 T LOADING-2008 & HIGH RISE OHE.
12. TELEPHONE CABLE TO BE LAID FOR TELECOMMUNICATION.
13. ALL ELECTRICAL X-ING WILL BE AS PER PARA II (I) OF CHAPTER 1.GENERAL OF SCHEDULE 1 OF SOD 2004.

LIST OF TBM

TBM No.	Easting	Northing	Elevation
SM-9	699327.653	3121920.632	253.2
SM-10	699041.016	3122185.520	271.558
SM-11	698349.641	3122451.730	284.291
SM-12	697601.855	3122685.020	278.11

LEGEND

EXISTING CENTRE LINE	—
PROPOSED CENTRE LINE	—
DFC CENTRE LINE	—
EXISTING TPTC	●
PROPOSED TPTC	●
TBM	⊠
KM-STONE	KM
PROPOSED BOUNDARY	— ·· — ·· —
EXISTING BRIDGE	][
PROPOSED BRIDGE	][
NALA,CANAL,DRAIN	═
PERMANENT STRUCTURE	▨
TEMPORARY STRUCTURE	□
PROPOSED GATE LODGE	■
TOE LINE	— — —
ROAD	═
POWER LINE WITH POLE	T · · · · · T
PYLON	⊞
EMBANKMENT / BUND	═
ROCKY AREA	⬭
COMPOUND WALL	⊓
DITCH / QUARRY	⬭
BARBED WIRE FENCING	—
GROUND LEVEL	—

GC/HORC		HRIDC	
NAME /DESIGNATION	SIGN	NAME /DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/SOUTH*	
KRISHAN CHAND SAINSI *CRE/CIVIL*			

NORTHERN RAILWAY

DELHI DIVISION

PROJECT:
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:
HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

SIGN

RITES
THE INFRASTRUCTURE PEOPLE

SMEC

DRAWING NAME CONCEPTUAL PLAN AND LONGITUDINAL SECTION FROM CHAINAGE 24.0KM TO CHAINAGE 30.0KM (TUNNEL)

GC/HORC DRG. NO:- GC-HRIDC-ALL-DRW-ALN-P&P-24-30KM_A1

ISSUE DATE: 07.11.2022 *REVISED DATE:* 02.01.2023

SCALE *HORIZONTAL 1 :5000* *VERTICAL 1:500*

SMC DRG. NO:- *SMC/HRIDC/TUNNEL/LS- (R-4)*

CONSULTANT:
S.M.C
S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

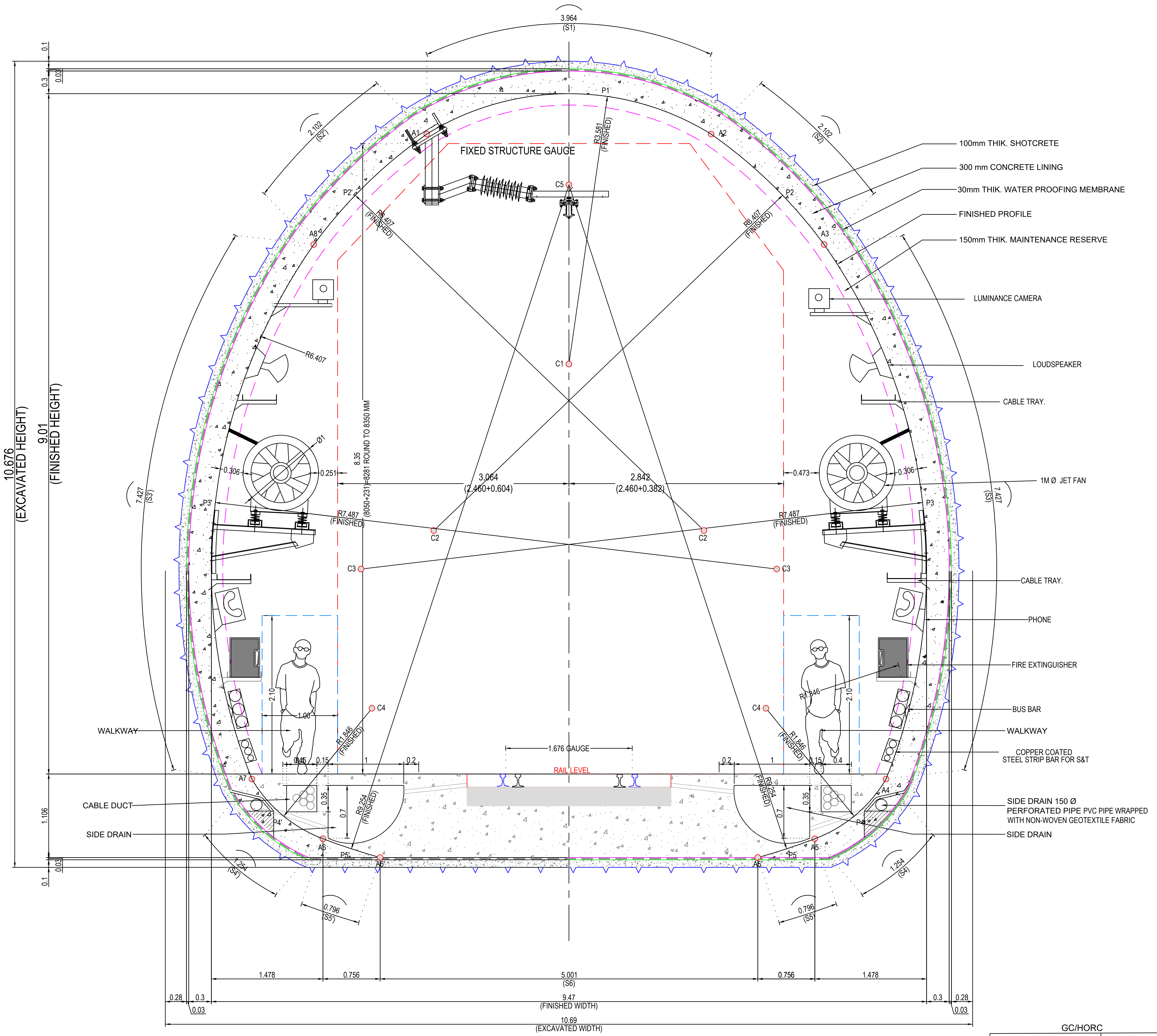
S.M. CONSULTANTS BHUBANESWAR

DRAWN BY:- *L.MOHANTY* *CHECKED BY:-* *SIVRAM J*

A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION

2. Tunnel



NOTES:-

1. ALL DIMENSIONS, NORTHING & EASTING AND LEVELS ARE IN METER, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE MEASURED FROM DRAWING.
3. TUNNEL EXCAVATED BY HEADING AND BENCHING METHOD (NATM).
4. THE GRADE OF SHOTCRETE WITH SFRS AS PER DETAIL DESIGN.
5. NEAR PORTAL PULL LENGTH SHOULD BE LIMITED TO 500 MM, ONLY AFTER SUPPORTING EXCAVATED STRETCH (500 MM) ,THEN NEXT CYCLE OF EXCAVATION SHALL BE CARRIED OUT .
6. IT IS PROPOSED TO PROVIDE 50 MM THICK SFRS IMMEDIATELY AFTER EXCAVATION OF FACE .
7. IT IS PROPOSED TO PROVIDE 100 MM THICK SFRS ON SLOPE PROTECTION. ALTERNATIVELY, PLAIN SHOTCRETE WITH WIREMESH 150x150x5mm MAY ALSO BE USED.
8. PROPOSED ROCK BOLT SHALL BE WITH FOLLOWING SPECIFICATION CONFORMING TO IS 1786 ,DIAMETER OF ROCK BOLT =25 MM , GRADE OF ROCK BOLT Fe415 FULLY GROUTED ,SIZE OF ANCHOR PLATE =150X150X8MM
9. PROPOSED SUPPORT SYSTEM IS BASED ON GIR PROVIDED BY GEOLOGIST. ACTUAL SUPPORT SYSTEM MAY BE REVISED BASED ON ACTUAL RESPONSE OF STRATA DURING EXCAVATION.
10. THE NUT OF THE GROUTED ROCK BOLT SHALL BE TIGHTENED 12 HOURS AFTER INSTALLATION TO ACHIEVE A FORCE AT THE ANCHOR PLATE OF APPROX. 20KN. THIS FORCE SHALL BE APPLIED BY CALIBRATED TORQUE WRENCH.
11. THE LENGTH AND THE DIRECTION OF ROCK BOLTS MAY BE ALTERED IN CONSULTATION WITH SITE GEOLOGIST AND ENGINEER-IN-CHARGE. WHEREVER REQUIRED, ADDITIONAL SPOT BOLTING SHALL BE DONE IN LOCALIZED AREA OF POTENTIAL INSTABILITY OR WEAKNESS AS DETERMINED DURING EXCAVATION.
12. SLOPE SUPPORT SHALL BE INSTALLED AS EXCAVATION PROGRESSES SUCH THAT NOT MORE THAN 2.0m VERTICAL HEIGHT OF SLOPE IS LEFT UNSUPPORTED AT ANY TIME.
13. PULLOUT TEST SHALL BE CARRIED OUT ON ROCK BOLTS FOR 190KN. .
14. DRAINAGE PIPE SHALL BE 150mmØ, PERFORATED PVC PIPE WRAPPED WITH NON-WOVEN GEOTEXTILE FABRIC AS PER IS-4984.
15. EXCAVATION SEQUENCE WILL BE PROVIDED BASED ON GFC.
16. EXCAVATION AT EAST PORTAL LOCATION SHALL BE MATCHED WITH DEEP CUT EXCAVATION.
17. GUARD RAIL SHALL BE PROVIDED THROUGHOUT THE LENGTH OF BALLASTLESS TRACK.
18. BALLASTLESS TRACK TO BE DESIGN FOR 32.5 T AXLE LOADING.
19. DIMENSIONS OF PRIMARY SUPPORT & CONCRETE ARE TENTATIVE.
20. 230V SOCKET AT 200M INTERVAL FOR S&T SYSTEM SHALL BE PROVIDED.
21. SEPARATE EARTHING MET CONNECTION FOR S&T SYSTEM SHALL BE PROVIDED.
22. ANCHOR BOLT FOR ROCS SHALL BE INSTALLED DURING TUNNEL LINING.
23. CABLE CROSSING SHALL BE PROVIDED AT EVERY CROSS PASSAGE.
24. LUMINANCE CAMERA, LOUDSPEAKER, JET FAN, PHONE, BUS BAR, COPPER COATED STEEL STRIP BAR FOR S&T AND ROCS WORK (EXCLUDING ANCHOR BOLTS) IS NOT IN THE SCOPE OF WORK OF C-4.

S.N.	CURVE NAME	RADIUS (m.)	START	END	ARCH. LENGTH (m.)
1	S1	R3.581	A1	A2	3.964
2	S2	R6.407	A2	A3	2.102
3	S3	R7.487	A3	A4	7.427
4	S4	R1.846	A4	A5	1.254
5	S5	R9.254	A5	A5'	0.796
6	S6	R0	A5'	A6'	5.001
7	S5'	R9.254	A6'	A6	0.796
8	S4'	R1.846	A6	A7	1.254
9	S3'	R7.487	A7	A8	7.427
10	S2'	R6.407	A8	A1	2.102

EXCAVATED AREA = 91.704 Sqm.
FINISHED AREA = 71.063 Sqm.
EXCAVATED WIDTH = 10.690m
EXCAVATED HEIGHT = 10.676m
FINISHED WIDTH = 9.470m
FINISHED HEIGHT = 9.010m

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES
THE INFRASTRUCTURE PEOPLE
SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01001_A1

DRAWING NAME
CONCEPTUAL DRAWING FOR
SINGLE TRACK TUNNEL CROSS SECTION (ROCK)

ISSUE DATE: *07.11.2022* *REVISED DATE:* 03.01.2023
SCALE- *AS SHOWN*
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

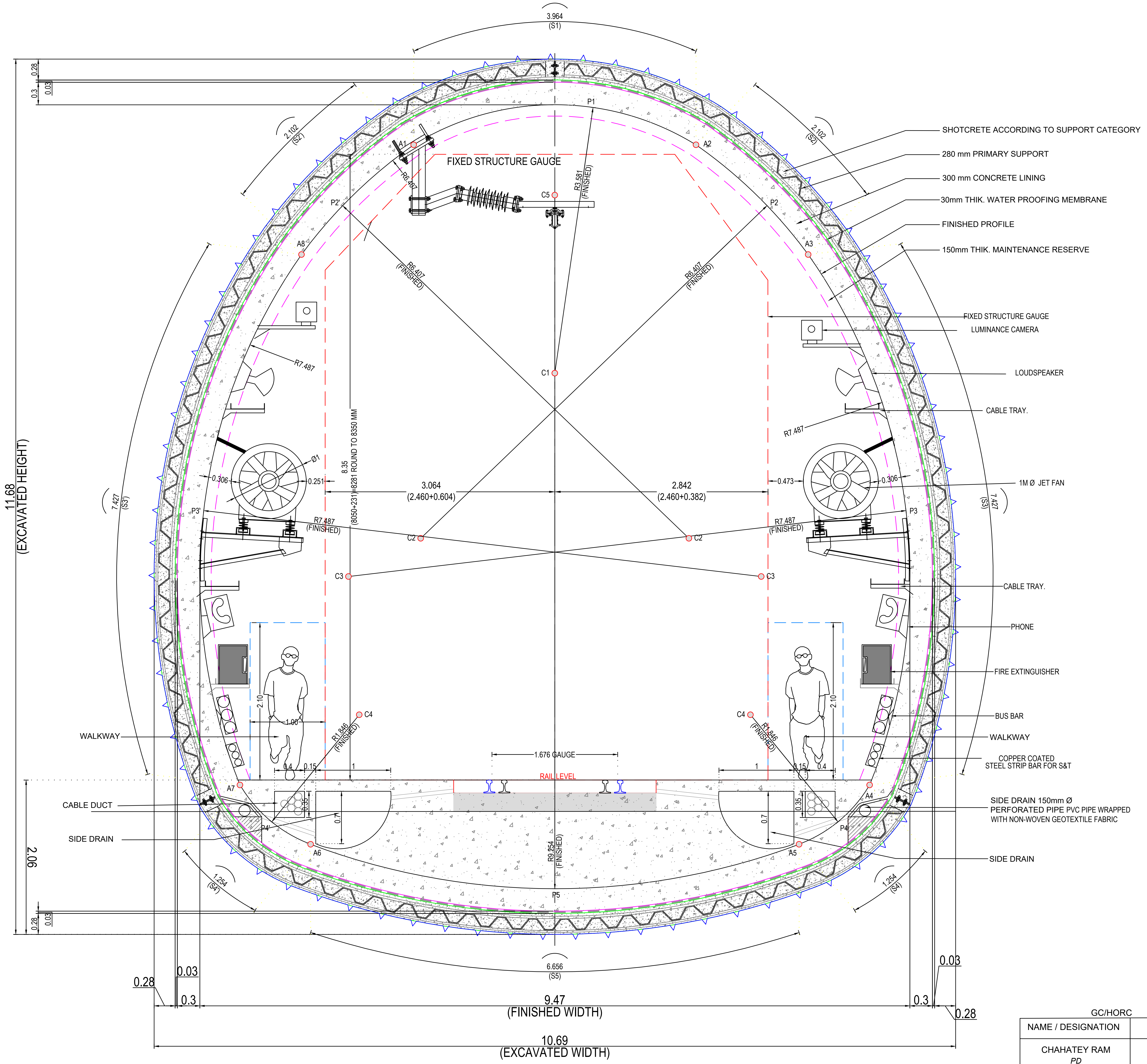
CONSULTANT:
S.M.C.
S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S. kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

B.R.SHARMA
Sr.CONSULTANT / TUNNEL

A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



1. ALL DIMENSIONS, NORTHING & EASTING AND LEVELS ARE IN METER, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE MEASURED FROM DRAWING.
3. TUNNEL EXCAVATED BY HEADING, BENCHING / MULTI DRIFT METHOD (NATM).
4. THE GRADE OF SHOTCRETE WITH SFRS AS PER DETAIL DESIGN.
5. PROPOSED SUPPORT SYSTEM IS BASED ON GIR PROVIDED BY GEOLOGIST. ACTUAL SUPPORT SYSTEM MAY BE REVISED BASED ON ACTUAL RESPONSE OF STRATA DURING EXCAVATION.
6. DRAINAGE PIPE SHALL BE 150mmØ, PERFORATED PVC PIPE WRAPPED WITH NON-WOVEN GEOTEXTILE FABRIC AS PER IS-4989
7. EXCAVATION SEQUENCE WILL BE PROVIDED BASED ON GFC.
8. PIPE ROOFING/FOREPULING OF 114 MM DIA SHALL BE PROVIDED WHERE EVER IT IS REQUIRED.
9. SELF DRILLING ANCHOR OF CAPACITY 190 KN SHALL BE PROVIDED FOR PRIMARY SUPPORT DURING EXCAVATION.
10. LATTICE GIRDER 25-25-32 OF DEPTH 187 MM/ ISMB 200 MM SHALL BE INCASED IN SFRS OF MINIMUM THICKNESS 250 MM.
11. GUARD RAIL SHALL BE PROVIDED THROUGHOUT THE LENGTH OF BALLASTLESS TRACK.
12. BALLASTLESS TRACK TO BE DESIGN FOR 32.5 T AXLE LOADING.
13. DIMENSION OF PRIMARY SUPPORT & CONCRETE ARE TENTATIVE.
14. SEPARATE EARTHING MET CONNECTION FOR S&T SYSTEM SHALL BE PROVIDED.
15. ANCHOR BOLT FOR ROCS SHALL BE INSTALLED DURING TUNNEL LINING.
16. CABLE CROSSING SHALL BE PROVIDED AT EVERY CROSS PASSAGE.
17. LUMINANCE CAMERA, LOUDSPEAKER, JET FAN, PHONE, BUS BAR, COPPER COATED STEEL STRIP BAR FOR S&T AND ROCS WORK (EXCLUDING ANCHOR BOLTS) IS NOT IN THE SCOPE OF WORK OF C-4.

S.N.	CURVE NAME	RADIUS (m.)	START	END	ARCH. LENGTH (m.)
1	S1	R3.581	A1	A2	3.964
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4	S4	R1.846	A4	A5	1.254
5	S5	R9.254	A5	A6	6.656
6	S4	R1.846	A6	A7	1.254
7	S3	R7.487	A7	A8	7.427
8	S2	R6.407	A8	A1	2.102

EXCAVATED AREA = 101.090 Sqm.
FINISHED AREA = 71.063 Sqm.
EXCAVATED WIDTH = 10.690m
EXCAVATED HEIGHT = 11.680m
FINISHED WIDTH = 9.470m
FINISHED HEIGHT = 9.010m

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES
THE INFRASTRUCTURE PEOPLE

SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01002_A1

DRAWING NAME CONCEPTUAL DRAWING FOR
SINGLE TRACK TUNNEL CROSS SECTION (SOIL)

ISSUE DATE: *07.11.2022* *REVISED DATE:* 03.01.2023
SCALE- *AS SHOWN*
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

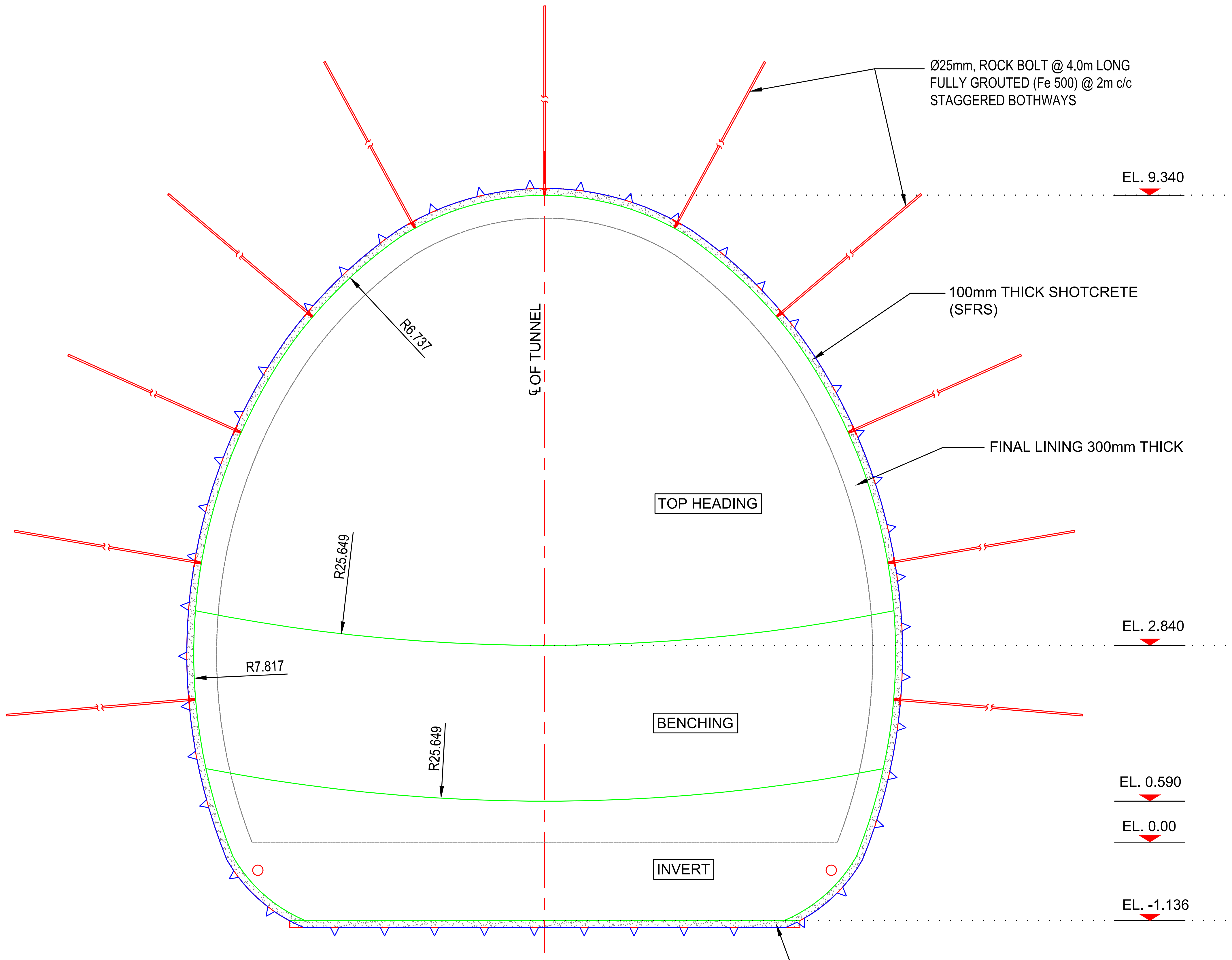
CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S.kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

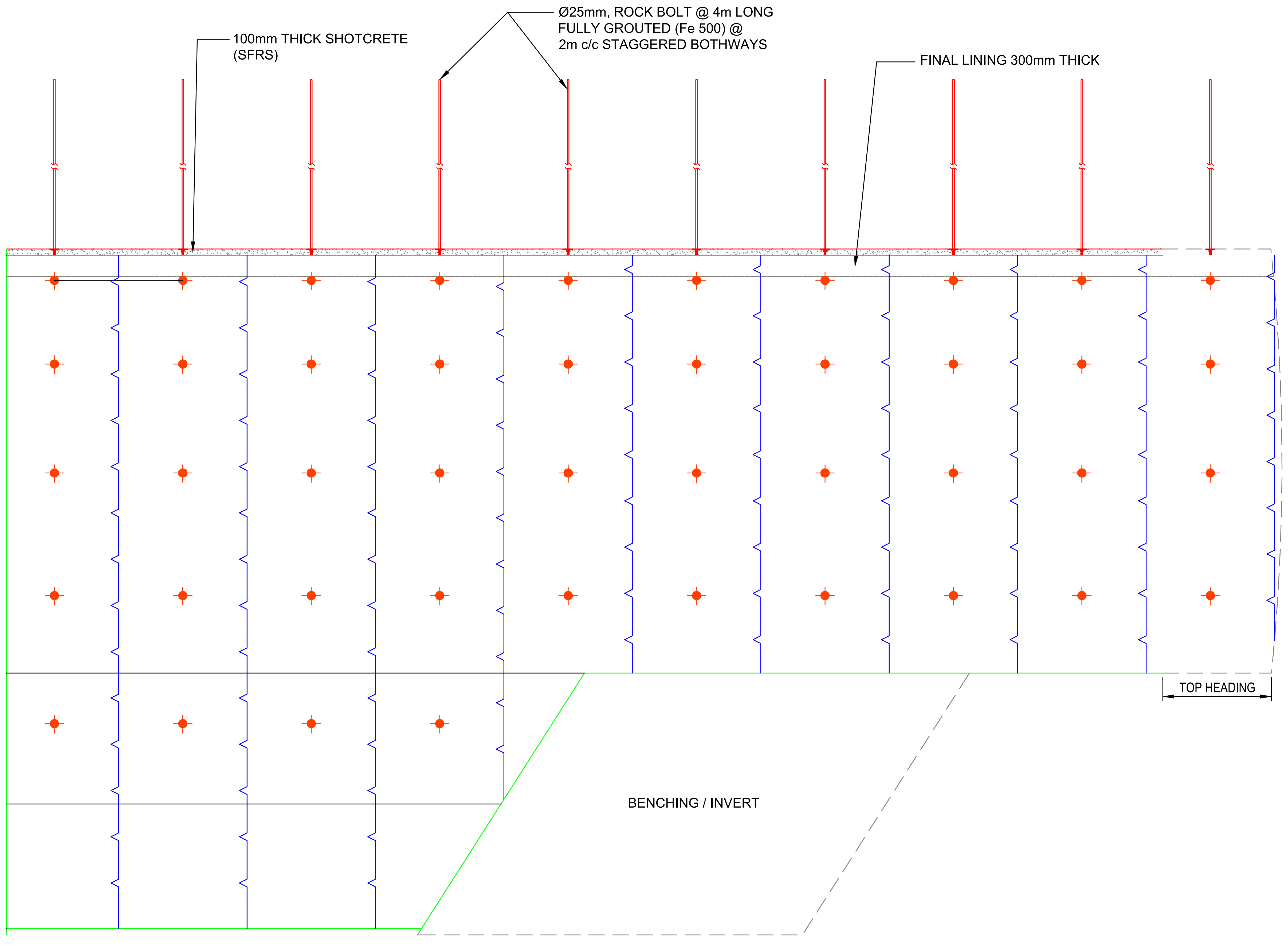
B.R.SHARMA
Sr.CONSULTANT / TUNNEL

S.M. CONSULTANTS BHUBANESWAR
A. A. SAMANT
PROJECT INCHARGE

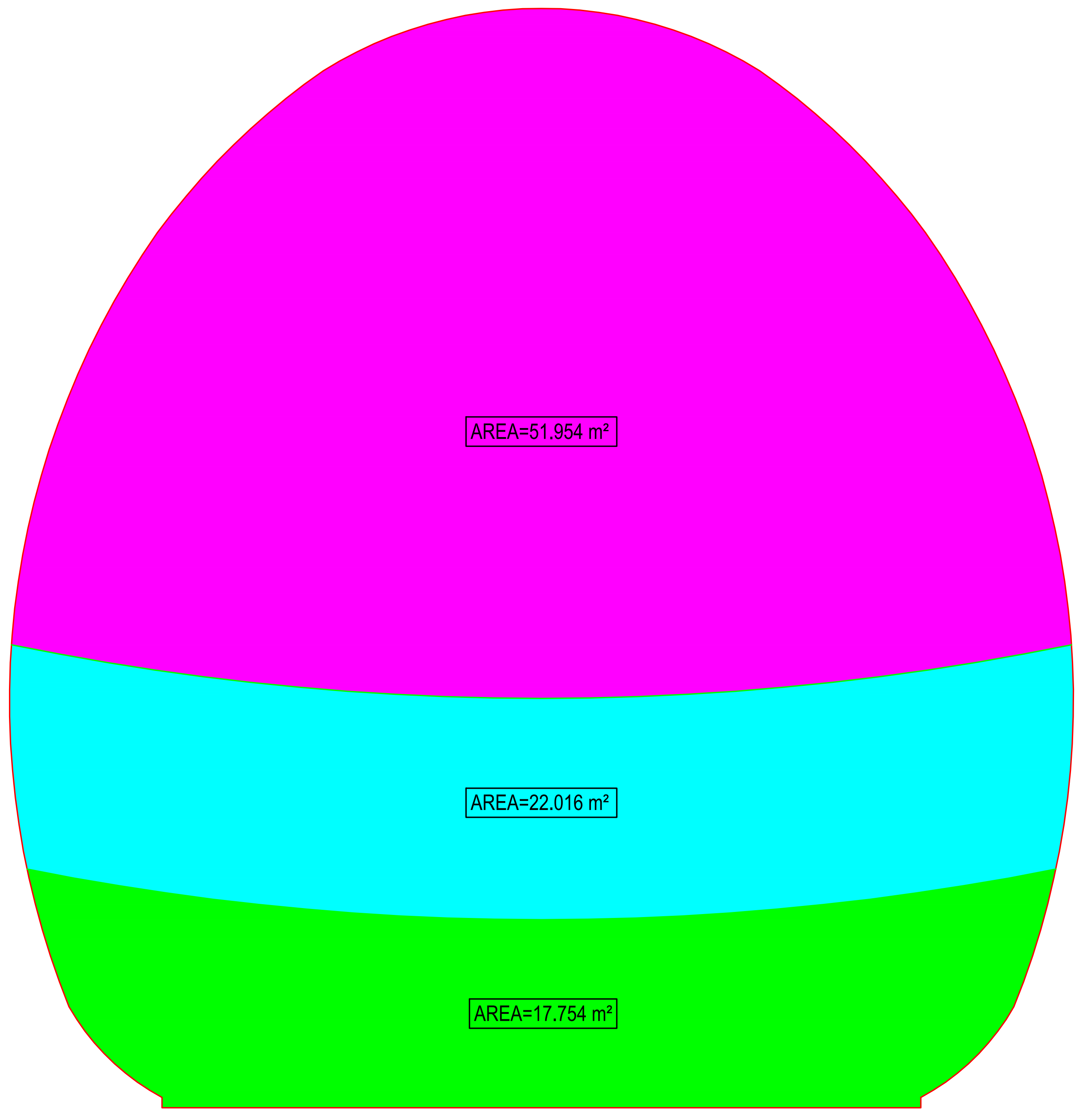
RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



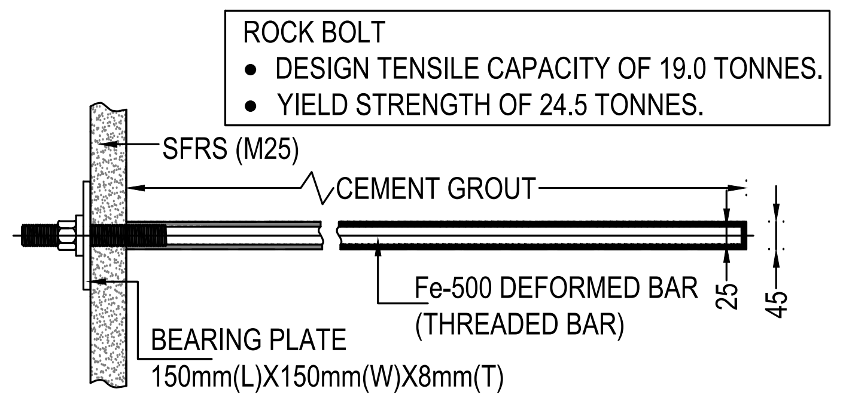
CROSS SECTION (SUPPORT CLASS III)
SCALE(A1) 1:50



LONGITUDINAL SECTION
SCALE(A1) 1:50



EXCAVATION AREA
SCALE(A1) 1:50



FULLY CEMENT GROUTED SPOT / ROCK BOLT

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	ChahateyRam	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	AmarnathSingh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES
THE INFRASTRUCTURE PEOPLE

SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01003_A0

DRAWING NAME CONCEPTUAL DRAWING FOR
SUPPORT CLASS III
FROM CH:24940 TO CH:26000

ISSUE DATE: *07.11.2022* *REVISED DATE:*

SCALE- *AS SHOWN*

SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

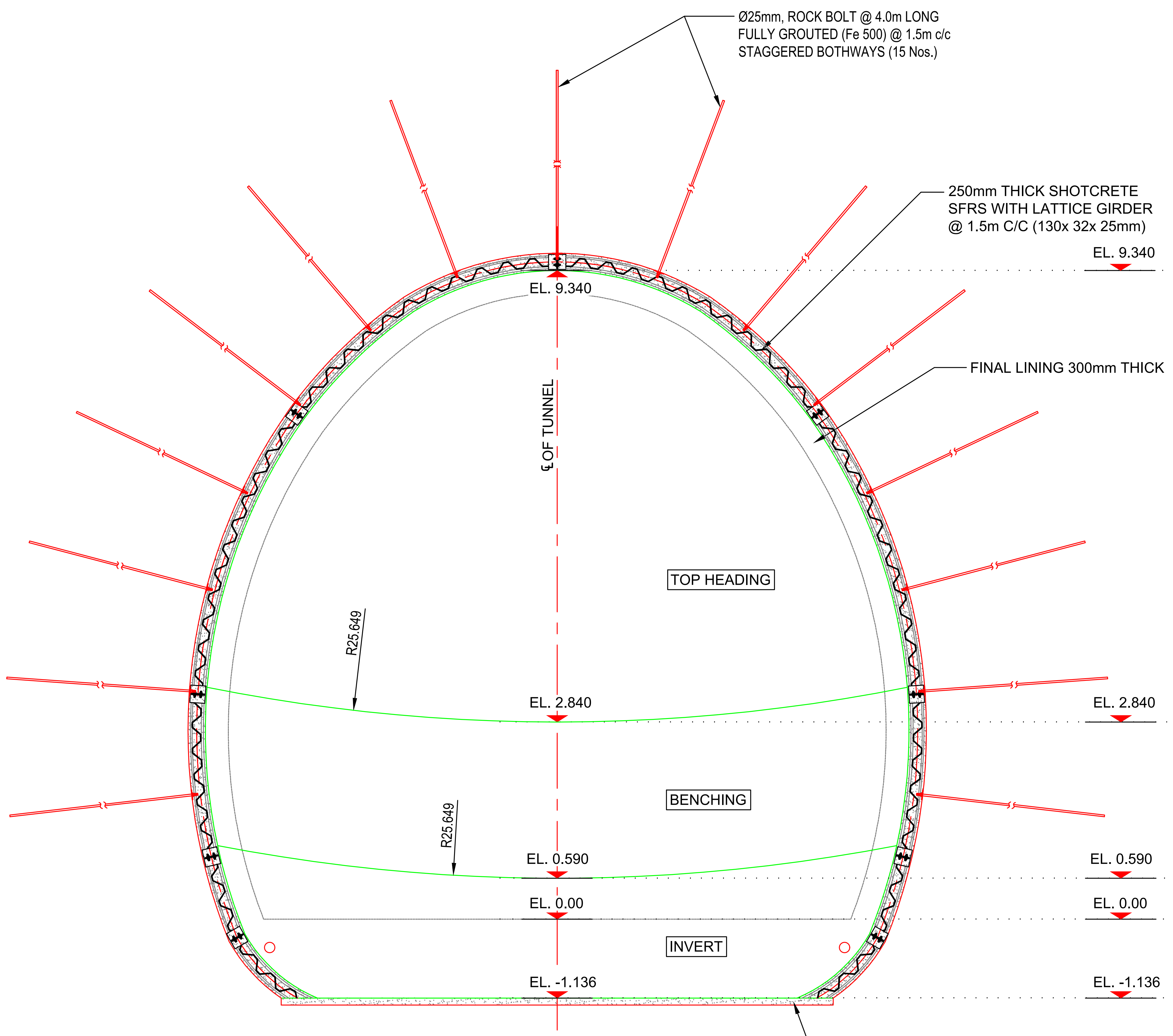
CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S.kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

B.R.SHARMA
Sr.CONSULTANT / TUNNEL

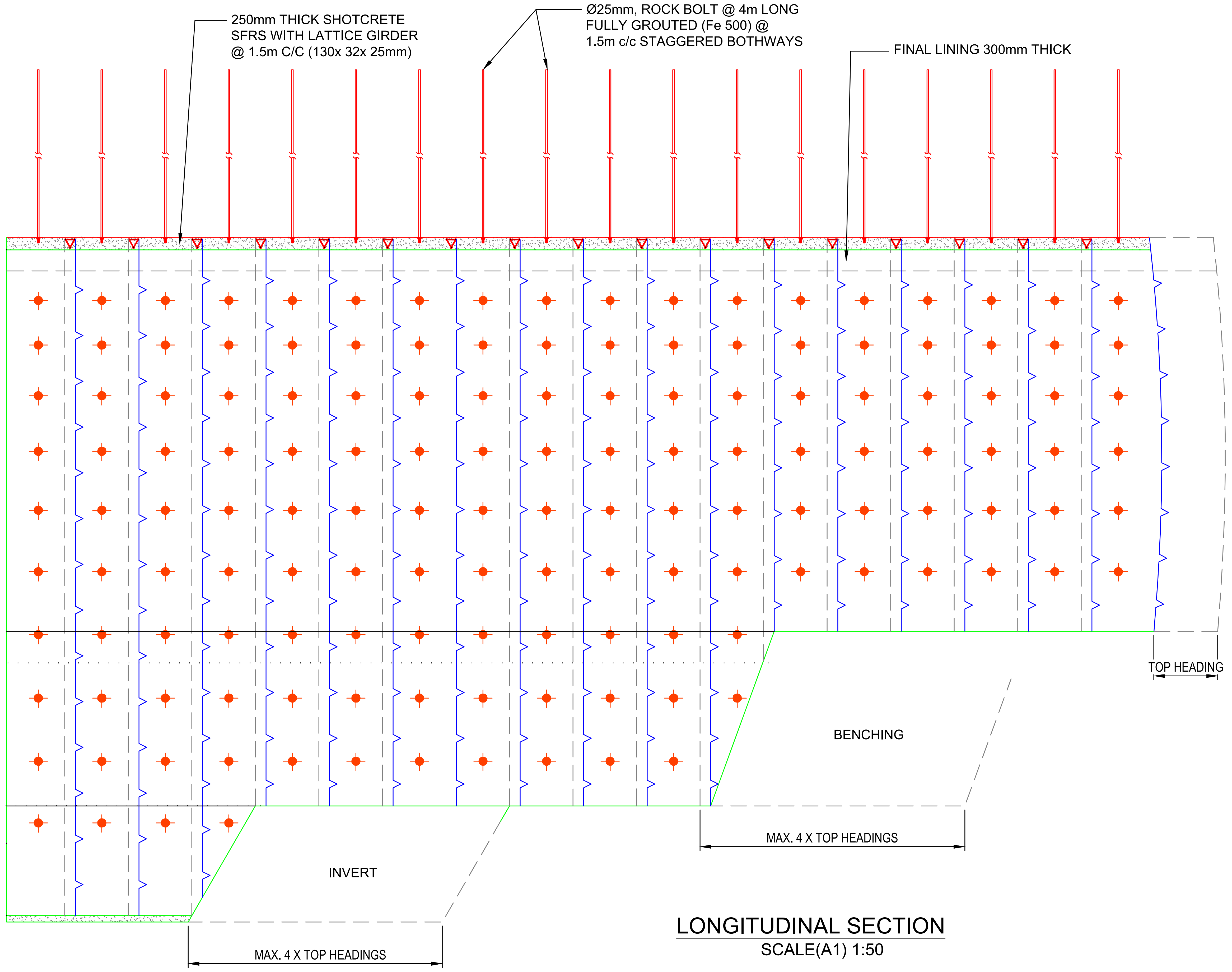
A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



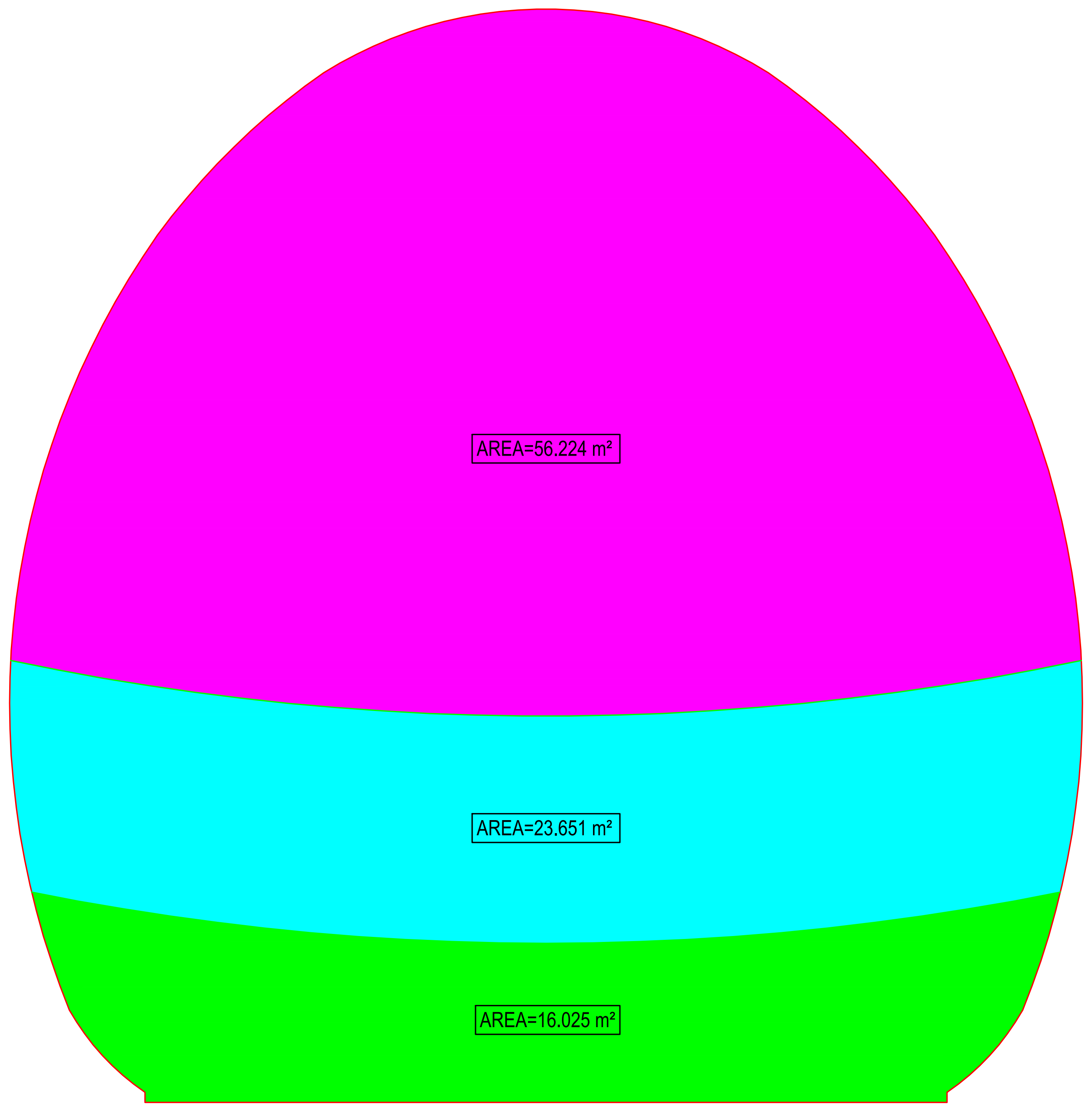
CROSS SECTION (SUPPORT CLASS IV)

SCALE(A1) 1:50



LONGITUDINAL SECTION

SCALE(A1) 1:50



EXCAVATION AREA

SCALE(A1) 1:50

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*		*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES
THE INFRASTRUCTURE PEOPLE
SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01004_A0

DRAWING NAME
CONCEPTUAL DRAWING FOR
SUPPORT CLASS IV
FROM CH:24880 TO 24940

ISSUE DATE: *07.11.2022* *REVISED DATE:*

SCALE- *AS SHOWN*

SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

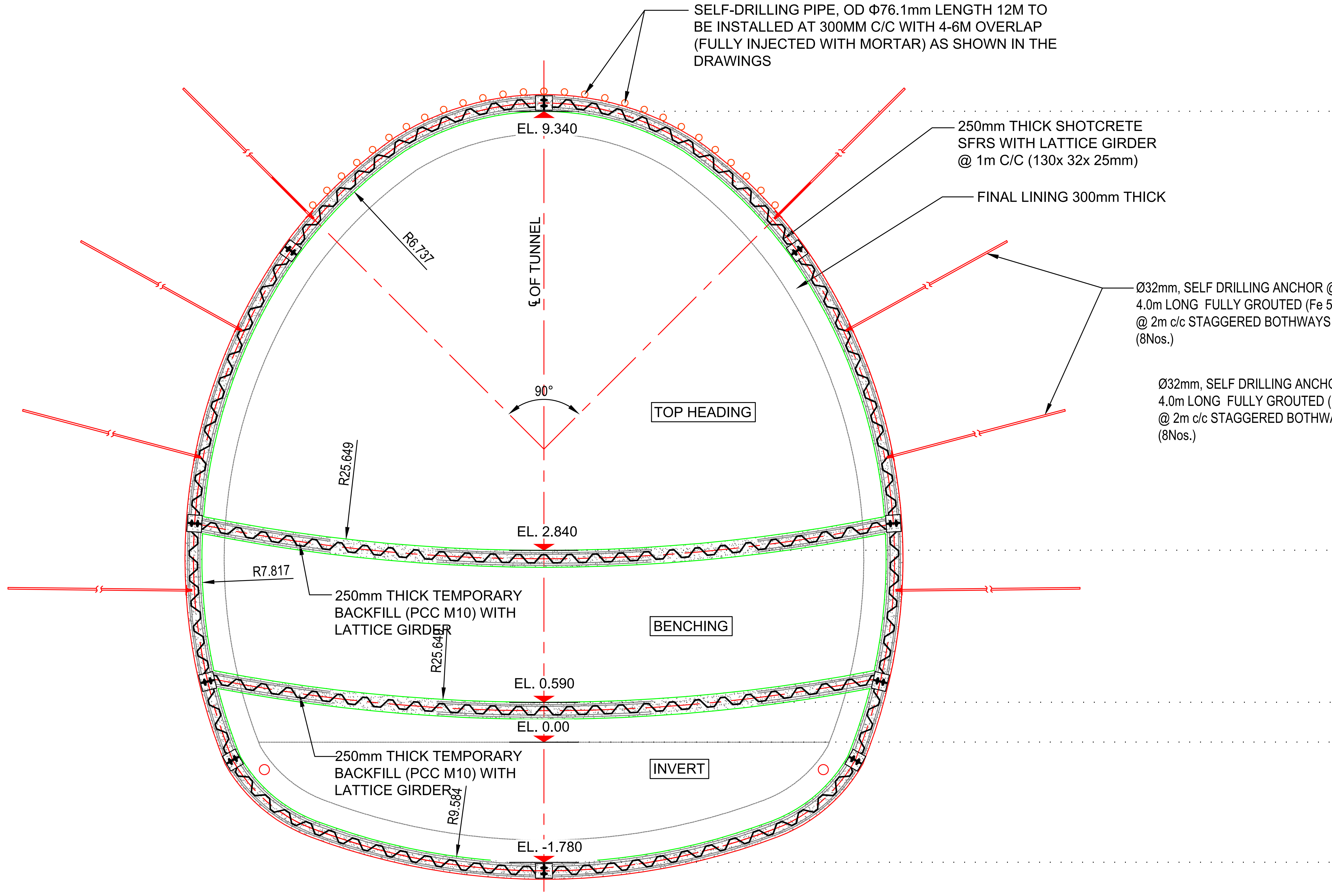
CONSULTANT:
S.M.C.
S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S. kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

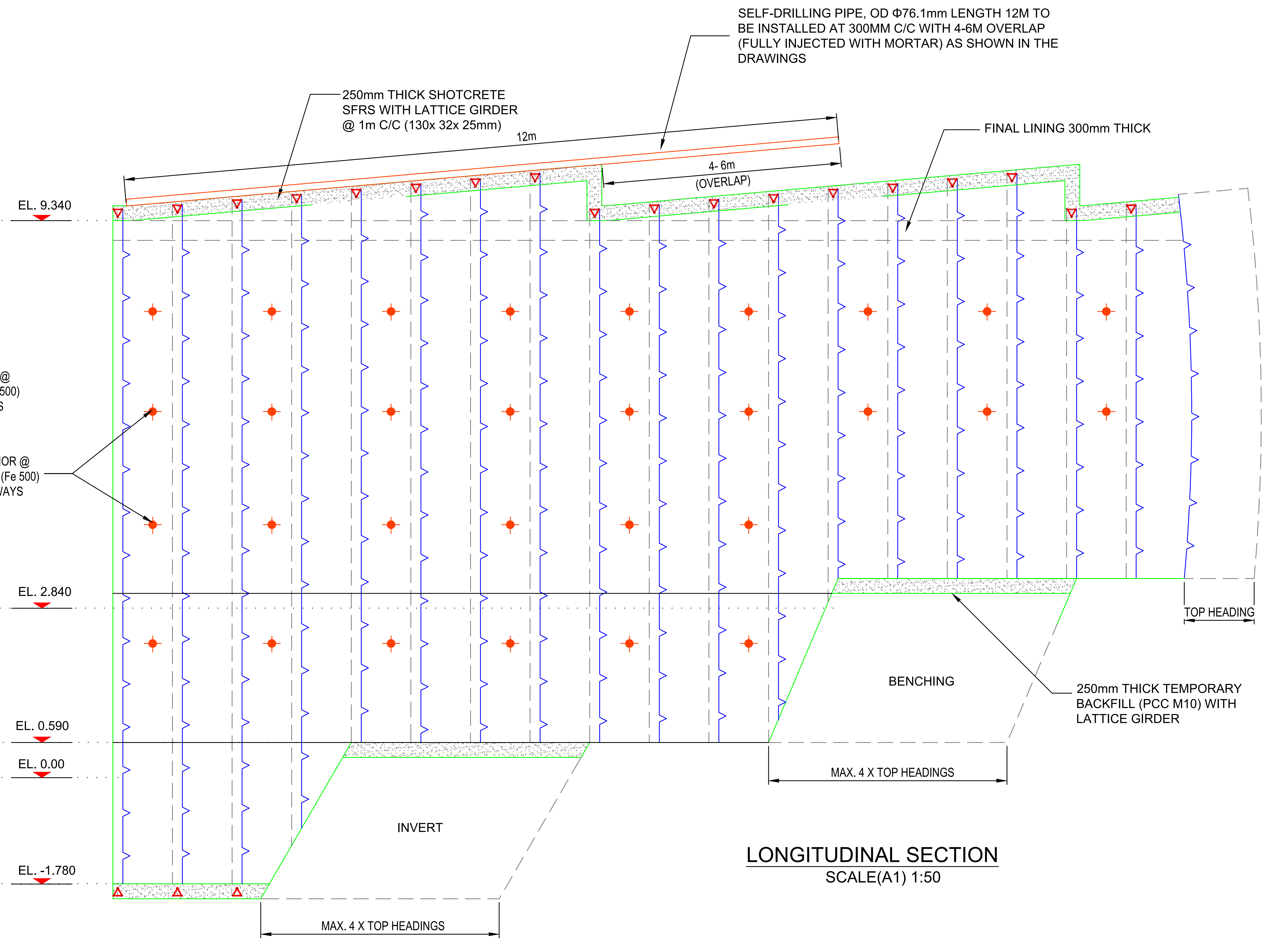
B.R.SHARMA
Sr.CONSULTANT / TUNNEL

S. M. CONSULTANTS BHUBANESWAR
A. A. SAMANT
PROJECT INCHARGE

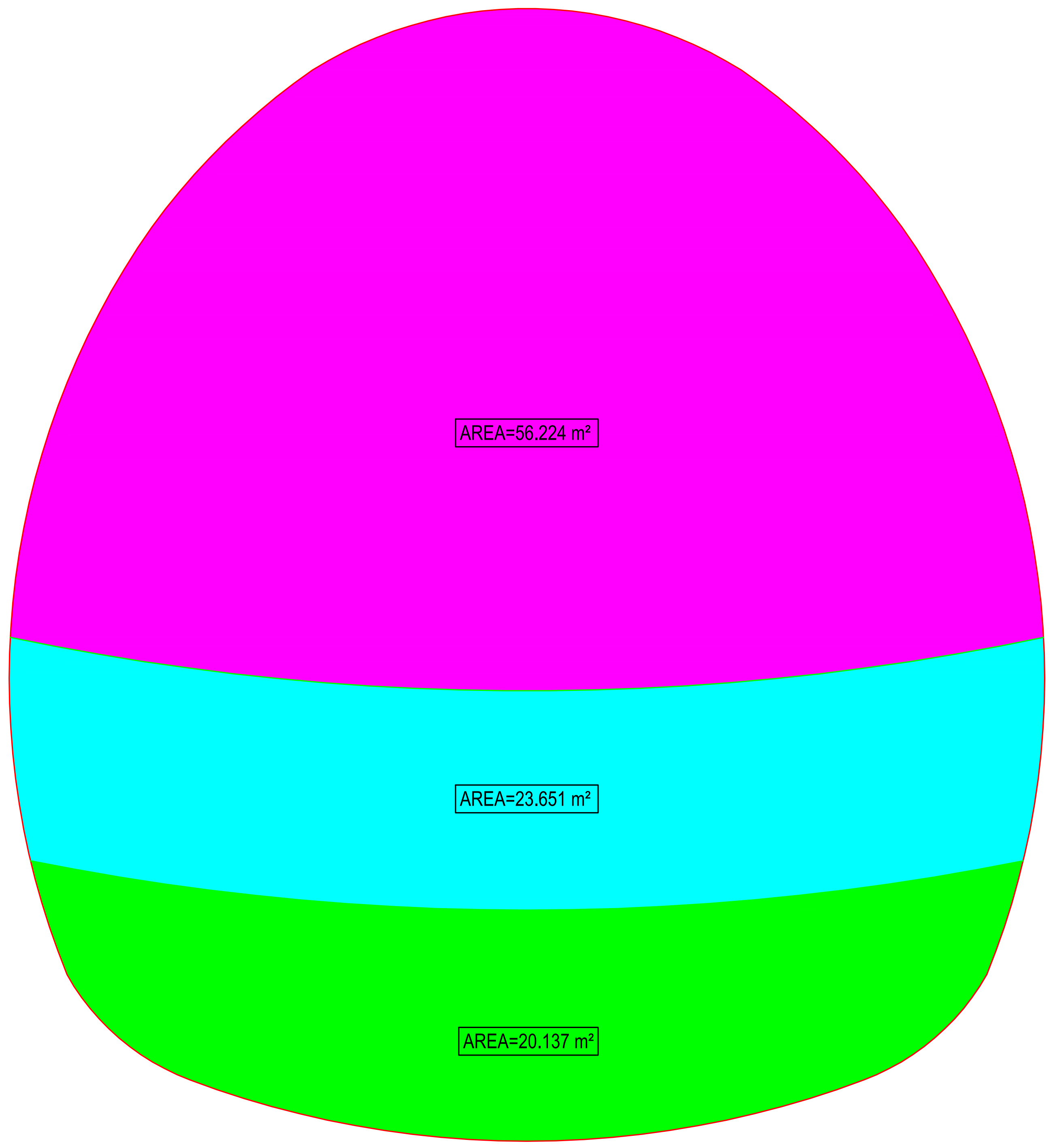
RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



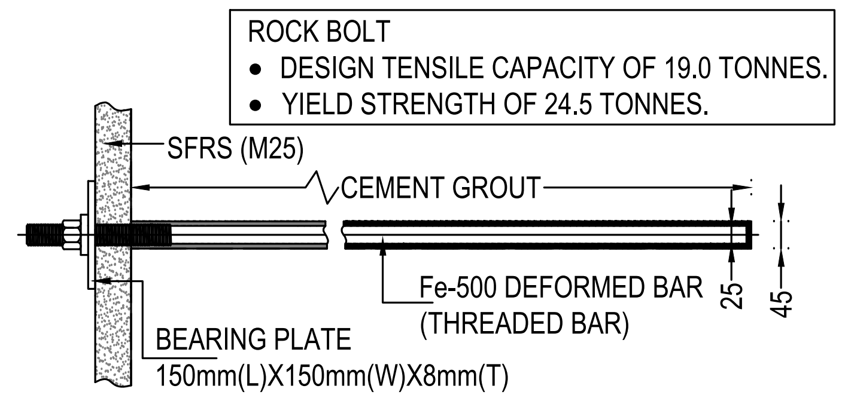
CROSS SECTION (SUPPORT CLASS VI (i))
SCALE(A1) 1:50



LONGITUDINAL SECTION
SCALE(A1) 1:50



EXCAVATION AREA
SCALE(A1) 1:50



FULLY CEMENT GROUTED SPOT / ROCK BOLT

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:- HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:- HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT: GENERAL CONSULTANT FOR HARYANA ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES THE INFRASTRUCTURE PEOPLE
SMEC Member of the Surbana Jurong Group

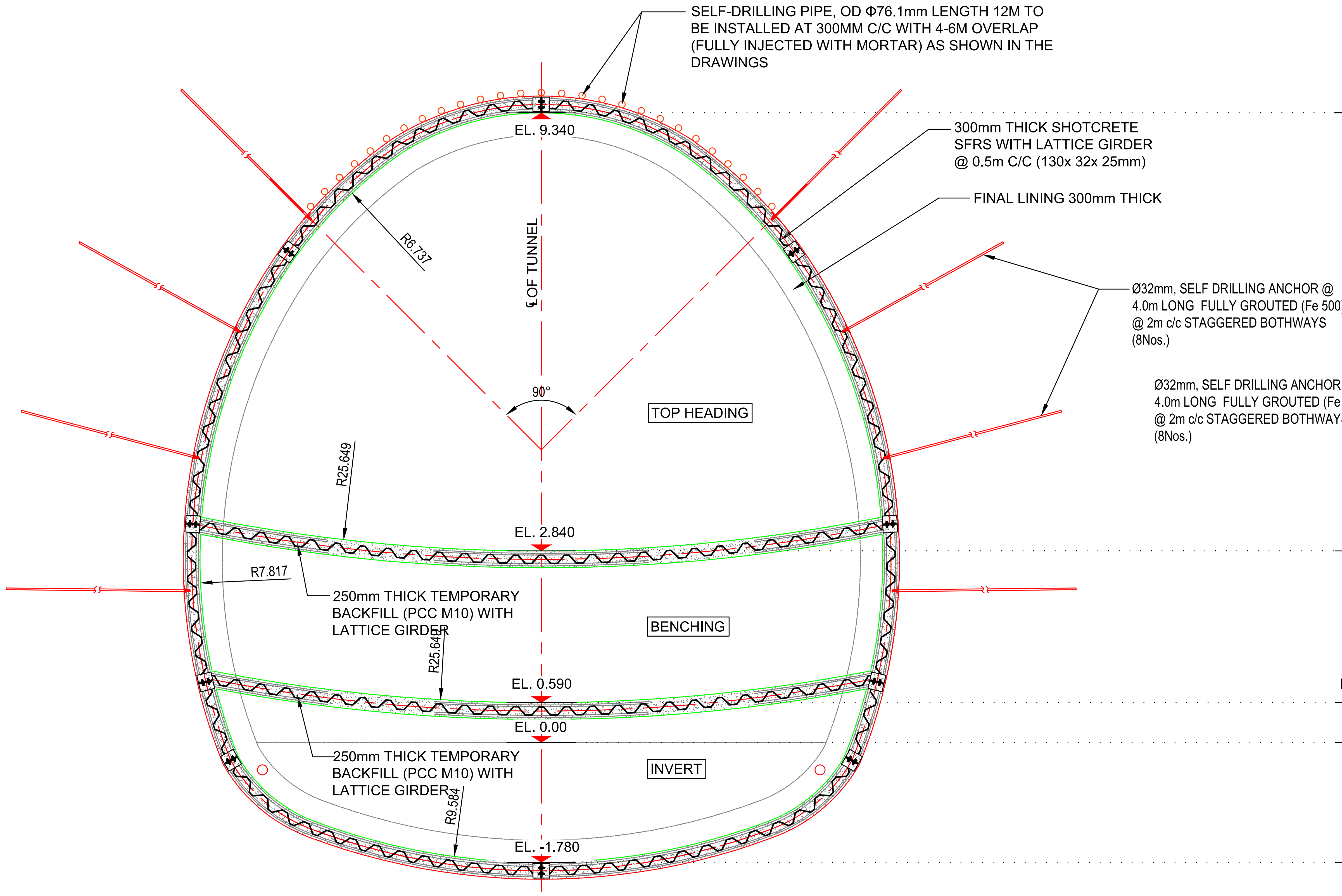
GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01005_A0
DRAWING NAME: CONCEPTUAL DRAWING FOR SUPPORT CLASS VI(i) FROM CH:26000 TO 28420
ISSUE DATE: 07.11.2022 REVISED DATE:
SCALE- AS SHOWN
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7
CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S.Kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

B.R.SHARMA
Sr.CONSULTANT / TUNNEL

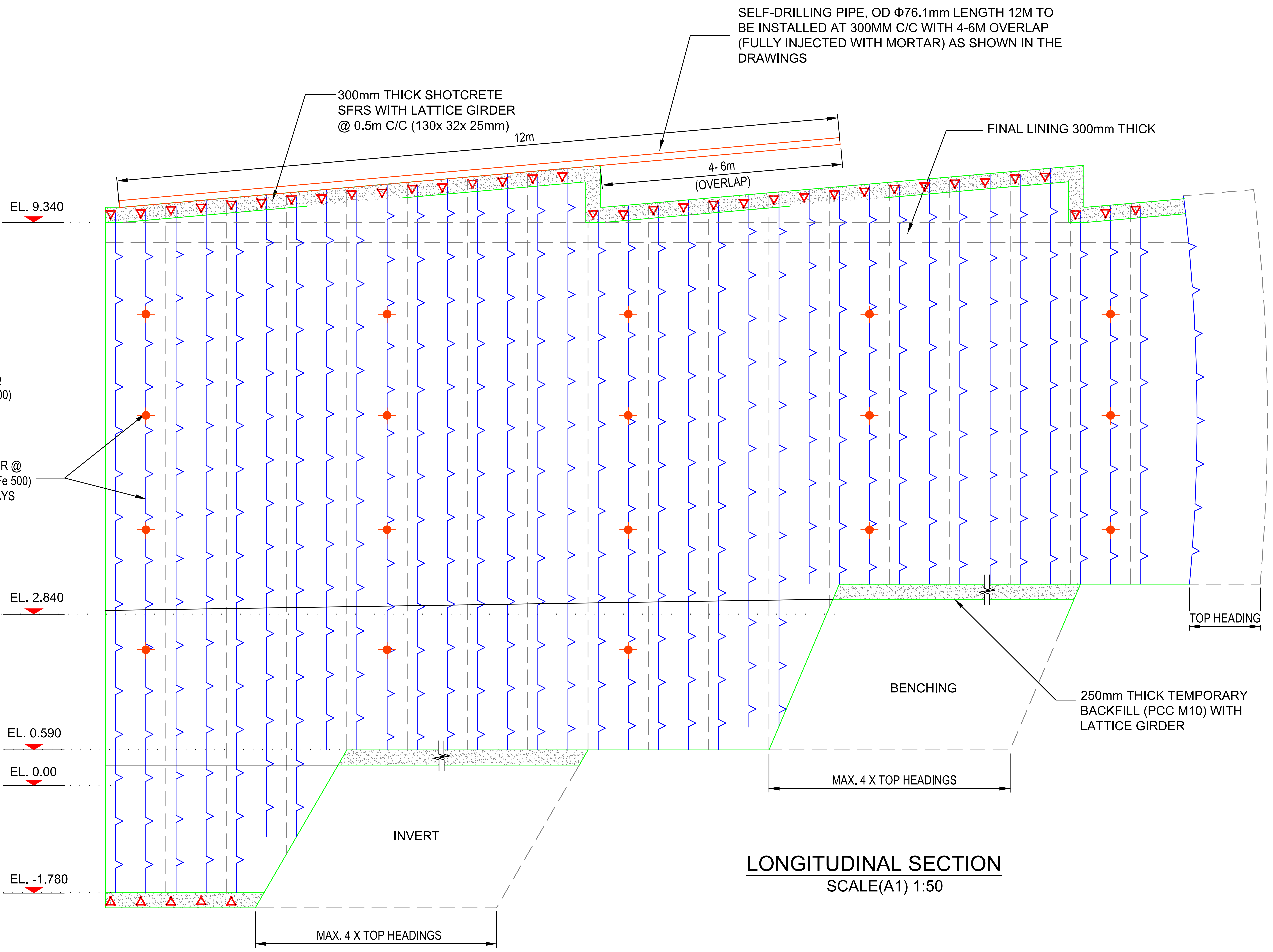
S. M. CONSULTANTS BHUBANESWAR
A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



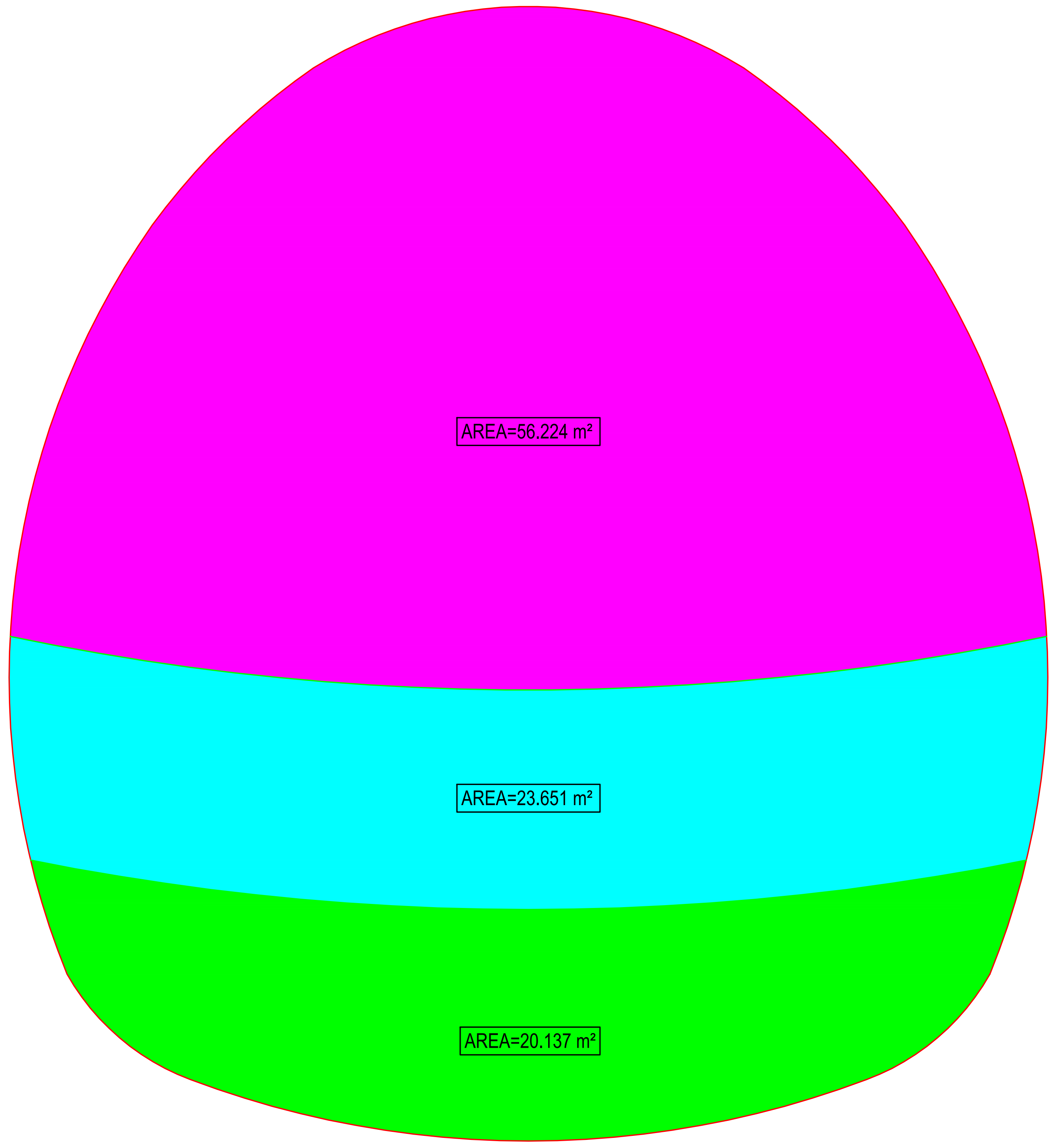
CROSS SECTION (SUPPORT CLASS VI (ii))

SCALE(A1) 1:50



LONGITUDINAL SECTION

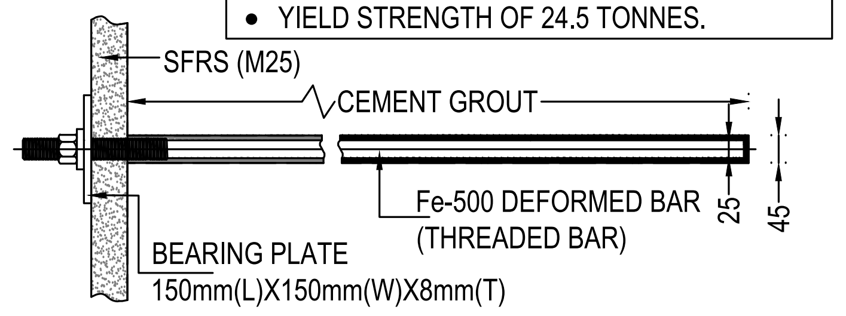
SCALE(A1) 1:50



EXCAVATION AREA

SCALE(A1) 1:50

ROCK BOLT
- DESIGN TENSILE CAPACITY OF 19.0 TONNES.
- YIELD STRENGTH OF 24.5 TONNES.



FULLY CEMENT GROUTED SPOT / ROCK BOLT

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES
THE INFRASTRUCTURE PEOPLE
SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01006_A0

DRAWING NAME CONCEPTUAL DRAWING FOR
SUPPORT CLASS VI(ii)
FROM CH:28420 TO CH:28480

ISSUE DATE: *07.11.2022* *REVISED DATE:*

SCALE- *AS SHOWN*

SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S.M. CONSULTANTS BHUBANESWAR

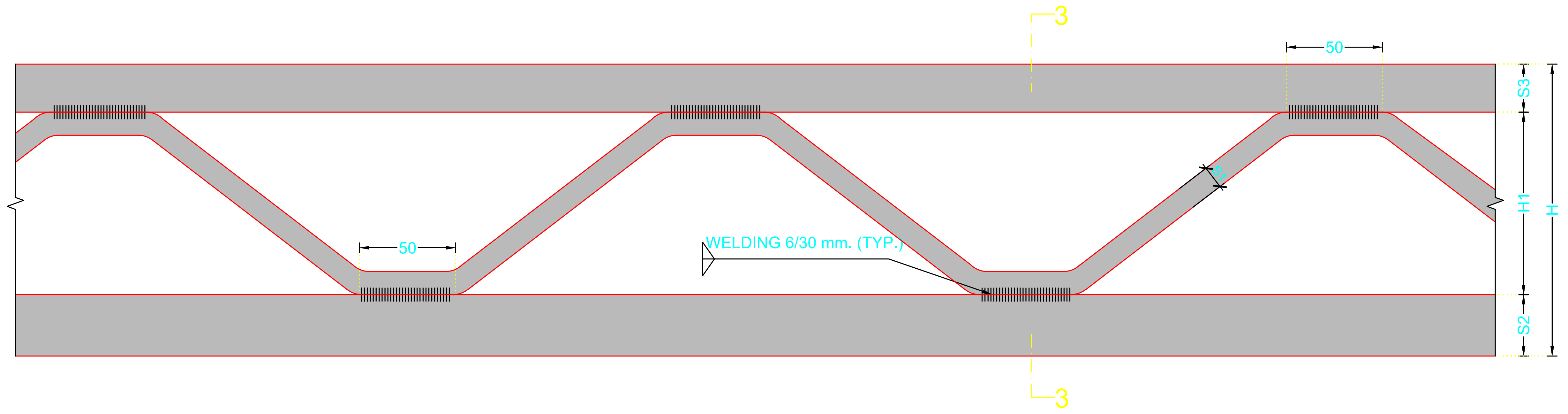
S. kumar		
SIVENDRA KUMAR *TUNNEL DESIGNER*	*B.R.SHARMA* *Sr.CONSULTANT / TUNNEL*	*A. A. SAMANT* *PROJECT INCHARGE*

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION

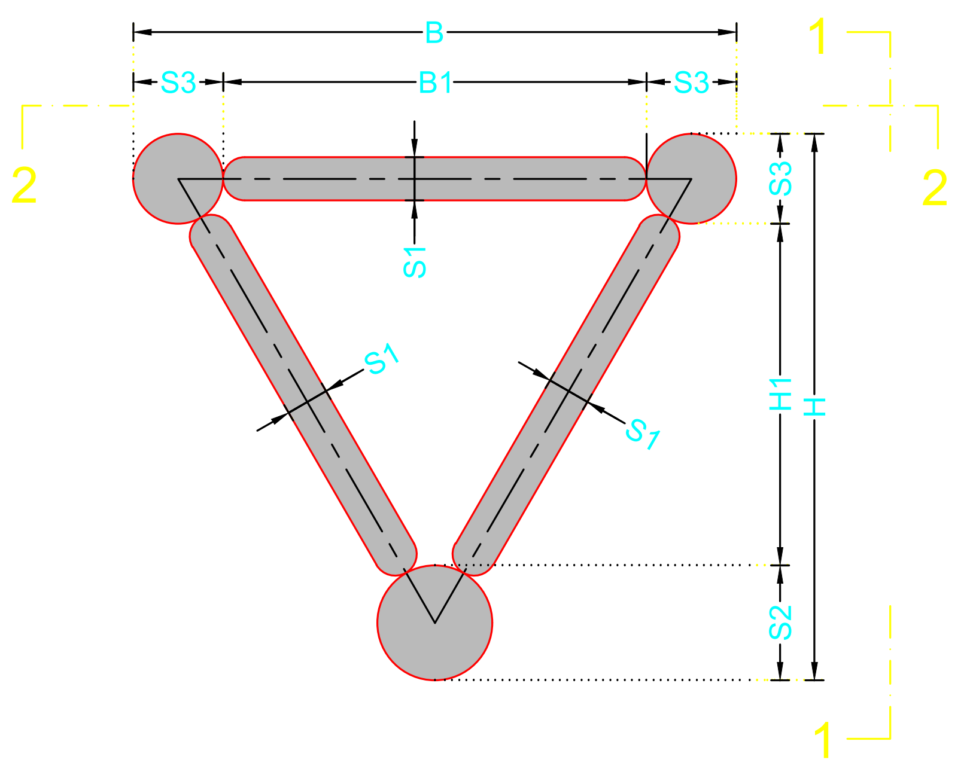
DETAILS OF LATTICE GIRDERS

TYPE	H (mm)	H1 (mm)	B (mm)	B1 (mm)	S1 (mm)	S2 (mm)	S3 (mm)	BXB (mm)	T (mm)
TYPE-1	187	130	208	158	Ø12	Ø32	Ø25	240X240	12

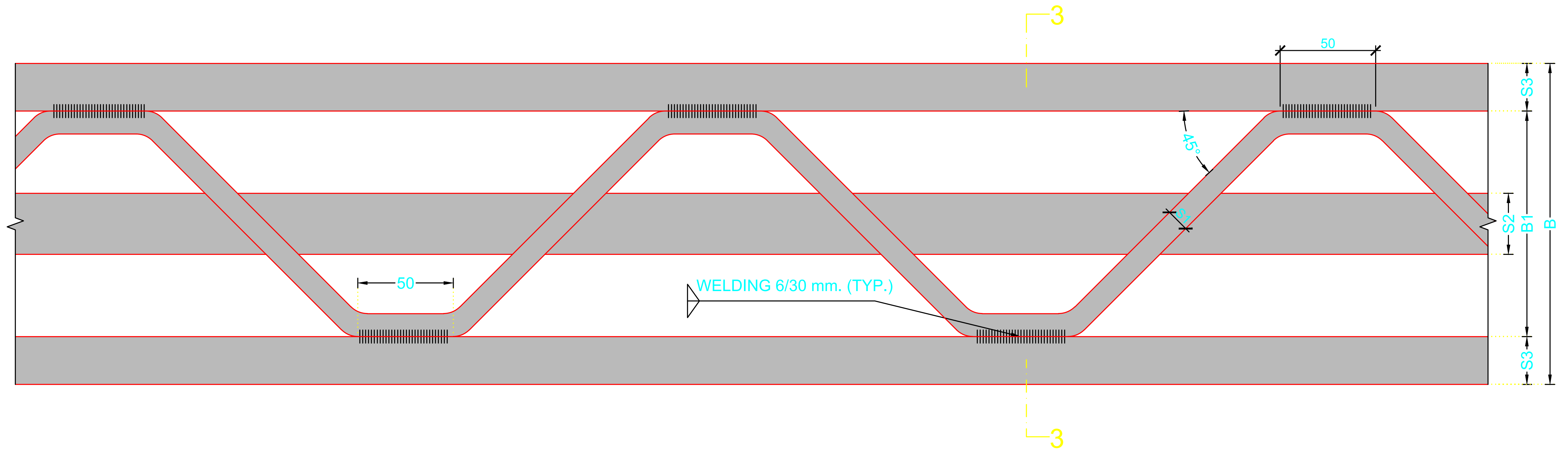
VIEW 1-1



SECTION 3-3

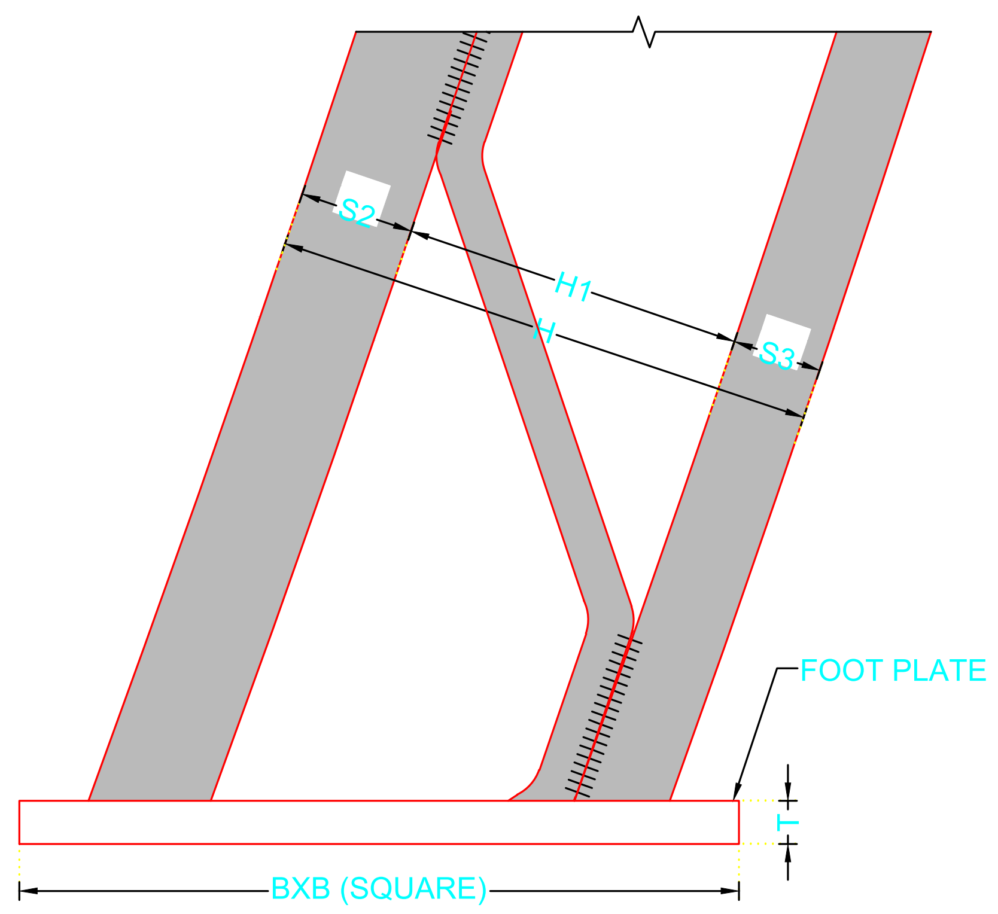


VIEW 2-2

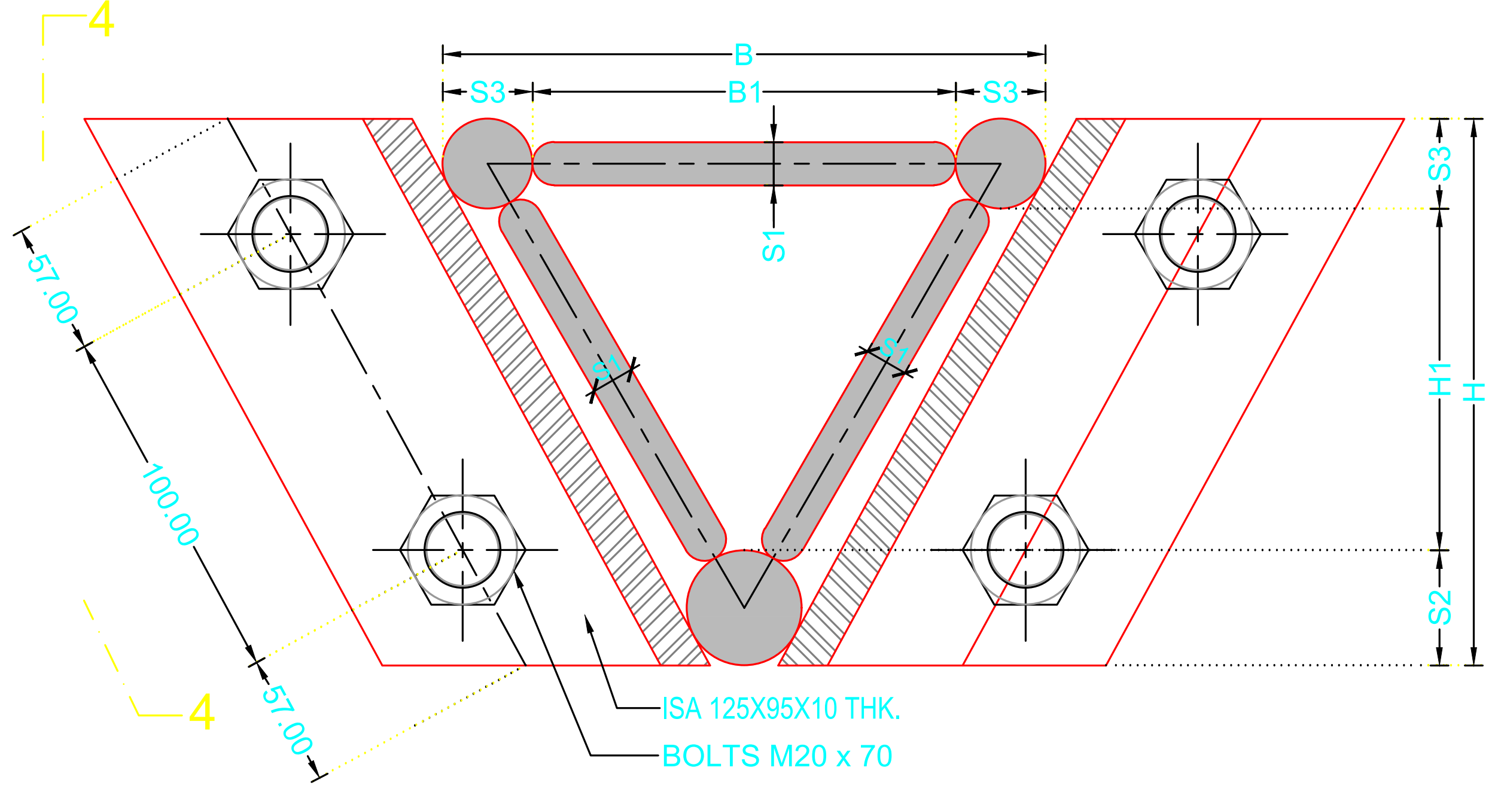


DETAIL OF FOOT PLATE

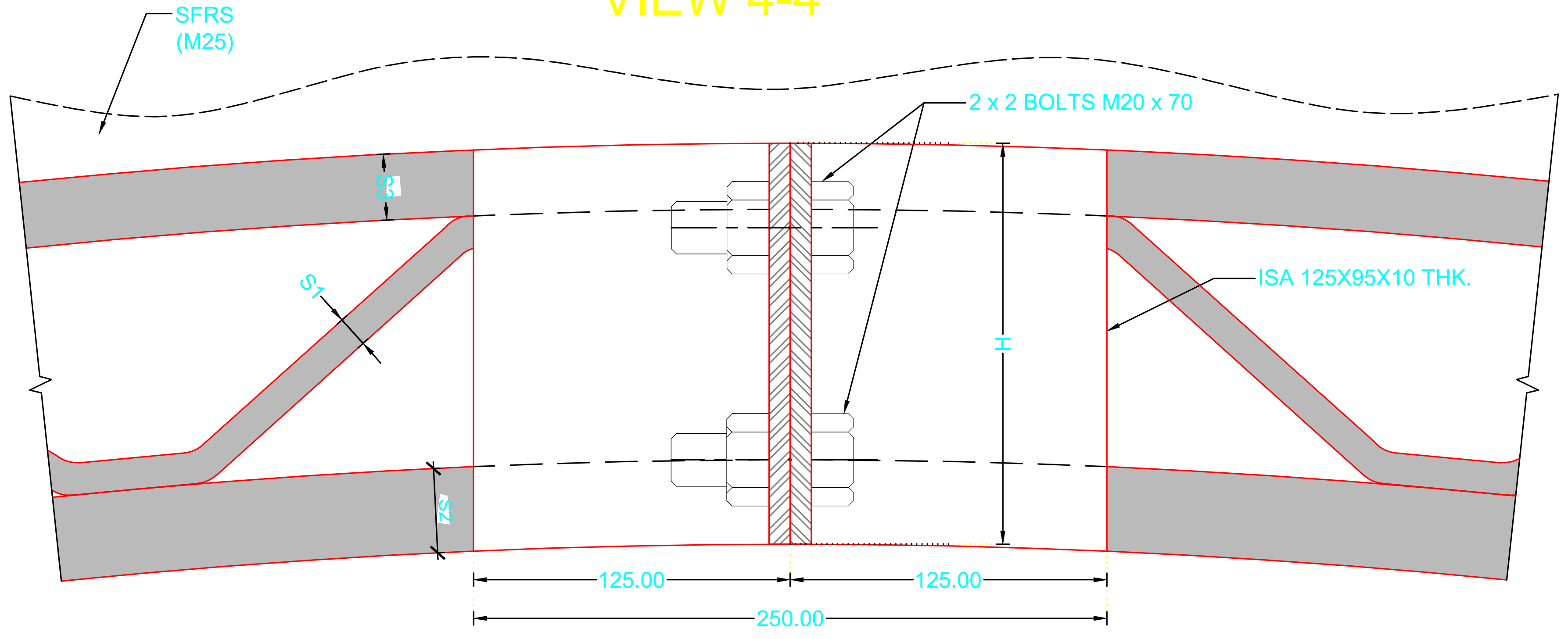
(VALID FOR TEMPORARY STRUCTURE)



JOINT DETAIL (TYP.)



VIEW 4-4



NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE MEASURED FROM THE DRAWING.
3. STEEL BARS SHOWN AS S1, S2 & S3 SHALL BE OF GRADE Fe-500 CONFORMING TO IS:1786.
4. ALL STRUCTURAL STEELS SHALL CONFORM TO IS:2062.
5. ALL WELDING SHALL BE CARRIED OUT BY USING SHIELDED ARC METHOD AS DESCRIBED IN THE SP-12, ISI HAND BOOK FOR GAS WELDERS AND ISI HANDBOOK OF MANUAL METAL ARC WELDING FOR WELDERS.

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES
THE INFRASTRUCTURE PEOPLE

SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01007_A0

DRAWING NAME CONCEPTUAL DRAWING FOR
TUNNEL TYPICAL DETAIL OF LATTICE GIRDER

ISSUE DATE: *07.11.2022* *REVISED DATE:*

SCALE- *AS SHOWN*

SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

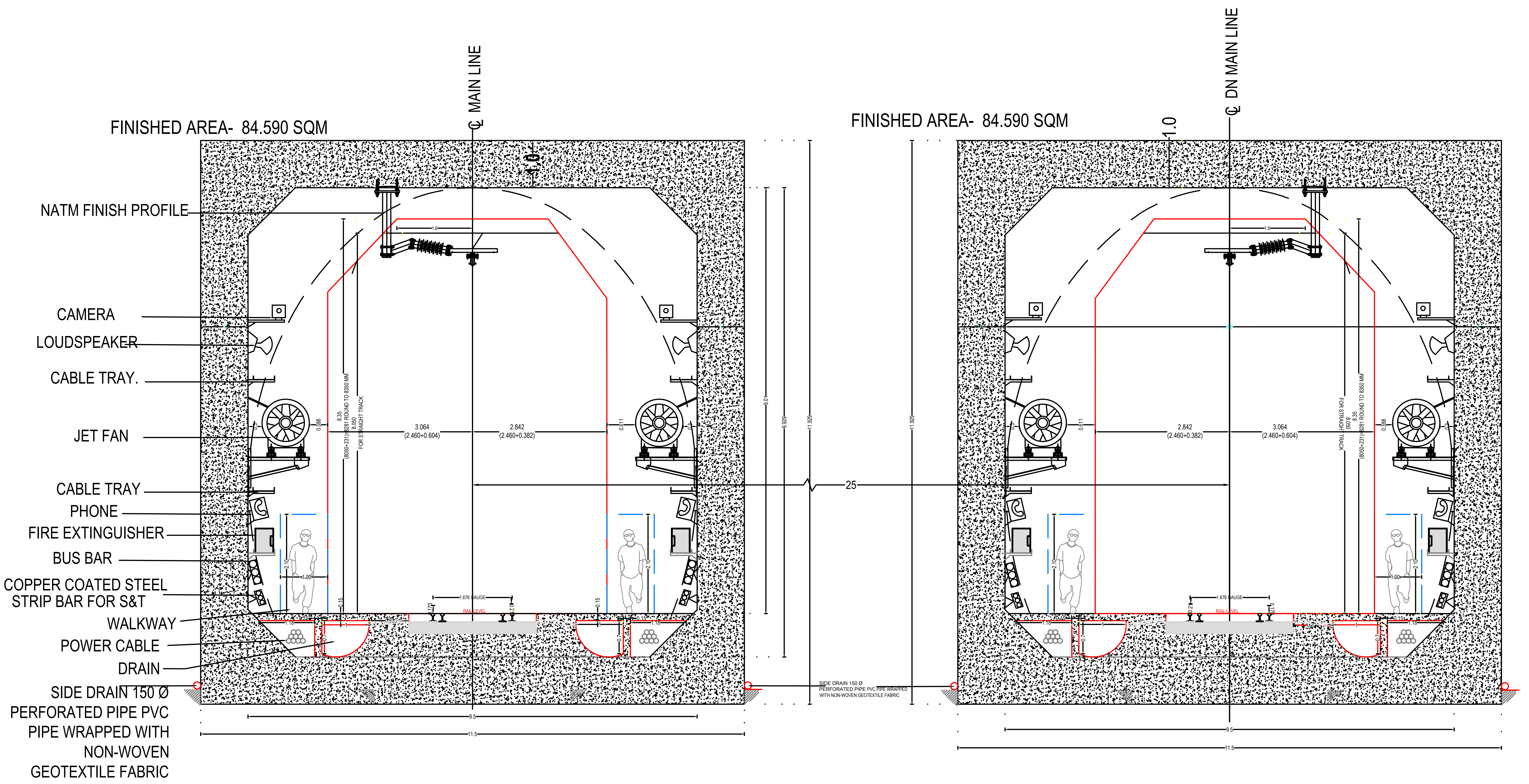
CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S. kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

B.R.SHARMA
Sr.CONSULTANT / TUNNEL

S. M. CONSULTANTS BHUBANESWAR
A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



NOTES:~

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE MEASURED FROM THE DRAWING.
3. MINIMUM EXCAVATION LINE SHALL INCLUDE CONSTRUCTION & DEFORMATION TOLERANCE.
4. GUARD RAIL SHALL BE PROVIDED THROUGHOUT THE LENGTH OF BALLASTLESS TRACK
5. BALLASTLESS TRACK TO BE DESIGN FOR 32.5 T AXLE LOADING
6. DIMENSIONS OF SLAB THICKNESS ARE TENTATIVE.
7. SEPARATE EARTHING MET CONNECTION FOR S&T SYSTEM SHALL BE PROVIDED.
8. ANCHOR BOLT FOR ROCS SHALL BE INSTALLED DURING TUNNEL LINING.
9. CABLE CROSSING SHALL BE PROVIDED AT EVERY CROSS PASSAGE.
10. LUMINANCE CAMERA, LOUDSPEAKER, JET FAN, PHONE, BUS BAR, COPPER COATED STEEL STRIP BAR FOR S&T AND ROCS WORK (EXCLUDING ANCHOR BOLTS) IS NOT IN THE SCOPE OF WORK OF C-4.

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES THE INFRASTRUCTURE PEOPLE
SMEC Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01008_A1

DRAWING NAME CONCEPTUAL DRAWING FOR CUT & COVER SECTION OF TUNNEL

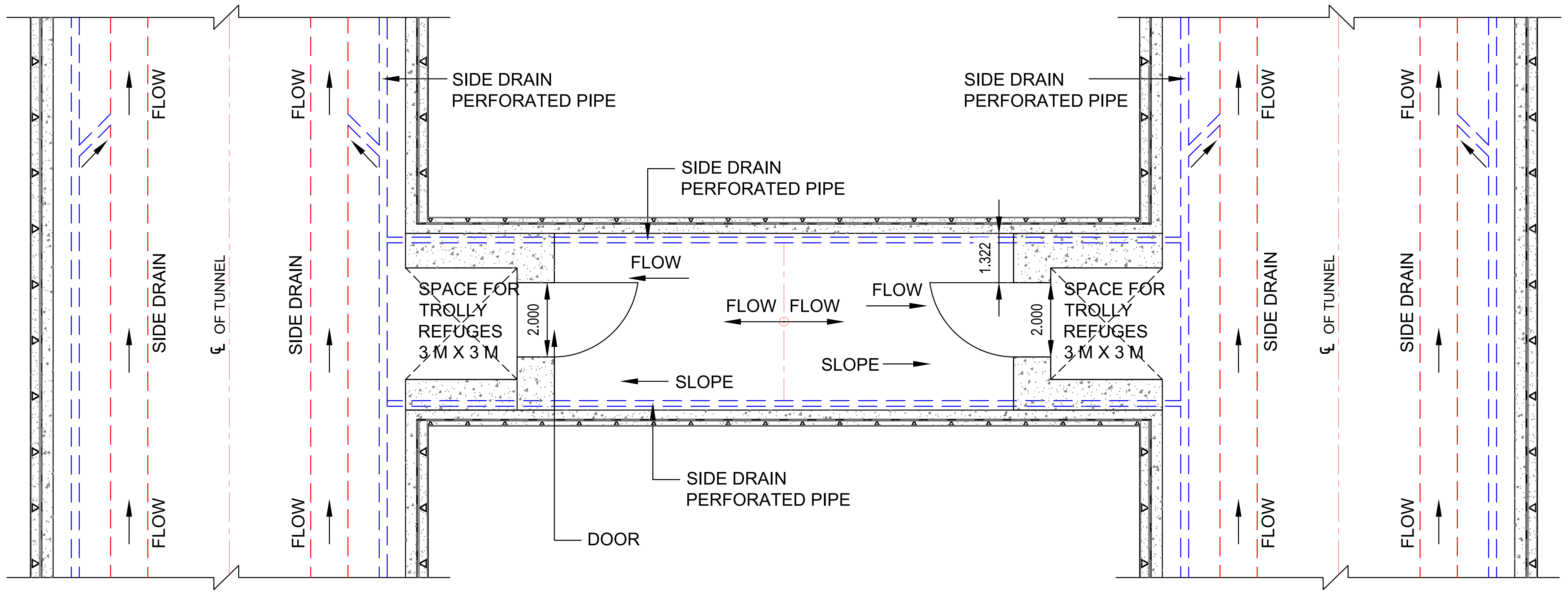
ISSUE DATE: *07.11.2022* *REVISED DATE:* 03.01.2023
SCALE- *AS SHOWN*
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

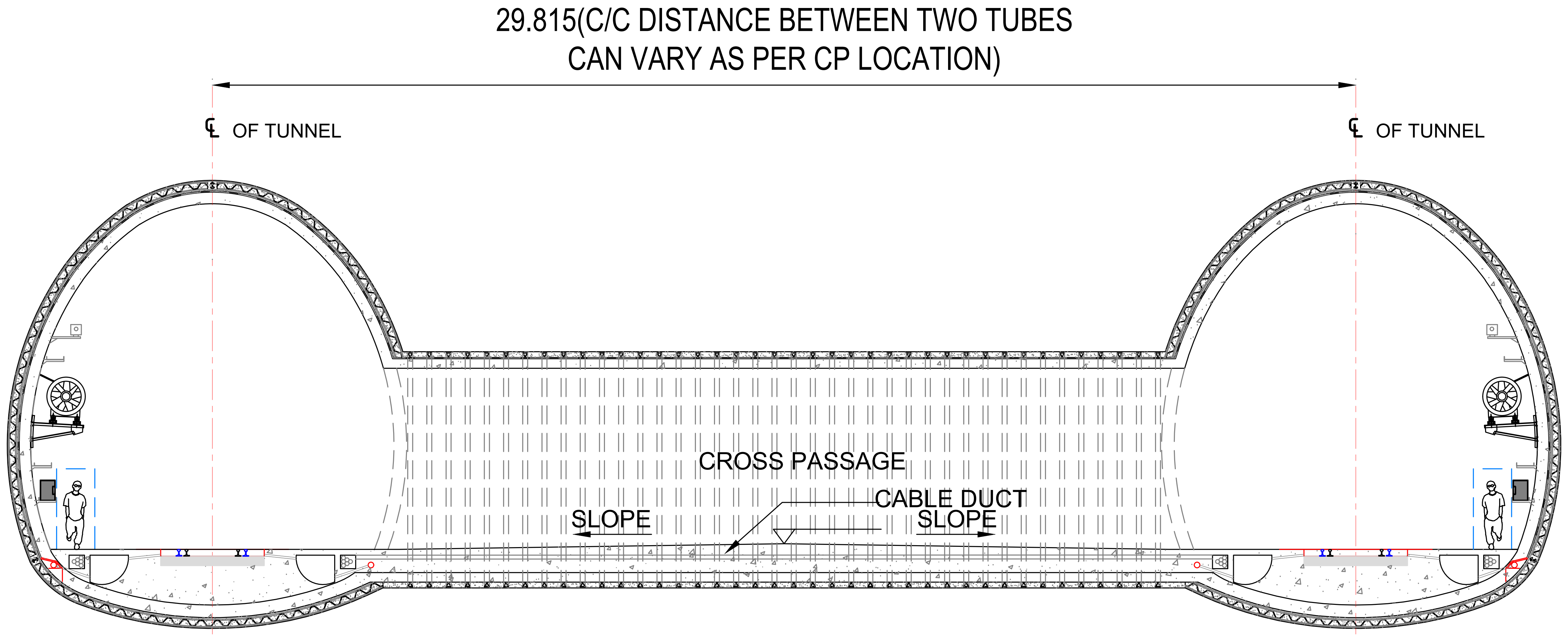
CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

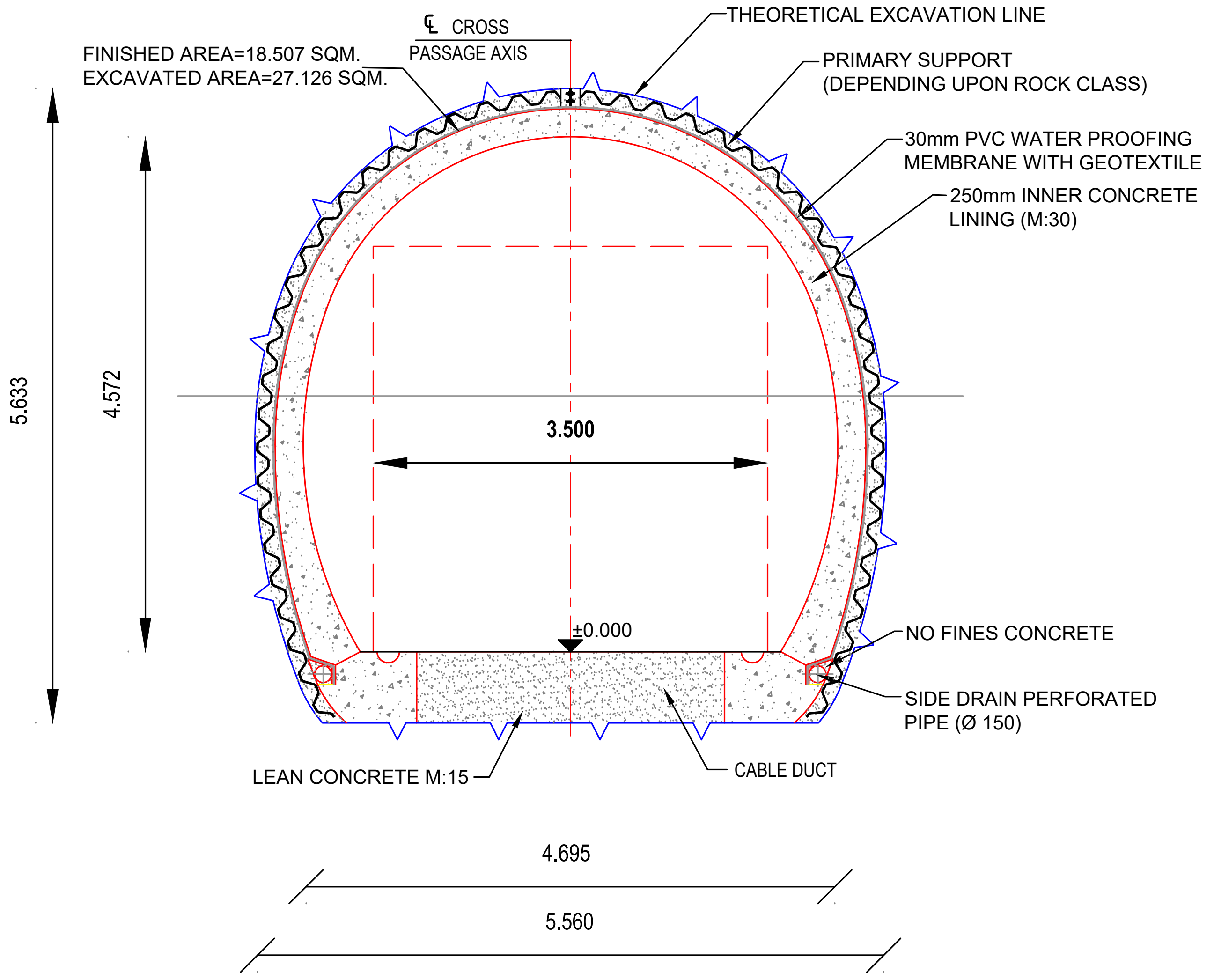
S.M. CONSULTANTS BHUBANESWAR

S.Kumar *SIVENDRA KUMAR* *TUNNEL DESIGNER*	*B.R.SHARMA* *Sr.CONSULTANT / TUNNEL*	*A. A. SAMANT* *PROJECT INCHARGE*

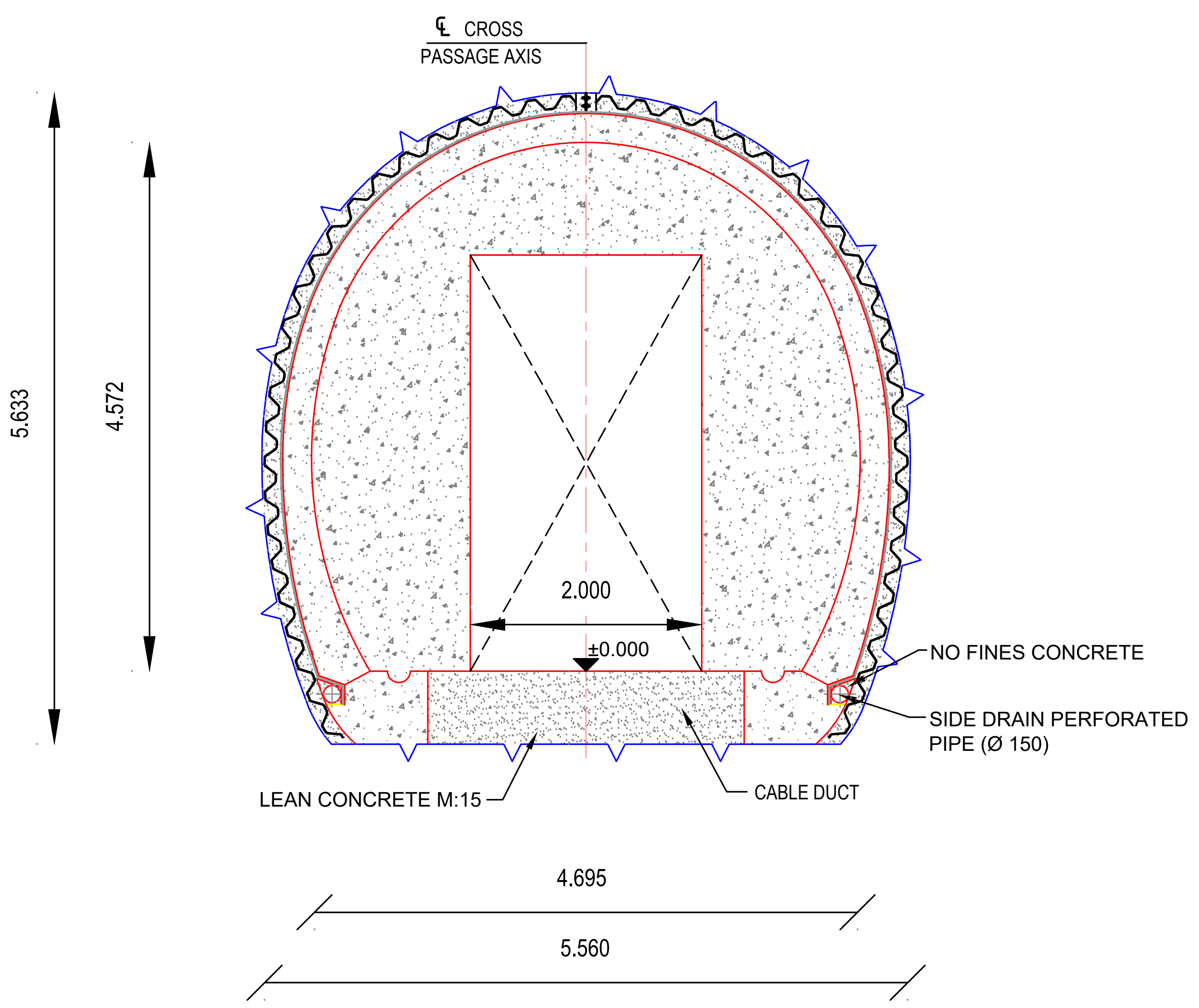
RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



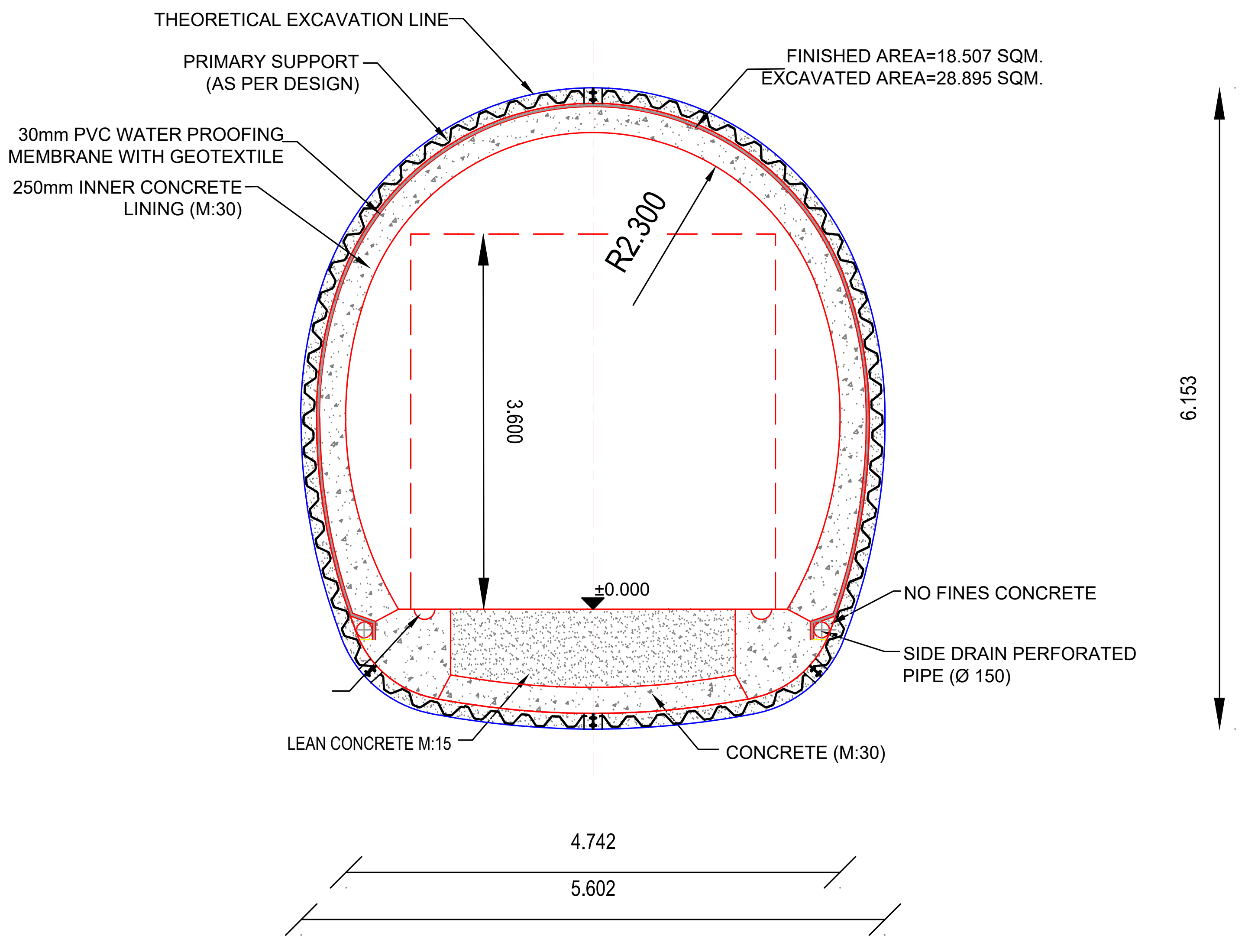




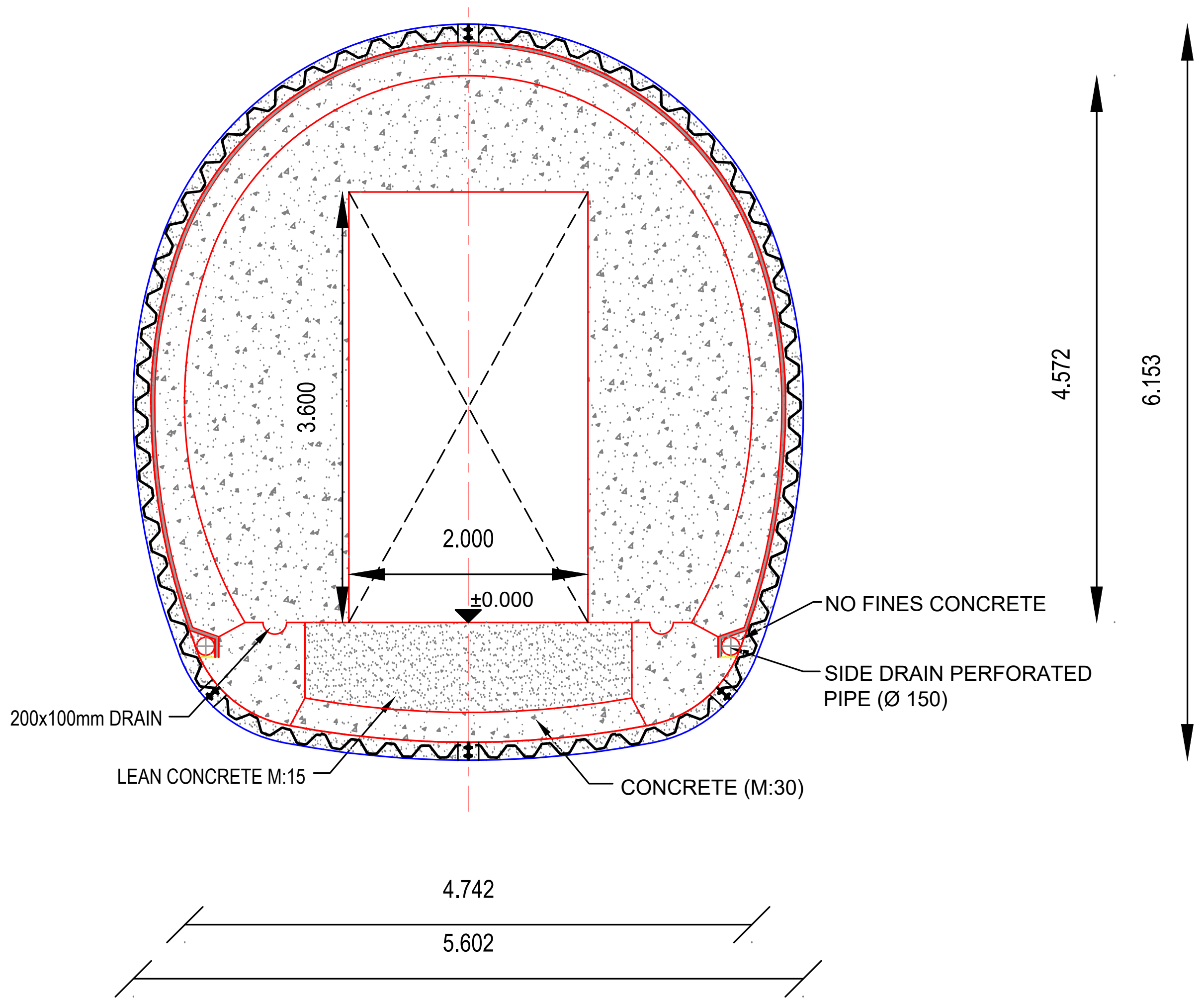
CROSS PASSAGE ROCK



CROSS PASSAGE ROCK WITH DOOR



CROSS PASSAGE SOIL



CROSS PASSAGE SOIL WITH DOOR

NOTES:-

1. ALL DIMENSIONS, NORTHING & EASTING AND LEVELS ARE IN METRE, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE MEASURED FROM DRAWING.
3. TUNNEL EXCAVATED BY HEADING, BENCHING / MULTI DRIFT METHOD (NATM).
4. CROSS PASSAGE SHALL BE PROVIDED AT 400 M INTERVAL.
5. THE GRADE OF SHOTCRETE WITH SFRS AS PER DETAIL DESIGN.
6. PROPOSED SUPPORT SYSTEM IS BASED ON GIR PROVIDED BY GEOLOGIST. ACTUAL SUPPORT SYSTEM MAY BE REVISED BASED ON ACTUAL RESPONSE OF STRATA DURING EXCAVATION.
7. DRAINAGE PIPE SHALL BE 150mmØ, PERFORATED PVC PIPE WRAPPED WITH NON-WOVEN GEOTEXTILE FABRIC AS PER IS-4989
8. EXCAVATION SEQUENCE WILL BE PROVIDED BASED ON GFC.
9. PIPE ROOFING/FOREPULING OF 114 MM DIA SHALL BE PROVIDED WHERE EVER IT IS REQUIRED.
10. SELF DRILLING ANCHOR OF CAPACITY 190 KN SHALL BE PROVIDED FOR PRIMARY SUPPORT DURING EXCAVATION.
11. LATTICE GIRDER 25-25-32 OF DEPTH 187 MM/ ISMB 200 MM SHALL BE INCASED IN SFRS OF MINIMUM THICKNESS 250 MM.
12. DIMENSION OF PRIMARY SUPPORT & CONCRETE ARE TENTATIVE.

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES THE INFRASTRUCTURE PEOPLE
SMEC Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01009_A1

DRAWING NAME CONCEPTUAL DRAWING FOR
CROSS PASSAGE JUNCTION WITH MAIN TUNNEL

ISSUE DATE: *07.11.2022* *REVISED DATE:* 03.01.2023
SCALE- *AS SHOWN*
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

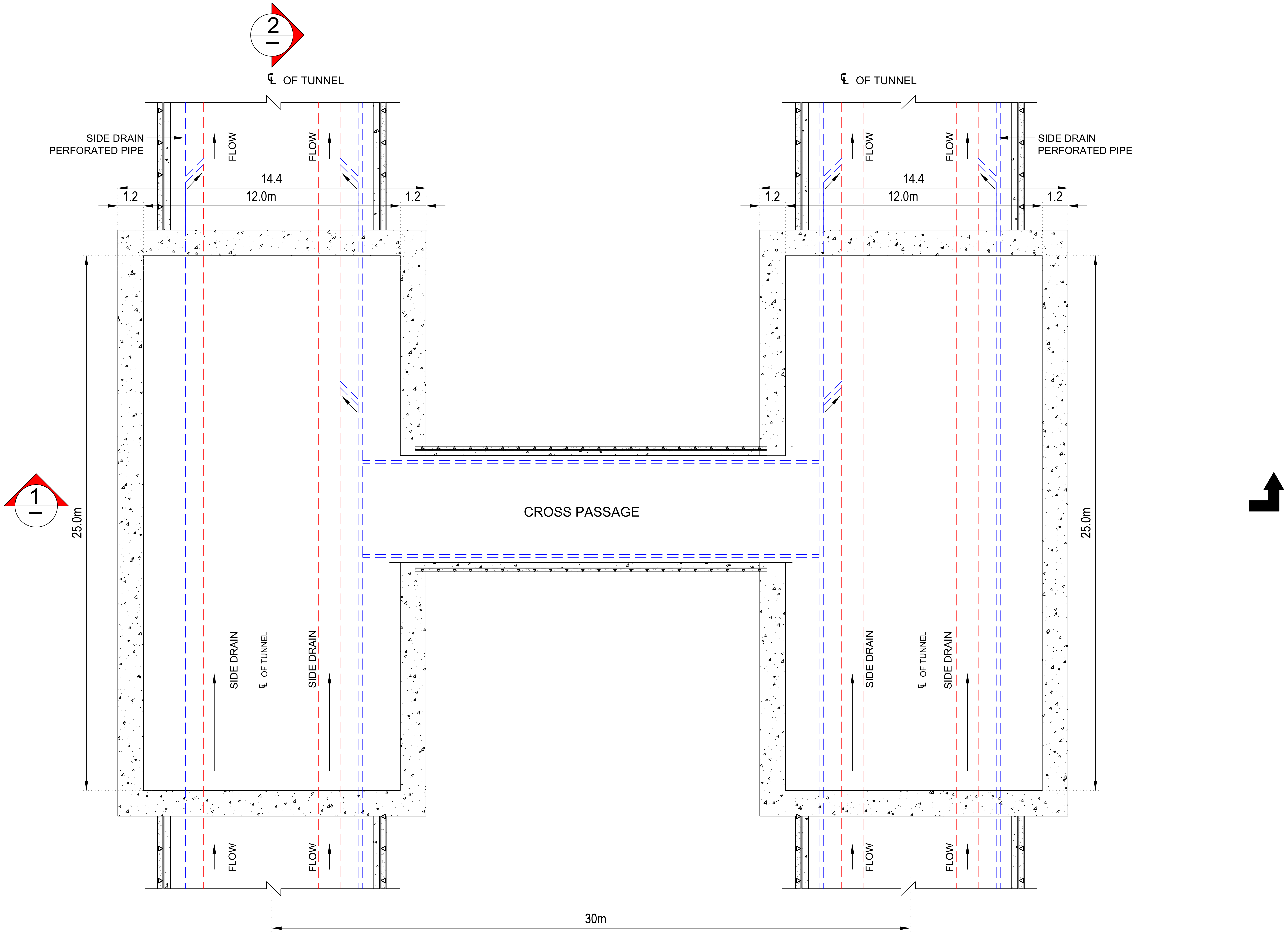
CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S. kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

B.R.SHARMA
Sr.CONSULTANT / TUNNEL

S. M. CONSULTANTS BHUBANESWAR
A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



PLAN

NOTES:-

1. ALL DIMENSIONS, NORTHING & EASTING AND LEVELS ARE IN METER, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE MEASURED FROM DRAWING.
3. TUNNEL EXCAVATED BY HEADING, BENCHING / MULTI DRIFT METHOD (NATM).
4. THE GRADE OF SHOTCRETE WITH SFRS AS PER DETAIL DESIGN.
5. PROPOSED SUPPORT SYSTEM IS BASED ON GIR PROVIDED BY GEOLOGIST. ACTUAL SUPPORT SYSTEM MAY BE REVISED BASED ON ACTUAL RESPONSE OF STRATA DURING EXCAVATION.
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11. DIMENSION OF PRIMARY SUPPORT & CONCRETE ARE TENTATIVE.
12. INSERT PLATES SHALL BE PROVIDED IN THE WALL FOR PROVISION OF SS STAIRS OF MINIMUM WIDTH OF 1.5M.
13. ROOFING SYSTEM OVER SHAFTS SHALL BE PROVIDED AS PER DBR.

LOCATION	
SHAFT-1	CH:26080
SHAFT-2	
SHAFT-3	CH:27680
SHAFT-4	

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES THE INFRASTRUCTURE PEOPLE
SMEC Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01010_A2 SHEET: 1 OF 3
DRAWING NAME CONCEPTUAL DRAWING FOR PERMANENT VENTILATION SHAFT JUNCTION WITH MAIN TUNNEL
ISSUE DATE: *07.11.2022* *REVISED DATE:* 09.01.2023
SCALE- *AS SHOWN*
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7
CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S.Kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

B.R.SHARMA
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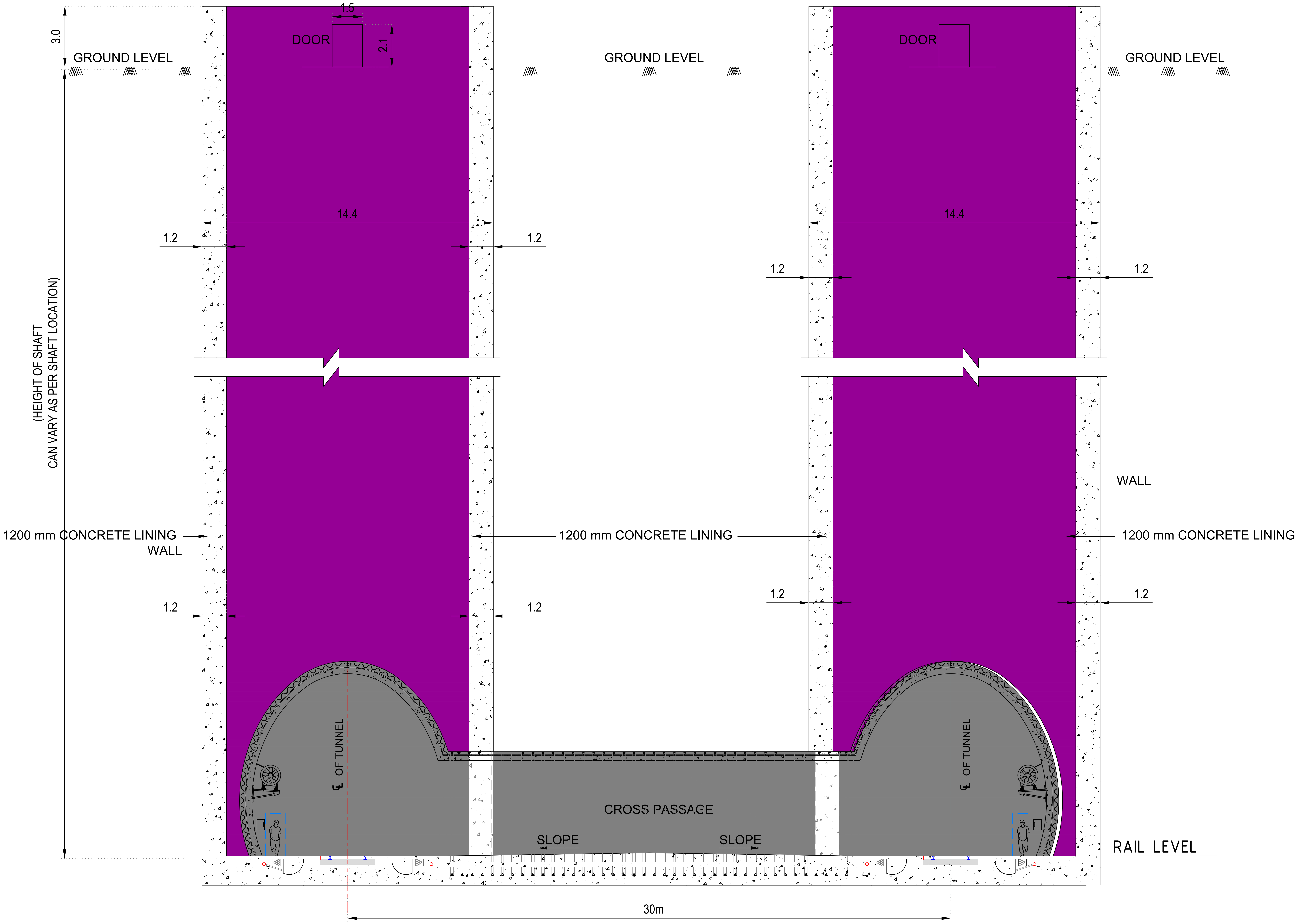
S. M. CONSULTANTS BHUBANESWAR
A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



SECTIONAL ELEVATION 1-1

NOTES:-

1. ALL DIMENSIONS, NORTHING & EASTING AND LEVELS ARE IN METER, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE MEASURED FROM DRAWING.
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12. INSERT PLATES SHALL BE PROVIDED IN THE WALL FOR PROVISION OF SS STAIRS OF MINIMUM WIDTH OF 1.5M.

LOCATION	
SHAFT-1	CH:26080
SHAFT-2	
SHAFT-3	CH:27680
SHAFT-4	

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:- HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:- HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT: GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES THE INFRASTRUCTURE PEOPLE
SMEC Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01010_A2 SHEET: 2 OF 3

DRAWING NAME CONCEPTUAL DRAWING FOR
PERMANENT VENTILATION SHAFT JUNCTION WITH
MAIN TUNNEL

ISSUE DATE: *07.11.2022* *REVISED DATE:* 09.01.2023
SCALE- *AS SHOWN*
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

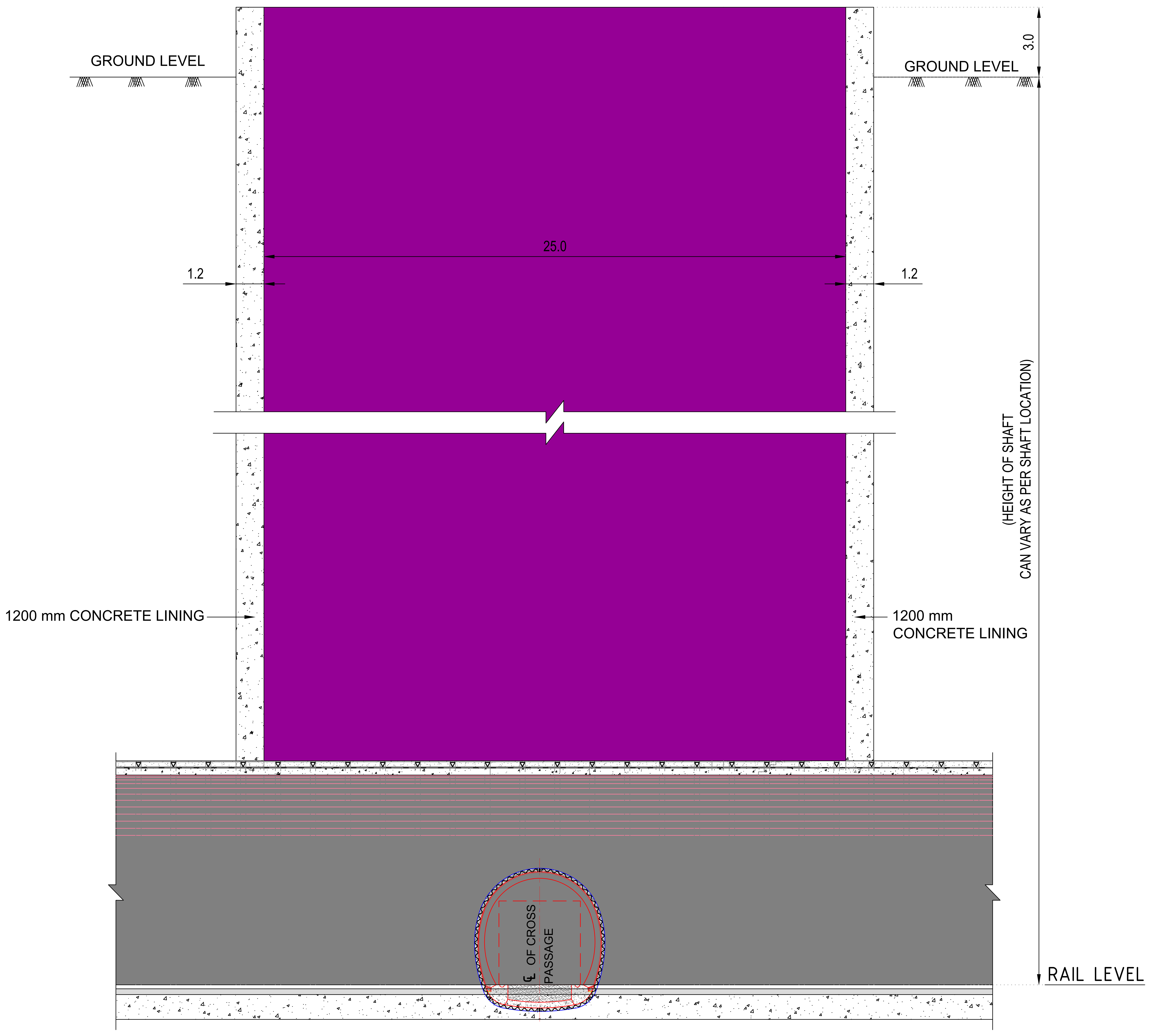
CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S.kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

B.R.SHARMA
Sr.CONSULTANT / TUNNEL

S. M. CONSULTANTS BHUBANESWAR
A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



SECTIONAL ELEVATION 2-2

NOTES:-

1. ALL DIMENSIONS, NORTHING & EASTING AND LEVELS ARE IN METER, UNLESS OTHERWISE SPECIFIED.
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LOCATION	
SHAFT-1	CH:26080
SHAFT-2	
SHAFT-3	CH:27680
SHAFT-4	

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
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		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES
THE INFRASTRUCTURE PEOPLE
SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01010_A2 SHEET: 3 OF 3

DRAWING NAME CONCEPTUAL DRAWING FOR
PERMANENT VENTILATION SHAFT JUNCTION WITH
MAIN TUNNEL

ISSUE DATE: *07.11.2022* *REVISED DATE:* 09.01.2023
SCALE- *AS SHOWN*
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

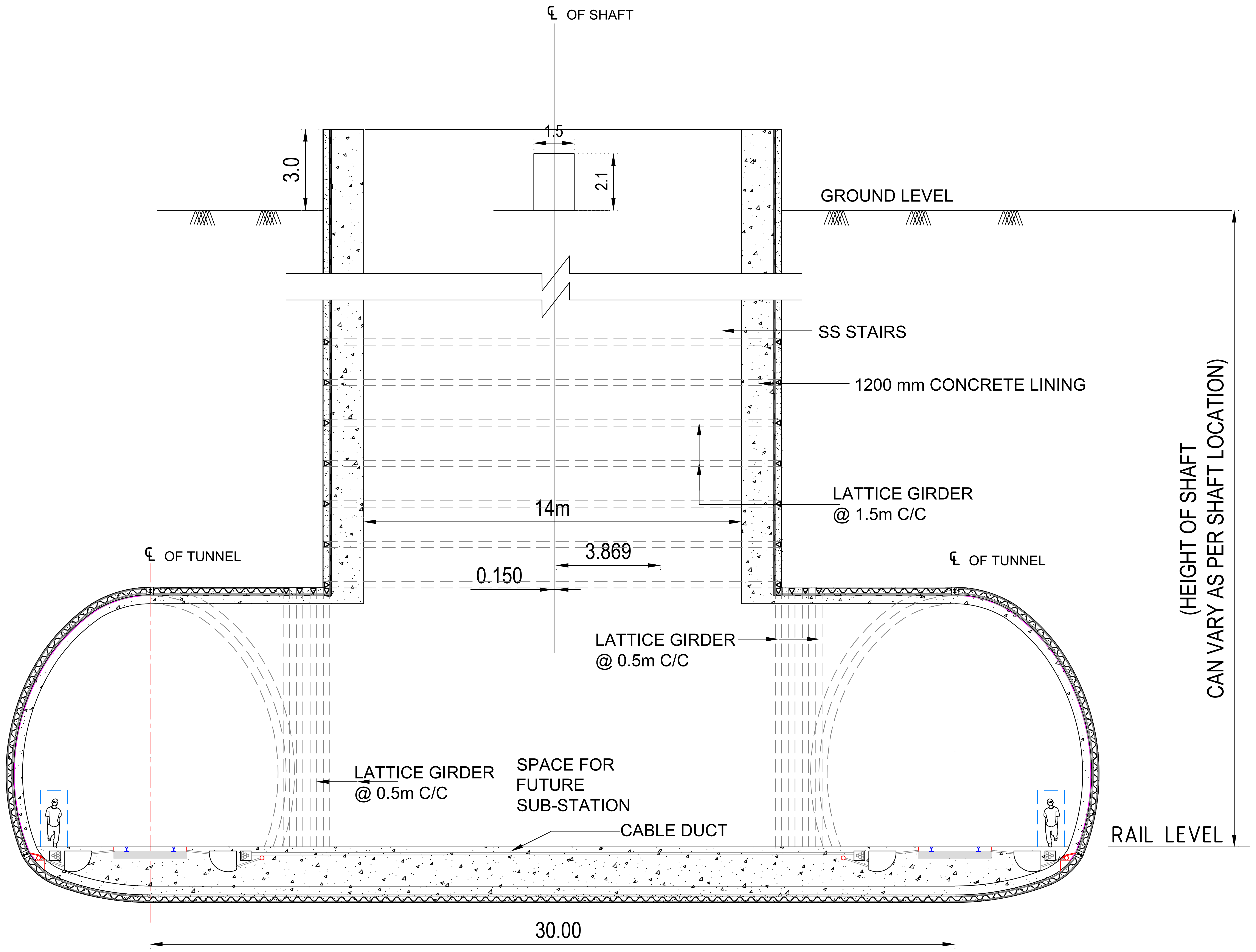
CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S. Kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

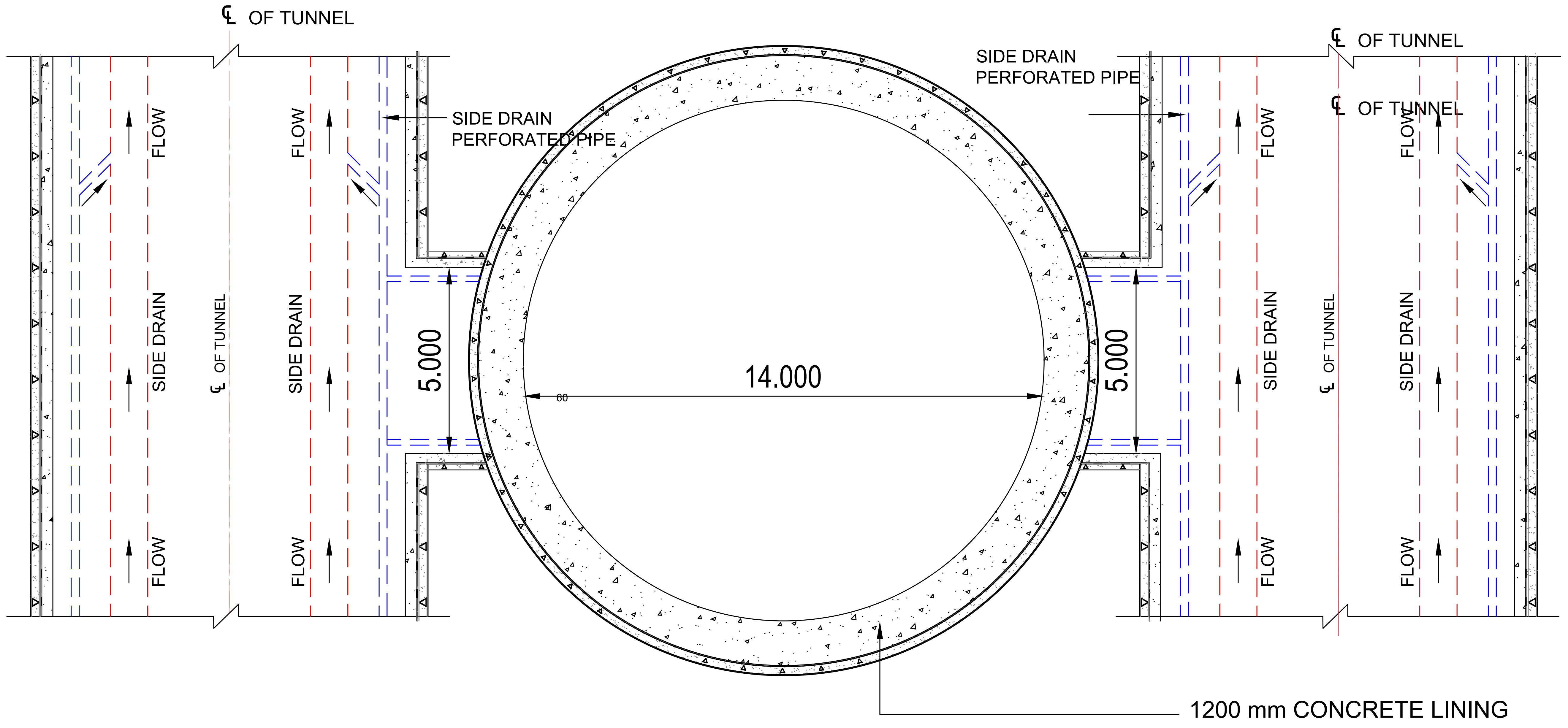
B.R.SHARMA
Sr.CONSULTANT / TUNNEL

S. M. CONSULTANTS ★ BHUBANESWAR ★
A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



SECTIONAL ELEVATION



PLAN

NOTES:-

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3. TUNNEL EXCAVATED BY HEADING, BENCHING / MULTI DRIFT METHOD (NATM).
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NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
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SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES
THE INFRASTRUCTURE PEOPLE
SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:-	GC-HRIDC-C4-DRW-TTL-CLT-01011_A2
DRAWING NAME	CONCEPTUAL DRAWING FOR CONSTRUCTION CUM UTILITY SHAFT
ISSUE DATE:	*07.11.2022*
REVISED DATE:	09.01.2023
SCALE-	*AS SHOWN*
SMC DRG. NO:-	SMC/HRIDC/TUN/CS- 7
CONSULTANT:	S.M.C. S.M. CONSULTANTS **An ISO 9001 Company** Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi Web : www.smcindia.com , E-Mail : support@smcindia.com

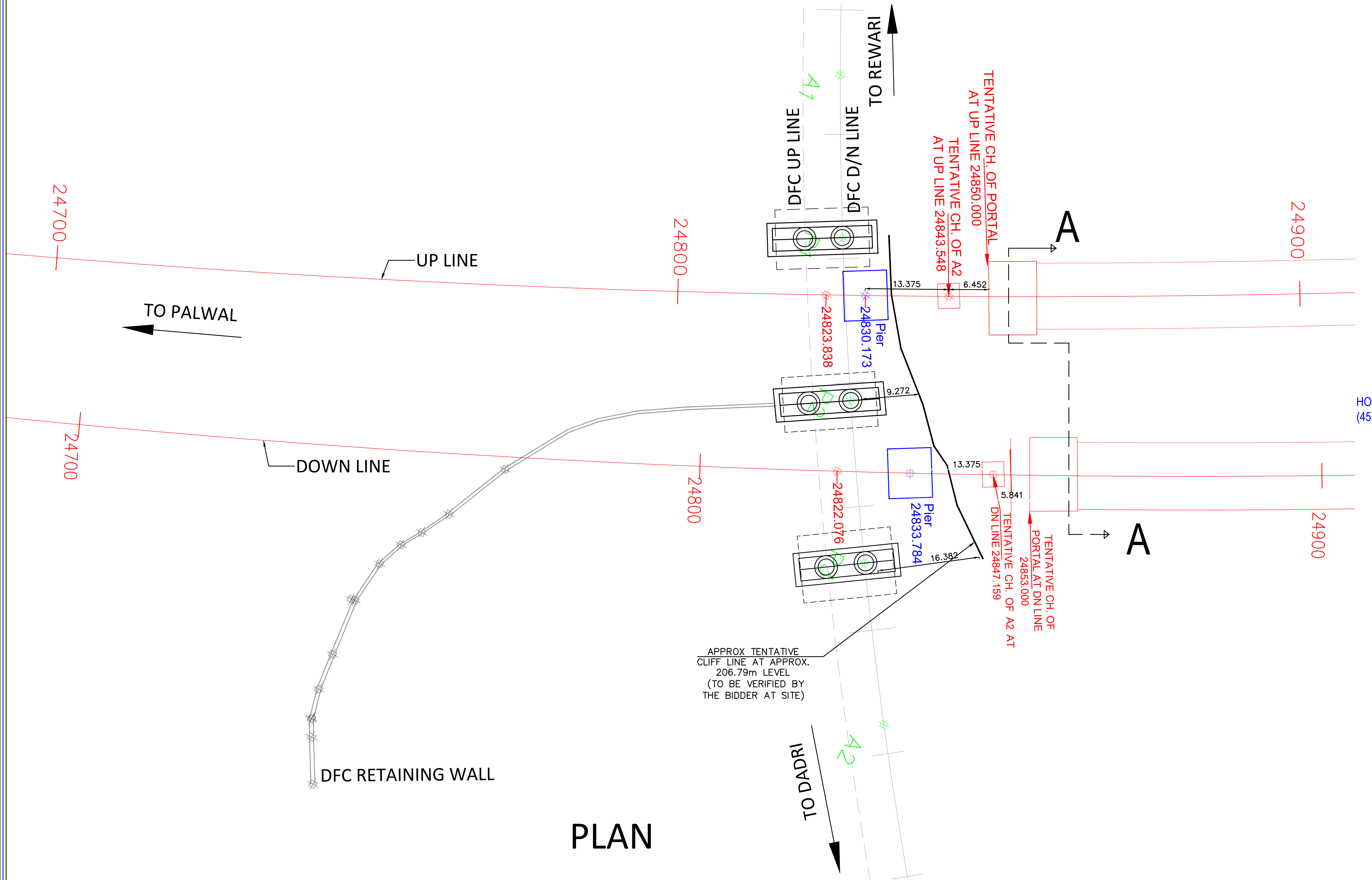
S. M. CONSULTANTS ★ BHUBANESWAR ★

S. Kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

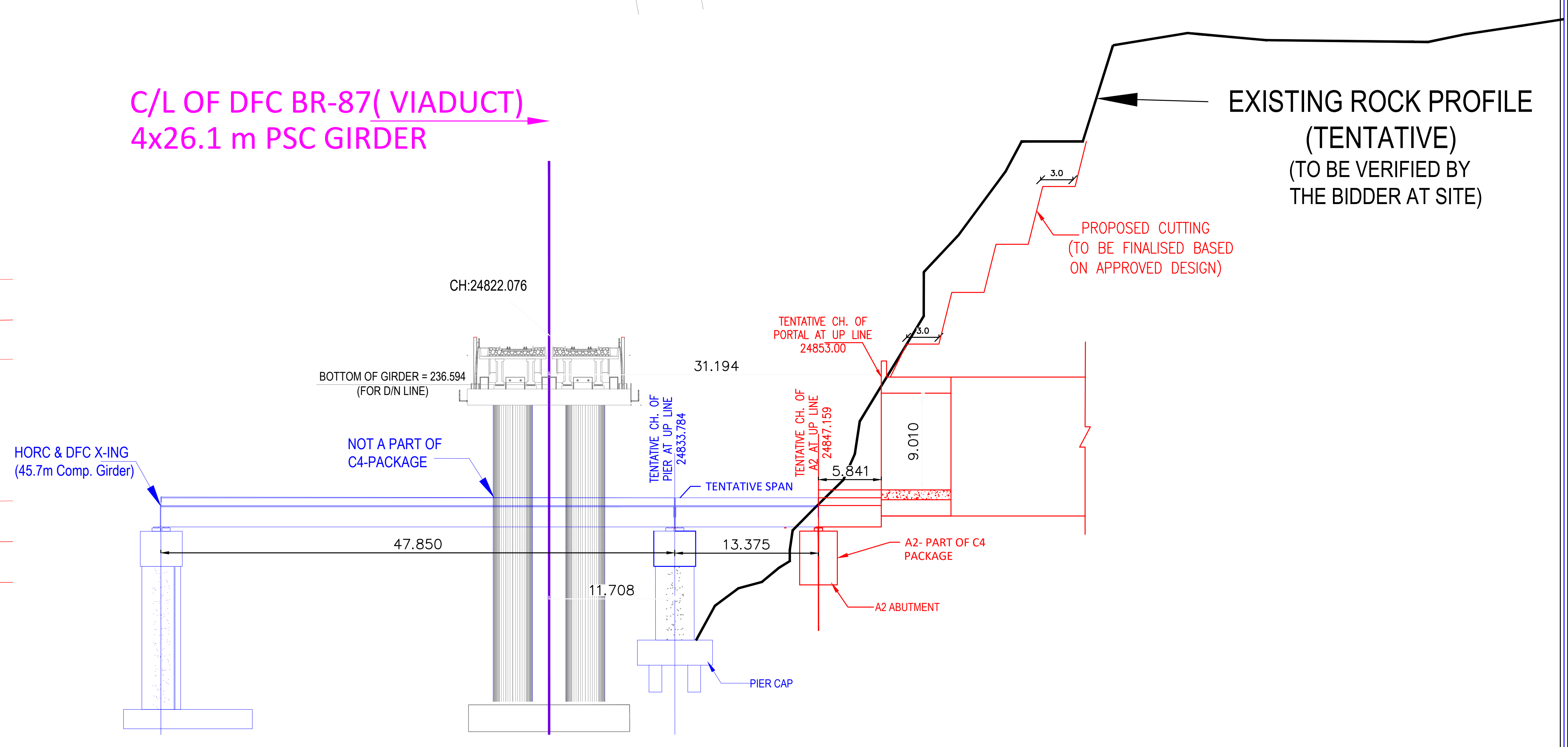
B.R.SHARMA
Sr.CONSULTANT / TUNNEL

A. A. SAMANT
PROJECT INCHARGE

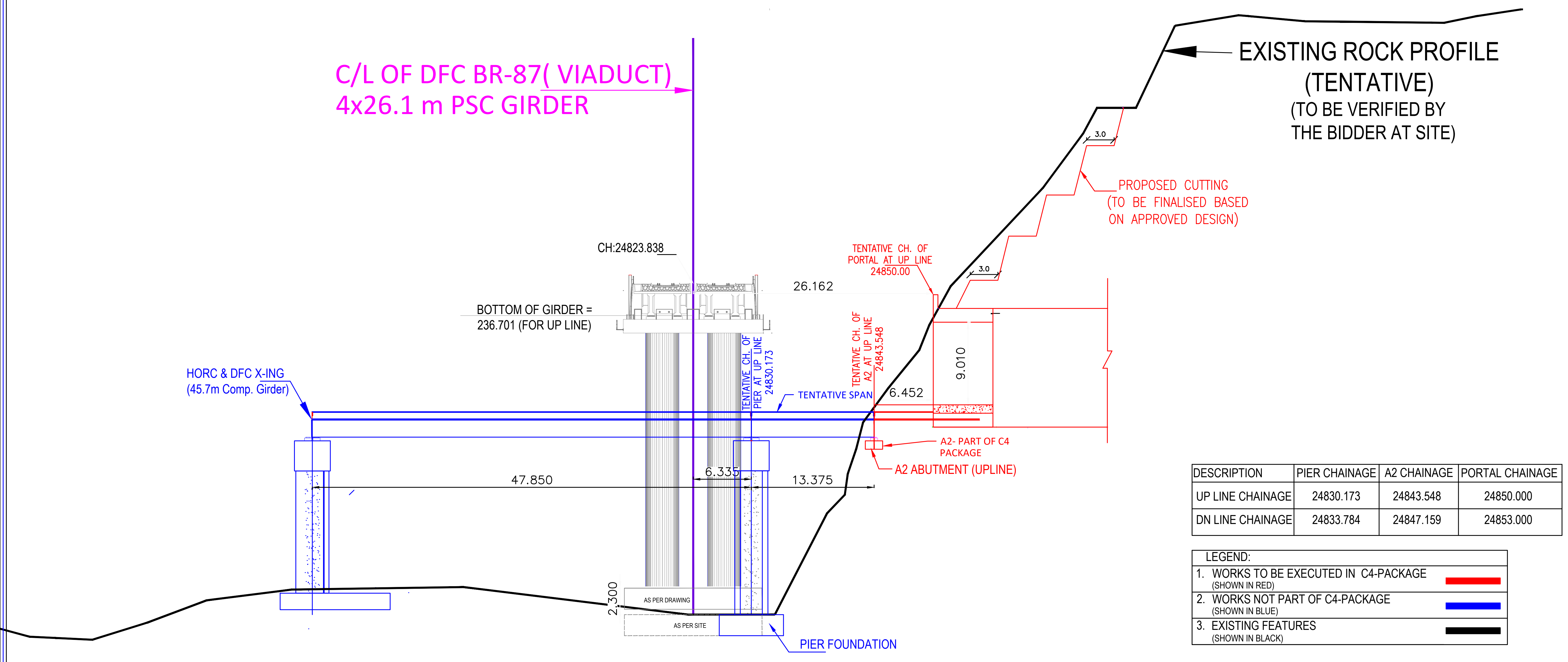
RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



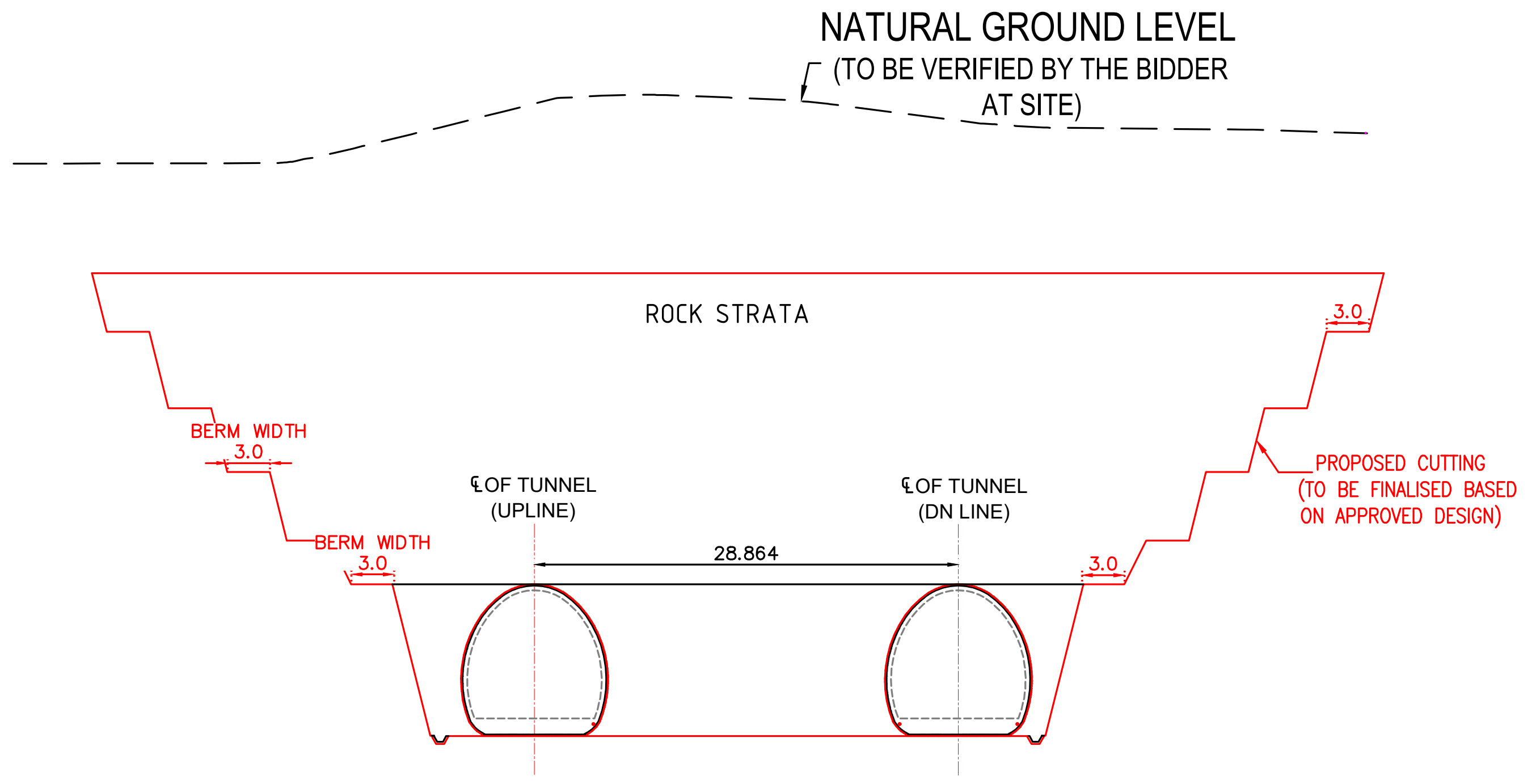
PLAN



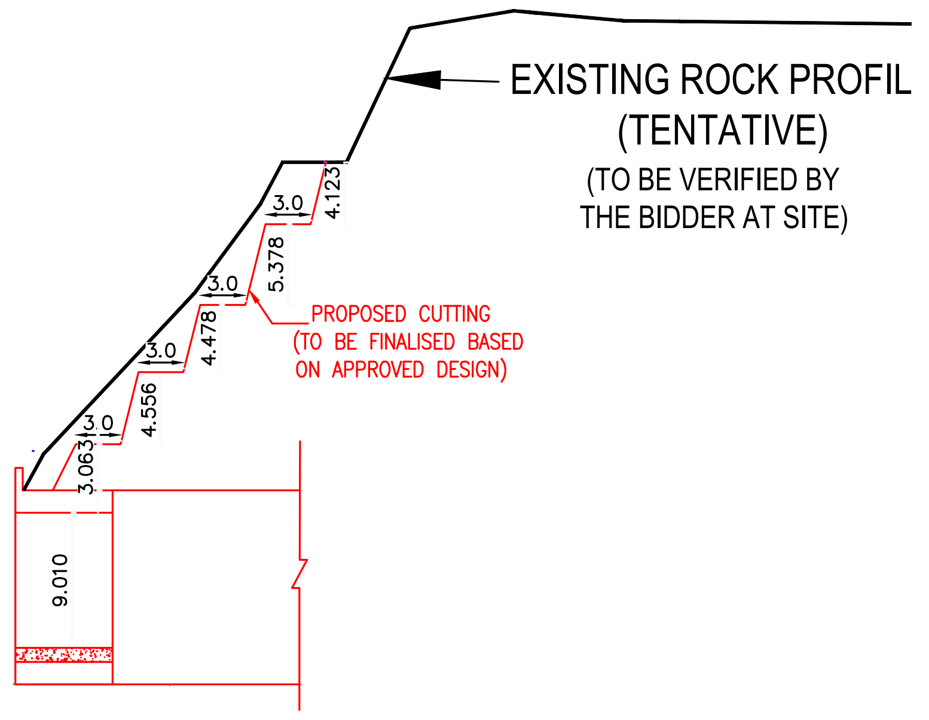
SECTION AT DN LINE



SECTION AT UP LINE



SECTION A-A
(ELEVATION)



SECTION A-A
(SIDE VIEW)

DESCRIPTION	PIER CHAINAGE	A2 CHAINAGE	PORTAL CHAINAGE
UP LINE CHAINAGE	24830.173	24843.548	24850.000
DN LINE CHAINAGE	24833.784	24847.159	24853.000

LEGEND:	
1. WORKS TO BE EXECUTED IN C4-PACKAGE (SHOWN IN RED)	🟥
2. WORKS NOT PART OF C4-PACKAGE (SHOWN IN BLUE)	🟦
3. EXISTING FEATURES (SHOWN IN BLACK)	⬛

NOTE:

1. THE CHAINAGE OF PORTALS OF UP & DOWN LINE SHOWN ARE TENTATIVE AND WILL BE FINALISED BASED ON THE APPROVED DESIGN OF TUNNEL.
2. CHAINAGES SHOWN ARE RECKONED FROM C/L OF PRITHALA STATION BUILDING TAKEN AS 0.00m, WITH RESPECT TO UP MAIN LINE.

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
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STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-

HARYANA ORBITAL RAIL CORRIDOR

CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT
CORPORATION LIMITED.

GENERAL CONSULTANT:

GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES THE INFRASTRUCTURE PEOPLE
SMEC Member of the Surbana Jurong Group

GC/HORC DRG. NO:-	GC-HRIDC-C4-DRW-TTL-CLT-01012_A0
DRAWING NAME	CONCEPTUAL DRAWING FOR PORTAL-1 & ABUTMENT A2 OF PROPOSED HORC VIADUCT
ISSUE DATE:	*07.11.2022*
REVISED DATE:	*09.01.2023*
SCALE-	*AS SHOWN*
SMC DRG. NO:-	SMC/HRIDC/TUN/CS– 7
CONSULTANT:	S.M.C. S.M. CONSULTANTS An ISO 9001 Company Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi Web : www.smcindia.com , E-Mail : support@smcindia.com

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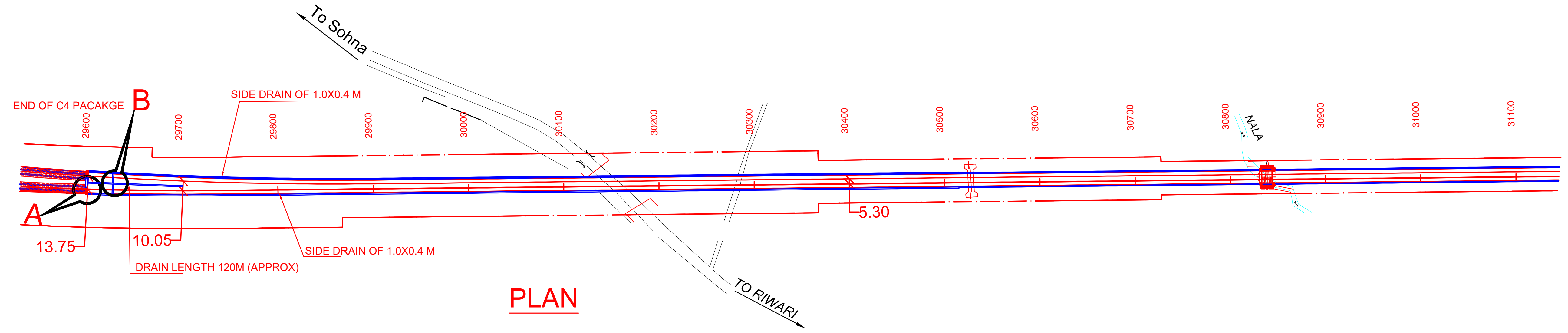
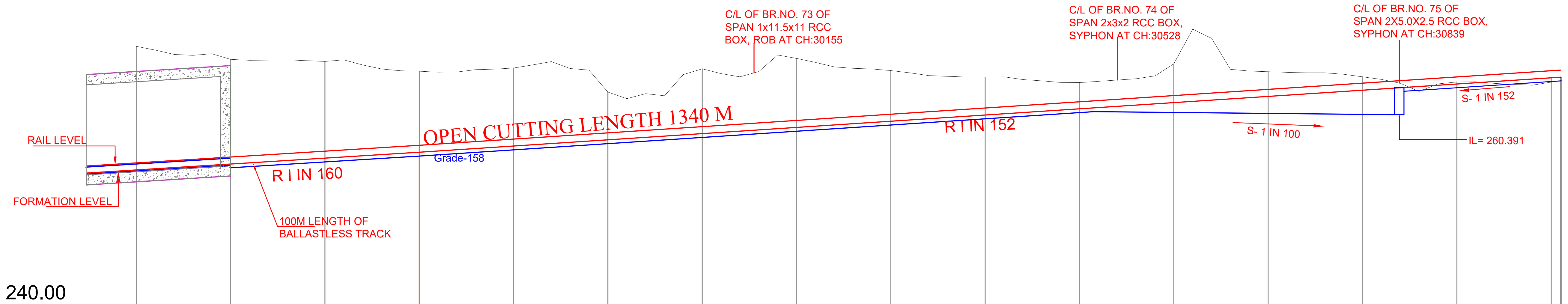
A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION

DETAILS OF SIDE DRAIN & PORTAL 2



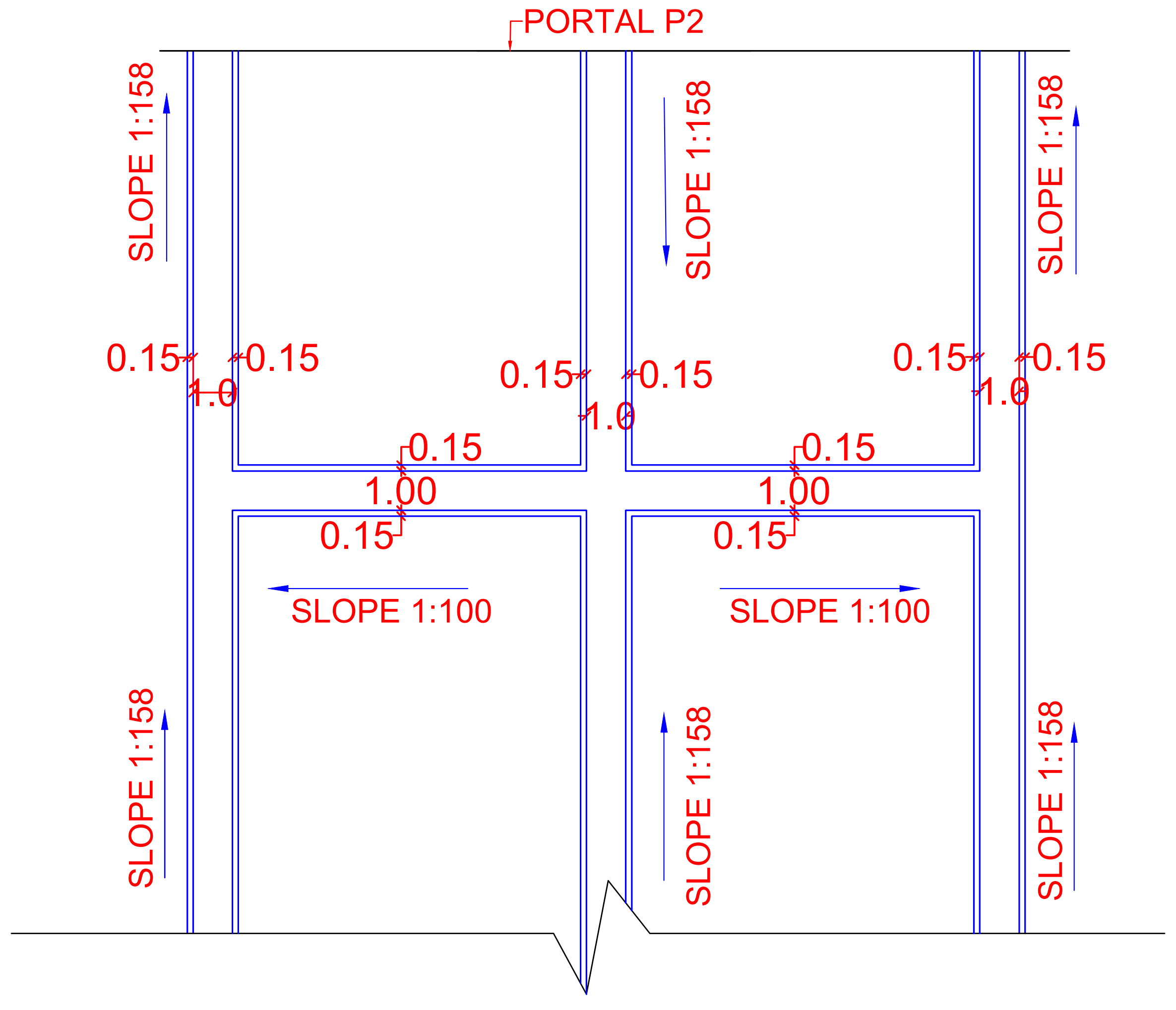
PLAN



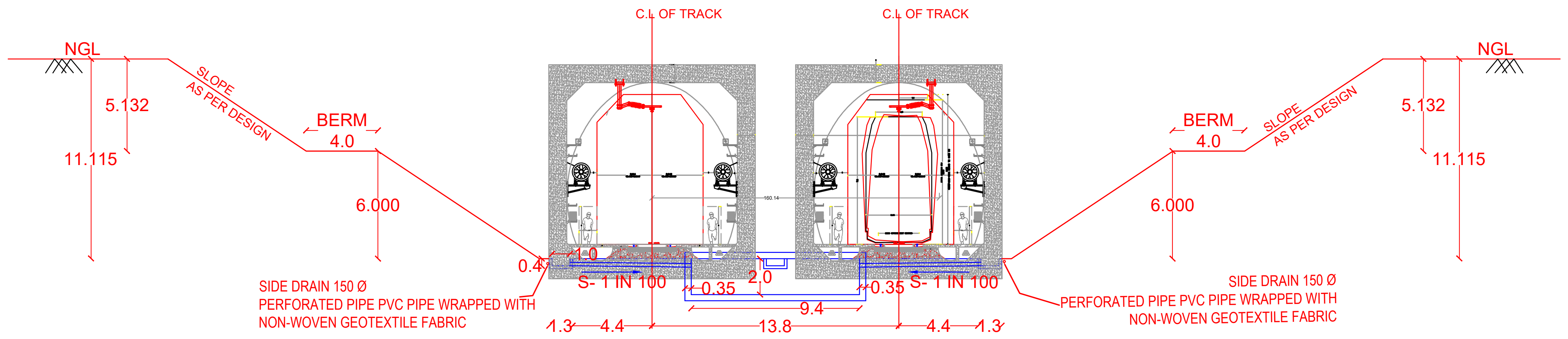
DATUM = 240.00

BANKING (+ ve) CUTTING (- ve)	-13.110	-11.108	-10.254	-8.600	-8.269	-5.060	-6.878	-7.315	-5.376	-4.025	-2.777	-4.112	-2.612	-1.418	-0.218	0.468
PROPOSED FORMATION LEVEL	254.530	255.155	255.780	256.405	257.063	257.721	258.379	259.037	259.695	260.353	261.010	261.668	262.326	262.984	263.642	264.300
GROUND LEVEL	267.640	266.263	266.034	265.005	265.332	262.781	265.257	266.352	265.071	264.378	263.787	265.780	264.938	264.402	263.860	263.832
CHAINAGE	29500	29600	29700	29800	29900	30000	30100	30200	30300	30400	30500	30600	30700	30800	30900	31000

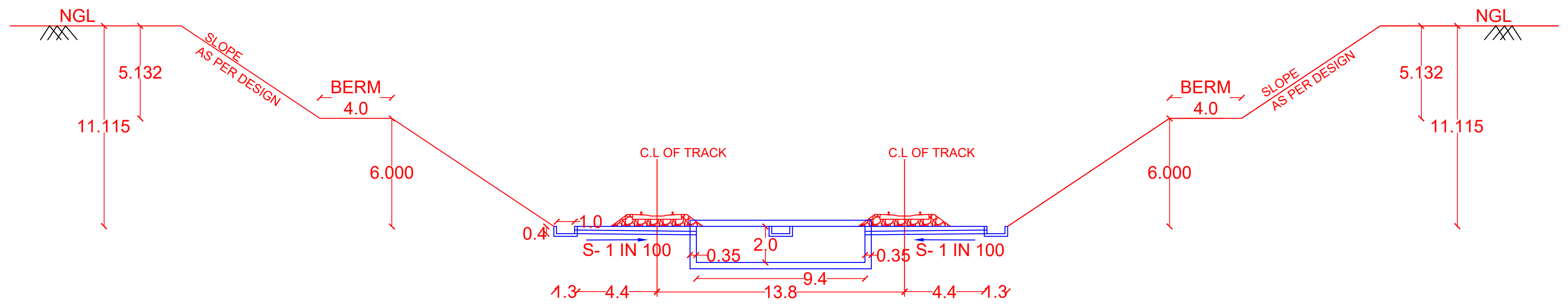
LONGITUDINAL SECTION



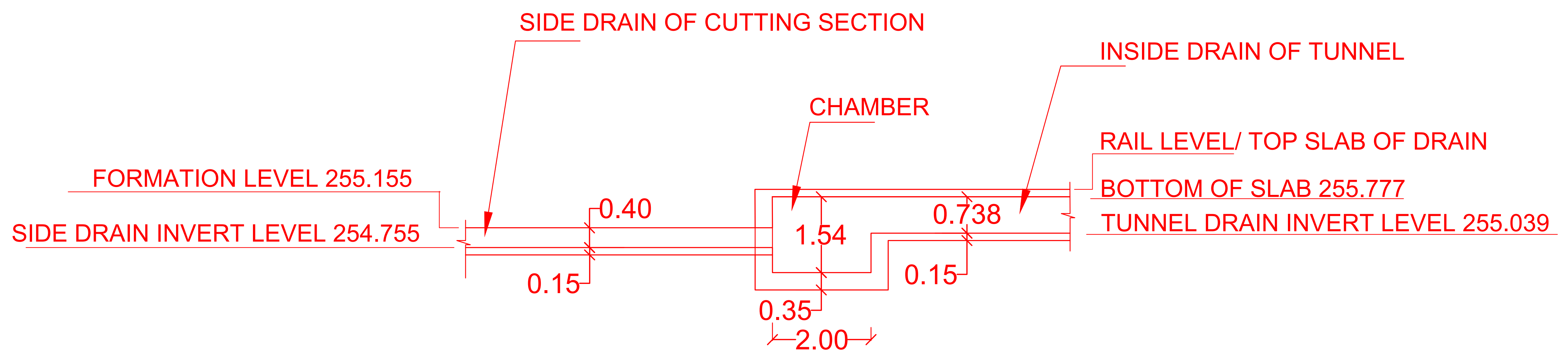
DETAILS OF 'B'



CROSS SECTION AT CUTTING AT PORTAL



CROSS SECTION AT CUTTING BEFORE PORTAL



DETAILS OF 'A' DRAIN SLOPE AS PER FORMATION

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*		*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES THE INFRASTRUCTURE PEOPLE
SMEC Member of the Surbana Jurong Group

GC/HORC DRG. NO:-	GC-HRIDC-C4-DRW-TTL-CLT-01013_A1
DRAWING NAME	CONCEPTUAL DRAWING FOR PORTAL -2 & OPEN CUTTING AREA WITH 100M BALLASTLESS TRACK
ISSUE DATE:	*07.11.2022*
REVISED DATE:	06.01.2023
SCALE-	*AS SHOWN*
SMC DRG. NO:-	SMC/HRIDC/TUN/CS- 7
CONSULTANT:	S.M.C. S.M. CONSULTANTS **An ISO 9001 Company** Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi Web : www.smcindia.com , E-Mail : support@smcindia.com

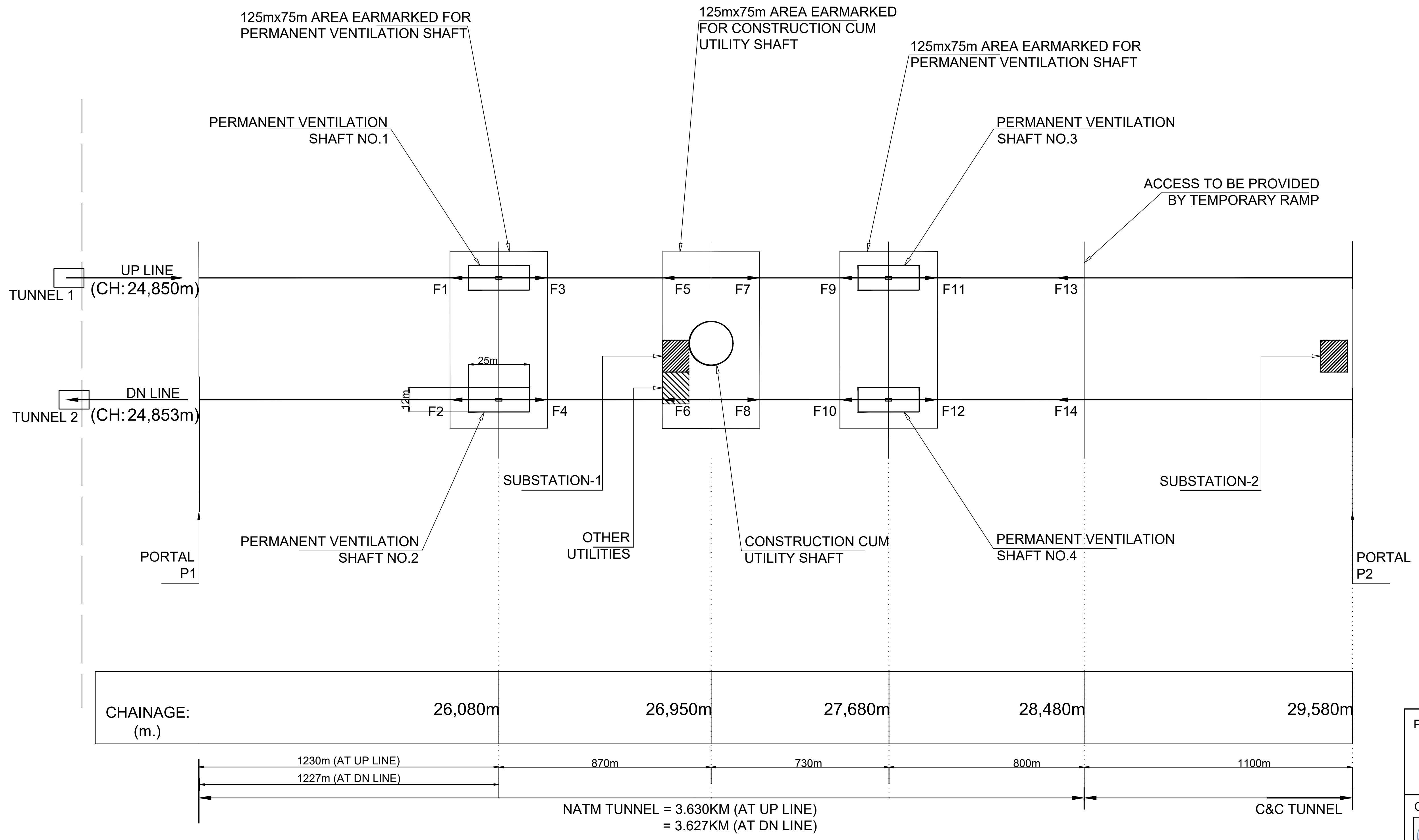
S. Kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

B.R.SHARMA
Sr.CONSULTANT / TUNNEL

S. M. CONSULTANTS BHUBANESWAR
A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION

3. Miscellaneous Drawings (Conceptual Plans)



NOTES:

- F1 - F14 ARE THE WORKING FACES OF NATM TUNNEL.
- CHAINAGES SHOWN ARE RECKONED FROM C/L OF PRITHALA STATION BUILDING TAKEN AS 0.00m, WITH RESPECT TO UP MAIN LINE.

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM PD	Chahatey Ram	SHIV OM DWIVEDI CPM/HRIDC	
SUDHIR AGRAWAL DPD/CIVIL		RAJU SOLANKI DGM/CIVIL/SOUTH	
REETU PATIAL CDE/ CIVIL	Reetu		

PROJECT:
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:
HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

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RITES
THE INFRASTRUCTURE PEOPLE
SMEC
Member of the Surbana Jurong Group

TITLE:- **SCHEMATIC DIAGRAM OF HORC TUNNEL**

SKETCH NO. **GC-HRIDC-C4-SK-TUNNEL-001_A1**	SHEET NO.

SCALE :	ISSUE DATE	REVISED DATE
AS SHOWN	07-11-2022	09.01.2023

6B. Documents

1. DESIGN BASIS REPORT

DESIGN BASIS REPORT

(FINAL)

EXPLORING ALTERNATE ALIGNMENTS, FINAL LOCATION SURVEY, GEOLOGICAL MAPPING, GEO-TECHNICAL INVESTIGATION, DETAIL DESIGN OF TUNNEL & ITS APPROACHES INCLUDING VIADUCT IF ANY AND OTHER ANCILLARY WORK IN SOHNA-MANESAR SECTION OF HRDC PROJECT.

Client:

HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

Prepared By:

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
MANCHESWAR INDUSTRIAL ESTATE,
RASULGARH, BHUBANESWAR-751010, ODISHA

DESIGN BASIS REPORT
(FINAL)

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Prepared & Submitted By		
M/s. S. M. Consultants		
Prepared By	**Tunnel Designer**	(Shivendra Kumar)
Approved By	**Sr. Tunnel Consultant**	(B. R. Sharma)

Client:

HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION
LIMITED.

Prepared By:

S.M. CONSULTANTS, S.M.TOWER,
PLOT NO.-130, MANCHESWAR
INDUSTRIAL ESTATE, RASULGARH,
BHUBANESWAR-751010, ODISHA

Contents

LIST OF TABLE

1. Introduction

Haryana Rail Infrastructure Development Corporation Ltd. (HRIDC) has been incorporated under the provision of Companies Act on 22.08.2017 with equity contribution of 51% from Govt. of Haryana and 49% from Ministry of Railways with an objective to develop, finance and implement viable railway projects (by itself or through a subsidiary SPV) including projects which require viability gap funding (VGF). Presently, HRIDC is implementing various Railway infrastructure development projects in Haryana with necessary cooperation from Indian Railways. As a sequel to its project development in Haryana state, HRIDC has planned for design and construction of New Board Gauge Double Railway line from Palwal to Sonipat via Sohna, Manesar and Kharkhouda for passenger and freight traffic. It will provide seamless connectivity to Dedicated Freight Corridors (DFC) at Prithala station and to Indian Railways at Palwal, Patli, Sultanpur, Asaudha and Harsana Kalan stations. The projected route named as Haryana orbital rail corridor, which is 140 km rail link project to provide alternative route to Goods traffic presently moving in a circuitous and congested path via Delhi and consuming more time. Once this line is constructed movement by rail only instead of road due to curb pollution menace. This project will be beneficial to the industrial Hubs of Kharkhouda, Manesar and Sohna and will help in development, traffic can run faster and attract new traffic because of opening of rail transport. In future, environmental issues will come up in a big way favoring long distance traffic of this region of Haryana. This project has a tunnel for crossing Aravali Range near Sohna.

2. Salient Features of Tunnel Portion

FEATURES		
SL.NO,	***DESCRIPTION***	***DETAILS***
1	PROJECT SECTION	IMT SOHANA-DULAWAHT SECTION
2	NO OF TUNNEL	2 Nos Tunnel (UP Main/DN Main)
3	TUNNEL	Single Tube single track
4	STANDARD OF LOADING	32.5T Axel Load
5	TOTAL LENGTH OF TUNNEL	4700 M (EACH LINE)
6	LENGTH OF NATM TUNNEL IN ROCK	1120 M (24880-26000)
7	LENGTH OF NATM TUNNEL IN SOIL	2480 M (26000-28480)
8	LENGTH OF CUT &COVER TUNNEL IN SOIL	1100M (28480-29580)
9	PORTAL 1 IN ROCK	CH:24880 M
10	PORTAL 2 IN SOIL (Cut& Cover)	CH:29580 M
11	NO. OF SHAFT	5Nos (4 Permanent Ventilation Shafts & 1 Construction cum utility Shaft)
12	LOCATION OF SHAFTS	Permanent Ventilation Shaft Ch:26080
		Construction cum utility shaft Ch:26950
		Permanent Ventilation Shaft Ch:27680
13	MAX. DEGREE OF CURVATURE IN TUNNEL	1-degree RHS
		0.5-degree LHS
14	LENGTH OF STRAIGHT TRACK IN TUNNEL	1660.32 M
15	LENGTH OF CURVATURE TRACK IN TUNNEL	3039.68 m
16	TYPE OF TRACK	Ballast Less track
17	TRACTION	Electrified with high rise OHE (rocs)
18	CROSS PASSAGE	At 350.0 m interval.
17	MAX.ROCK/SOIL PILLAR THICKNESS BETWEEN TWO TUNNEL	2D

3. Scope of DBR

This DBR deals with preparation of methodology and baseline of support system design for portals (P1 & P2), cut and cover, tunnel excavation and primary lining design of the proposed alignment of tunnel between chainage 24+880 to Ch 29+580, total length of4700m long tunnel (1120m tunnel in Phyllite Rock, 2480m in Soil& 1100m in Cut &Cover).

4. References

The following references are used in the context of the analysis and design of slope:

i. Finite Element Analysis code for Excavations and Slopes.
ii. Redate Manual
iii. IS: 456: 2000–Plain and Reinforced Concrete Code of Practice
iv. RDSO Design and Construction Guidelines of Tunnels – G17
v. IS:13365 (Part-2)-1992: Quantitative Classification Systems of Rock Mass- Guidelines - Rock Mass Quality for Prediction of Support Pressure in Underground Openings, Bureau on Indian Standards, New Delhi.
vi. IS:15026-2002: Tunneling methods in rock masses – Guidelines, Bureau on Indian Standards, New Delhi.
vii. Indian Railway Standard Code of Practice for Plain, Reinforced and Pre-Stressed Concrete Bridge [IRS-CBC]
viii. IS 1893(Part-1): 2002 Criteria for earthquake resistant design of structures
ix. Seismic design and analysis of underground structures" by YMA Hashish, JJ Hook, Birger Schmidt and John I-Chiang Yao.
x. Lowson, A.R., and Z.T. Bieniawski. 2013. Critical Assessment of RMR based Tunnel Design Practices: a Practical Engineer's Approach. Rapid Excavation &Tunneling Conference. Washington DC.16 pp
xi. ITA guidelines for Tunnel ventilations and Fire Safety.
xii. Other relevant IS Codes and IRS Code.
xiii. U.S. Army Corps of Engineers Manual EM1110-2-2901 - Engineering and Design Tunnel and Shafts in Rock

5. Geological/Geotechnical Conditions of Project Area

Tunnel proposed lies in Delhi Ridge, Delhi ridge constitutes northernmost extension of the Aravalli range in the form of two ridges, i.e. Sohna ridge in Haryana, nearly 45 km from Delhi, and west of it is Harachandpur ridge also known as Delhi ridge, which has become famous for its environmental importance to this region. Physio-graphically the north-western part of the India covers deserts of the Rajasthan and Haryana, Aravalli ranges and Indo-Gangetic alluvium. The Aravalli Mountains constitute remnant monuments of Precambrian times, whereas Thar desert and alluvium are Quaternary features formed by

Aeolian and alluvial processes. In Haryana and Delhi region quartzites are exposed as NE-SW trending ridges amidst the alluvial and aeolian cover. Sohna-Ferozpur Jhiraka ridge runs from Nowganawa in Rajasthan to Bhundsi a place about 45 km south of Delhi. Northeast of the Sohna is a broad Harachandpur ridge, which extends up to Delhi, where it is known as famous Delhi ridge. These two ridges consist of thickly bedded quartzites with minor schist. The quartzites are reported to exhibit sedimentary structures like ripple marks, current bedding, mud cracks, flute cast and certain depositional features. Volcanic fragments and bands within the Alwar quartzites in and around Sohna and stratified tuffbeds in Badkhal-Surajkund area have also been reported, indicating pen contemporaneous volcanic activity in the area. The region around the site consists of metamorphosed arenaceous rocks of the Alwar group. The Lithology is dominated by Quartzite's with some intercalations of phyllites near the southern portal. The Quartzite's are met sedimentary rocks that comprise greater than 80% quartz along with feldspar and mica minerals, the mineral grains show an equigranularity interlocking texture.

The phyllites are low-grade metamorphic rocks, they have a marked fissility (a tendency to split into sheets or slabs) due to the parallel alignment of platy minerals; they have a sheen on their surfaces due to tiny plates of micas.

The quartzite's near to surface showed high weathering and were highly friable and non-cohesive while as we move deeper (> 15 m) the quartzite becomes more resistive and less weathered. Quartz is a tectosilicate mineral that ranks 7 on the Mohr hardness scale, since it crystallizes later according to the Bowen reaction series it is also resistive to weathering. Feldspar on the other hand ranks 6 on the Mohr hardness scale and crystallizes earlier thus is prone to weathering. in the southern part intercalation of phyllites/schist along with quartzite are observed.

The total tunnel length is 4.7 km, out of which 1.1 km of tunnel will be within the quartzite rock mass of Delhi Supergroup and 2.9 km will run through soil and remaining 0.7Km will be Cut Cover type structure. Based on the available surface information from the geological field investigation and close observation of the drilled cores from the litho-logs, it has been observed that after crossing the soil the tunnel will enter into a folded rock mass where the axis of the tunnel will be perpendicular to the fold axis, thus favorably oriented with respect to the folded bedding planes. However, the folded rock layer has suffered extreme level of later brittle fracturing, which has been testified by the presence of 6 sets of joints of different orientation and a few late brittle discrete shear zones (which is certainly not active in nature). These joints and the fractures have significantly reduced the strength of the otherwise sufficiently cohesive metamorphic rock mass. Presence of the intersecting closely spaced joint sets make the tunnel part within the rock body highly susceptible to wedge failure.

Figure 1: Google Map of proposed Tunnel

6. Determination of Cross Section of Tunnel

Following factors shall be taken into account while deciding the cross section of tunnel,

1. Fixed Structure Gauge for tunnel of HORC
2. Horizontal & Vertical clearance on curves as per IRSOD
3. Footpath Size

4. Drain Size
5. Type of OHE.
6. Provision for Space for Ventilation Fan
7. Geological Features

Maximum fixed structure gauge provided by RDSO for the HORC tunnel is shown in Annexure-1. Based on the above parameters tentative cross section of tunnel for rock and soil has been shown in **Annexure-*1.***

7. Design Basis Report for Portal Slope Stability Analysis

7.1. Geology of Portal Area

For the proposed tunnel, Portal-1 is placed in moderately strong phyllite which is suitable for portal location whereas Portal-2 is placed in soil whose stability shall be ensured by suitable protection measures. The Proposed portals of tunnel are namely Portal P1 and Portal P2 at chainage 24+880 m and 29+580 m of the project area. At portal P1 there is an overburden of Rock of around 25m while at portal P2 there is an overburden of soil of less than around 1m. During the excavation and portal formation adequate slope shall be provided so that failure of any overburden material (rock/soil) shall be avoided.

Major discontinuity sets mapped in and around the portals area are presented below which is taken from **GIR Table No-3.2.**

Joint Set	Average Strike	Average True Dip amount	Average True Dip direction
J1	035	80	SE
J2	035	20	NW
J3	000	84	E
J4	000	40	W
J5	300	55	NE
J6	300	80	NE

Table 1: Discontinuity Sets for Portal-P1

Test on joint infill material have not been carried out by the Employer. The contractor shall get infill material tested for shear strength parameters. The above proposed joint set and shear parameter which shall be obtained by the Contractor, shall be considered for kinematic analysis of rock slope at portal P1. Tunnel portal P2 falls in soil. So kinematic analysis of the same is not required. Its slope protection measures shall be designed for global failure using suitable protection measures such as SDA, shotcrete with wire mesh**.**

7.2. Design Data for Portal Slopes

7.2.1. Factor of Safety for portal

Local stability for portal P1 and global stability of cut slope of Portals P1 & P2 shall be checked. Minimum factors of safety for different failure load cases are tabulated in Table 2. These are based on FHWA (Federal Highway of America) guidelines

Load Case	Description	Minimum FOS Required
Dead Load + Water	Normal condition	1.5
Dead Load + Water + Seismic	Extreme Condition	1.1

Table 2: FOS for various Loading Conditions

7.2.2. Self-Weight of Rock Mass:

As per GIR Para 4.5.1.2-self-weight of rock mass (saturated unit weight) may be taken as 26.72 kN/m^3 for rock while for soil it may be taken as 19kN/m3 as per GIR Para 5.4.2.

7.2.3. Earthquake Loads:

This Project area falls under seismic zone IV of Indian Seismic Zoning Map, where maximum seismic zone coefficient (Z) is0.24, so Horizontal seismic coefficient Ah = Z/2 *Sa/g *I/R here Sa/g =2.5, I =importance Factor = 1.5, R=

Response Reduction Factor =2.5 so Ah = 0.24/2*2.5*1.5/2.5 =0.18 and Vertical Seismic Coefficient equal to 2/3rd of horizontal Coefficient will be 0.12.

7.2.4. Geotechnical Parameters for Portal P1:

Intact rock properties are based on bore holeBH-13. Rock mass properties have been determined based on laboratory test results of intact rock using Mohr Columb fit parameters using Roc Data software. For deriving rock mass property for FEM analysis of cut slope, shear strength parameters are required which have been derived using Roc lab software in which input parameters are UCS, GSI and mi.

Description		Unit	Rock Mass Portal (P1) From Bore Hole BH-13
Intact Rock Properties	UCS(Table 6.1 of GIR)	MPa	60
	RMR (Table 6.1 of GIR)		20-40
	GSI=RMR$_{av}$-5		25
	mi (Roc Lab Software)		20(For quartzite)
	D-disturbance factor		0.2
	v		0.3
Rock Mass Parameters	c (peak)	MPa	0.395
	Φ (peak)	deg	49.38
	c (residual)	MPa	0.354
	Φ (residual)	deg	46.93
	Tensile Strength	MPa	0.008
	Deformation Modulus	MPa	1836
Disturbed 2m thick Rock Mass D=0.7(Will be modelled in Phase2 to consider effect of blasting during excavation.)	c	MPa	0.233
	Φ	deg	37.06
	Tensile Strength	MPa	0.004
	Deformation Modulus	MPa	1193

Table 3: Rock Mass Parameters for Portal Slopes.

The above tabulated parameter of rock mass may be used for Global slope stability analysis of Portal Cut Slopes (Portal P1). The Mohr Coulomb fit parameter for rock mass has been attached as ***Annexure-2.***

Value of K (In -situ stress ratio) for slope stability analysis for the Portal P1 and P2shall be taken as 0.5.

7.2.5. Geotechnical Parameters for Portal P2:

As per geological section Portal P2 falls in soil .and bore hole data obtained from **BH-32 &33 has been considered to derive geotechnical parameter** for global stability of slope. Following geotechnical parameters may be taken for global stability analysis of slope. Refer **Table 3.3 of GIR.**

Soil Properties for Portal	E Value	MPa	31
	C Cohesion	KPa	8
	Φ	Degree	26
	Saturated Density	kN/m3	22

Table 4: Soil Properties for Portal

7.2.6. Support/Reinforcement Properties for Portals:

Support in the form of systematic rock bolt/self-drilling anchor SDA and shotcrete with wire mesh shall be used for portals. The following support properties will be considered for the shotcrete and soil nails.

7.2.7. Shotcrete with wire mesh:

The 28 days strength of shotcrete shall be minimum 25 N/mm2. The early strength will be estimated using young shotcrete strength development curve as per class J2 of Austrian guidelines (Fig 2). At portals shotcrete with wire mesh (100mmx100mm x5 mm) will be used.

Grade of mix	Unit	Reference Code	M25
Characteristic Compressive	MPa	IS 456:2000	25

strength(fck)			
Allowable Compressive Strength	MPa	IS 456:2000	6.0
Tensile strength=	MPa	IS 456:2000, B2.1.1	3.2
Allowable Shear Strength	MPa	*IS15026:2002*	5.5
Young's Modulus	MPa	IS 456:2000	25000

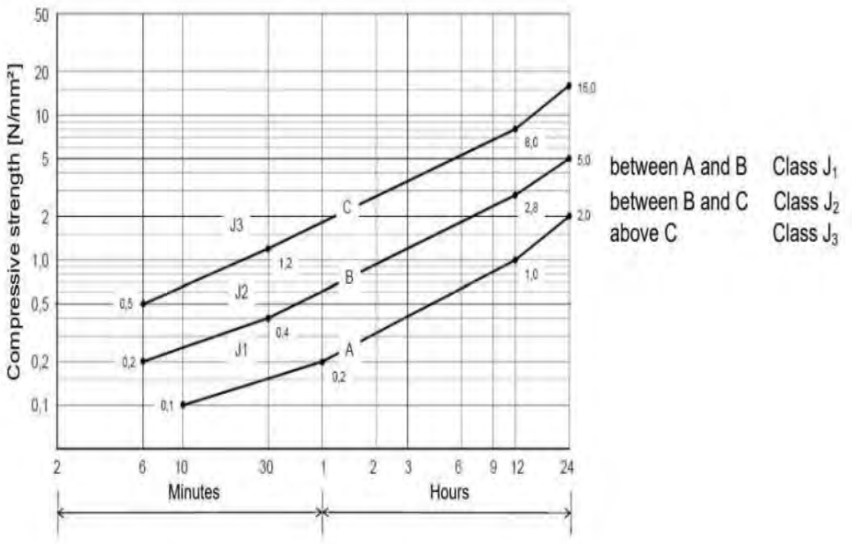


*Figure 2:*Early strength development of young shotcrete

7.2.8. *Anchor Plate*

For rock bolt anchor plate of Mild steel Fe 500 of size 150 mm x150 mm x 8 mm shall be used, which is adequate for 25 mm diameter rock bolts but its adequacy will be verified at site during pull out test of rock bolts.

7.2.9. *Fully Grouted rock bolt*

Rock bolt of Portals will be deformed bar of Grade Fe500D, whose characteristic curve with reference to IS 456:2000 is attached as figure 3.

Diameter of Rock Bolt	mm	25
Minimum Dia of Hole	mm	38/45*
Steel Grade (Yield Strength)	MPa	Fe 500 (500)

Cross-sectional Area	mm^2	491
Yield Capacity	kN	245.43
Elastic Capacity (0.80x yield)	kN	196
Design Capacity Considered (Approx.)	kN	190
Length of Rock Bolt	m	4/6/8
Factor of Safety		1.25

*Diameter of hole of rock bolt may vary from 38 mm to 45 mm. Final decision of its diameter will be taken after pull out test carried out on rock bolt at site. Pull out test shall be carried out for its full design capacity of 190 kN.

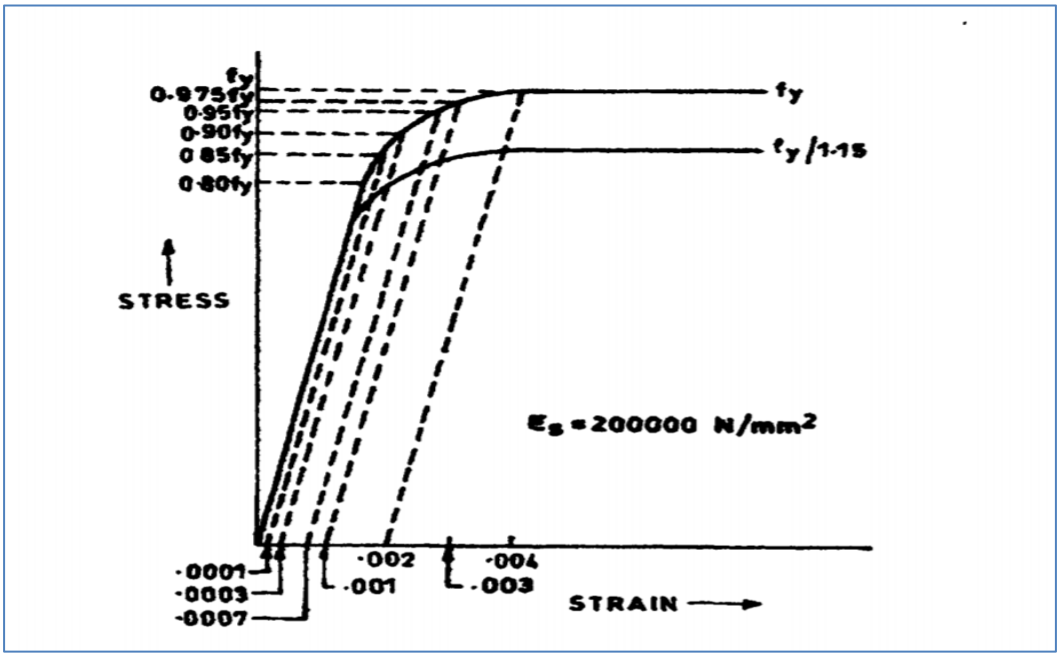


Figure 3: Characteristic Curve of Fe500D

7.2.10. *Self-Drilling Anchor*

For Portal P2 which falls in soil self-drilling anchor of suitable length shall be used along with shotcrete and wire mesh.

Specification of Self Drilling Anchor	**SDRA 38/19**
Outside Diameter (mm)	38
Internal Diameter (mm)	19

Cross Sectional Area (mm^2)	700
Ultimate Load (kN)	500
Yield Load (kN)	400
Weight (kg/m)	5.5
Length of Self Drilling Anchor	6m/8m/10m
Factor of Safety	1.25
Design Capacity (KN)	300kN (Approx.)

7.2.11. Steel Rib

Steel Ribs shall be used in portal region (around 15 m from start) where chance of rock mass movement due to planar slide and creep is more. Size of steel ribs can be optimized as per design. Steel ribs used will be of Grade Fe250. Characteristic curve of mild steel with reference to IS456:200 is attached as figure -4.

Support type	Steel rib			
Grade of Steel	Fe 250			
Description of section as per IS 808		ISMB 150 @15 kg/m	ISMB200@	ISMB 250 @ 37.3 kg/m
Depth of section	mm	150	200	250
Cross-sectional Area	mm^2	1910	30800	4750
Moment of Inertia	m^4	7.18x10^{-6}	2.12 x 10^{-5}	5.13 x 10^{-5}
Modulus of Elasticity	MPa	200000	200000	200000
Yeild Strength of Steel Rib	MPa	250	250	250

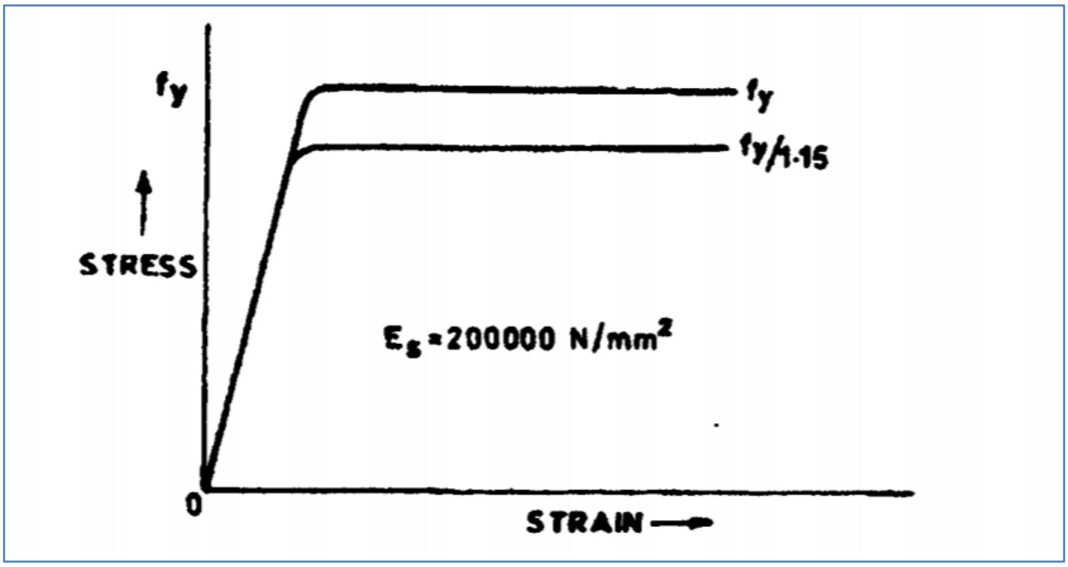


Figure 4:Characteristic Curve of Fe250

7.3. Methodology for Portals Slope Design

Tunnel Portal P1 is located in quartzite's and quartzitewith thin- inter bedded layer schist type rock. The rock mass available around the portal P1 is slightly weathered rock. Excavation of Portal shall be planned so as to minimize excavation and cut height. Portal P2 falls in soil. So kinematic analysis is omitted but global stability check shall be carried out as described below.

1 First Kinematic analysis shall be carried out to check toppling, planar and wedge failure.

2 Planar and wedge failure shall be checked with and without support system, if wedges are not stable (FOS is less than desirable) wedge shall be analyzed with support system and its adequacy against desired FOS shall be checked.

3 An excavated slope will be checked against global failure using strength reduction method with help of RS^2. Excavated slope shall be analyzed stage wise- first up to heading excavation level and then upto final excavation level. If excavated slope is unstable (factor of safety is less than desired), it shall be reanalyzed with suitable slope protection measures to achieve desired factor of safety.

7.3.1. Design of Portal Slope for various failure mode.

Portal slope shall be analyzed for various failure modes to check stability of slope. Following sections describe the methodology for slope stability of portal for different failure modes.

7.3.2. Types of Failure

Various types of failure of portal cut slope have been given below, for which adequacy of support system shall be checked.

7.3.3. Planar Failure for Portal Slope

For this type of failure to occur, the following geometrical conditions must be satisfied:

a) The plane on which sliding occurs must strike parallel or nearly parallel (within approximately ± 20°) to the slope face.

b) The sliding plane must “daylight” in the slope face, which means that the dip of the plane must be less than the dip of the slope face, that is, $\psi_p<\psi_f$.

c) The dip of the sliding plane must be greater than the angle of friction of this plane, i.e.$\psi_p> \varphi$.

d) The upper end of the sliding surface either intersects the upper slope, or terminates in a tension crack.

e) Release surfaces that provide negligible resistance to sliding must be present in the rock mass to define the lateral boundaries of the slide. Alternatively, failure can occur on a sliding plane passing through the convex “nose” of a slope.

The typical plane sliding mechanism is shown in Figure 7.

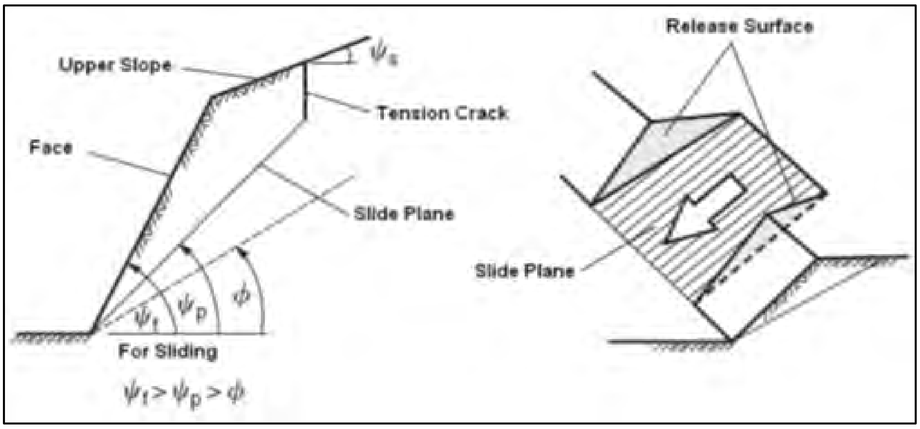


Figure 5: Geometric Conditions for Planar Failure

7.3.4. *Wedge Failure for Portal Slope*

This failure occurs when slopes containing discontinuities striking obliquely to the slope face and sliding of a wedge of rock takes place along the line of intersection of two such planes. The geometry of the wedge for analyzing the basic mechanics of sliding is defined in Figure 8. Based on this geometry, the general conditions for wedge failure are as follows:

a) Two planes will always intersect in a line. On the stereo net, the line of intersection is represented by the point where the two great circles of the planes intersect, and the orientation of the line is defined by its trend (α_i) and its plunge (ψ_i).

b) The plunge of the lb line of intersection must be flatter than the dip of the face, and steeper than the average friction angle of the two slide planes, that is $\psi_{fi}>\psi_i> \varphi$. The inclination of the slope face ψfi is measured in the view at right angles to the line of intersection. (**Note:** ψ_{fi} would only be the same as ψ_f, the true dip of the slope face, if the dip direction of the line of intersection were the same as the dip direction of the slope face).

The line of intersection must dip in a direction out of the face for sliding to be feasible; the possible range in the trend of the line of intersection is between α_i and $\alpha_{i'}$.

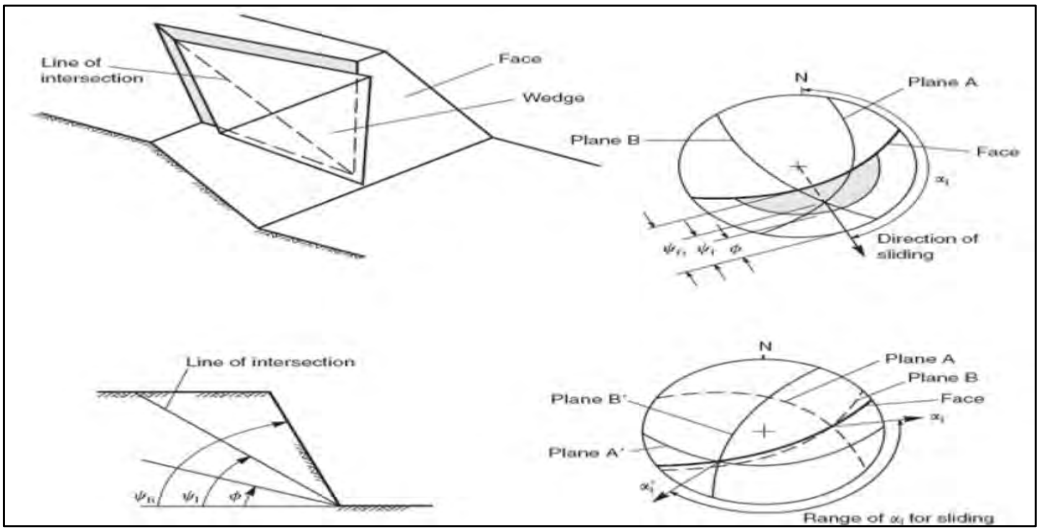


Figure 6: Geometric Conditions for Wedge Failure

7.3.5. Global Stability Check for Portal Slopes

The stage wise global stability analysis for portal slopes shall be carried out for critical section using RS^2 software. First The critical section will be analyzed without any support system. The results of the analysis will be expressed as a factor of safety which is defined as the ratio of available shear strength to the shear stresses developed on the sliding plane. If FOS of unsupported slope is less than desired, suitable support system shall be used, and it will be reanalyzed to achieve desired FOS. In global stability analysis of portal slope stage wise analysis first up to tunnel heading excavation level shall be carried out.After that analysis for final excavation up to invert level will be carried out.Although support requirement for analysis of final stage is likely to govern but stage analysis shall be included in design report pertaining to portal cut slopes.

7.3.6. Global Stability Check with Tunnel opening

After excavation and support of portal slope tunnel will be excavated stage wise up to heading level and then up to invert level. So stability of rock mass after tunnel opening shall be checked for various conditions and requirement of steel ribs, concrete lining and fore poling will be assessed. The analysis of portal slope with tunnel opening will be covered in report pertaining to design of underground support system.

At site at many places big size boulders are available which can cause problem during portal excavations. So it will be advisable to use rock fall barrier at different locations specially at portal locations.

7.3.7. Rock Fall Barrier

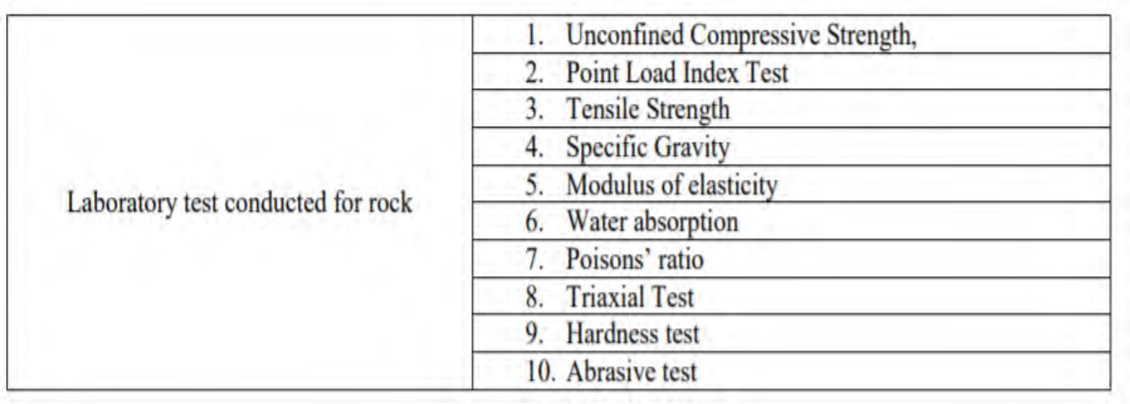
At portal-1 rock fall barrier at different locations shall be installed based on the size of the boulder and its kinetic energy to protect both portal and DFCC track.

8 Design Basis Report for Tunnel Underground Excavation

8.1. Geology of Tunnel

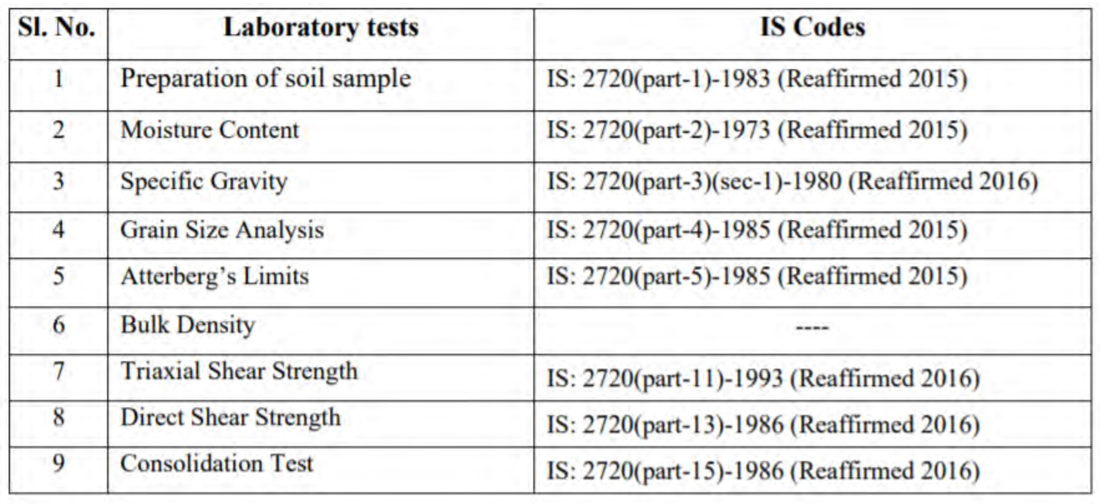
Proposed HORC tunnel for NATM is around3600 m long out of which 1120m is inside the rock while remaining 2480 m falls in soil as indicated in geological section. For 1120m long Tunnel sub surface exploration has been carried out with total 6 Nos of bore hole namely BH-13, BH-14, BH-15, BH-15A, BH-16& BH-17. It is anticipated that rock mass encountered inside the tunnel will be mainly strong phyllite with more than six joints.

For assessing the material properties for tunneling in soil 16 Nos of bore holes have been carried out which are namely BH-17 to BH-33.



Laboratory test conducted for rock	1. Unconfined Compressive Strength,
	2. Point Load Index Test
	3. Tensile Strength
	4. Specific Gravity
	5. Modulus of elasticity
	6. Water absorption
	7. Poisons' ratio
	8. Triaxial Test
	9. Hardness test
	10. Abrasive test

Table 5: Laboratory Test carried out in rock



Sl. No.	Laboratory tests	IS Codes
1	Preparation of soil sample	IS: 2720(part-1)-1983 (Reaffirmed 2015)
2	Moisture Content	IS: 2720(part-2)-1973 (Reaffirmed 2015)
3	Specific Gravity	IS: 2720(part-3)(sec-1)-1980 (Reaffirmed 2016)
4	Grain Size Analysis	IS: 2720(part-4)-1985 (Reaffirmed 2015)
5	Atterberg's Limits	IS: 2720(part-5)-1985 (Reaffirmed 2015)
6	Bulk Density	----
7	Triaxial Shear Strength	IS: 2720(part-11)-1993 (Reaffirmed 2016)
8	Direct Shear Strength	IS: 2720(part-13)-1986 (Reaffirmed 2016)
9	Consolidation Test	IS: 2720(part-15)-1986 (Reaffirmed 2016)

Table 6: Laboratory Test carried out in Soil

8.2. Geotechnical Design Parameters for Tunnel

The geotechnical design parameters for the analysis shall be derived from bore holes information of tunnel (Laboratory test data & GIR). Major Discontinuities based on geological report of tunnels for kinematic analysis have been tabulated in **Table-7**.

Tunnels	Bore Hole	Unconfined Compressive Strength (MPa)	Modulus of Elasticity (GPa)	Point Load Index Range (MPa)
Tunnel (1100 m long) in Quartzite Rock	BH-13	63	53-31	2.18
	BH-14	56	53-33	2.99
	BH-15	67	52-41	3.37
	BH-15A	65	50-42	3.14
	BH-16	64	55-39	3.07

Table 7: Summary of Intact Rock Mass properties

Joint Set	Average Strike	Average True Dip amount	Average True Dip direction
J1	035	80	SE
J2	035	20	NW
J3	000	84	E
J4	000	40	W
J5	300	55	NE
J6	300	80	NE

Table 8: Discontinuity Sets along Tunnels (As per GIR Table No 3.2)

8.3. Material Strength Criterion

For the numerical analysis of underground excavations, selection of the material model is a critical issue in terms of the rock mass behavior. Most widely accepted material models that phase^2 supports are,

- Mohr-Coulomb (for Tunnel in Soil)

- Hoek-Brown (For tunnel in rock)

The first material model Mohr-Coulomb is best suited to model the behaviour of soils, especially shear strength characteristics of soils. In case of rock, where shear modulus is high, it is recommended to use the Hoek-Brown material model. Hoek-Brown criterion is extensively used in analysis of underground excavations in rock and is based upon an assessment of the interlocking of rock blocks and the condition of the surface between these blocks. The generalized Hoek-Brown criterion is expressed by the equation

$\sigma 1' = \sigma_{3'} + \sigma_{ci} ((m_b \text{ x } \sigma_{3'} / \sigma_{ci}) + s)^{a}$

$m_b = m_i \exp ((GSI - 100)/(28-14D))$

$s = \exp ((GSI-100)/ (9-3D))$

$a = ½ + 1/6 \text{ x } (e\text{-}GSI/15 - e\text{-}20/3)$

$Em = Ei (0.02 + ((1-D/2)/ (1+e ((60+15D-GSI)/11))))$

$\sigma_3$and σ_1' are the minor and major effective principal stresses at failure.

σ_{ci} is the uniaxial compressive strength of the intact rock material.

m_i , s and a are material constants.

m_b is a reduced value of the material constant mi.

GSI = Geological Strength Index.

D = Factor depends on degree of disturbance to which the rock mass has been subjected by blast damage and stress relaxation.

Ei = Intact Rock modulus.

Erm = Rock mass deformation modulus.

8.4. Strength Properties of Material for Tunnel

A summary of the material strength parameters for Hoek-Brown criterion adopted in the analysis is presented in Table 9 below.

Rock mass Designation	**Class IV** **(Poor Rock)**
RMR Range (GIR Table 6.1)	20< RMR≤40
RMR_{av}	30
GSI= RMR-5	25
UCS (MPa) (GIR Table 6.1)	60
m_i(Rock Lab for Quartzite Rock)	20
D=Disturbance Factor	0
m_b	1.373
s	0.0002
a	0.531
E_d (MPa)	1836
Residual Property has been calculated by taking D=0.2	
m_b	1.516
s	0.0004
a	0.516
Poisson's ratio	0.20

Table-9: Material Strength Parameters for Hoek-Brown Criterion-Rock

Above parameter shall be used as rock mass parameter for support design using FEM software RS^2 ($Phase^2$) software. It is anticipated as per Geological Exploration that all condition of rock mass of whole stretch of tunnel in rock will be covered in Class IV category. Derived rock mass parameter from Roclab software is appended as ***Annexture-3***.

Parameter	***Type of Soil***	
Φ for cohesive soil (from Laboratory Test)	CL	19°
Φ for non-cohesive soil (from corrected N Value)	ML	32°
	ML-CL	
	SM	
Cohesion (C) (from Laboratory Test)	CL	25 KPa
Cohesion (C) (from Laboratory Test)	ML	3 KPa
	ML-CL	
	SM	
Modulus of Elasticity (E)	Cohesive (CL)	28 MPa
	Non-Cohesive (ML, SM, ML-CL)	30 MPa
Density	Cohesive (CL)	1852 kg/m^3
	Non-Cohesive (ML, SM, ML-CL)	1765 kg/m^3

Table-10: Recommended material Properties for tunneling in Soil

Note: Above mentioned property of soil has been taken from Table 6.2 of GIR**.**

8.5. In-Situ Stress for Tunnel

In tectonically active areas, tectonic stresses affect the stress regime possibly leading to development of locked-in stresses within rock mass Also, overlying rock mass strata gives rise to stresses due to its weight which plays important role in local stress field. Due to excavation, redistribution of stresses will take place creating new stress field around the opening. Thus, the magnitude and orientation of virgin stress field plays an important role in deciding the stability of an opening. As tunnelling projects always have limited information on in-situ stress testing, it is proposed to undertake a sensitivity analysis and adopt such stress values which may lead to the development of the critical stress field. Calculations, in the general case where field test data is absent, will be based on Sheory simplified equation to estimate the horizontal to vertical stress ratio k. This equation is **k = 0.25+7Eh(0.001+1/z)**, where z (m) is the depth below surface and Eh (GPa) is the average deformation modulus of the upper part of the earth's crust measured in a horizontal direction. For different classes of rock horizontal stress coefficient by Sheory's formula has also been calculated. This tunnel is shallow tunnel (where cover is less than 3 times the diameter of tunnel) and no Techtronic stress is anticipated. So, taking K value as more than 1 is not advisable. So, considering fair rock k value of 1 may be considered. While k Value for soil has been adopted as per Jacky's formula

K by Sheory's Formula		K	0.73
K Value to be considered for Rock		K	**1.0**
K value considered for soil		K	0.5
In-Situ Stress	Vertical Stress (σ_3)	MPa	It will be applied according to Natural Surface of above tunnel surface by in-built command of RS^2 (Phase^2 software)
	In Plane Horizontal Stress (σ_1)	MPa	
	Out of Plane Horizontal Stress (σ_z)	MPa	

Table 11: In-Situ Stress Parameters for Tunnels

8.6. Support Properties for Tunnel

8.6.1. Shotcrete Properties

The shotcrete is modeled as plastic standard beam element, so that the excess forces are transferred to the adjacent rock mass and support element, if the shotcrete yield at any point. Shotcrete with Steel Fiber or Polymer Fiber will be used for Tunnel. Addition of fiber in shotcrete will increase its flexural and shear strength, which will be validated by laboratory test. Compressive Strength, Cracking Strength and Elastic Modulus variation with addition to fiber has been attached in ***Annexure**-3*. For improving strength of shotcrete either steel fiber or synthetic polymer fiber shall be used.

8.6.2. Steel fibers:

Steel fibres shall comply with the requirements given in ASTM A 820 or similar national regulations. Following will be specification of steel fibre used for SFRS.

- Average Tensile strength of fibre shall not be less than 345 MPa.
- The tensile strength of any one of the ten specimens shall not be less than 310 MPa).
- Fibers shall withstand being bent around 3.2-mm diameter pin to an angle of 90° at temperatures not less than 16°C without breaking.
- Type I:Straight/Deformed cold-drawn wire shall be used for fibers.
- Aspect ratio (l/d) shall be 40 to 60.

- The length of the steel fibers shall not exceed 0.7 of the internal diameters of the pipes or hoses used unless a test has proven that longer fibers can be sprayed without blockage.

- *During design of secondary lining fiber content per kg/m^3 of shotcrete shall be derived.*

8.6.3. Synthetic fibers:

Synthetic fibres shall be in accordance with ASTM C1116 or regulations valid in the place of use of the sprayed concrete. Product description of synthetic fibre reinforcement is given below

Name: Structural Synthetic Fibres

Product Description: Macro Structural Synthetic Polypropylene Fibre. Minimum tensile strength 550 MPa. These fibers show very defined ductile behavior characteristics. Performance levels are excellent in shotcrete. Width = 1.6825 Thickness = 0.4822 Length = 65mm Generates a very high energy absorption rate when used in the concrete mix for shotcreting, enabling the matrix to provide greater flexural toughness.

Since tunnel will be lined with SFRS and its durability is very important for 120 years of life so we proposed higher grade shotcrete. During design of secondary lining synthetic fiber content per kg/m^3 of Shotcrete shall be derived.

Grade of mix	FRS	Reference Code	M35
Modelled in Phase^2 as			*Elasto-Plastic element*
Characteristic Compressive strength(fck) Cube	MPa	IS456:2000	35
Mean Tensile Strength of SFRS	MPa	IS 456:2000	3.5
Allowable Shear strength	MPa	IS15026	5.5
Young's Modulus	MPa	IS 456:2000	29580

Table 12: Shotcrete Properties (SFRS)

8.6.4. Fully Grouted Rock Bolt

Rock Bolt used for tunnel shall be deformed bar type of Fe500D Grade whose characteristic curve is attached ***Annexure-3.*** Grout hole may vary from 38 mm to 45 mm, which will be verified by pull out test up to design load at site.

Modelled in Phase2 as		**Elastic -Element**
Diameter of rock bolts	mm	25
Dia of Grout Hole	mm	38/45*
Steel Grade (Yield Strength)	MPa	500
Cross-sectional Area	mm^2	491

Modelled in Phase2 as		**Elastic -Element**
Yield Capacity	kN	245
Elastic Capacity (0.80x yield)	kN	203.2
Design Capacity Considered (approx)	kN	190

Table 13: Rock Bolt Properties

Specification of Self Drilling Anchor	**SDRA 38/19**
Outside Diameter (mm)	38
Internal Diameter (mm)	19
Cross Sectional Area (mm^2)	700
Ultimate Load (kN)	500
Yield Load (kN)	400
Weight (kg/m)	5.5
Length of Self Drilling Anchor	4m/6m
Factor of Safety	1.25
Design Capacity (KN)	300KN (Approx.)

Table 14: Self Drilling Anchor Properties

8.6.5. Lattice Girder

Steel of Fe500D grade will be used for lattice girder formation which will be used for poor and very poor rock condition. Adequacy of lattice girder such as size and spacing will be validated by empirical and FEM design.

Support type	Lattice Girder	
Modelled in Phase2 as	Elastic Element	
Description of section	Lattice Girder (25-25-32)	
Depth of section	mm	187
Cross-sectional Area	mm^2	1784
Moment of Inertia	m^4	1.16 x 10^{-5}
Modulus of Elasticity	MPa	200000
Yield Strength of Steel	MPa	500

Table 15: Lattice Girder Properties

8.7. NATM Tunnelling – Concept

The tunnel construction is proposed to be carried out in accordance with the principles of the New Austrian Tunnelling Method (NATM). The method is based on the concept of a cyclic sequence of excavation with subsequent installation of a primary support (outer lining) followed by the delayed installation of a secondary lining (inner or final lining).

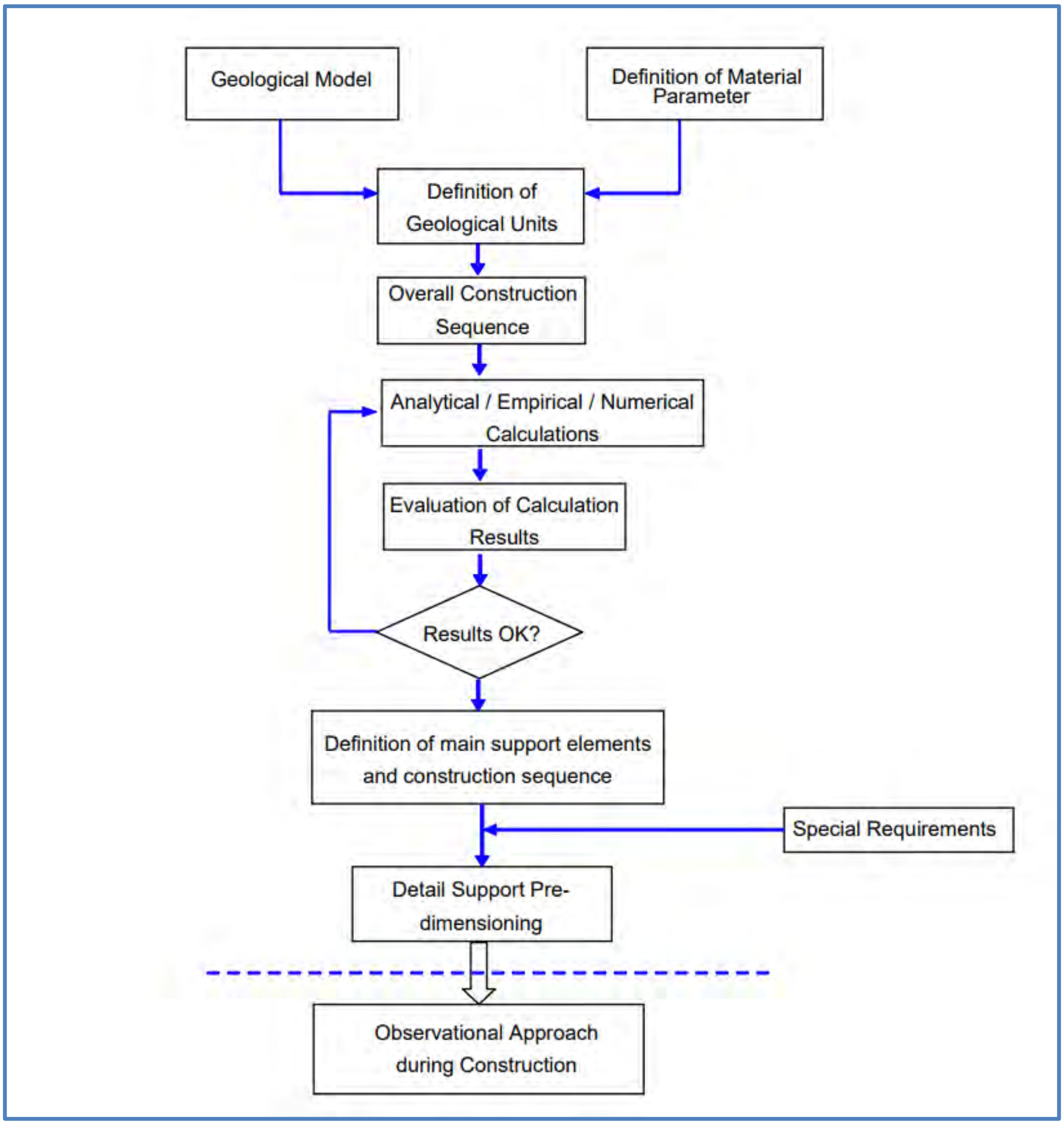
The primary support, which consists of shotcrete, generally reinforced by wire mesh, lattice girders (where required) and rock bolts, will provide the immediate support and stability of the excavation. The secondary lining will provide the long-term support and durability of the tunnel.

Tunnel excavation will generally be carried out by means of drilling & blasting with drilling jumbos in rock or by tunnel excavator in soil. The ground support system will vary from place to place along the tunnel length, depending on ground properties.

8.8. Design Approach

NATM tunnel design shall be based on well accepted empirical, analytical methods and finite element numerical modeling. Empirical method shall be used for preliminary design of support system as per IS:13365 using RMR. Analytical method shall be used as the second method for design calculations for the support system and deflection. After assessing support requirement with empirical and analytical method, numerical method shall be used to check adequacy of support system, deflection and other parameters for tunnel.

The following flowchart shows the general design approach for the primary (outer) lining of NATM tunneling sections.



The design methodology shall cover design phases (preliminary design & definitive design) prior to construction. The design will be adjusted (if required) during construction in an "observational approach".

8.9. Design Methodology for Tunnel Support Design

The support system shall be designed by considering rock mass type, rock mass quality and in-situ stress conditions expected to be encountered along the tunnel alignment as determined by review and assessment of available geotechnical data.

The preliminary support assessment will be carried out using rock mass classification by IS RMR system (Bieniwaski2013). For the analysis, various parameters like rock strength, joint characteristics, ground water and orientation of discontinuities will be taken into consideration. Support recommendations will be made, based on stress-deformation analysis using RS^2 FEM software. The possibility of any wedge formation and tunnel stability will be also checked with UNWEDGE software (kinematic analysis will be carried out strictly for tunnel which falls in jointed rock mass).

During construction process, the support assessment shall be continuously reviewed to account for the actual geological conditions including joints, bedding, faults and fractures, infill material, surface roughness, water bearing properties and stress state and required changes in designed support shall be made accordingly.

Following steps will be followed to design rock support system of tunnel:

Step 1 : Assess rock type and find rock mass property such as RMR (Rock Mass Rating), GSI (Geological Strength Index), MR$_{value}$, M$_i$ and UCS (Unconfined Compressive Strength)

Step 2 : From assessed rock mass categorize different class of rock mass using software Roc Data.

Step 3 : Assess major discontinuities available along tunnel alignment and shear strength parameter of joint infill material.

Step 4 : Find unstable wedges formed for defined tunnel section using Unwedge software, if factor of safety is greater than desired ok, otherwise re –analyse with support system as shotcrete and rock bolt at suitable spacing so that factor of safety of unstable wedges become greater than desired.

Step 5: Design preliminary support system by empirical method (IS Code method) using RMR.

Step 6: After design of support system by empirical method use analytical method as a second method to verify the support system.

Step 7: Finally, verify support system by numerical method in following steps.

Step 7A	: Model different class of rock/Soil with different rock/soil parameters obtained from Roc Data and also incorporate different stages of excavation.
Step 7B	: Simulate and analyse each class of rock/soil without support systems and observe deformation, strength factor and yielded zone.
Step 7C	: Simulate and analyse each class of rock/soil with suitable support systems and observe deformation, yielded zone, and strength factor and check suitability of support system provided with capacity plots.

8.10. Wedge Analysis-Kinematic Analysis

Geo-mechanical wedge analysis shall also be carried out for rock portion. Analysis shall be carried out taking into account available joint data as main input and based upon the assumption that the wedges defined by three intersecting discontinuities are subjected to gravitational loading only.

The steps which are taken to support the structural instability caused due to discontinuities shall be as follows-

- Determination of average dip and dip direction of significant discontinuity sets.
- Identification of potential wedges which can slide or fall from the roof or walls.
- Calculation of the factor of safety of these wedges, depending upon the mode of failure.
- Calculation of the amount of reinforcement required to bring the factor of safety of individual wedges up to an acceptable level (FOS 1.5).
- Calculation of the amount of reinforcement required to bring the factor of safety of individual wedges up to an acceptable level (FOS 1.1) with seismic loading.

In this analysis, wedges that will be formed on excavation boundary will be evaluated providing detailed information for each wedge as listed below:

- Weight of the wedge

- Apex height
- Safety factor without support
- Required support pressure
- Bolt type (diameter & design tensile capacity)
- Length
- Pattern spacing (in plane, and out of plane)
- Safety factor with support

8.11. IS Code Method-Tunnel in Rock

IS code 13365 (Part-1) gives guidelines to use support pressure in terms of RMR as load on opening of tunnel which needs to be balanced by support system. In the present case the height of overburden above the crown of tunnel is moderate (varies from 20 m to 40m), hence the ground has been considered as non-squeezing for the design of rock support of tunnel. For non-squeezing ground IS: 13365 (part 1) has recommended following empirical equations for calculating Roof and wall support pressure. For deriving design parameter/roof pressure latest Lawson -Beniawiski RMR method shall be used (10).

The permanent roof support pressure Proof (kN/m^2) can be estimated using the following empirical relationship between the joint number RMR, Density of rock and Span of Tunnel.

$$P_r = \frac{100-RMR}{100}.10m.\left(\frac{Span}{10m}\right)^{\frac{1}{2}}.\rho_r.\gamma_r$$

By Lawson and Bieniawiski (10)

Where γ_r is partial safety factor and ρ_r density of rock , $\gamma_r = 1$ shall be adopted.

P$_v$ rock load intensity in kN/m^2

8.12. *Ultimate wall support pressure*

In view of the more favorable position of walls as compared to roofs, the following formula shall be applied for calculating P_{wall}:

$P_{wall} = K_h x P_v$

Where $K_h = 1\text{-Sin}\varphi$

where φ is friction angle

Horizontal Stress Coefficient which shall be taken as 0.5, considering a conservative value of 30 degree.

8.13. *Bolt Spacing*

Bolt spacing is taken as a function of RMR only. Spacing has to reflect fracture frequency and the need for shotcrete to provide adequate support between the bolts at the better rock end of the scale where the shotcrete cannot realistically be considered as working on its own as an arch. Spot bolting only is assumed to be needed above RMR = 85.

Rock bolt spacing

a) if 20<RMR<=85

$$\boxed{S_b = 0.5m + 2.5m.\frac{RMR-20}{65}}$$

b) if 10 < RMR<= 20

$$\boxed{S_b = 0.25m + \frac{(RMR-10)^{1.5}}{140}.m}$$

c) RMR <=10

$$\boxed{S_b = 0.25m}$$

8.14. *Bolt Length*

Bolt length must vary with span and RMR. Based on empirical guidelines used in mining and the results of numerical modeling studies, the following relationship was obtained:

$$Span = \frac{(L_b + 2.5)^{\frac{RMR+25}{52}}}{3.6}$$

where Span is width of excavation in meters and L_b is embedded bolt length in meters.

8.15. Rock bolt capacity

Bolt capacity

$$F_{bd} = \frac{F_b}{\gamma_b} \cdot \left(\frac{RMR}{85}\right)^{\frac{40}{RMR}}$$

8.16. Shotcrete capacity

The design capacity of shotcrete support is based on the concept of the shotcrete acting simply as an arch in compression. The basic formula for this type of support is:

Support Pressure = Thickness x design strength / Radius

Design capacity

$$f_{cd} = \frac{f_{ck}}{\gamma_s} \cdot \left[0.2 + 0.8 \cdot \left(\frac{RMR}{100}\right)^{\frac{3}{2}}\right]$$

Wheref_{ck} is shotcrete cylinder strength and γ_s is a partial factor. Ys may be taken as = 1

8.17. : Analytical Method According to Prof. Feder and Erdmann/Duddeck

The detailed geotechnical and structural design of the primary support shall be carried out using the closed-form solutions according to Prof. Feder (Mining University of Leoben, Austria) and the analytical approach according to H. Duddeck / J. Erdmann. The main variables considered in the analyses shall be tunnel overburden, excavation cross-section, ground types and its properties and in-situ stress condition.

The analytical calculation approach after Prof. Feder is based on the closed – form solution for a circular opening in an elastoplastic medium with a primary stress field of K_0 = 1.0. This closed form solution has been extended by Prof. Feder to allow for primary stress fields different from K_0 = 1. Different rock strength parameters in the elastic and the plastic (fractured) zone around the tunnel and volume increase of the rock mass material in the fractured zone due to crack development is considered. The method allows for easy and fast parameter studies regarding the determination of the stress and displacement field around a tunnel. The bending moments are derived by assuming an eccentricity of the normal forces by 1/30 of the sprayed concrete shell thickness or 20mm whichever is higher (according to EN 1992-1-1: 2004).

This analytical calculation approach uses elastic, uniform soil/rock conditions and full shear bond between the elastic lining and the subsoil. Further circular shaped full-face excavation is assumed. As result of the Erdmann / Duddeck calculation normal forces N, bending moments M and shear forces V in the shotcrete shell at the crown, bench and invert – sections are obtained. The analysis according to Erdmann/Duddeck is generally used for shallow tunnels with a low stress-level.

9 Numerical Analysis for Tunnel

9.1 Loads

Following loads shall be considered for design of support system of tunnel excavation. Numerical analysis shall be carried out using FEM program RS^2.

9.2 Dead Load

Dead Load of support element (liner, rib etc.) shall be simulated in FEM program RS^2 by using inbuilt command.

9.3 Rock Load:

In-Situ Stress corresponding maximum vertical cover above the tunnel shall be considered with given horizontal stress coefficient in Table 7.

9.4 Seismic Load

In the underground tunnel, seismic loading is not generally considered, unless any poor ground condition (i.e., fault) is passing through the tunnel.

9.5 External Water Pressure

The water table is below the grade level for most of the reach of tunnel. Hence, no permanent water table anticipated above the tunnel. However, to account for saturation due to rains/monsoons, saturated unit weight is considered in the analysis. Therefore, there is no need to consider the effect of external water pressure on tunnel support system design.

9.6 Future Road Traffic Load

A load of 20 kN/m^2 shall be considered over top of the tunnel for future road traffic.

9.7 Properties of Proposed support system

Properties for support system for tunnel excavation such liner and rock bolts shall be adopted as per working stress method.

9.8 Material Factor of Safety

For rock bolt, lattice girder and steel rib material factor of safety of 1.25 will be taken, while shotcrete will be allowed to yield and its full strength can be used for design of support system.

10 Stages of Analysis in Numerical Method of Design:

The stability analysis of the Tunnel shall be carried out using Finite Element Program RS^2, as a continuum model using Hoek and Brown criteria and stresses and deformations around the tunnel shall be estimated to check the stability of the tunnel. The numerical model of excavated cavity has been conceived as plain strain model with external boundaries as natural surface around tunnel. Six node triangular finite elements with fine meshing shall be used close to the excavation boundaries of the tunnel, so that the variations in the stress field could be captured with higher precision. Size of the elements shall be gradually increased toward the external boundaries to reduce the number of elements and calculation time. External boundaries shall be taken as fixed and in-situ stresses are applied as per the loading corresponding to cover and horizontal stress coefficient obtained for tunnel.

Excavation sequence of the tunnel shall be simulated in the model using the stage construction approach. For all class of rock mass, heading and benching excavation will be simulated. Stage-1 is generation of model and initialization of in-situ stress. stage-2 is material softening of heading portion. stage-3 is heading excavation and support, stage-4 is material softening of benching-1 portion and stage-5 is benching-1 excavation and installation of rock support. stage-6 is material softening of benching-2 portion and stage-7 is benching-2 excavation and installation of rock support.

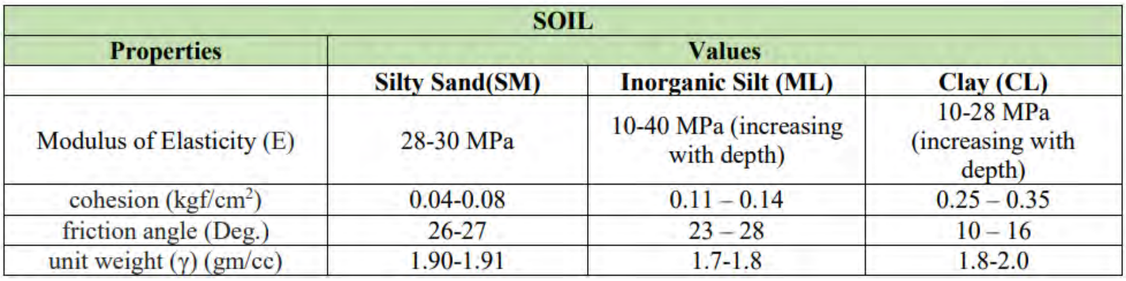
10.1 Sensitivity Analysis:

While doing Analysis and design of tunnel support system specifically in soil where parameters are very sensitive and has serious impact on requirement of tunnel support system, deflection and method of excavation.

Following parameters are sensitive.

1. Overburden depth in soil (H)
2. Cohesion Value of Soil C
3. Friction Angle value of Soil φ
4. Deformation Modulus of Soil E

As per GIR and Longitudinal profile specifically in soil overburden depth varies between 8m to 40m while other parameters are varying too, which has been taken from Table 5-7 of GIR as follow.



SOIL			
Properties	**Values**		
	Silty Sand(SM)	**Inorganic Silt (ML)**	**Clay (CL)**
Modulus of Elasticity (E)	28-30 MPa	10-40 MPa (increasing with depth)	10-28 MPa (increasing with depth)
cohesion (kgf/cm^2)	0.04-0.08	0.11 – 0.14	0.25 – 0.35
friction angle (Deg.)	26-27	23 – 28	10 – 16
unit weight (γ) (gm/cc)	1.90-1.91	1.7-1.8	1.8-2.0

For sensitivity analysis of support system above mentioned 4 Parameters shall be varied and its adequacy shall be checked.

10.2 Interpretation of Results

The analysis results shall be used to investigate the influence of geometry and in-situ stress variability on stress changes. The induced stresses in the plane of the analysis can be viewed by means of stress contour patterns in the region surrounding the excavations. As a tool for interpreting the amount of deviatory overstress (principal stress difference) around openings, strength factor contours give a quantitative measure of "(strength) / (induced stress)" according to failure criterion for the rock mass. Adequacy of rock support system as estimated by rock classification approach will thus be verified. Analysis results will provide the following information.

- Deformation of tunnel calculated by FEM analysis shall be permitted up to 1% of the excavated size of the opening. If deformation is more than 1%, these cases shall be treated separately.
- Depth of Plastic Zone: It will be used to check the adequacy of bolt length.
- Utilization of Rock Bolts and Liners: Utilization of rock bolt shall be assessed by its axial force, while utilization of steel liners will be assessed through capacity plot with significant factor of safety to cater uncertainty of geological parameters.
- Shotcrete will be modeled as elasto-plastic element and its yielding will be allowed below springing line as this will not depict complete failure of shotcrete.

10.3 Instrumentation and Support Performance

In NATM, the primary purpose of geotechnical and structural instrumentation is to monitor the performance of the underground construction process in order to avoid or mitigate problems. Instrumentation and monitoring scheme for NATM tunnel shall be submitted by contractor to Engineer for approval.

List of Instrumentation to be provided in NATM tunnel is given below in table 16.

S. No	Instrumentation Details	Locations of Instrumentation to be provided in tunnel
1	3 Point MPBX	3 Nos of 3 Point MPBX at every 50 m.
2	Optical 3-D Deformation Monitoring	7 Point Optical Convergence Array (with accuracy of 1 mm) at every 25 m.
3	Roof settlement Point	1-Point roof settlement at every 25m.
4	Load Cells	five center hole load cells (with accuracy 0.5%) of250 kN capacity at identified locations as approved by the Engineer.
5	Pressure Cells	7 Nos of Pressure cells of 100 bars (accuracy 0.25%) at each section at every 100 m.
6	Switch Box	2 Nos of Switch Box at every 50 m
7	Strain Gauge	7 Nos of Strain Gauge per section @ every 100 m.

Table-16: Instrumentation Proposed for Tunnel Excavation

11 *Design of RCC Portal*

RCC portal with adequate thickness shall be designed at both end of NATM Tunnel for a length of 10m. Final thickness of portal members and size shall be decided as per structural design of portal.

11.1. Material Properties

- **Concrete**
  - Grade of Concrete: M35
  - Young's Modulus of Concrete (E) :29580MPa (as per IS 456:2000)
- **Reinforcement steel**

The steel for structural reinforcement shall correspond to Fe 500D according to IS 1786-2008:

Young's modulus : E=200 GPa
Yield strength : f_y=500 MPa

11.2. Methodology for Design of RCC Portals

The structural analysis of portal frame shall be carried out using 2D model. The model shall be analyzed for various load combinations using STAAD Pro software. The resulting moments and forces shall be used to verify the ultimate limit state of collapse. The beam and columns of portal shall be designed for Limit state of collapse. The area of the footings shall be fixed on the basis of the allowable bearing pressure and the applied loads and moments under service load conditions.

11.3. Design Assumptions

(a) Unit Weights:

Following unit weights for different materials shall be considered for the design:

Material	**Unit weight (kN/m^3)**
Reinforced Concrete	25
Rock	27
Soil-rock debris	22

(b) Site Specific Peak ground acceleration for DBE shall be 0.24 g.

Portal frame structure shall be considered as primary structure with importance factor 1.5 and IS456:2000 shall be adopted for design and detailing.

(c) Response reduction factor shall be taken as 3.

(d) Allowable Bearing Capacity:

The allowable bearing capacity of rock mass shall be calculated as per IS:12070 – 1987. Allowable Bearing capacity of soil shall be calculated from the shear strength parameters of the soil as per GIR .

11.4. Boundary Conditions

The model of portal frame shall be fixed at foundation level.

11.5. Design Loads

The following loads shall be applied to the frame model:

(a) Dead load [G1]

(i) The dead load shall include self-weight of structural concrete. The self-weight of structural concrete is calculated internally by STAAD Pro software.

(ii) Rock Load: Distribution of rock loading on the portal beam along its length shall be assumed as triangular with 45° dispersion at the ends.

(b) Live Load [G2]

Live load to be applied on the beam element of portal frame shall be as follows:

Accidental Load: Uniformly distributed load corresponding to 2.0 m height of soil-rock debris over portal beam shall be considered to account for additional load in the event of slide of rock mass.

(c) Earthquake Load (EQ):

Lateral loads on joints at the beam level shall be applied on the structure.

Wind load and temperature load shall not be considered for the design.

11.6. Load Combinations

Following load combinations shall be considered as applicable loading conditions for the structure:

11.6.1. Ultimate Limit State (ULS)

I $=1.25\times G_1$
II $=1.25\times G_1+1.70\times G_2$
III $=1.25\times G_1+1.70\times G_2+1.6\times EQ$

11.6.2. Serviceability Limit State (SLS)

I $=1.0\times G_1$
II $=1.0\times G_1+1.0\times G_2$
III $=1.0\times G_1+1.0\times G_2+1xEQ$

11.6.3. Concrete Cover

Nominal cover to the reinforcement shall be provided considering mild exposure condition of weather and 1.5 hours of fire resistance. The nominal cover to the reinforcement (including links) shall not be less than dia of bar or 20 mm (for mild exposure). The nominal concrete covers adopted for the different members are as below:

Beam	35 mm
Columns	50 mm

11.6.4. Reinforcement

All members shall be designed based on IS 456: 2000. The reinforcements are designed to resist factored flexural moments, shear forces and axial forces for the most critical combination of loads. Shear reinforcement is designed as per the provisions stipulated in IS 456:2000

11.6.5. Crack width

A maximum crack width of 0.25 mm (moderate durability exposure) is proposed. The crack width will be calculated in accordance with IS 456-2000 or RCC shall be designed such that tensile stress in lining is within cracking strength.

11.6.6. Deflection:

The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the supports of floors, roofs and all other horizontal members, should not normally exceed Span/250.

12 Secondary Lining Design

Secondary lining shall be provided in complete length of NATM tunnel. RCC lining shall be provided in soil portion tunnel and initial 20 m reach of Portal P1 of rock. The minimum grade of concrete shall be M35. Minimum thickness of secondary lining shall be 300mm.

12.1 Method of Analysis

A two-dimensional Plane Frame Analyses shall be performed using the computer program STAAD Pro. V8i SS5. A near realistic 2Dmodel using beams bedded by radial and tangential springs shall be considered. Analysis and design shall be carried out as per CBC.

12.2 Calculation of Spring Constants

The lining shall be modeled as a beam bedded by springs. Multiple beam elements shall be created along centroidal axis of lining subtending angle of 5^0 to 10^0 representing linear 2D structure.

Beam model spring constants shall be derived from following formula:

$$C_r = K_S \times A$$

$$K_S = \frac{E}{(1+\nu)\times R}$$, **From EM 1110-2-2901**

where:

Cr = Radial Spring Constant of soil/rock

A= Tributary area of beam element

Ks = Modulus of Sub grade reaction

E… Young's Modulus of soil/rock (As per GIR)

ν Poisson's Ratio of rock mass (As per GIR)

R…. Radius of Tunnel (with R ≤ 7 m)

The tangential spring constants are set as 1% of normal (radial) spring constants:

Kt = 0.01× Ks

12.3 Load Cases

12.3.1 Self-Weight [G1]

The volume used for calculation of self-weight of structures is based on the nominal dimensions of the structure. Self-weight of the reinforced concrete lining will be calculated with unit weight of concrete of y_{con}=25kN/m^3.

Self-Weight will be considered as dead load with partial load safety factor of 1.25 as per IRS – CBC 1997.

12.3.2 Invert Fill [G1]

As the invert fill is acting favorable on the tunnel invert, this load is not considered in the analysis.

12.3.3 Exhaust Fan & Overhead System [G1]

An overhead system for exhaust fan load is considered to be acting on inner lining of the tunnel. These systems are directly fixed by anchors. A suitable load on 7.2kN acting apart 1m shall be applied to inner lining.

An overhead system is considered as a single vertical concentrated load with a value of *3.0* kN placed 1m horizontal from the centerline of the tunnel on the left side of the arch.

A load factor of 1.25 is considered as per as per IRS – CBC 1997.

12.3.4 Earth Pressure [G2]-Rock

With regard to vertical rock pressure (vertical load of overburden to the lining),) following loads are considered to be I to be applied on lining:

Earth Pressure shall be calculated based on RMR value of different class of rock.

$$P_r = \frac{100 - RMR}{100}.10m.\left(\frac{Span}{10m}\right)^{\frac{1}{2}}.\rho_r.\gamma_r$$

By Lawson and Bieniawiski

Where γ_r is partial safety factor for lining design this will be equal to unity and ρ_r density of rock.

P_v rock load intensity in kN/m^2

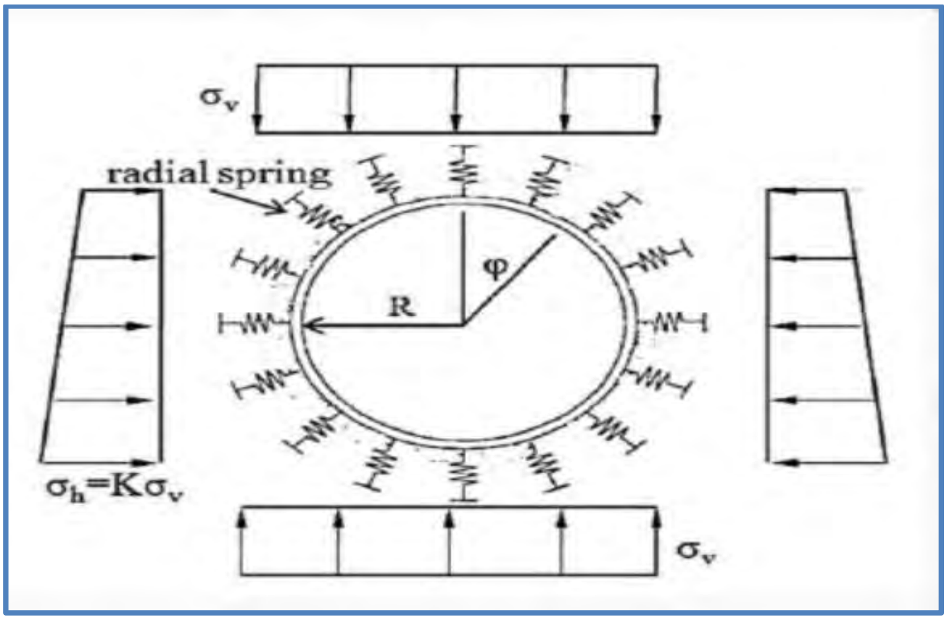
The effective lateral earth pressure is equal to the product of load due to weight of overburden and coefficient of lateral earth pressure K_0. The assumed Earth Pressure Coefficient $K_0 = 0.5$

Earth pressure is considered with partial load safety factor of 1.70 as per IRS – CBC 1997.

12.3.5 Earth Pressure [G2]-for Soil:

With regard to vertical earth pressure (vertical load of overburden to the lining) the same shall be applied as follows:

For soil, earth pressure σ_v shall be given by equation $\sigma_v = H^*\gamma_s$ subject to a maximum of $D^*\gamma_s$ where H is height of overburden. For secondary lining design earth pressure shall be applied as indicated in sketch below.



12.3.6 Lateral Load for Rock and soft ground:

The effective lateral earth pressure is equal to the product of load due to weight of overburden and coefficient of lateral earth pressure K0. The invert loading shall be applied up to springing line as per given vertical load distribution. For lining design both for rock and soil K value shall be considered as 0.5.

12.3.7 Shrinkage [G3]

The self-tension of the tunnel bearing elements due to concrete shrinkage is simulated as uniform cooling of the lining. The amount of lining deformation is calculated according to IS 456 -2000 and converted into uniform cooling temperature difference of -15°C.

Since the internal forces due to shrinkage results from constraint deformation the partial load factor shall be set equal to 1.25 as per IRS – CBC 1997.

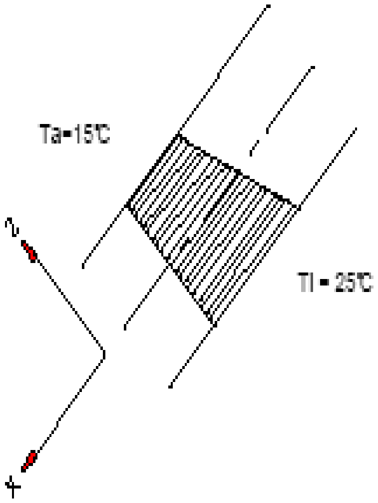
12.3.8 Water Pressure [G4]

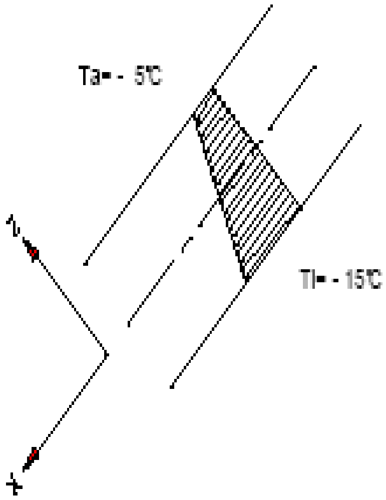
Water pressure on permanent lining shall be considered as per "design water table" along tunnel.

12.4 Live Loads [Q]

12.4.1 Temperature Load [Q1]

The temperature loads are applied only onto the tunnel arch above the construction joint. An average temperature during construction equal to t_m=+10° is assumed and active temperature differences acting on the tunnel lining are taken as follows:





b) Since the internal forces due to temperature differences result from constraint deformation the partial load safety factor according is adopted equal to 1.15 for ULS and 0.80 for SLS as per IRS – CBC 1997.

12.4.2 Earthquake

In general, subsurface structures are subjected to much less stress in earthquake than buildings/structures above ground. These stresses reduce with increase in depth. So, it can be assumed that earthquake induced stress in tunnel are much lower due to earthquakes. As a rule, tunnels are not designed for earthquake forces. (Pl refer "Guide 853.9120 to 853.2001 DB directive", concerning paragraph 16).

Hence, the effect of earthquake force is not considered for structural design of tunnel inner lining.

Further, to verify this assumption, effect of seismic on tunnel evaluated as described in literature "***Seismic design and analysis of underground structures***" by YMA Hashish, JJ Hook, Birger Schmidt and John I-Chiang Yao (ref Tunneling and Underground Space Technology 16 (2001) 247-293) shall be considered and manually seismic forces induced shall be considered.

But at initial 20m reach of the portal tunnel lining shall be designed for earthquake forces due to inclined cutting /movement of overburden of portal slope.

12.4.3 Applied load cases

The applied load cases will be following:

- G_1 Self weight (Includes Fan & Overhead System Weight)
- G_2 Earth pressure
- G_3 Shrinkage
- Q_1 Temperature loads (winter and summer)
- E Earthquake loads

The general formats for combinations of actions for the ultimate and serviceability limit states as given in Indian Railway Standard- Concrete Bridge Code 1997 (IRS-CBC), Table-12

The partial factors for actions and combination of actions are taken from IRS Concrete Bridge Code 1997.

The load combinations used for the calculation are listed in the following tables.

12.4.4 Ultimate Limit State (ULS)

Calculations of ultimate limit state consider the following load combinations:
Ordinary load combinations:

I $=1.25\times G_1$
II $=1.25\times G_1+1.70\times G_2$
III $=1.25G_1+1.70\times G_2+1.25\times G_3$
IV $=1.25\times G_1+1.70\times G_2+1.25\times G_3+1.15\times Q_{1,summer}$
V $=1.25\times G_1+1.70\times G_2+1.25\times G_3+1.15\times Q_{1,winter}$

12.4.5 Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

I $=1.0\times G_1$
II $=1.0\times G_1+1.0\times G_2$
III $=1.0\times G_1+1.0\times G_2+1.0\times G_3$
IV $=1.0\times G_1+1.0\times G_2+1.0\times G_3+0.80\times Q_{1,summer}$
V $=1.0\times G_1+1.0\times G_2+1.0\times G_3+0.80\times Q_{1,winter}$

12.4.6 Structural design method

The structural design is carried out in accordance with EN 1992 as Indian codes does not provide any guidelines for design of plain cement concrete

Load combinations for the Ultimate Limit States (ULS) and the Serviceability Limit States (SLS) are considered for the reinforcement design as described in section above.

Partial safety factors for materials for ultimate limit states are adopted according to Indian codes IS456- 2000

Load Combination	***Concrete***	***Reinforcement Steel***
Ordinary Load Combination	**1.5**	**1.15**

Table-17: Partial factors for materials for ULS

12.4.7 Concrete cover

The minimum concrete covers to all reinforcement (main and distribution reinforcing bars) considering the exposure conditions are adopted as follows:

- Concrete exposed to earth (external face) 50 mm
- Concrete not exposed to earth (internal face) 40 mm

12.4.8 Crack width

A maximum crack width of 0.2 mm (moderate durability exposure) is proposed. The crack width shall be calculated in accordance with IS 456-2000 or RCC shall be designed such that tensile stress in lining is within cracking strength.

13 Design Basis for Cut and Cover Tunnel

The following Cross Section of Cut & Cover Structures shall be used as described in Figure7. As per proposed alignment where soil cover is less than 10m, twin rectangular Cut and Cover tunnel is proposed.

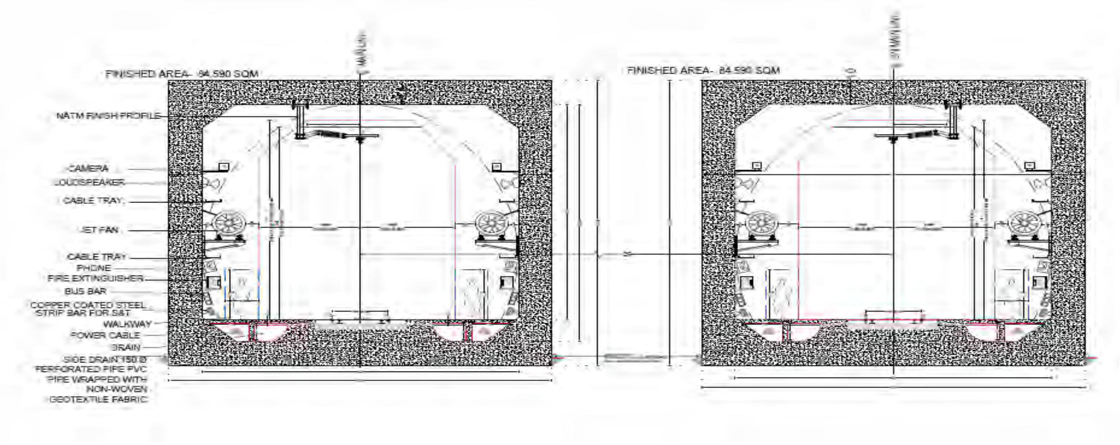


*Figure 7:*Twin Rectangular Shape Cut and Cover for Two Single track

The proposed cross section is preferred over a circular crown section due to anticipated difficulties by the construction agency.

13.1 Soil parameters

The following geotechnical parameters have been considered for the analysis and design of Cut & Cover structures.

Below Mentioned soil parameter for Cut and Cover has been taken from Table 3.3 of GIR.

Location	Depth from N.G.L in m.	Group of sample	Cohesion (C) in KPa	Angle of internal friction (Φ)	E (in MPa)	Safe Bearing Pressure for 25 mm settlement in T/m²	Recommended SBC in T/m²
BH-32	21.0	ML	4	26	31	39.0	35
	24.0					35.0	35
BH-33	20.0	ML-CL	8	26	27.6	27	27

Table-18: Soil parameter for Cut& cover Box

13.2 Cast in place concrete

- Specified characteristic compressive Cylinder strength f_{ck} = 35 N/mm^2 (Concrete Grade M35 according to IS 456:2000)
- Young’s modulus: E = 29580 MPa
- Poisson’s ratio: ν = 0.2
- Unit weight: Ύ = 25 kN/m^3
- The steel for structural reinforcement shall correspond to Fe 500 according to IS 1786-2008:
- Young’s modulus E=200 Gpa
- Yield strength f_{yk}=500 MPa

13.3 Concrete cover

For Underground structural elements in contact with non- aggressive soil

Sl. No.	Structural Components	Nominal Cover(mm)
1.	Inner slabs, walls	50
2.	Outer slabs	70
3.	Walls outer	70

13.4 Crack Width

All structural concrete elements shall be designed to prevent excessive cracking due to flexure. The maximum crack widths shall be as specified below.

A. Permissible crack width

Flexural crack width for different structural components is to be checked for all the load combinations at service stage except for instantaneous loading like seismic, winds.

1. For Members in Contact with Soil: -
    - 0.2mm for soil face
    - 0.3mm for inner face

13.5 Calculation of Spring Constants

The cut and cover box are modelled as a beam bedded by springs.

Beam model spring constants are derived from modulus of sub grade reaction Ks, which is calculated from: Ks= E / [1+ѵ] **From EM 1110-2-2901**

where: E… Young's Modulus of soil/rock mass

ѵ …Poisson's Ratio of soil/rock mass = 0.2

The spring constant of a bedding spring representing a certain area A of sub grade is derived as: (Ks x A) per meter.

For a typical E value of 30 MPa, Ks=25 MPa/m i.e. 25000 kN/m^2 /m

13.6 Primary Load case for Cut and Cover

13.6.1 G1 -Self-Weight:

The structural thickness/sizes of various elements are described in STAAD input and self-weight of all these members are calculated by STAAD itself by specifying the density of material used.

Density of reinforced concrete is considered as 25 KN/m3.

13.6.2 G2-Lateral Earth Pressure on Wall

The walls of the cut and cover tunnel will have compacted granular backfill and for that the soil properties proposed for design are as follows:

E = 15000 KN/m^2

Angle of Friction (Ø) = 30 degrees

Unit Weight (γ) = 20 KN/m^3

K_o the initial geological earth pressure at rest coefficient is used in the ground/structure interaction analysis with design earth pressure at rest (K_o = 0.5)

LEP at top of Roof slab ($K_o γH$)

13.6.3 G3- Weight of Fill

This load corresponds to dead weight of soil above roof of box. It is height of fill above top slab multiplied by density of soil.

13.6.4 E1 -Earthquake/Seismic Load

Following the seismic mapping as per Indian Seismic Zoning Map IS 1893 and 1984, the project site is situated in seismic zone *IV*. Seismic coefficient has been calculated as per IS 1893-1:2002,

As per IS 1893:2002, the design horizontal seismic coefficient (Ah) for a structure shall be determined by the following expression:

$$Ah = (ZISa) / (2Rg)$$

The description and values of above variables as per viii are provided below:

Z: Zone Factor = 0.24 (for Seismic Zone IV)

I: Importance factor = 1.5

Sa/g:Average response acceleration factor = 2.5

R Response reduction factor = 3.0 (OMRF)

Hence, the design horizontal seismic coefficient (Ah), using above values has been calculated as,

$$Ah = 0.15$$

Seismic load due to earth pressure from soil has been calculated in accordance with IS 1893-2002, wherein Dynamic earth pressure (full value) is considered up to a depth of $0.5H_T$ (where H_T = Depth to bottom of Tunnel box) and reduces linearly from this value to half of this value at the base of the structure.

Dynamic lateral soil pressure increments at top of box = $A_h \times \gamma \times H_T$

Dynamic lateral soil pressure increments at Bottom of box = $0.5{*}A_h \times \gamma \times H_T$

13.6.5 Future Road Traffic Load [G2]

A load of 20 kN/m^2 shall be considered over top of the tunnel for future road traffic.

13.6.6 Exhaust Fan & Overhead System [G1]

An overhead system for exhaust fan load is considered to be acting on inner lining of the tunnel. These systems are directly fixed by anchors. A suitable load on 7.2kN acting apart 1m shall be applied to inner lining.

An overhead system is considered as a single vertical concentrated load with a value of 3.0 kN placed 1m horizontal from the centerline of the tunnel on the left side of the arch.

A load factor of 1.25 is considered as per as per IRS – CBC 1997.

13.7 Applied load cases

The applied load cases will be following:

G1 Self weight (Includes Fan & Overhead System Weight)

G2 Earth pressure & Future Road Traffic Load

G3 Weight of Fill

Q1 Temperature Loads (Winter and Summer)

E1 Earthquake loads

The general formats for combinations of actions for the ultimate and serviceability limit states as given in Indian Railway Standard- Concrete Bridge Code 1997 (IRS-CBC), Table-12

The partial factors for actions and combination of actions are taken from IRS Concrete Bridge Code 1997.

13.8 A layer of PCC of grade M20 150 mm thick shall be provided below bottom slab of the Cut and Cover tunnel.

13.9 Analysis Method of Cut and Cover

A two-dimensional Plane Frame Analyses are performed using the computer program from STAAD Pro. V8i SS5. A near realistic 2Dmodel using beams bedded by springs has been created and loads have been applied using STAAD command Springs have been generated by using Staad command and reference can be made to STAAD manual for further details.

The bedding is modeled in such a way that the parts of the cross-sections where inward deformation occurs, i.e. where the springs would be subject to tensions, are neglected. The material behavior of ground and lining is generally assumed as being elastic.

After applying all the forces on the model in STAAD Pro .The loads are combined as per the prescribed and the Members are checked for the load combiation for Ultimate Limit State (ULS) and Serviceability Limit State (SLS).

ULS Load Combinations

I $=1.25\times G_1$

II $=1.25\times G_1+1.70\times G_2$

III $=1.25\times G_1+1.70\times G_2+1.25\times G_3$

IV $=1.25\times G_1+1.70\times G_2+1.25\times G_3+1.15\times Q_{1,summer}$

V $=1.25\times G_1+1.70\times G_2+1.25\times G_3+1.15\times Q_{1,winter}$

SLS Load Combinations

I $=1.0\times G_1$

II $=1.0\times G_1+1.0\times G_2$

III $=1.0\times G_1+1.0\times G_2+1.0\times G_3$

IV $=1.0\times G_1+1.0\times G_2+1.0\times G_3+0.80\times Q_{1,summer}$

V $=1.0\times G_1+1.0\times G_2+1.0\times G_3+0.80\times Q_{1,winter}$

Seismic Load Combinations

Min V/ Max H == 1.0 x G_1 + 1.0 x E_1

Max V/Max H = = 1.0 x G_1 + 1.0 x G_2 + 1.0 x G_3 + 1.0 x E_1

Where G1, G2 , G3, E1 and Q1 is explained in Para 8.1.2.4

The Normal force, Bending moment and shear force for all members are taken from the Staad Pro and designed as per ,''*IS 456:2000 Plain and Reinforced Concrete (Fourth Revision)* .

Deflection:

As per clause No-23.2 of IS456:2000 Deflection of Top slab and Wall shall be restricted to Span/250 and H/250 respectively.

14 Cross Passages

Cross passages shall be provided at maximum distance of 350m c/c. The main purpose of cross passage is to connect the running twin tunnels for the purpose of emergency egress. The cross passages shall be constructed by NATM method and temporary support using rock bolt, shotcrete linings and lattice girders. The design of the temporary support will encompass issues such as:

- Temporary face stability and support;
- The need for ground treatment and/or pre-support measures;
- Control of groundwater; and
- Excavation and support sequencing to limit ground movement.

For cross passage Concrete lining of minimum thickness 250mm shall be used.

Primary support and secondary lining Design shall be carried similar to main tunnel.

15 Permanent Ventilation Shafts

15.1 To minimize ventilation requirement four rectangular permanent ventilation shafts at Chainage Km 26+080 and Chainage Km 27+680 have been provided. Size of rectangular ventilation shaft shall be 25m x 12m (clear opening). At the locations of permanent ventilation shafts it is mandatory to provide connecting cross passage with clear opening as shown in Tender drawings. All the permanent ventilation shafts shall be of RCC and shall be designed for all the loadings during construction and design life.

15.2 Permanent ventilation shafts shall be designed for all load cases and combination as mentioned in *Clause 13 of this DBR. Inspection arrangements of permanent ventilation shafts during service life shall also be designed by the Contractor.*

15.3 *Precast /Cast in Situ PSC/RCC roofing system over the shafts with proper ventilation arrangement shall be designed by the Contractor as per relevant IS Codes/NBC. Each shaft shall be provided with steel access door at natural ground level having sturdy locking arrangement with anti-theft features.*

16 Construction cum Utility Shaft

16.1 *A construction cum utility shaft shall be provided at Chainage Km 26+950. The main purpose of construction shaft is to provide multiple faces to expedite the tunnel excavation and to provide access for utilities to the tunnel. At the location of construction cum utility shaft cross passage shall be provided having the same cross-sectional area as the main tunnel.*

16.2 *Construction cum utility shaft shall be designed for all load cases and combination as mentioned in Clause 13 of this DBR. Inspection arrangements of construction cum utility shaft during service life shall also be designed by the Contractor.*

16.3 *Precast /Cast in Situ PSC/RCC roofing system over the shaft with proper ventilation arrangement shall be designed by the Contractor as per relevant IS Codes/NBC. Shaft shall be provided with steel access door at natural ground level having sturdy locking arrangement with anti-theft features.*

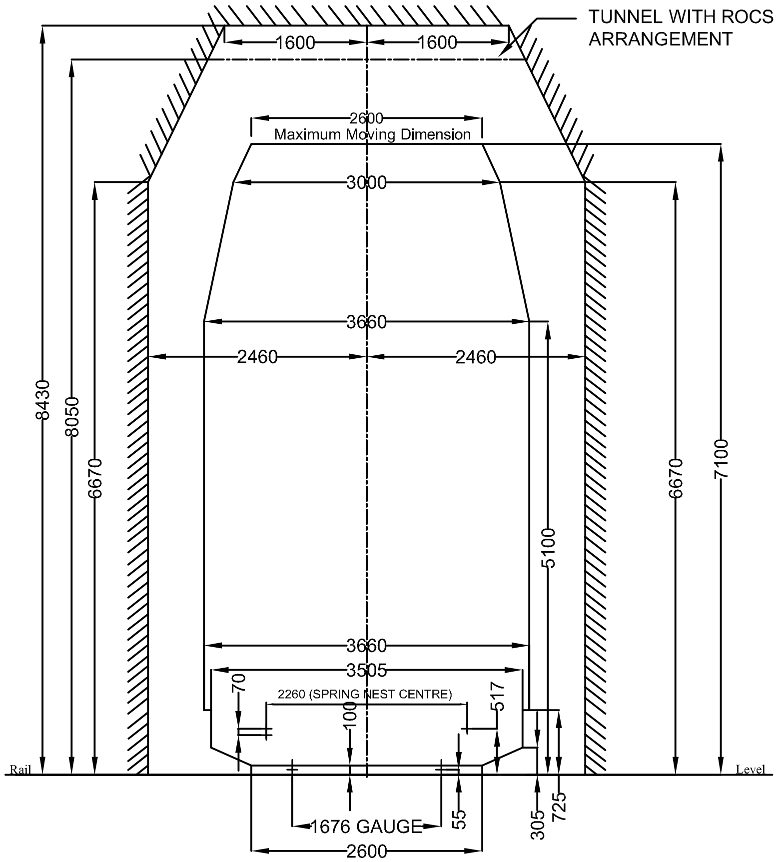
Annexures

ANNEXURE – 1

MMD AND FIXED STRUCTURE GAUGE FOR TUNNEL AND THROUGH GIRDER BRIDGES FOR HORC PROJECT OF HRIDC

(Applicable at location of connectivity at Palwal, Patli, Sultanpur, Asaudha and Harsana Kalan (Single Line)

Fixed Structure Gauge



NOTE :-

(i) ALL DIMENSIONS ARE IN MILIMETRES EXCEPT WHERE OTHERWISE SHOWN.

(ii) THE TRACK SHALL BE BALLASTLESS.

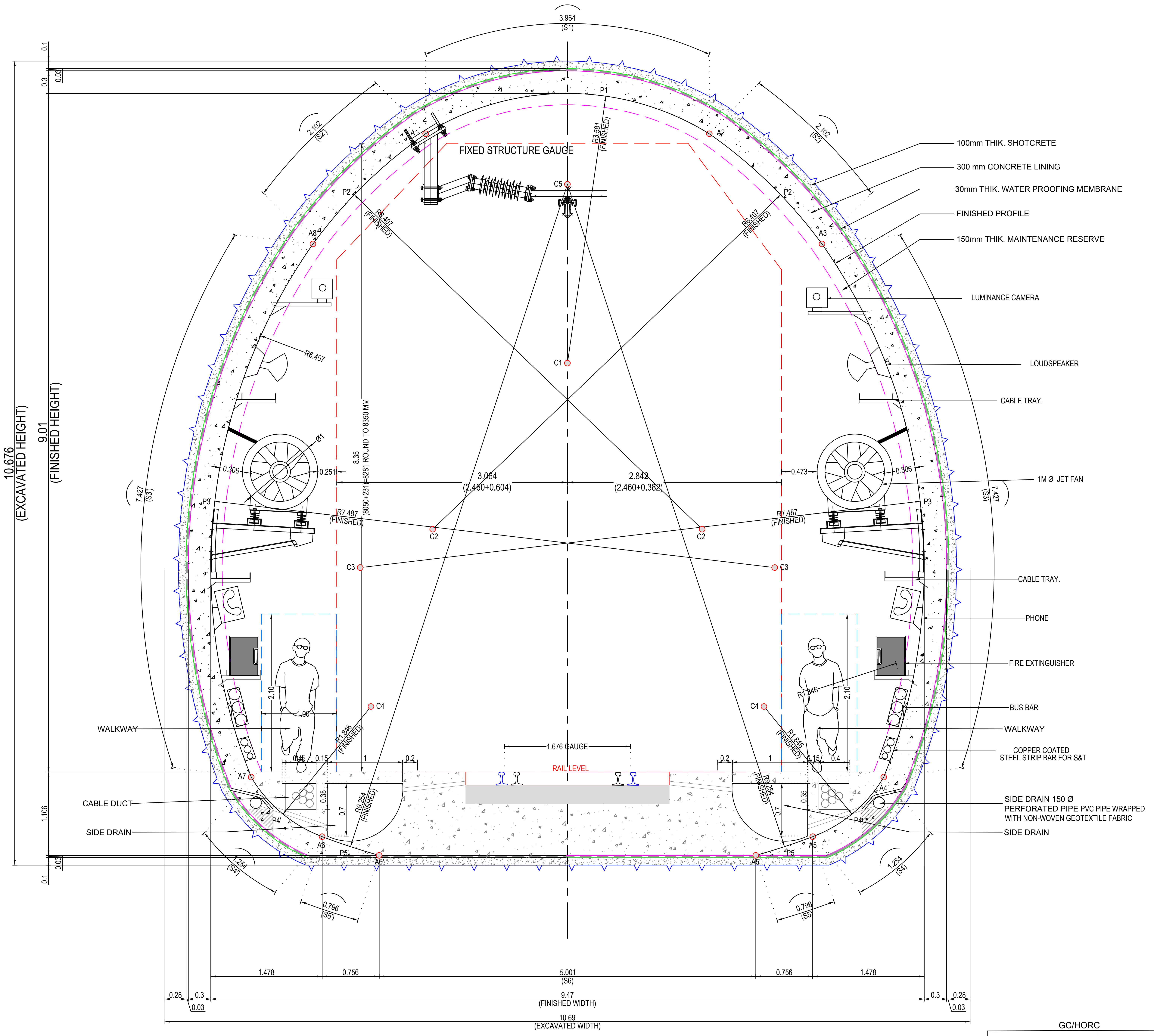
(iii) EXTRA HORIZONTAL CLEARANCES REQUIRED ON CURVES SHALL BE AS PER APPENDIX OF IRSOD (BG), REVISED - 2022.

(iv) EXTRA VERTICAL CLEARANCE SHALL BE PROVIDED ON CURVES AS UNDER:

$$\text{EXTRA VERTICAL CLEARANCE (MM)} = \frac{\text{WIDTH OF MMD(MM) X SUPERELEVATION (MM)}}{\text{DYNAMIC GAUGE (MM)}}$$

(v) HEIGHT OF FIXED STRUCTURE GAUGE WITH ROCS ARRANGEMENT WOULD BE 8050MM.

(vi) IN CASE OF BALLASTED TRACK, NECESSARY PROVISION SHOULD BE MADE IN OVERHEAD STRUCTURES AND OVERHEAD EQUIPMENT TO PERMIT POSSIBLE RAISING OF TRACK BY 275mm IN FUTURE TO CATER TO INCREASED HEIGHT OF TRACK STRUCTURE AND OTHER UNFORESEEN FACTORS SUCH AS RE-GRADING etc.



NOTES:-

1. ALL DIMENSIONS, NORTHING & EASTING AND LEVELS ARE IN METER, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE MEASURED FROM DRAWING.
3. TUNNEL EXCAVATED BY HEADING AND BENCHING METHOD (NATM).
4. THE GRADE OF SHOTCRETE WITH SFRS AS PER DETAIL DESIGN.
5. NEAR PORTAL PULL LENGTH SHOULD BE LIMITED TO 500 MM, ONLY AFTER SUPPORTING EXCAVATED STRETCH (500 MM) ,THEN NEXT CYCLE OF EXCAVATION SHALL BE CARRIED OUT .
6. IT IS PROPOSED TO PROVIDE 50 MM THICK SFRS IMMEDIATELY AFTER EXCAVATION OF FACE .
7. IT IS PROPOSED TO PROVIDE 100 MM THICK SFRS ON SLOPE PROTECTION. ALTERNATIVELY, PLAIN SHOTCRETE WITH WIREMESH 150x150x5mm MAY ALSO BE USED.
8. PROPOSED ROCK BOLT SHALL BE WITH FOLLOWING SPECIFICATION CONFORMING TO IS 1786 ,DIAMETER OF ROCK BOLT =25 MM , GRADE OF ROCK BOLT Fe415 FULLY GROUTED ,SIZE OF ANCHOR PLATE =150X150X8MM
9. PROPOSED SUPPORT SYSTEM IS BASED ON GIR PROVIDED BY GEOLOGIST. ACTUAL SUPPORT SYSTEM MAY BE REVISED BASED ON ACTUAL RESPONSE OF STRATA DURING EXCAVATION.
10. THE NUT OF THE GROUTED ROCK BOLT SHALL BE TIGHTENED 12 HOURS AFTER INSTALLATION TO ACHIEVE A FORCE AT THE ANCHOR PLATE OF APPROX. 20KN. THIS FORCE SHALL BE APPLIED BY CALIBRATED TORQUE WRENCH.
11. THE LENGTH AND THE DIRECTION OF ROCK BOLTS MAY BE ALTERED IN CONSULTATION WITH SITE GEOLOGIST AND ENGINEER-IN-CHARGE. WHEREVER REQUIRED, ADDITIONAL SPOT BOLTING SHALL BE DONE IN LOCALIZED AREA OF POTENTIAL INSTABILITY OR WEAKNESS AS DETERMINED DURING EXCAVATION.
12. SLOPE SUPPORT SHALL BE INSTALLED AS EXCAVATION PROGRESSES SUCH THAT NOT MORE THAN 2.0m VERTICAL HEIGHT OF SLOPE IS LEFT UNSUPPORTED AT ANY TIME.
13. PULLOUT TEST SHALL BE CARRIED OUT ON ROCK BOLTS FOR 190KN. .
14. DRAINAGE PIPE SHALL BE 150mmØ, PERFORATED PVC PIPE WRAPPED WITH NON-WOVEN GEOTEXTILE FABRIC AS PER IS-4984.
15. EXCAVATION SEQUENCE WILL BE PROVIDED BASED ON GFC.
16. EXCAVATION AT EAST PORTAL LOCATION SHALL BE MATCHED WITH DEEP CUT EXCAVATION.
17. GUARD RAIL SHALL BE PROVIDED THROUGHOUT THE LENGTH OF BALLASTLESS TRACK.
18. BALLASTLESS TRACK TO BE DESIGN FOR 32.5 T AXLE LOADING.
19. DIMENSIONS OF PRIMARY SUPPORT & CONCRETE ARE TENTATIVE.
20. 230V SOCKET AT 200M INTERVAL FOR S&T SYSTEM SHALL BE PROVIDED.
21. SEPARATE EARTHING MET CONNECTION FOR S&T SYSTEM SHALL BE PROVIDED.
22. ANCHOR BOLT FOR ROCS SHALL BE INSTALLED DURING TUNNEL LINING.
23. CABLE CROSSING SHALL BE PROVIDED AT EVERY CROSS PASSAGE.
24. LUMINANCE CAMERA, LOUDSPEAKER, JET FAN, PHONE, BUS BAR, COPPER COATED STEEL STRIP BAR FOR S&T AND ROCS WORK (EXCLUDING ANCHOR BOLTS) IS NOT IN THE SCOPE OF WORK OF C-4.

S.N.	CURVE NAME	RADIUS (m.)	START	END	ARCH. LENGTH (m.)
1	S1	R3.581	A1	A2	3.964
2	S2	R6.407	A2	A3	2.102
3	S3	R7.487	A3	A4	7.427
4	S4	R1.846	A4	A5	1.254
5	S5	R9.254	A5	A5'	0.796
6	S6	R0	A5'	A6'	5.001
7	S5'	R9.254	A6'	A6	0.796
8	S4'	R1.846	A6	A7	1.254
9	S3'	R7.487	A7	A8	7.427
10	S2'	R6.407	A8	A1	2.102

EXCAVATED AREA = 91.704 Sqm.
FINISHED AREA = 71.063 Sqm.
EXCAVATED WIDTH = 10.690m
EXCAVATED HEIGHT = 10.676m
FINISHED WIDTH = 9.470m
FINISHED HEIGHT = 9.010m

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*	Chahatey Ram	SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
ORBITAL RAIL CORRIDOR
RITES Limited in consortium with SMEC International Pty. Ltd.

RITES
THE INFRASTRUCTURE PEOPLE
SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01001_A1

DRAWING NAME CONCEPTUAL DRAWING FOR
SINGLE TRACK TUNNEL CROSS SECTION (ROCK)

ISSUE DATE: *07.11.2022* *REVISED DATE:* 03.01.2023
SCALE- *AS SHOWN*
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

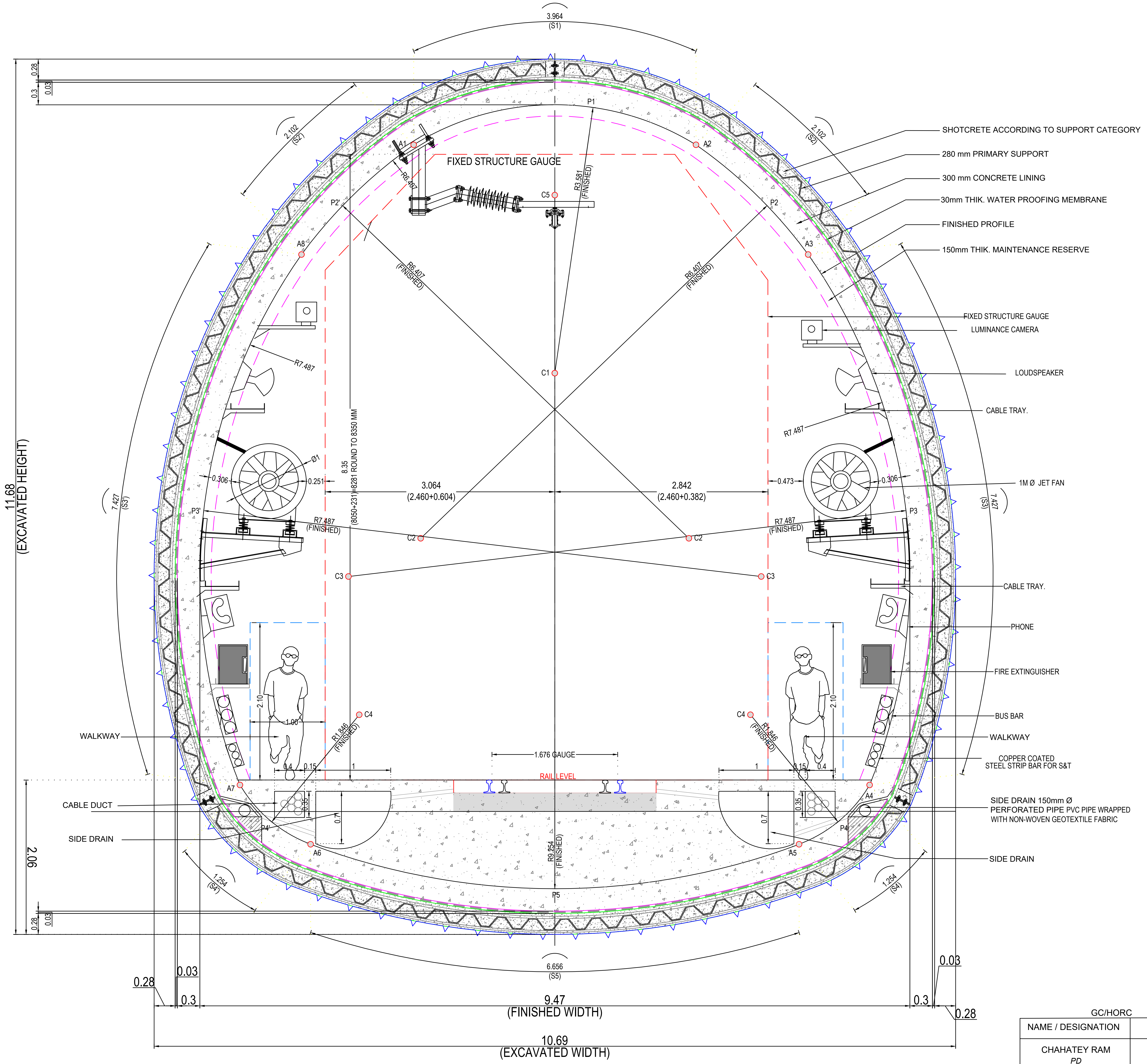
CONSULTANT:
S.M.C.
S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S. kumar
SIVENDRA KUMAR
TUNNEL DESIGNER

B.R.SHARMA
Sr.CONSULTANT / TUNNEL

A. A. SAMANT
PROJECT INCHARGE

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



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2. NO DIMENSIONS SHALL BE MEASURED FROM DRAWING.
3. TUNNEL EXCAVATED BY HEADING, BENCHING / MULTI DRIFT METHOD (NATM).
4. THE GRADE OF SHOTCRETE WITH SFRS AS PER DETAIL DESIGN.
5. PROPOSED SUPPORT SYSTEM IS BASED ON GIR PROVIDED BY GEOLOGIST. ACTUAL SUPPORT SYSTEM MAY BE REVISED BASED ON ACTUAL RESPONSE OF STRATA DURING EXCAVATION.
6. DRAINAGE PIPE SHALL BE 150mmØ, PERFORATED PVC PIPE WRAPPED WITH NON-WOVEN GEOTEXTILE FABRIC AS PER IS-4989
7. EXCAVATION SEQUENCE WILL BE PROVIDED BASED ON GFC.
8. PIPE ROOFING/FOREPULING OF 114 MM DIA SHALL BE PROVIDED WHERE EVER IT IS REQUIRED.
9. SELF DRILLING ANCHOR OF CAPACITY 190 KN SHALL BE PROVIDED FOR PRIMARY SUPPORT DURING EXCAVATION.
10. LATTICE GIRDER 25-25-32 OF DEPTH 187 MM/ ISMB 200 MM SHALL BE INCASED IN SFRS OF MINIMUM THICKNESS 250 MM.
11. GUARD RAIL SHALL BE PROVIDED THROUGHOUT THE LENGTH OF BALLASTLESS TRACK.
12. BALLASTLESS TRACK TO BE DESIGN FOR 32.5 T AXLE LOADING.
13. DIMENSION OF PRIMARY SUPPORT & CONCRETE ARE TENTATIVE.
14. SEPARATE EARTHING MET CONNECTION FOR S&T SYSTEM SHALL BE PROVIDED.
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NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
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SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*	Reetu		
AMARNATH SINGH *CRE/S&T*	Amarnath Singh	*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*	Stiphen	*JGM/L&U*	

PROJECT:-
HARYANA ORBITAL RAIL CORRIDOR
CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING
ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-
HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:
GENERAL CONSULTANT FOR HARYANA
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RITES
THE INFRASTRUCTURE PEOPLE
SMEC
Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01002_A1

DRAWING NAME CONCEPTUAL DRAWING FOR
SINGLE TRACK TUNNEL CROSS SECTION (SOIL)

ISSUE DATE: *07.11.2022* *REVISED DATE:* 03.01.2023
SCALE- *AS SHOWN*
SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

CONSULTANT: S.M.C. S.M. CONSULTANTS
An ISO 9001 Company
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S. kumar
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S. M. CONSULTANTS BHUBANESWAR
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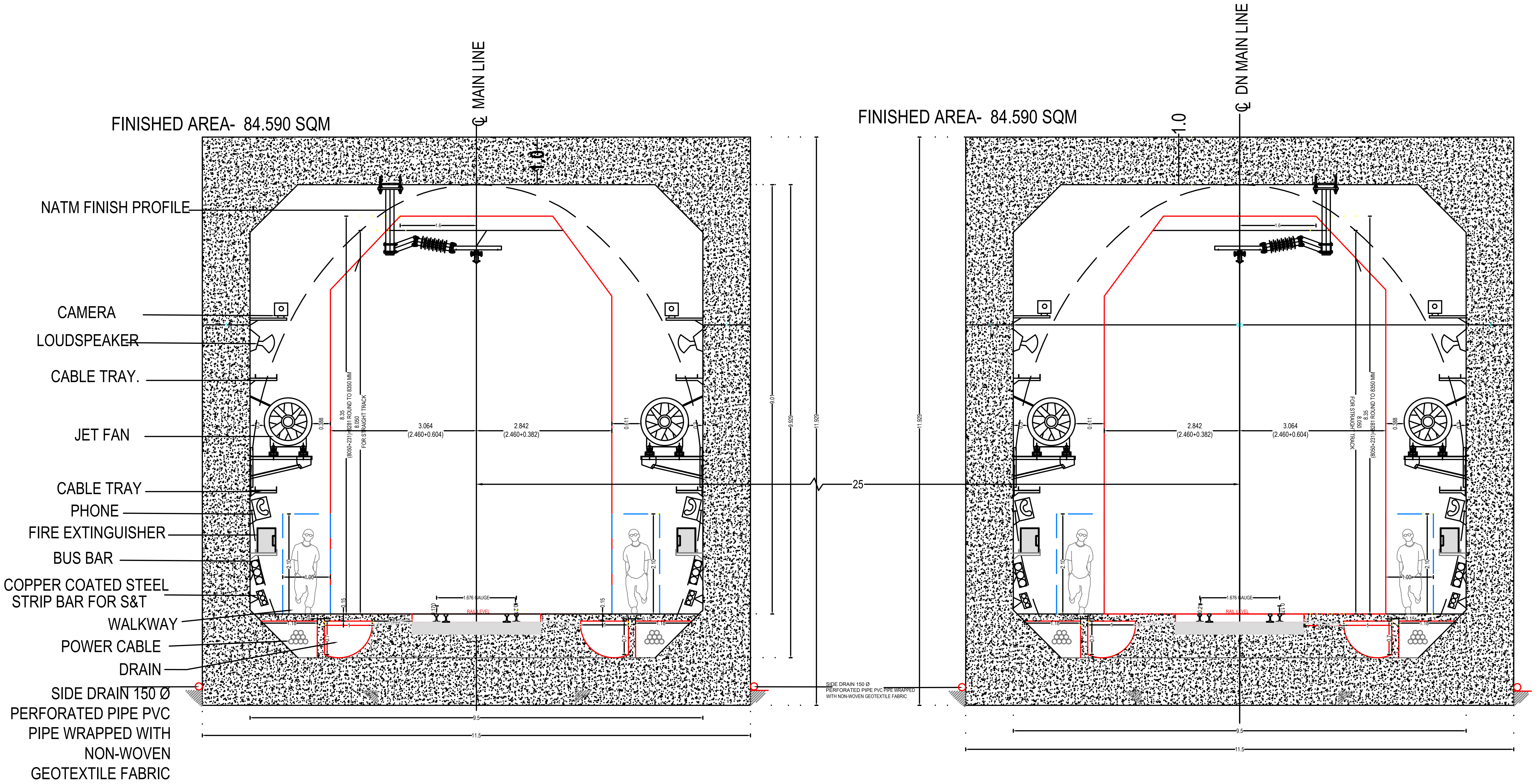

NOTES:~

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE MEASURED FROM THE DRAWING.
3. MINIMUM EXCAVATION LINE SHALL INCLUDE CONSTRUCTION & DEFORMATION TOLERANCE.
4. GUARD RAIL SHALL BE PROVIDED THROUGHOUT THE LENGTH OF BALLASTLESS TRACK
5. BALLASTLESS TRACK TO BE DESIGN FOR 32.5 T AXLE LOADING
6. DIMENSIONS OF SLAB THICKNESS ARE TENTATIVE.
7. SEPARATE EARTHING MET CONNECTION FOR S&T SYSTEM SHALL BE PROVIDED.
8. ANCHOR BOLT FOR ROCS SHALL BE INSTALLED DURING TUNNEL LINING.
9. CABLE CROSSING SHALL BE PROVIDED AT EVERY CROSS PASSAGE.
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SMEC Member of the Surbana Jurong Group

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DRAWING NAME CONCEPTUAL DRAWING FOR CUT & COVER SECTION OF TUNNEL

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CONSULTANT: S.M.C. S.M. CONSULTANTS
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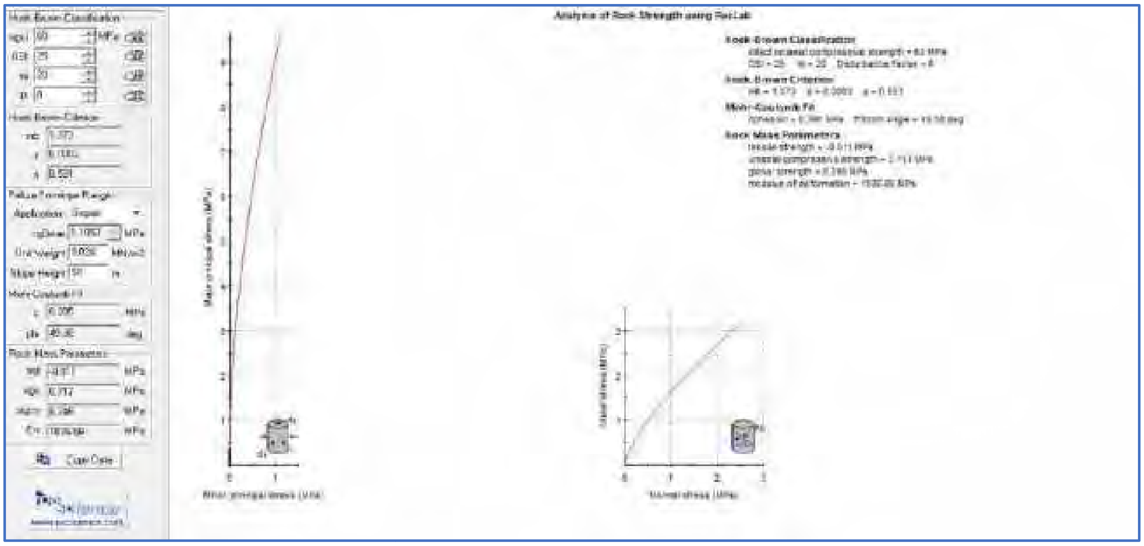

Figure 1: Above mentioned chart is Mohr Coulomb fit output from Roclab software for rock mass derived from intact rock property of laboratory with disturbance factor D=0.

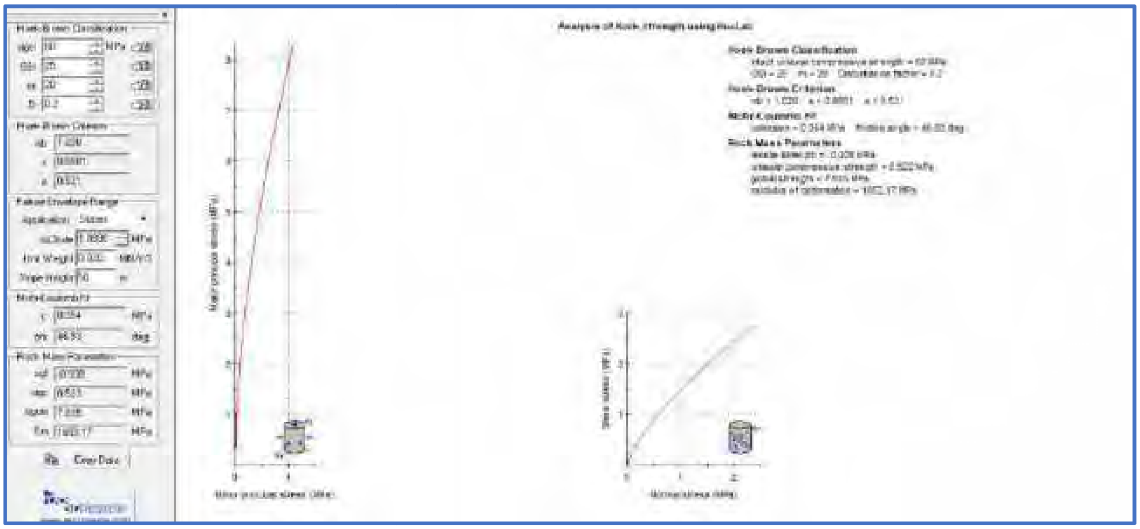

Figure 2: Above mentioned chart is Mohr Coulomb fit output from Roclab software for rock mass derived from intact rock property of laboratory with disturbance factor D=0.2.

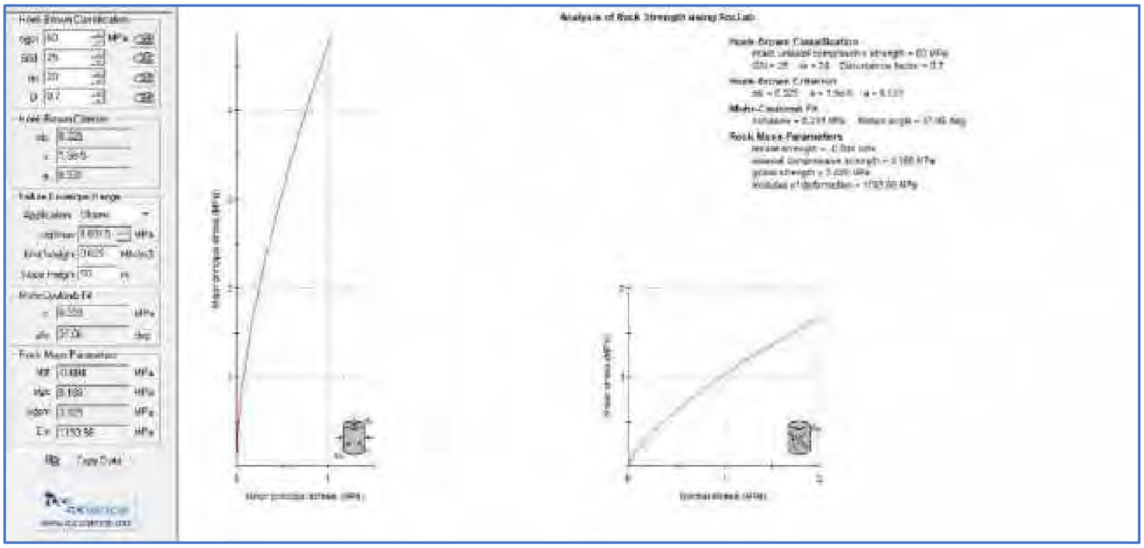

Figure 3 :Above mentioned chart is Mohr Coulomb fit output from Roclab software for rock mass derived from intact rock property of laboratory with disturbance factor D=0.7

ANNEXURE-3

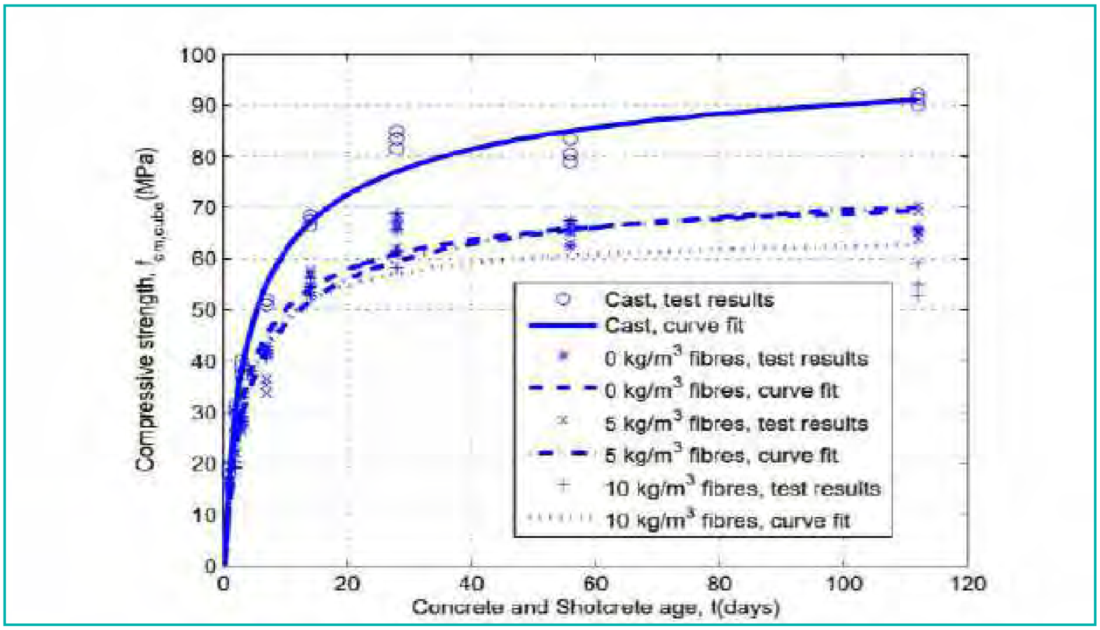

Figure 1: Shotcrete Compressive Strength

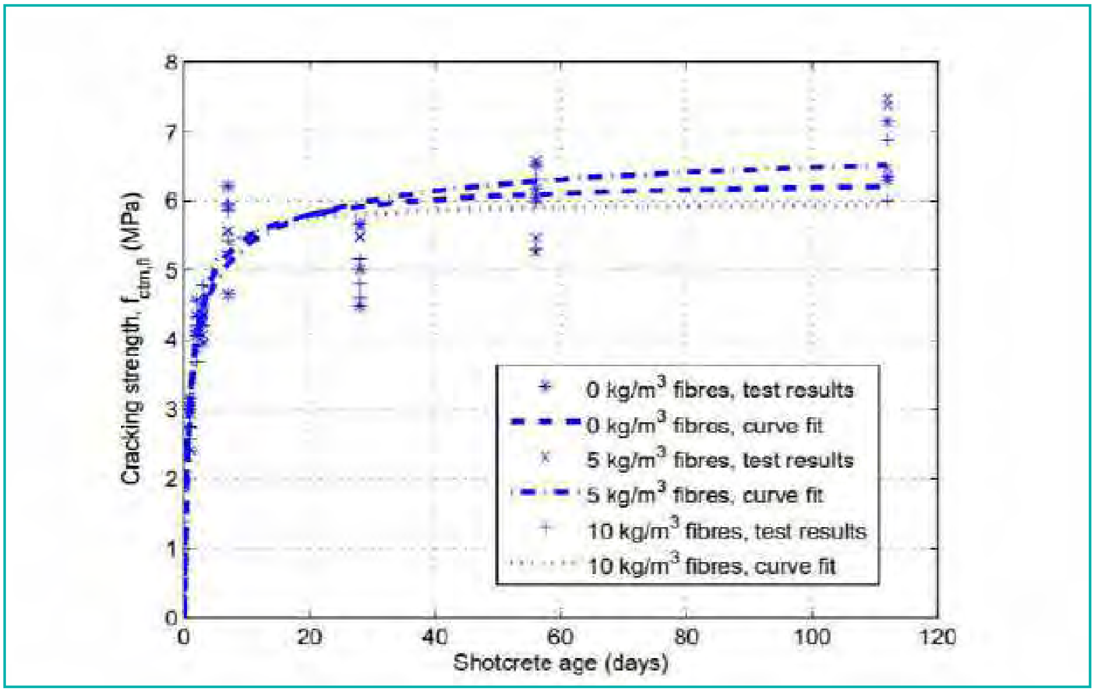

Figure 2:Shotcrete Cracking Strength

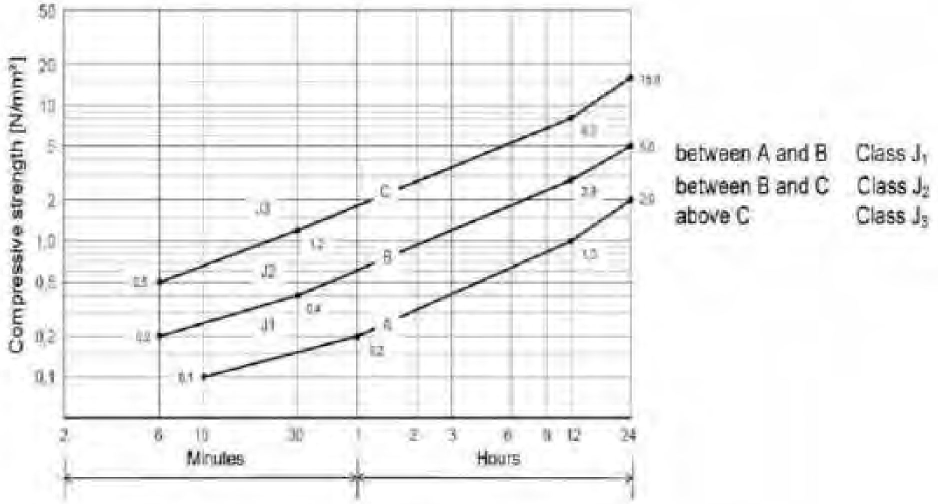

Figure 3: Early strength development of young shotcrete

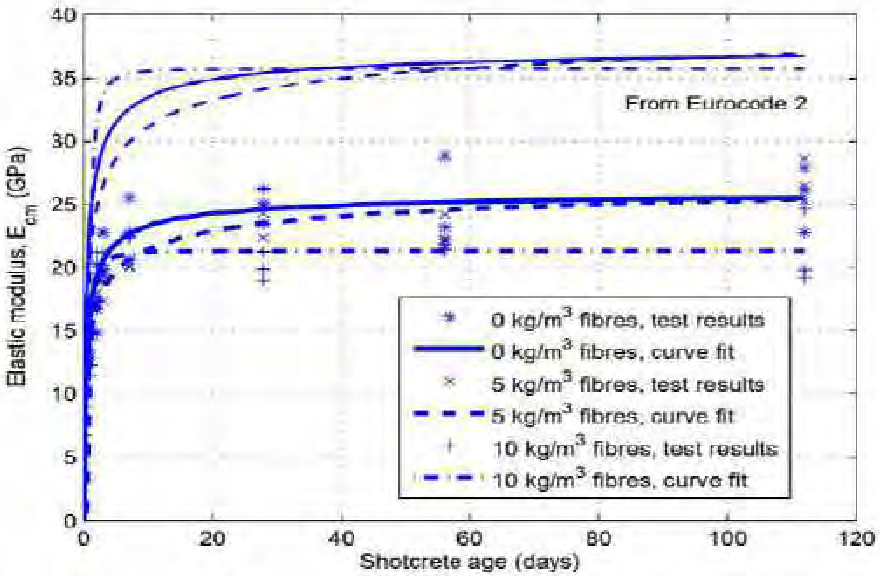

Figure 4:Shotcrete Elastic Modulus

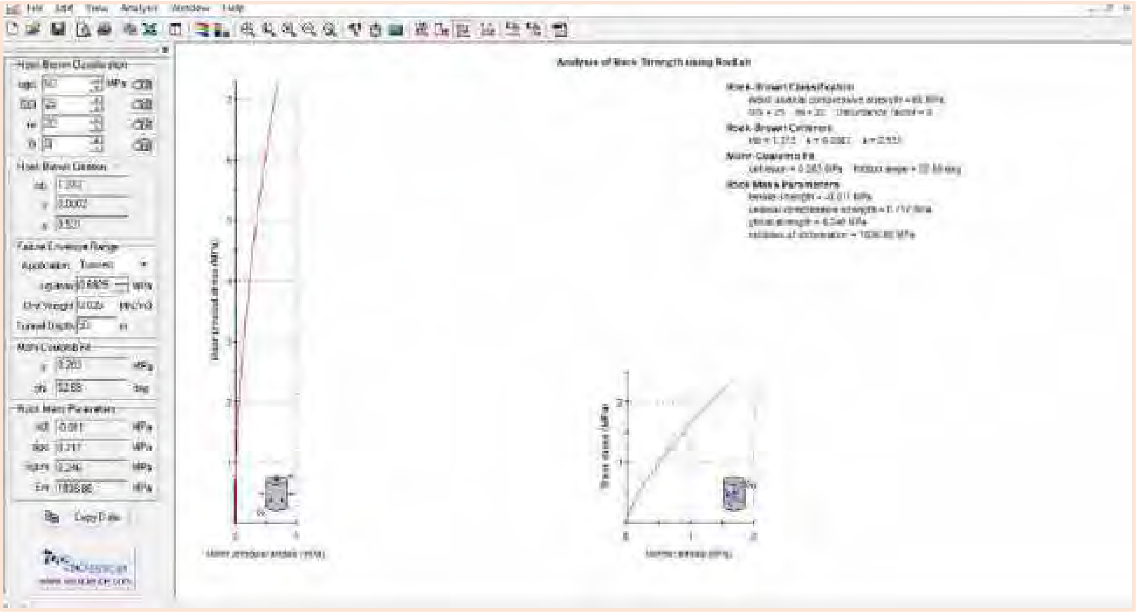

Figure 5 :For tunnel Above mentioned chart is Mohr Coulomb fit output from Roclab of rock mass derived from intact rock property of lab with disturbance factor D=0.

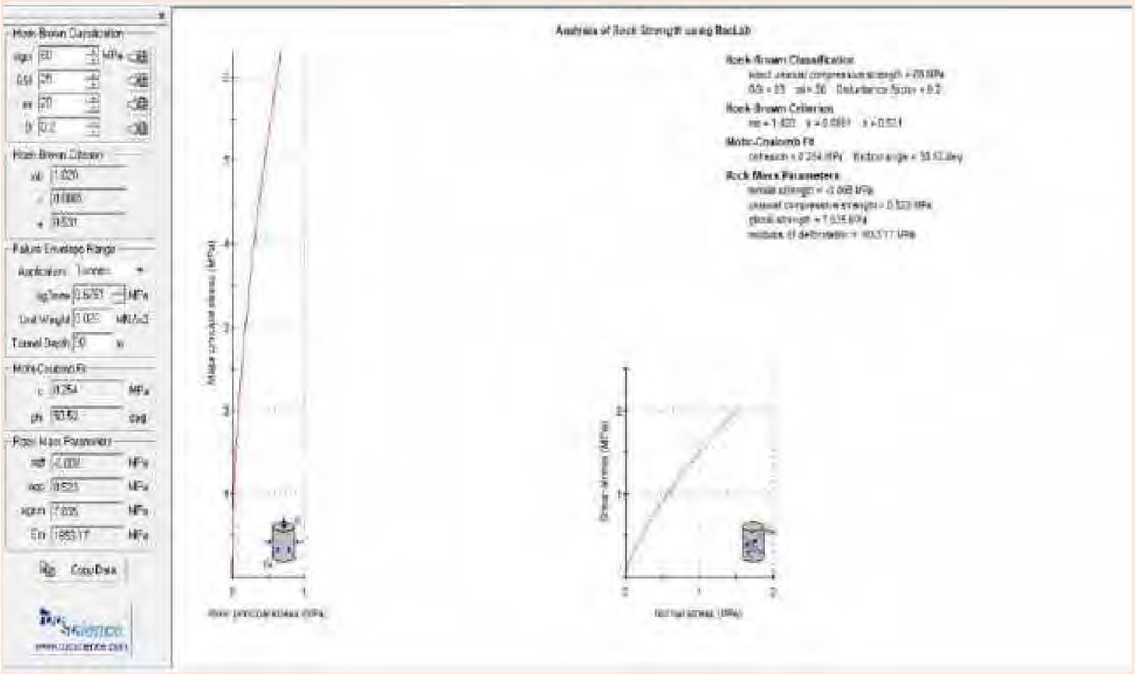

Figure 6 Above mentioned chart is Mohr Coulomb fit output from Roclab of rock mass derived from intact rock property of lab with disturbance factor D=0.2

5. GEOTECHNICAL INVESTIGATION REPORTS FOR TUNNEL

Contents

i. Geotechnical Investigation Report No. SMC/2050.

GEOTECHNICAL INVESTIGATION REPORT
FOR
TUNNEL

EXPLORING ALTERNATE ALIGNMENTS, FINAL LOCATION SURVEY, GEOLOGICAL MAPPING, GEO-TECHNICAL INVESTIGATION, DETAIL DESIGN OF TUNNEL & ITS APPROACHES INCLUDING VIADUCT IF ANY AND OTHER ANCILLARY WORK IN SOHNA-MANESAR SECTION OF HORC PROJECT.

Client:

HRIDC

HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

Prepared By:

S. M. C.

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
MANCHESWAR INDUSTRIAL ESTATE,
RASULGARH, BHUBANESWAR-751010, ODISHA

GEOTECHNICAL INVESTIGATION REPORT FOR TUNNEL

Prepared & Submitted By	
M/s. S. M. Consultants	
GEOTECHNICAL ENGINEER	Shreesty
GEOLOGIST	Dr Dipanjan Bhattacharjee Assistant Professor Department of Geology
SENIOR CONSULTANT	Senior Consultant Virinchisarma. Indira Gandhi National Tribal University (A central university established by an act of Parliament) Amarkantak, Madhya Pradesh-484887

For S.M. Consultants

General Consultant	
PD/GC	
DPD/GC/CIVIL	

Client		
CPM/HRIDCL		
DGM/CIVIL/S/ HRIDCL		
EXE/CIVIL/ HRIDCL		

Client:

HRIDC

HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION
LIMITED.

Consultant:

S. M. C.

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
MANCHESWAR INDUSTRIAL ESTATE,
RASULGARH, BHUBANESWAR-751010

Contents

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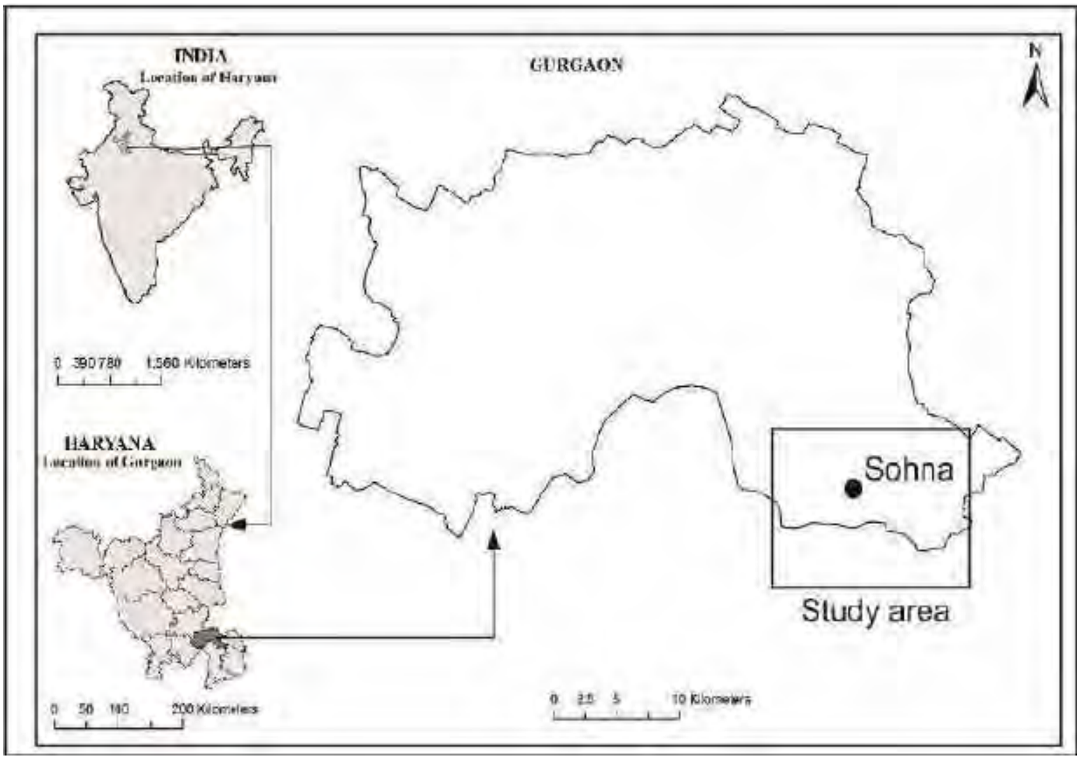
List of Tables:

1 CHAPTER: INTRODUCTION

This report presents results of sub-soil Exploration work for **"Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"**. This work was performed by **M/s. S. M. Consultants, Bhubaneswar** which was assigned by **Haryana Rail Infrastructure Development Corporation Ltd.** At the proposed site twenty-two numbers of bore holes were drilled to explore the sub-strata. The findings of work presented in this report are based on the subsurface conditions encountered at exploration site and results of laboratory testing of soil and rock samples. The properties of sub-strata should not be extrapolated to other areas without our prior review.

2 CHAPTER: LOCATION MAP AND TOPOGRAPHY



2.1 Locality:

Figure 1 Geographical location of study area

The area in the report lies within the district of Gurgaon of Haryana. The concerned region is a part of survey of India toposheet No. 53H/04 and spanned between longitude 77°58′36″& 77°06′00″and latitude 28°14′0″ & 28°10′30″.

2.2 Accessibility:

The area is 20km away from Gurgaon. The important towns in the area are Sohna, Gurgaon, Palwal. These towns are connected with important cities of the state and Delhi by metaled roads. Delhi Bombay National Highway (NH-6) passes through Gurgaon State Highway No 43 passes through Sohna. Gurgaon is a railway station on Delhi Rewari section of the meter gauge line of the Northern Railway whereas Faridabad and Palwal are on Delhi Bombay broad gauge line. Most of the villages in the area are connected by all-weather metaled roads

2.3 Flora and Fauna:

The vegetation is sparse in the area mainly composed of bushes and shrubs, palm trees can be seen at places where nalas emerge from hills. Among the common fauna found in the area are Nilgai (Becephalus tragecamelus), Hare (Lepus sp). Common bird species in the area include sparrow (Passer Domestica) Pigeon (Colomba Livia) spotted dove (Straptopelia Chinensism), House crow (Corvus splenders), Indian Parrot (Psittacula eupatria), Mynah (Acidotheras), Vultures, Owls etc. Migratory water birds are also found in the area.

2.4 Climate:

The area has semi-arid type of climate. Summer are extremely hot with the temperature shooting up to 47°C. The winters are quite cold. The minimum temperature recorded in Gurgaon during 1968-70 was 2.0°C. The related humidity is maximum in August (above 80%) and minimum in June (above 35%). In the month of November, the wind velocity in the morning remains about 2.5km whereas in June it is generally 8 km Per hour. The general wind direction is westerly. Summer monsoon starts by the end of June or early July and lasts up to September. Rainfall is generally

Figure 2: Graph showing month wise rainy days for Gurgaon district. (Climate-data.org)

restricted to this monsoon, though winter months also get some scanty rains Average annual rainfallis about 600 mm.

Climatic condition of the area is much varied characterized by hot and moist sub-humid climate. It has mainly 4 seasons. The summer season is from March to Mid-June, the period from Mid-June to September is the Rainy season, October and November constitute the post monsoon season and winter is from December to February. The best time to visit this district is during winter.

Ministry of housing and urban affair, Government of India has done vulnerability mapping for Haryana state which includes multiple hazard zonation maps. The results are given below:

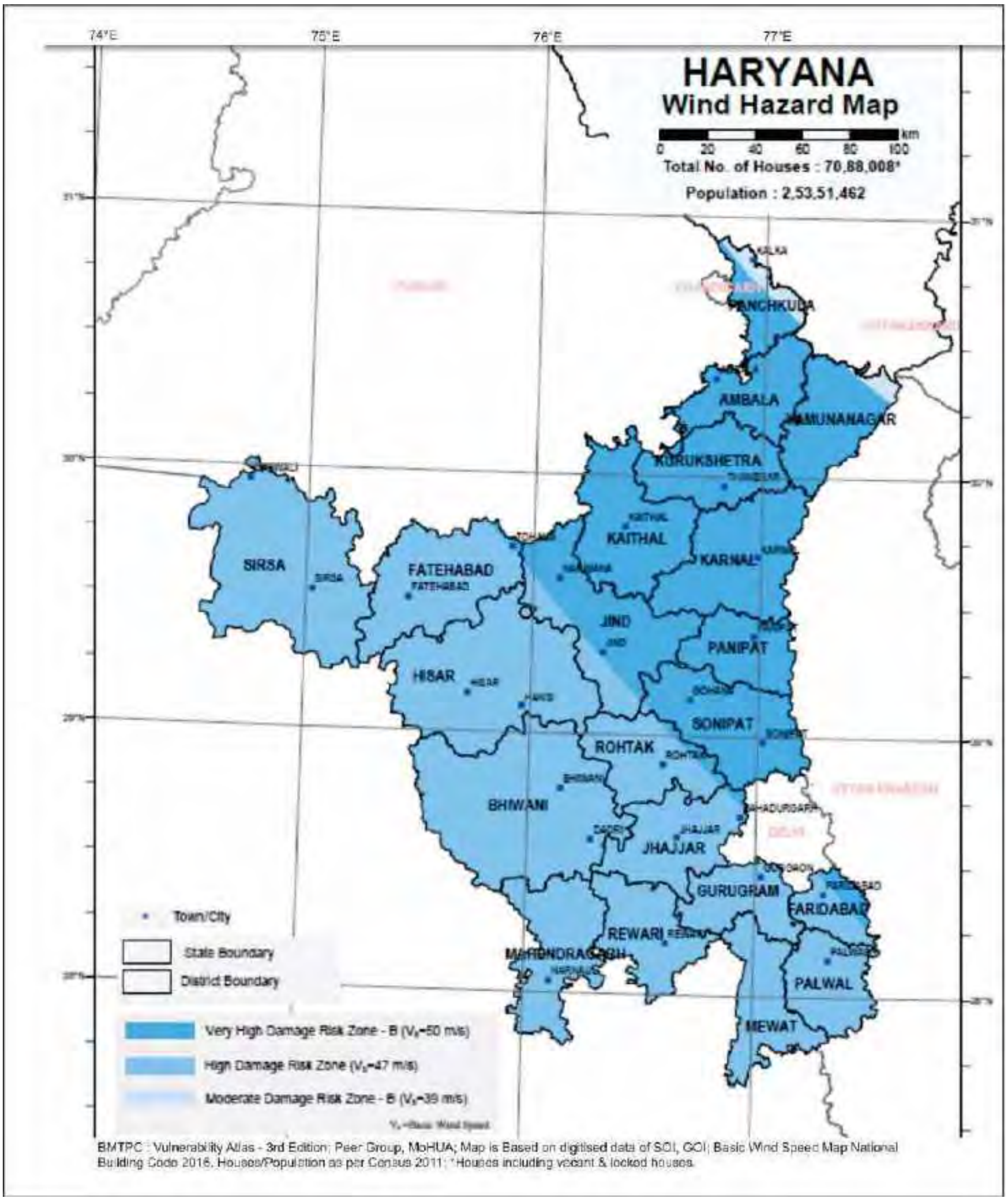
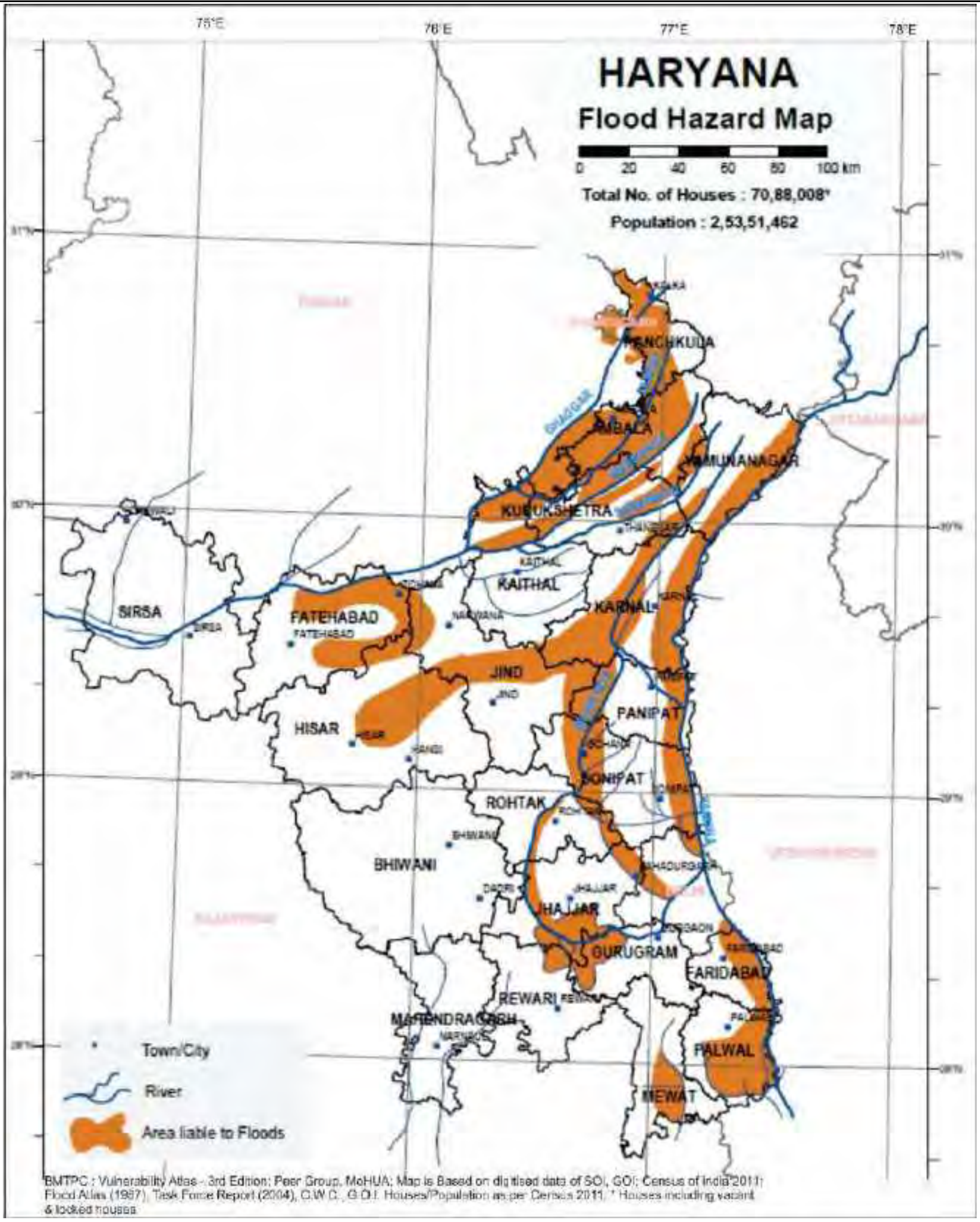


Figure 3: Wind Hazard map of Haryana (adopted from BMTPC)



BMTPC : Vulnerability Atlas - 3rd Edition; Peer Group, MoHUA; Map is Based on digitised data of SOI, GOI; Census of India 2011; Flood Atlas (1987), Task Force Report (2004), C.W.C., G.O.I. Houses/Population as per Census 2011. * Houses including vacant & locked houses

Figure 4: Flood zonation map of Haryana (adopted from BMTPC)

2.5 Seismicity:

According to National Center for Seismology the state of Haryana comprises three earthquake zone. The western part comes under zone II, the central part zone III and the eastern- south-eastern part in zone IV. The region around the site of construction comes under the zone IV of earthquake. Being within the earthquake zone IV the area of interest is at high risk with reference to the seismic activity. This region is liable to MSK VIII on Medvedev–Sponheuer–Karnik Scale, a macro seismic intensity scale or lower and is classified as the High Damage Risk Zone.

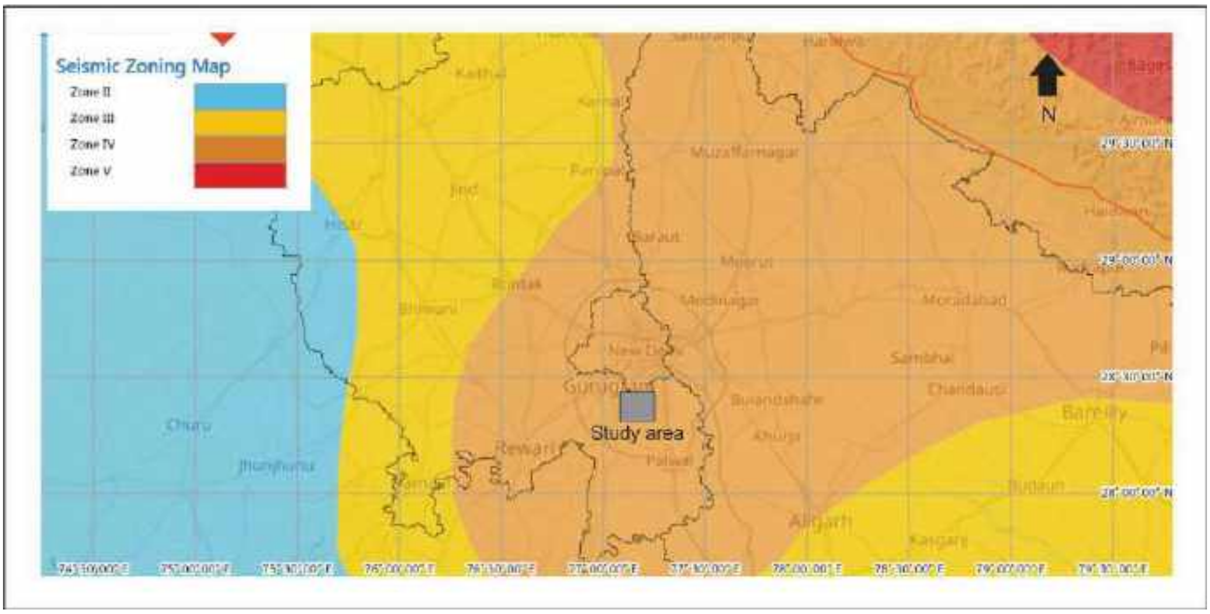


Figure 5: Seismic map of state Haryana (adopted from National Centre for seismology)

3 CHAPTER: SITE GEOLOGY: Geological Investigation of Rock and Soil

3.1 Regional Geology:

The rocks exposed in the area consist of Mesoproterozoic rocks of the North Delhi Fold belt which occur as long, linear, discontinuous chain of hills. The overall Delhi fold belt shows a NE-SW trend and extends from Gujrat (Deri- Ambaji) in the south to Delhi in the north. In the north and south the belt is overlain by Indo-Gangatic alluvium with sparse outcrop jutting out from the plain. Towards west it shows an unconformable contact with Marwar craton along a Phulad lineament and in the east the belt shows a faulted contact with Banded Gneissic Complex of pre-Delhi origin along Kaliguman lineament. The North Delhi Fold Belt has been divided into two groups by Heron (1935): the lower arenaceous Alwar Group and the upper argellaceous Ajabgarh Group. The Alwar Group comprises arkosic schists, phyllites, quartzites and meta- conglomerates whereas, the Ajabgarh Group comprises calc-schists, biotite schists, calc-silicates and marbles.

The regional structure of Delhi fold belt is considered as a broad synclinorium having N to NNE trend (Heron 1953) with core occupied by Delhi group, within the broad synclinorium four generations of deformation (D1 – D4) (Fig. 6) are seen in Delhi fold belt (Naha and Mohanty 1988). D1 and D2 are ubiquitous in all scales while D3 and D4 are seen only in some sectors. D1 folds are tight to isoclinal with a pervasive axial planar cleavage (S1). There are multiple occurrences of boudinage in D1 fold, which are parallel to axial planer cleavage (Naha et al.,1984). D2 folds ranges from open to isoclinal with vertical axial plane striking NNE -SSW to NE-SW. A crenulation cleavage (S2) is developed parallel to axial planes of the fold. D2 fold is coaxial with DF1 fold. Due to D2 various superposed folds have been developed in DFB, most common is Ramsay Type III fold (non-planar cylindrical) (Roy and Das 1985). DF3 folds are kink folds with sub horizontal axial planes. It has affected S1 and S2 cleavages and axial surfaces of DF1 and DF2 folds. At some places DF3 has conjugate axial plane striking NE-SW and SE-NW. It is formed by vertical compression

(Naha and Mohanty 1988). Due to interference from D3 fold there is development of Ramsay Type II fold (non-planer non-cylindrical fold) in the DF1 and Ramsay Type I fold (planer non-cylindrical fold) in DF2 (Roy and Das 1985).

DF4 fold are upright chevron fold, having NW-SE striking axial plane. They are formed by horizontal compression in an NE-SW direction (Naha and Mohanty 1988).

The different phase of deformation has led to metamorphism raging from greenschist to amphibolite facies.

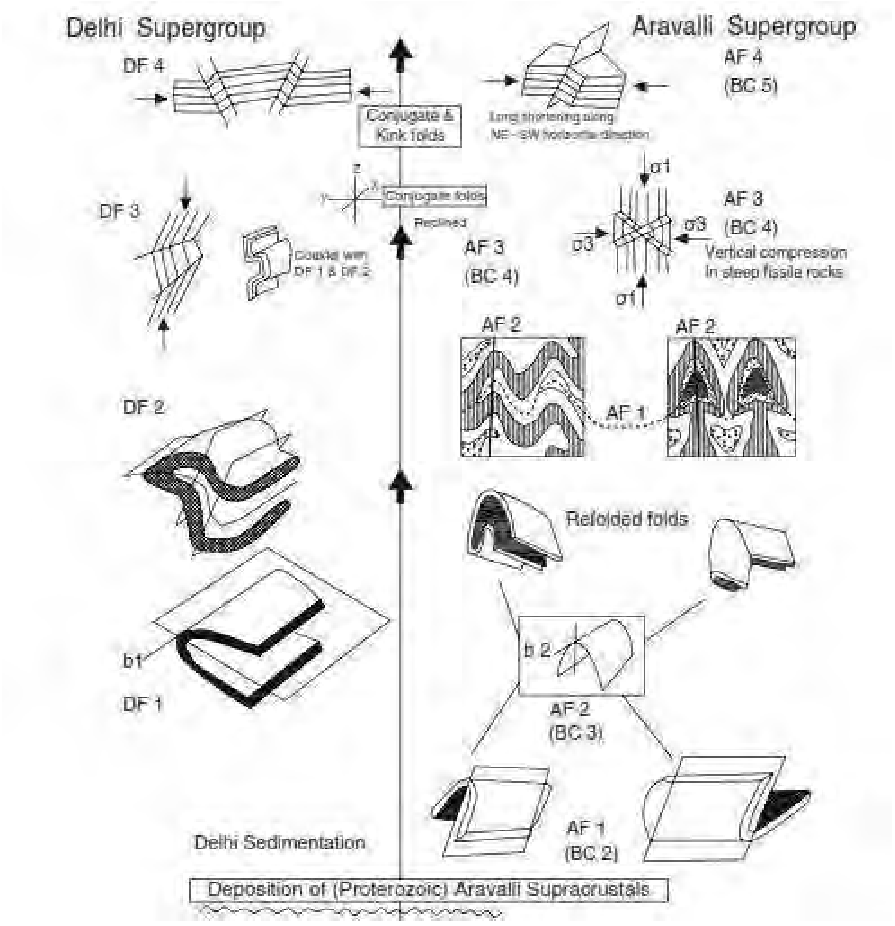
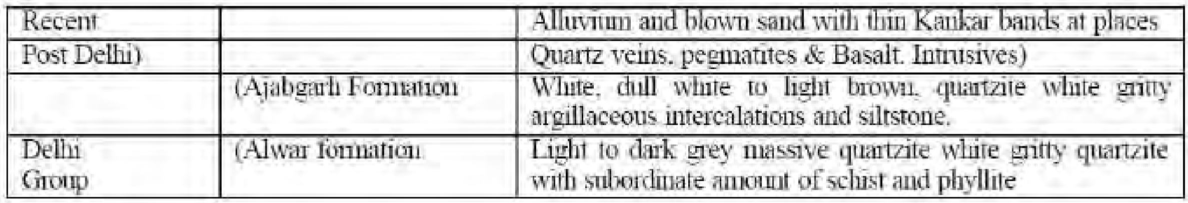


Figure 6: Regional structure of Delhi fold belt (Naha and Mohanty 1988).



Recent		Alluvium and blown sand with thin Kankar bands at places
Post Delhi)		Quartz veins, pegmatites & Basalt. Intrusives)
	(Ajabgarh Formation	White, dull white to light brown, quartzite white gritty argillaceous intercalations and siltstone.
Delhi Group	(Alwar formation	Light to dark grey massive quartzite white gritty quartzite with subordinate amount of schist and phyllite

3.2 Stratigraphy of the Area:

Table 1 : Stratigraphy of North Delhi fold belt (after Roy 1988).

3.3 Local Geology:

The region around the site consists metamorphosed arenaceous rocks of Alwar group. The Lithology is dominated by Quartzites with some intercalations of phyllites near the southern portal.

The Quartzites are metasedimentary rocks comprises greater than 80% quartz along with feldspar and mica minerals, the mineral grains show an equigranular interlocking texture.

The phyllites are low grade metamorphic rocks, they have a marked fissility (a tendency to split into sheets or slabs) due to the parallel alignment of platy minerals; they have a sheen on its surfaces due to tiny plates of micas.

The quartzites near to surface showed high weathering and were highly friable and non-cohesive while as we move deeper (> 15 m) the quartzite becomes more resistive and less weathered. Quartz is a tectosilicate mineral which ranks 7 on Mohr hardness scale, since it crystallizes later according to Bowen reaction series it is also resistive to weathering. Feldspar on the other hand ranks 6 on Mohr hardness scale and crystallizes earlier thus is prone to weathering.

In the southern part intercalation of phyllites/schist along with quartzite are observed.

3.3.1 Structural study of hard rock

The compositional change in quartzite beds defines the bedding in the area and the regional trend of bedding plane is NE-SW with a steep dip towards SE.

A superposed fold was observed at 28°12′33.57″, 77°02′57.08″. DF2 and DF3 deformation phases of Delhi group was observed in the area. DF1 is the prominent fold pattern which was super posed with DF2 folding phase. Signatures of later brittle shearing, possibly related to DF4 phase, was also observed near the proposed portal face. The fold showed Ramsay’s Type III folding pattern i.e., non-planar cylindrical (Fig. 7), the fold hinge showed a plunge of 20° towards 220. The Type III fold pattern in rest of the Delhi system of rocks are result of superposition of DF2 over DF3 deformation. The portal face lies perpendicular to the axial plane of the fold. The earlier generation of fold is isoclinal in nature where both the limbs dip towards south.

Near the fold area some quartz tension gashes were observed. Gash veins open up when rock gets stretched due to shearing and the tension fractures forms oblique to the shear zone which is later filled with mineral precipitate. In the present area the gash veins indicate a dextral shearing (Fig. 8)

At location 28° 12’ 20.93’’, 77° 02’ 40.50’’ another evidence of brittle-ductile shear zone was observed within the quartzite outcrop (Fig. 9). Prominent en-echelon fractures were observed within the outcrop which were rotated to form a sigmoidal structure, the fractures were not filled with mineral precipitate. The shear plane was dipping towards NE with a normal slip where the eastern block was showing a downthrown movement and the western block an upthrown movement. The last phase of deformation DF4 has led to the formation of brittle shearing.

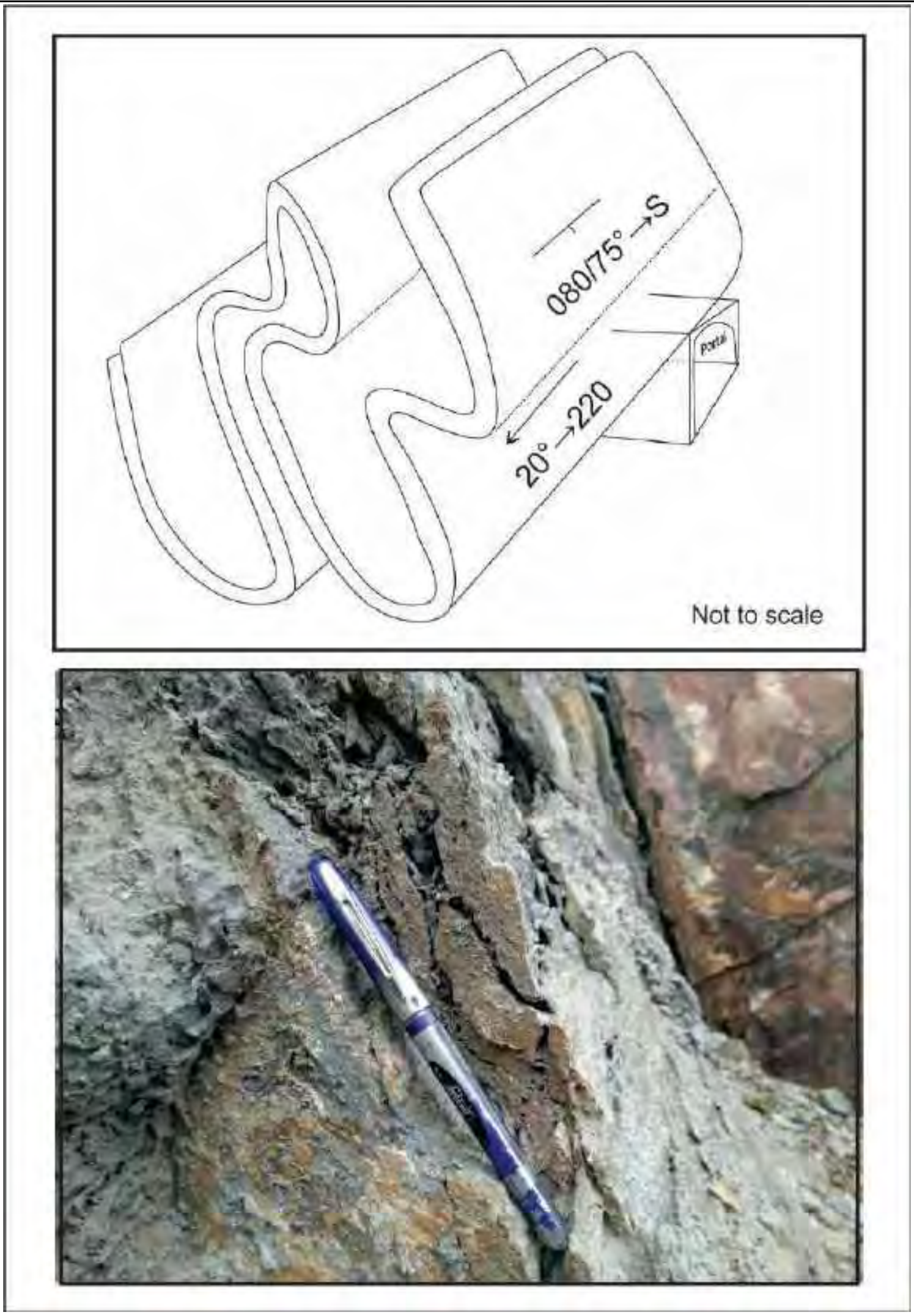


Figure 7: Superposed fold observed at 28 12' 33.57'', 77 02'57.08''

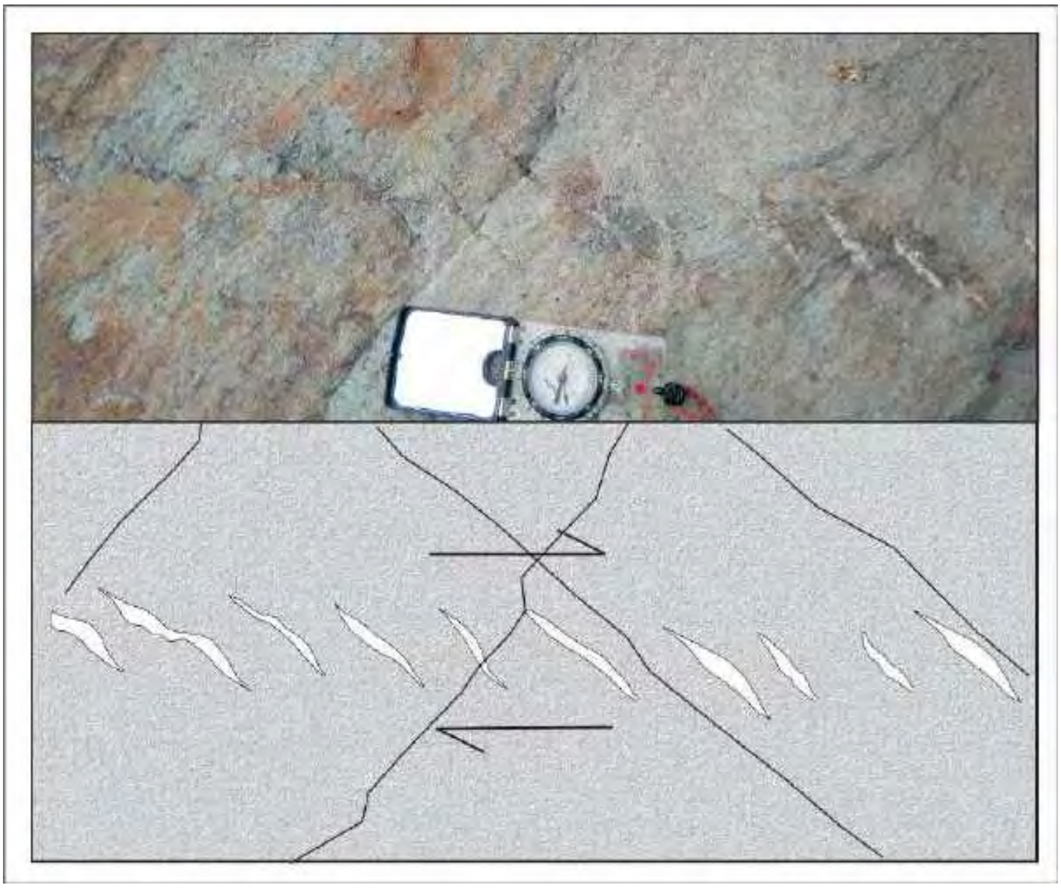


Figure 8 : Gash veins showing a dextral slip.

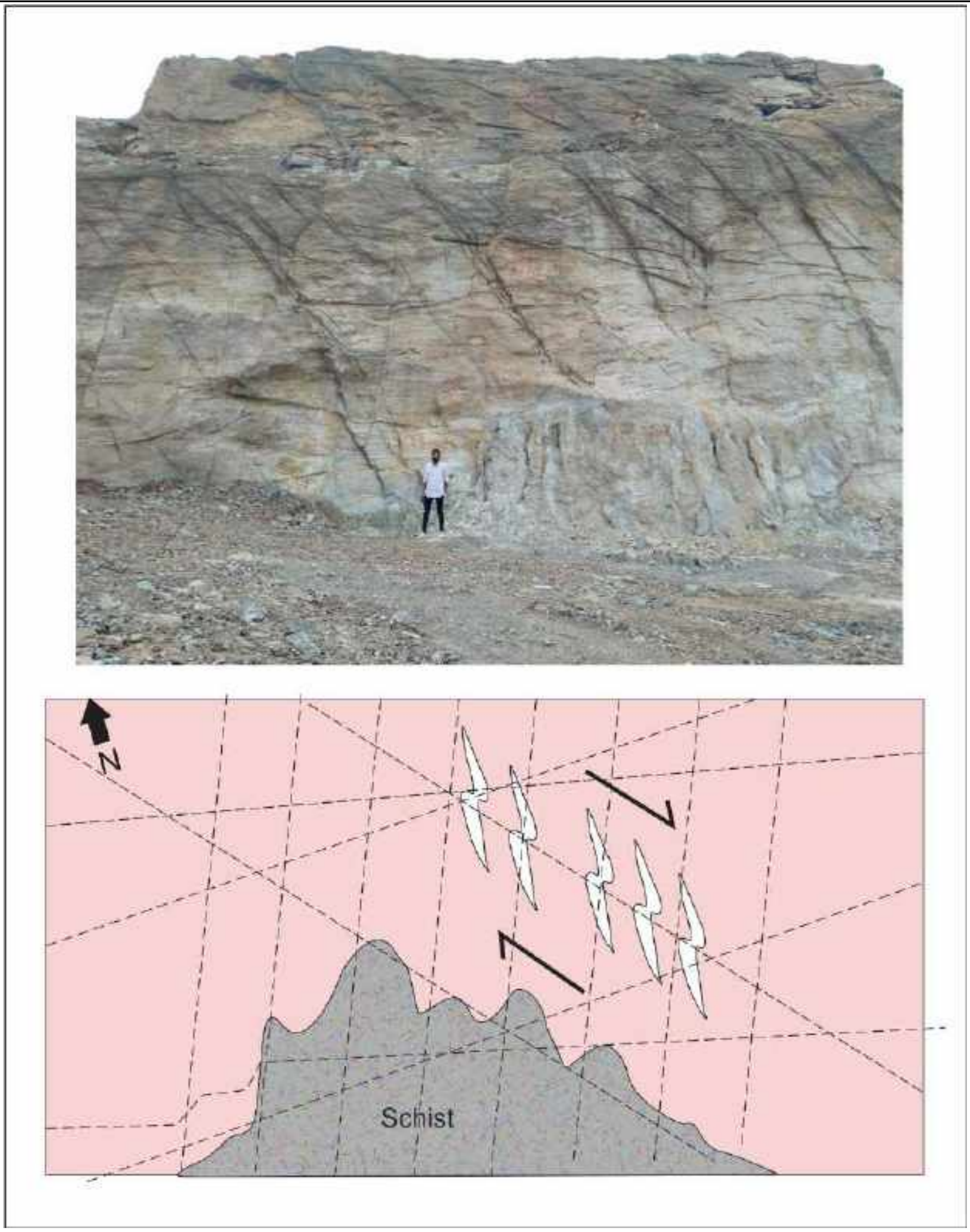


Figure 9: Shear zone observed at location 28 12’ 20.93’’, 77 02’ 40.

Figure 10: Multiple joint sets were observed throughout the area.

Orientation of the joints measured in field (Table 2) has been plotted on stereo net and contouring was done following Schimidt's 1% area rule (Figure 11).The diagram shows 6 distinct cluster of the poles to the joint planes, hence we designate the sets as J1, J2, J3, J4, J5, and J6 (Table 3).

Table 2: Orientation of the joints at places around the site.

S. NO	Strike	Dip	Dip Direction
1.	034	11	NW
2.	028	13	NW
3.	029	13	NW
4.	027	15	NW
5.	027	15	NW
6.	026	16	NW
7.	029	18	NW
8.	033	18	NW
9.	028	19	NW
10.	032	19	NW
11.	042	21	NW
12.	040	22	NW
13.	036	23	NW
14.	041	24	NW
15.	037	25	NW
16.	036	26	NW
17.	043	27	NW
18.	040	28	NW
19.	037	30	NW
20.	038	30	NW
21.	178	31	W
22.	172	32	W
23.	175	32	W
24.	170	34	W
25.	174	34	W
26.	172	36	W
27.	178	37	W
28.	172	38	W
29.	178	38	W
30.	178	39	W
31.	003	40	W

S. NO	Strike	Dip	Dip Direction
32.	006	40	W
33.	004	41	W
34.	005	43	W
35.	008	43	W
36.	119	45	NE
37.	008	46	W
38.	009	46	W
39.	119	46	NE
40.	008	47	W
41.	002	49	W
42.	116	49	NE
43.	007	50	W
44.	110	50	NE
45.	110	51	NE
46.	111	51	NE
47.	114	51	NE
48.	117	51	NE
49.	115	52	NE
50.	119	52	NE
51.	122	57	NE
52.	126	59	NE
53.	127	60	NE
54.	130	60	NE
55.	121	62	NE
56.	129	62	NE
57.	122	63	NE
58.	128	63	NE
59.	124	64	NE
60.	126	65	NE
61.	117	70	NE
62.	117	70	NE
63.	029	71	SE
64.	032	71	SE
65.	026	72	SE
66.	111	72	NE
67.	028	73	SE
68.	030	73	SE
69.	035	73	SE
70.	116	73	NE

S. NO	Strike	Dip	Dip Direction
71.	119	74	NE
72.	117	75	NE
73.	178	76	E
74.	030	76	SE
75.	170	77	E
76.	174	77	E
77.	030	77	SE
78.	110	77	NE
79.	113	77	NE
80.	171	79	E
81.	178	79	E
82.	179	79	E
83.	027	79	SE
84.	032	79	SE
85.	174	80	E
86.	176	80	E
87.	114	80	NE
88.	116	80	NE
89.	040	81	SE
90.	042	81	SE
91.	122	81	NE
92.	171	82	E
93.	175	82	E
94.	045	82	SE
95.	126	82	NE
96.	039	83	SE
97.	122	83	NE
98.	125	83	NE
99.	125	83	NE
100.	005	84	E
101.	038	84	SE
102.	001	85	E
103.	008	85	E
104.	129	85	NE
105.	124	86	NE
106.	127	86	NE
107.	002	87	E
108.	006	87	E
109.	037	87	SE

S. NO	Strike	Dip	Dip Direction
110.	042	87	SE
111.	127	87	NE
112.	009	88	E
113.	002	89	E
114.	043	89	SE
115.	130	89	NE
116.	001	90	E
117.	036	90	SE
118.	040	90	SE
119.	006	91	E
120.	007	93	E
121.	045	82	SE
122.	126	82	NE
123.	039	83	SE
124.	122	83	NE
125.	130	89	NW

Table 3 : Average orientation of Joint sets

Joint Set	Average Strike	Average True Dip amount	Average True Dip direction
J1	035	80	SE
J2	035	20	NW
J3	000	84	E
J4	000	40	W
J5	300	55	NE
J6	300	80	NE

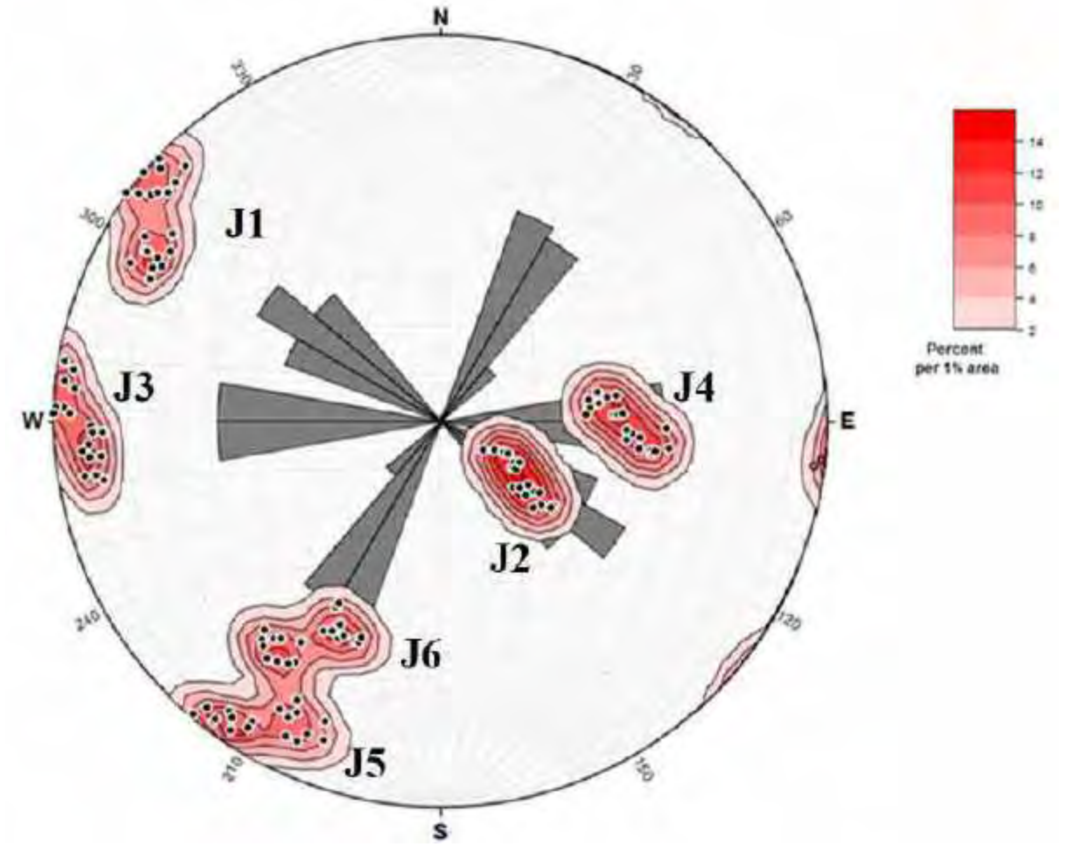


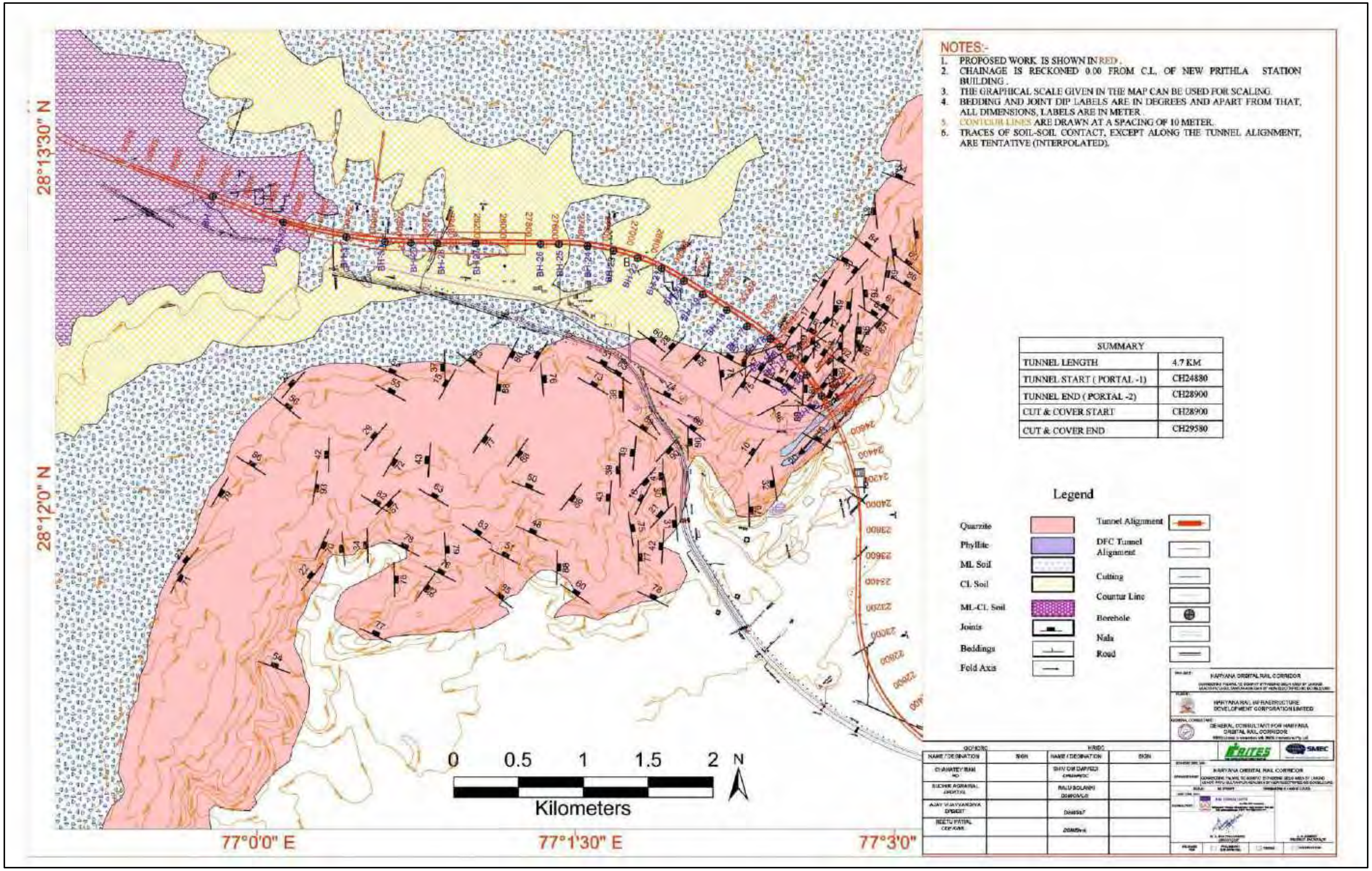
Figure 11: Rose and contour diagram of the orientation of the joint set.

3.3.2 Geological study of unconsolidated material and soil:

There are 4 types of soil were encountered along the tunnel alignment i.e., CL, ML, SM, ML-CL. From CH25800, the rock soil contact point in L-Section (Figure 19), upto CH26700 area were covered with ML type of soil. A very long patch of CL soil, from the boundary of ML at CH26700 up to CH28880, was present. A few small patches of ML and ML-CL soil were appeared within the large patch of CL. Two patches of ML soil, near CH27200 (around BH24) and near CH28560 (around BH29), and a patch of SM soil near CH 28500were found. Again, a portion of ML soil from CH2880 to CH29420 were found and rest of soil along the alignment were categorised into ML-CL type of soil.

Presence of any hot spring, artesian well/ free flowing well was not found and further, no active fault was detected in soil region along the proposed tunnel alignment.

A detailed geological map in a scale 1:25000 (Figure 12) and in 1:2000 scale showing all structural elements which includes faults, thrusts, shear zones, folds, joints, lithological boundaries along with finalised tunnel alignment(Figure 13), L-Section (Figure 19) along the hilly terrain (1:25000 H and 1:2500 V) and detailed cross sections (Figure 20,Figure 21,Figure 22) of the portal face on the mountain front and in the soil are given below;

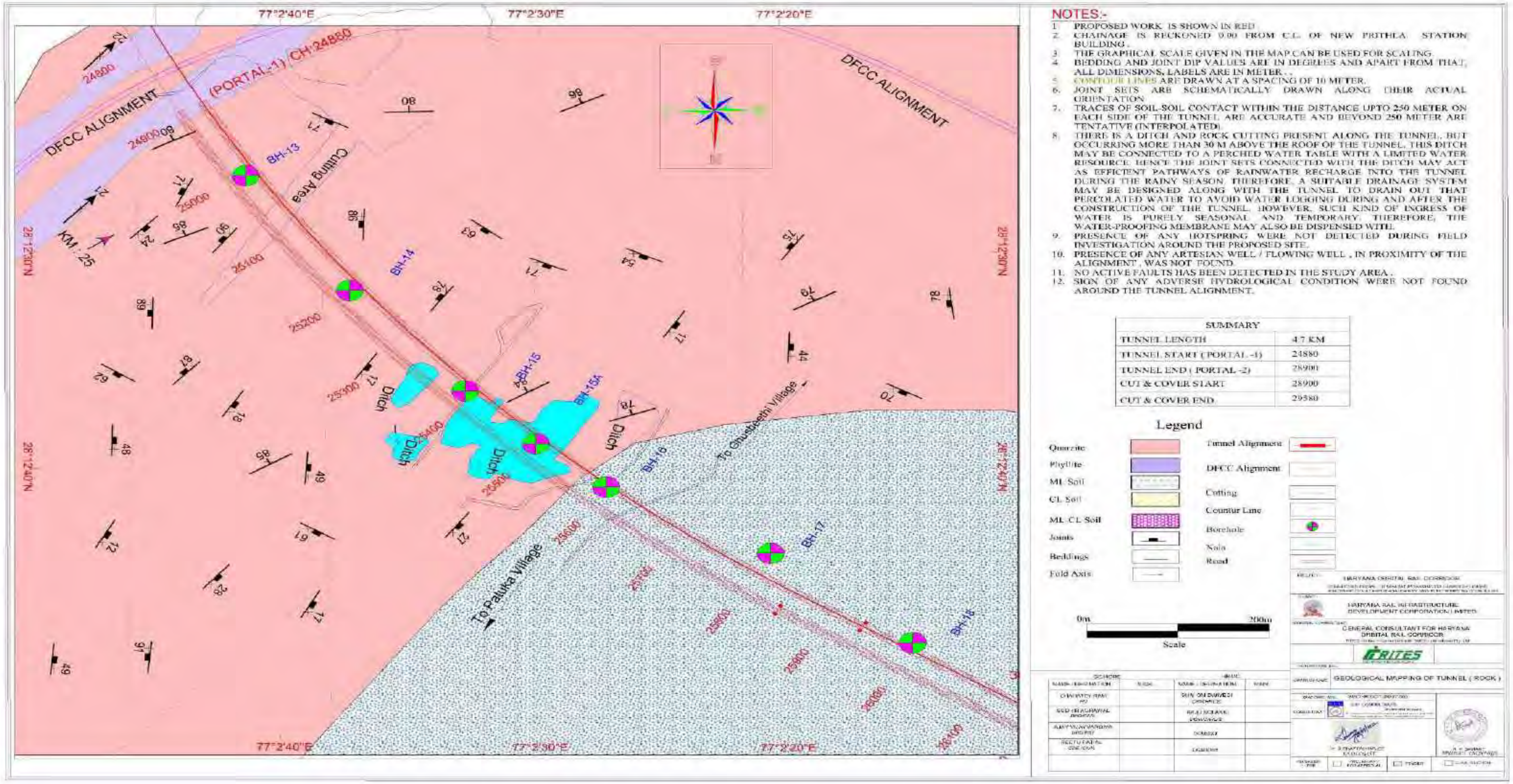


NOTES:-
1. PROPOSED WORK IS SHOWN IN RED.
2. CHAINAGE IS RECKONED 0.00 FROM C.L. OF NEW PRITHLA STATION BUILDING.
3. THE GRAPHICAL SCALE GIVEN IN THE MAP CAN BE USED FOR SCALING.
4. BEDDING AND JOINT DIP LABELS ARE IN DEGREES AND APART FROM THAT, ALL DIMENSIONS, LABELS ARE IN METER.
5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. TRACES OF SOIL-SOIL CONTACT, EXCEPT ALONG THE TUNNEL ALIGNMENT, ARE TENTATIVE (INTERPOLATED).

SUMMARY	
TUNNEL LENGTH	4.7 KM
TUNNEL START (PORTAL -1)	CH24880
TUNNEL END (PORTAL -2)	CH28900
CUT & COVER START	CH28900
CUT & COVER END	CH29580

Figure 12: Geological map of the area at 1:25000 scale.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"



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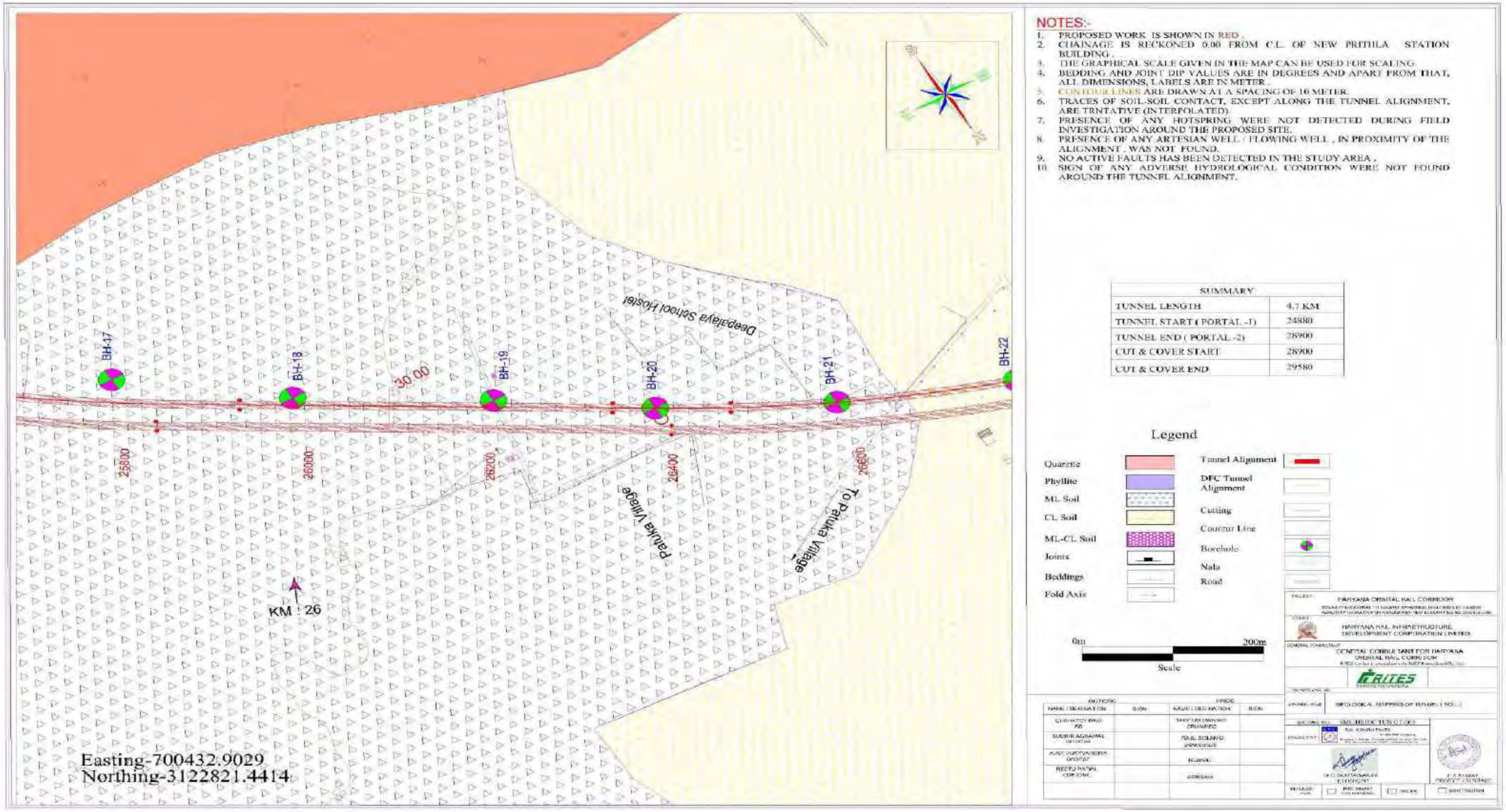
4. BEDDING AND JOINT DIP VALUES ARE IN DEGREES AND APART FROM THAT, ALL DIMENSIONS, LABELS ARE IN METER . .
5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. JOINT SETS ARE SCHEMATICALLY DRAWN ALONG THEIR ACTUAL ORIENTATION
7. TRACES OF SOIL-SOIL CONTACT WITHIN THE DISTANCE UPTO 250 METER ON EACH SIDE OF THE TUNNEL ARE ACCURATE AND BEYOND 250 METER ARE TENTATIVE (INTERPOLATED)
8. THERE IS A DITCH AND ROCK CUTTING PRESENT ALONG THE TUNNEL, BUT OCCURRING MORE THAN 30 M ABOVE THE ROOF OF THE TUNNEL. THIS DITCH MAY BE CONNECTED TO A PERCHED WATER TABLE WITH A LIMITED WATER RESOURCE. HENCE THE JOINT SETS CONNECTED WITH THE DITCH MAY ACT AS EFFICENT PATHWAYS OF RAINWATER RECHARGE INTO THE TUNNEL DURING THE RAINY SEASON. THEREFORE, A SUITABLE DRAINAGE SYSTEM MAY BE DESIGNED ALONG WITH THE TUNNEL TO DRAIN OUT THAT PERCOLATED WATER TO AVOID WATER LOGGING DURING AND AFTER THE CONSTRUCTION OF THE TUNNEL. HOWEVER, SUCH KIND OF INGRESS OF WATER IS PURELY SEASONAL AND TEMPORARY. THEREFORE, THE WATER-PROOFING MEMBRANE MAY ALSO BE DISPENSED WITH.
9. PRESENCE OF ANY HOTSPRING WERE NOT DETECTED DURING FIELD INVESTIGATION AROUND THE PROPOSED SITE.
10. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL , IN PROXIMITY OF THE ALIGNMENT , WAS NOT FOUND.
11. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA .
12. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

SUMMARY	
TUNNEL LENGTH	4.7 KM
TUNNEL START (PORTAL -1)	24880
TUNNEL END (PORTAL -2)	28900
CUT & COVER START	28900
CUT & COVER END	29380

Figure 13: Detailed structural map of the major rocky area at 1:2000 scale. Joint sets are schematically drawn with their actual orientation. Average spacing between the joints are as follows J1: 300 cm, J2:252.78cm, J3:160cm, J4:80cm, J5:32cm, J6:100cm.



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5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. TRACES OF SOIL-SOIL CONTACT, EXCEPT ALONG THE TUNNEL ALIGNMENT, ARE TRNTATIVE (INTERPOLATED)
7. PRESENCE OF ANY HOTSPRING WERE NOT DETECTED DURING FIELD INVESTIGATION AROUND THE PROPOSED SITE.
8. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL , IN PROXIMITY OF THE ALIGNMENT , WAS NOT FOUND.
9. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA .
10. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

SUMMARY	
TUNNEL LENGTH	4.7 KM
TUNNEL START (PORTAL -1)	24880
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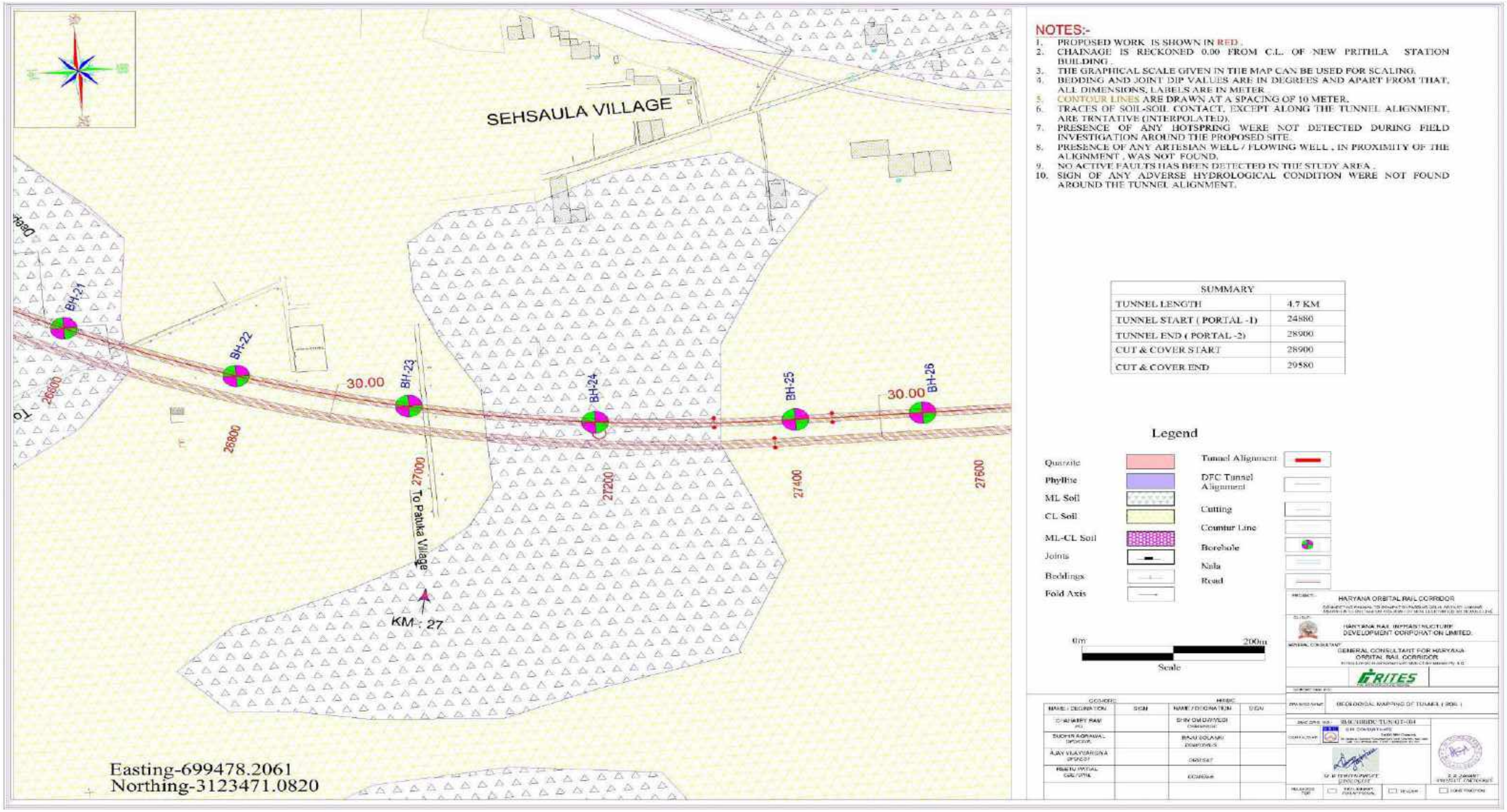
CUT & COVER START	28900
CUT & COVER END	29580

Figure 14: Detailed structural map of the major soil area at 1:2000 scale.



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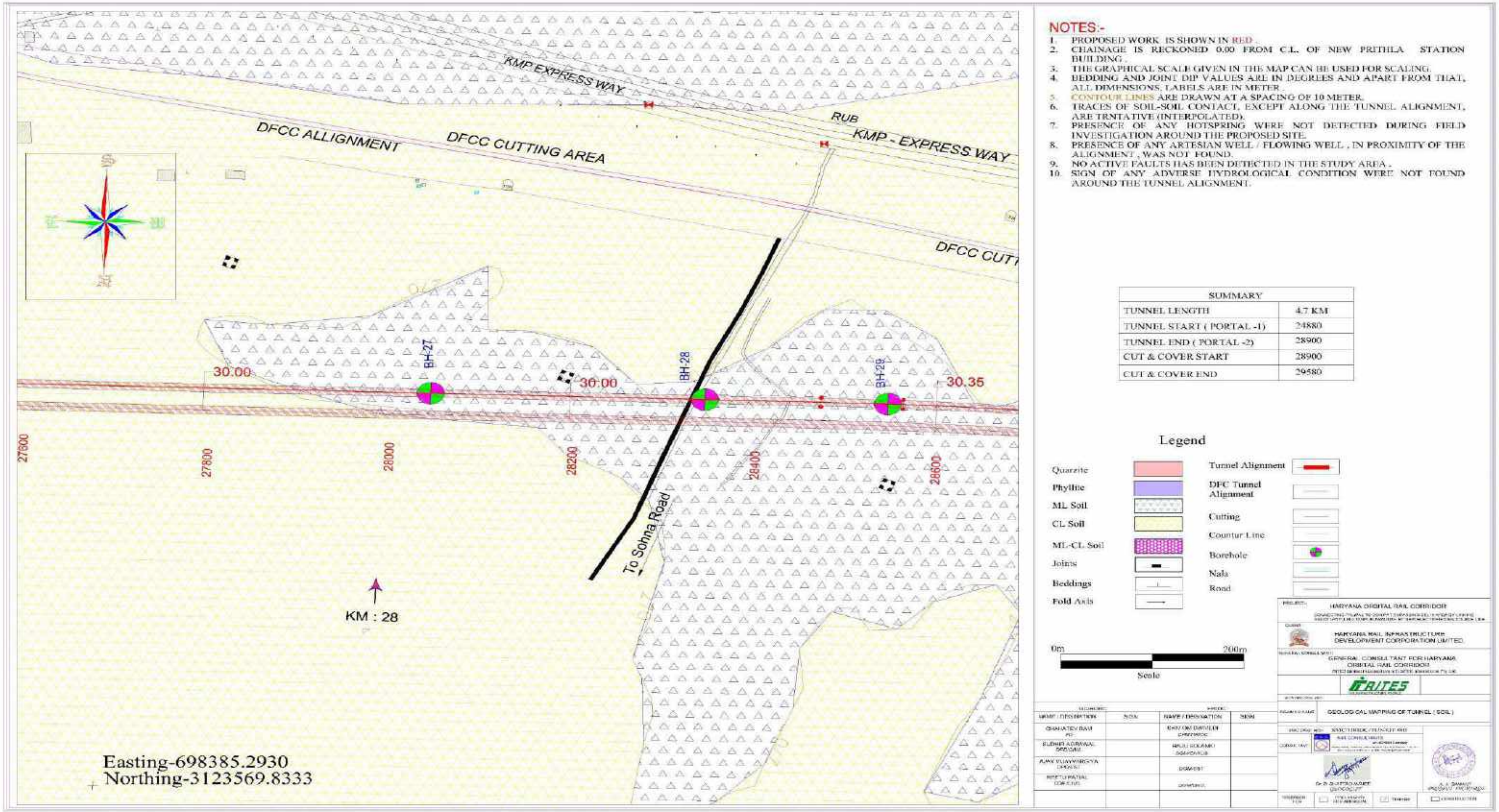
8. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL , IN PROXIMITY OF THE ALIGNMENT , WAS NOT FOUND.
9. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA .
10. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

SUMMARY	
TUNNEL LENGTH	4.7 KM
TUNNEL START (PORTAL -1)	24880
TUNNEL END (PORTAL -2)	28900
CUT & COVER START	28900
CUT & COVER END	29580

Figure 15: Detailed structural map of the major soil area at 1:2000 scale.



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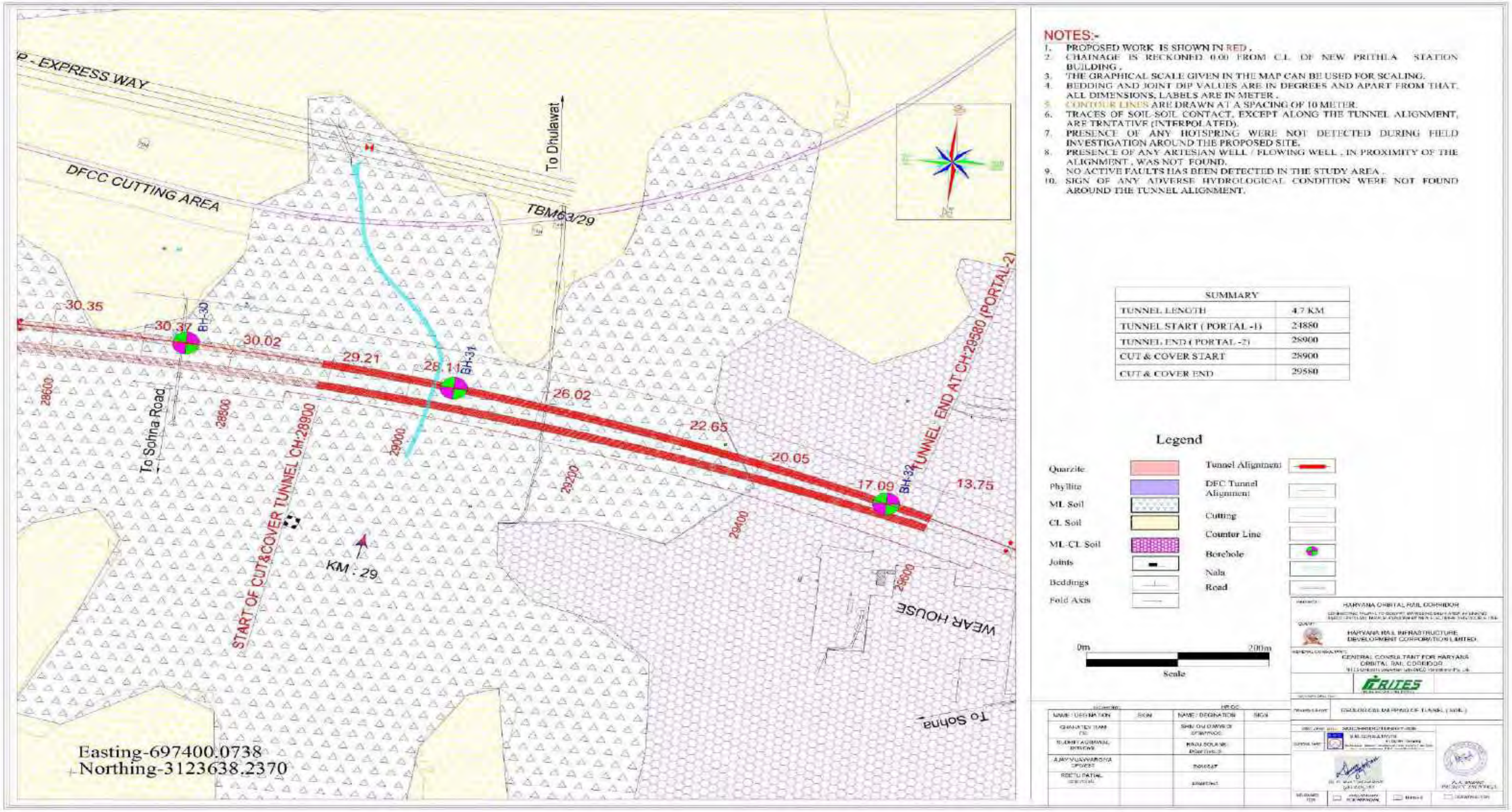
7. PRESENCE OF ANY HOTSPRING WERE NOT DETECTED DURING FIELD INVESTIGATION AROUND THE PROPOSED SITE.
8. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL , IN PROXIMITY OF THE ALIGNMENT , WAS NOT FOUND.
9. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA .
10. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

SUMMARY	
TUNNEL LENGTH	4.7 KM
TUNNEL START (PORTAL -1)	24880
TUNNEL END (PORTAL -2)	28900
CUT & COVER START	28900
CUT & COVER END	29580

Figure 16: Detailed structural map of the major soil area at 1:2000 scale.



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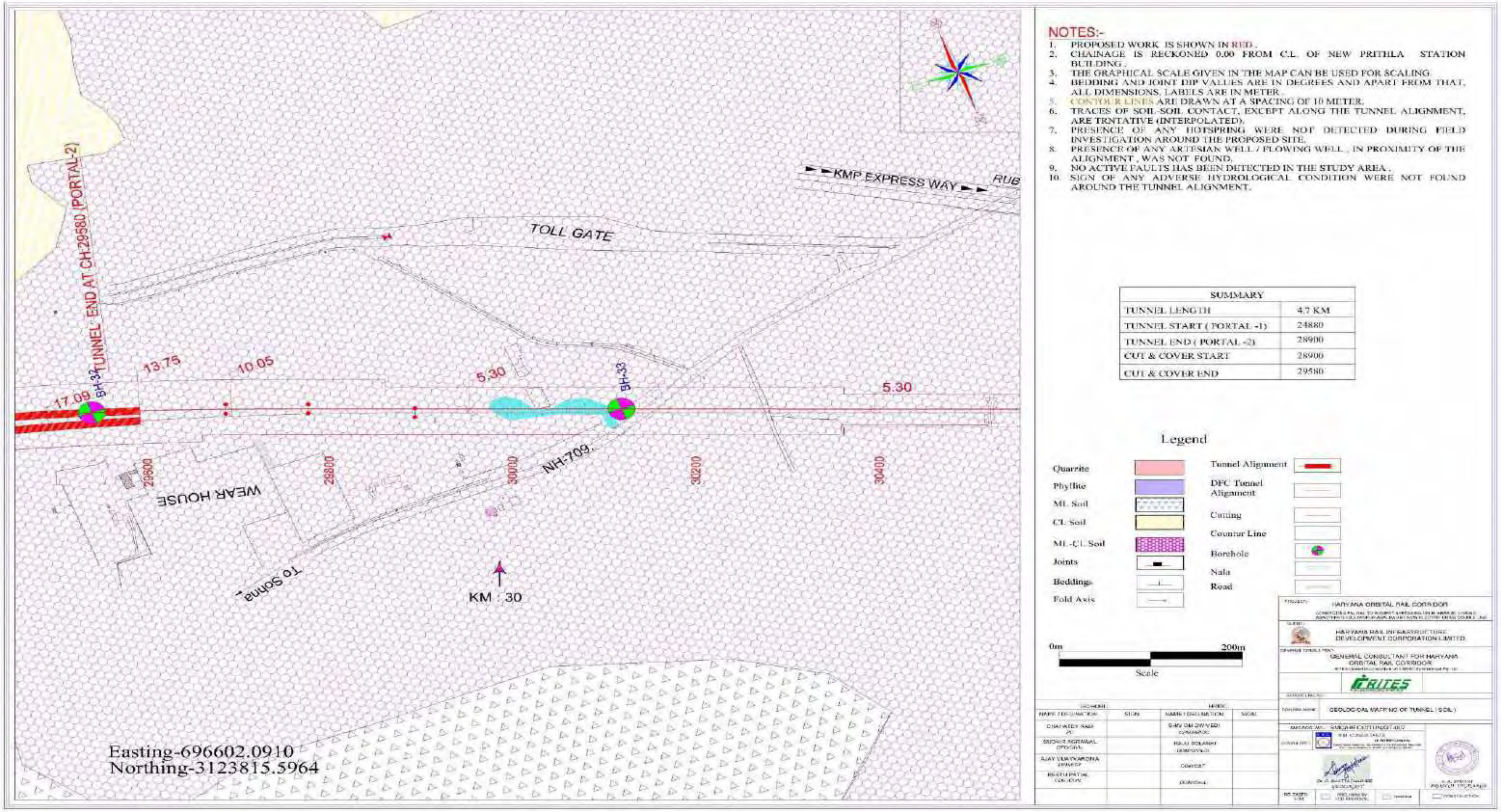
5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. TRACES OF SOIL-SOIL CONTACT, EXCEPT ALONG THE TUNNEL ALIGNMENT, ARE TRNTATIVE (INTERPOLATED).
7. PRESENCE OF ANY HOTSPRING WERE NOT DETECTED DURING FIELD INVESTIGATION AROUND THE PROPOSED SITE.
8. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL , IN PROXIMITY OF THE ALIGNMENT , WAS NOT FOUND.
9. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA .
10. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

SUMMARY	
TUNNEL LENGTH	4.7 KM
TUNNEL START (PORTAL -1)	24880
TUNNEL END (PORTAL -2)	28900
CUT & COVER START	28900
CUT & COVER END	29580

Figure 17: Detailed structural map of the major soil area at 1:2000 scale.



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5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. TRACES OF SOIL-SOIL CONTACT, EXCEPT ALONG THE TUNNEL ALIGNMENT, ARE TRNTATIVE (INTERPOLATED).
7. PRESENCE OF ANY HOTSPRING WERE NOT DETECTED DURING FIELD INVESTIGATION AROUND THE PROPOSED SITE.
8. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL, IN PROXIMITY OF THE ALIGNMENT, WAS NOT FOUND.
9. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA.
10. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

SUMMARY	
TUNNEL LENGTH	4.7 KM
TUNNEL START (PORTAL -1)	24880
TUNNEL END (PORTAL -2)	28900
CUT & COVER START	28900
CUT & COVER END	29580

Figure 18: Detailed structural map of the major soil area at 1:2000 scale.

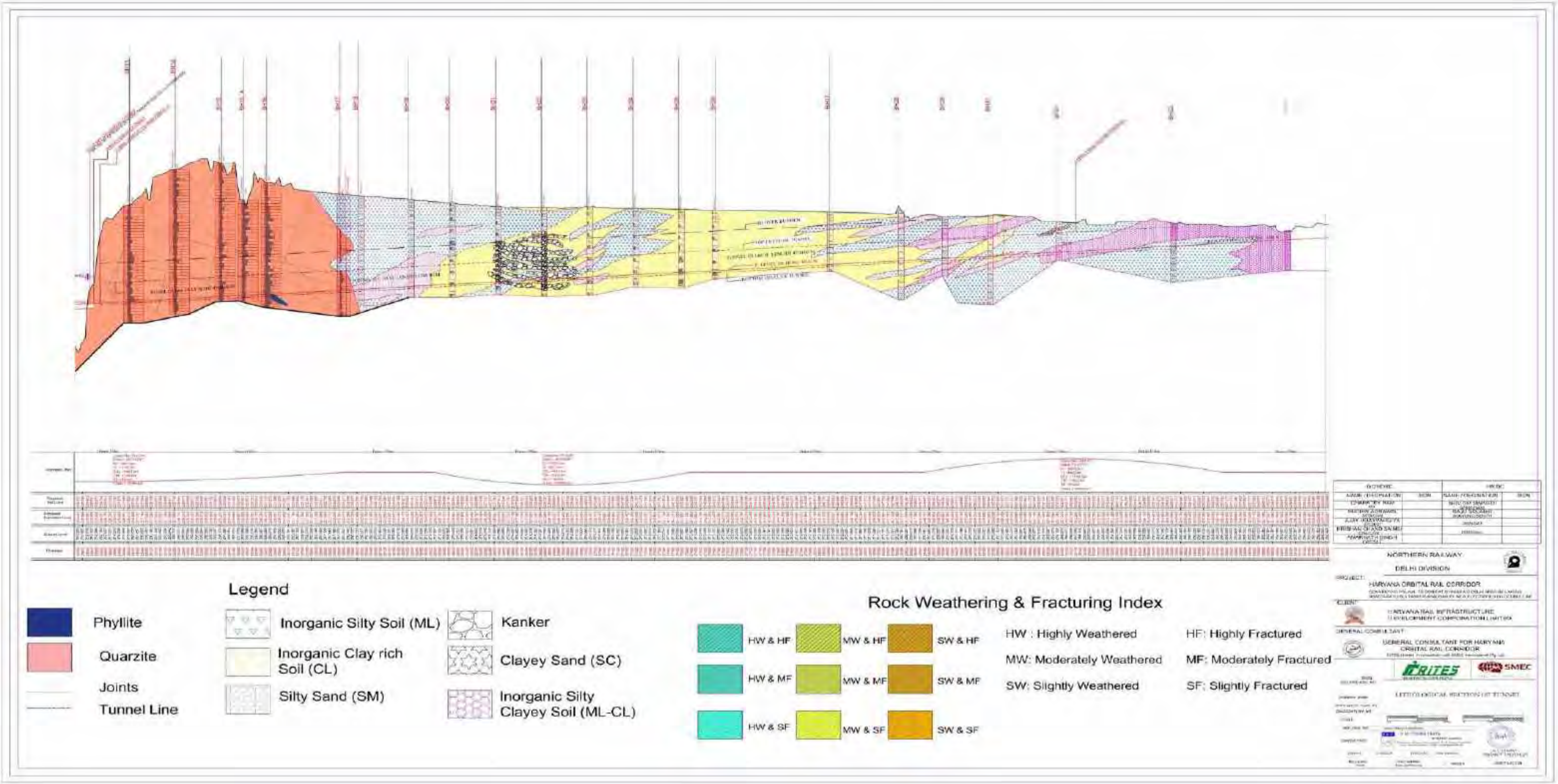


Figure 19: L-Section along the hilly terrain (1:25000 H and 1:2500 V). Joint sets are schematically drawn along their actual orientation.

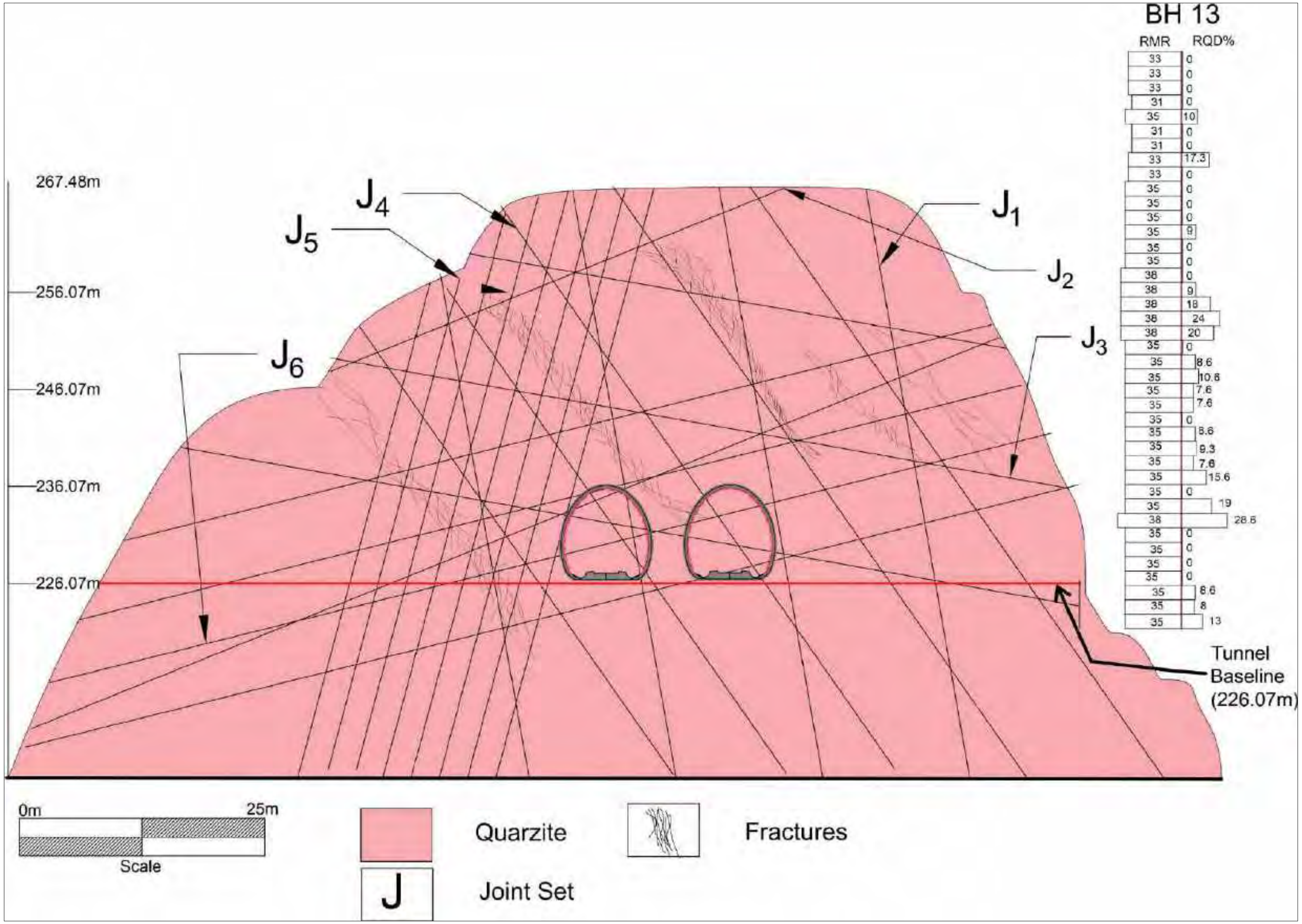


Figure 20: Detailed cross section of the portal face on the mountain front. Joint sets are schematically drawn along their actual orientation. Average spacing between the joints are as follows J1: 300 cm, J2:252.78cm, J3:160cm, J4:80cm,J5:32cm,J6:100cm.

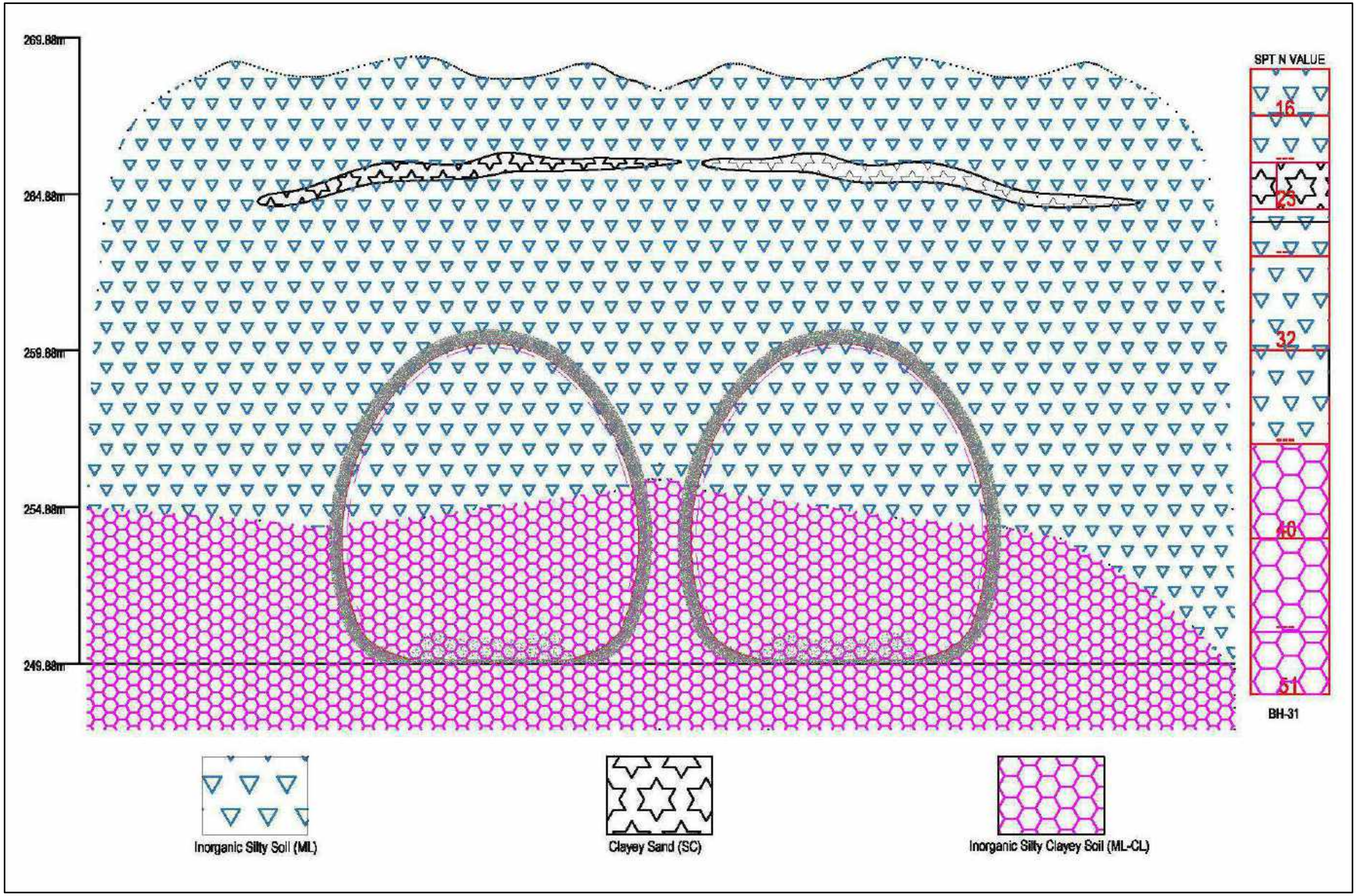


Figure 21: Detailed lithological cross section at the end of NATM Structure in soil (CH 28900).

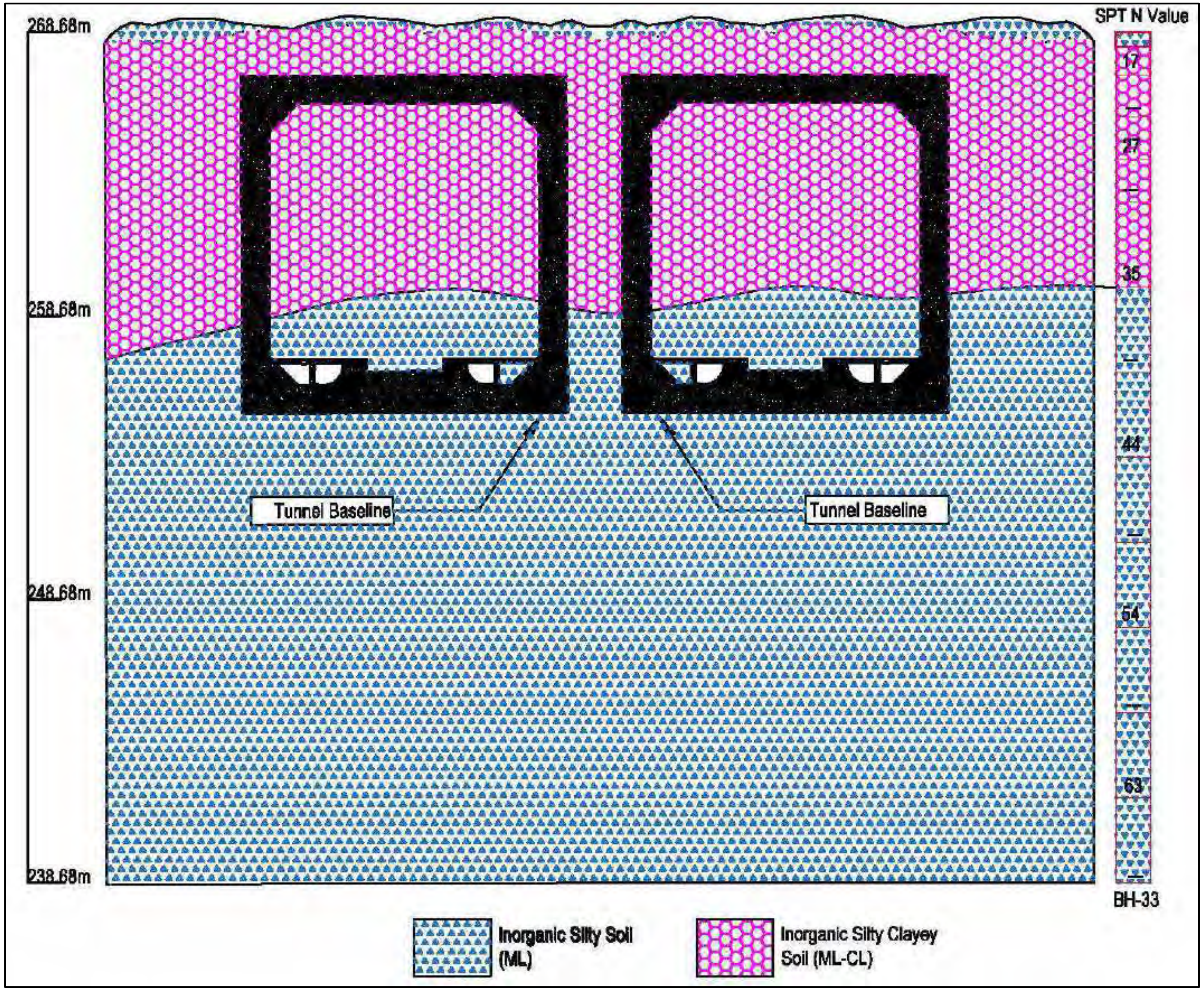


Figure 22: Cut and Cover structure at the end of tunnel – Portal II (CH29600).

4 CHAPTER: EXPLORATORY DRILLING

As per the requirement of scope of work outlined in the terms of reference, 20 bore holes were drilled with a cumulative length of 4.6 Km (Approx) at different locations along the proposed alignment. Necessary care has been taken during drilling operations by deploying good quality diamond drill machines to obtain good core recovery to obtain RQD values. The locations of the boreholes were selected in such a way, so that these holes more or less intersect the envisaged ground/ strata conditions at different depths. The location and details of boreholes drilled; total depth of drillings is shown in table below.

Table 4: Boreholes Details

BH No.	Chainage No.	Ground Elevation, RL (m)	Total Depth (m)
BH-13	25000	276.867	60
BH-14	25195	294.218	75
BH-15	25380	295.532	70
BH-15A	25488	276.442	50
BH-16	25586	287.324	62
BH-17	25785	282.461	62
BH-18	25990	280.253	55
BH-19	26210	278.116	50
BH-20	26387	276.795	48
BH-21	26587	274.993	45
BH-22	26787	274.321	45
BH-23	26980	274.85	45
BH-24	27187	274.075	40

BH-25	27410	273.565	40
BH-26	27550	273.112	35
BH-27	28050	272.210	30
BH-28	28350	272.799	45
BH-29	28550	269.964	30
BH-30	28750	270.808	45
BH-31	29050	267.159	20
BH-32	29550	266.684	30
BH-33	30125	265.581	20

4.1 Borehole Core Details :

4.1.1 Borehole Core details from Rock Region;

The homogenous rock mass of quartzite is found in boreholes from BH13- BH17 up-to a maximum depth of 216m MSL. Rocks are weathered in a varying degree in this region. Only in BH16 at below 40m a very small amount of phyllitic rock was found.

4.1.2 Borehole Core details from Soil Region;

BH NO- 17

1. From N.G.L to 18.0.0 m depth, a low-plastic, stiff to hard consistency Inorganic silty clayey soil stratum exists from which three UDS were collected at 1.50 m, 4.5 m & 9.0 m depth. The field SPT N values were found to be 12,16,26,21,37 and greater than 50 at 3.0 m,6.0 m,12.0 m,15.0 m ,16.50 m & 18.0 m depth respectively
2. From 18.0 m to 35.0 m depth, rock stratum was encountered.
3. From 35.0 m to 39.50 m depth, a non-plastic, very dense compacted silty sand stratum exists. The field SPT N values were found to be greater than 50 at 36.50 m,38.0 m & 39.50 m depth
4. From 39.50 m to 62.0 m (max. explored) depth, rock stratum was encountered.

BH NO- 18

1. From N.G.L to 15.0.0 m depth, a non-plastic, medium compacted clayey silts with none to low plasticity stratum exists from which one DS & three UDS were collected at 0.5 m, 1.5 m, 4.50 m, & 9.0 m depth. The field SPT N values were found to be 11,20 & 24 at3.0 m,6.0 m, & 12.0 m depth.
2. From 15.0 m to 24.0 m depth, low plastic, hard consistency Inorganic silty clayey soil stratum exists. The field SPT N values were found to be 31,35 & 40 at 15.0 m,18.0 m, & 21.0 m depth.
3. From 24.0 m to 55.0 m (max. explored) depth, a non-plastic, dense to very dense compacted clayey silts with none to low plasticity stratum exists. The field SPT N values were found to be 47,49,57,64,69,77,84 and greater than 50 at 24.0m,27.0 m,30.0 m,33.0 m,36.0 m,39.0 m,42.0 m,45.0 m,47.0 m,50. 0 m,53.0 m & 55.0 m depth

BH NO- 19

1. From N.G.L to 33.0 m depth, a non-plastic, medium to dense compacted clayey silts with none to low plasticity stratum exists from which one DS & six UDS were collected at 0.5 m, 3.0 m, 6.0 m, 12.0 m, 18.0 m, 24.0 m & 30.0 m depth. The field SPT N values were found to be 17, 23, 30, 35, 35 & 39 at 1.50 m, 4.50 m, 9.0 m, 15.0 m, 21.0 m, & 27.0 m depth.
2. From 33.0 m to 50.0 m (max. explored) depth, a non-plastic, dense to very dense compacted Silty sand stratum exists.

BH NO- 20

1. From N.G.L to 12.0 m depth, a non-plastic, dense compacted clayey silts with none to low plasticity stratum exists from which one DS & two UDS were collected at 0.5 m, 3.0 m & 6.0 m depth. The field SPT N values were found to be 18, 32 & 48 at 1.50 m, 4.50 m & 9.0 m depth.
2. From 12.0 m to 15.0 m depth, a non-plastic, Silty sand stratum exists.
3. From 15.0 m to 18.0 m depth, a non-plastic, very dense compacted clayey silts with none to low plasticity stratum exists. The Field SPT N values was found to be 60 at 15.0 m Depth.
4. From 18.0 m to 21.0 m depth, a non-plastic, Silty sand stratum exists.

5. From 21.0 m to 27.0 m depth, non-plastic, very dense compacted clayey silts with none to low plasticity stratum exist. The Field SPT N values were found to be 67 & 76 at 21.0 m & 24.0 m Depth.
6. From 27.0 m to 48.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist from which four UDS sample were collected at 27.0 m, 33.0 m,39.0 m & 45.0 m depth. The field SPT N values were found to be 58, 67, 75 & 79 at 30.0 m, 36.0 m, 42.0 m & 48.0 m depth respectively

BH NO- 21

1. From N.G.L to 18.0 m depth, a non-plastic, medium to dense compacted clayey silts with none to low plasticity stratum exists from which one DS & three UDS were collected at 0.5 m, 3.0 m, 6.0 m & 12.0 m depth. The field SPT N values were found to be 14, 20, 31 & 38 at 1.50 m, 4.50 m 9.0 m & 15.0 m depth.
2. From 18.0 m to 39.0 m depth, fragmented rock stratum encountered.
3. From 39.0 m to 45.0 m (max. explored) depth, non-plastic, very dense compacted stratum exists from which two DS sample was collected at 39.0 m and 45.0 m depth. The field SPT N values was found to be 77 at 42.0 m depth respectively.

BH NO- 22

1. From N.G.L to 1.50 m depth, a medium-plastic silt & clay with low compressibility stratum exists from which one DS was collected at 0.5 m depth.
2. From 1.50 m to 12.0 m depth, a non-plastic, medium compacted clayey silts with none to low plasticity stratum exists from which two UDS were collected at 3.0 m & 6.0 m depth.
3. From 12.0 m to 42.0 m depth Fragmented Rock stratum encountered.
4. From 42.0 m to 45.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist. from which one DS sample was collected at 42.0 m depth. The field SPT N value was found to be 91 at 45.0 m depth.

BH NO- 23

1. From N.G.L to 9.0 m depth, a medium-plastic, stiff to very stiff consistency silt & clay with low compressibility stratum exists from which one DS & two UDS were collected at 0.5 m, 3.0 m & 6.0 m depth. The field SPT N values were found to be 16 & 23 at 1.50 m & 4.50 m depth.
2. From 9.0 m to 12.0 m depth, a non-plastic, dense compacted clayey silts with none to low plasticity stratum exists. The Field SPT N value was found to be 34 at 9.0 m Depth.
3. From 12.0 m to 21.0 m depth, a medium-plastic, hard consistency silt & clay with low compressibility stratum exists. The field SPT N value was found to be 38 at 21.0 m depth.
4. From 21.0 m to 24.0 m depth, a non-plastic, dense compacted Silty sand stratum exists. The field SPT N value was found to be 50 at 15.0 m depth.
5. From 24.0 m to 27.0 m depth, medium-plastic, silt & clay with low compressibility stratum exist from which one UDS was collected at 24.0 m depth.
6. From 27.0 m to 30.0 m depth, a non-plastic, very dense compacted Silty sand stratum exists. The field SPT N value was found to be 63 at 27.0 m depth.
7. From 30.0 m to 33.0 m depth, a non-plastic, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 30.0 m depth.
8. From 33.0 m to 36.0 m depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist. The field SPT N value was found to be 73 at 33.0 m depth.
9. From 36.0 m to 39.0 m depth, a non-plastic, Silty sand stratum exists from which one UDS was collected at 36.0 m depth.
10. From 39.0 m to 45.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist from which one UDS sample was collected at 42.0 m depth. The field SPT N values were found to be 77 & 85 at 39.0 m & 45.0 m depth respectively.

BH NO- 24

1. From N.G.L to 24.0 m depth, a non-plastic, medium compacted clayey silts with none to low plasticity stratum exists from which one DS & four UDS were collected at 0.5 m, 3.0 m, 6.0 m, 12.0 m & 18.0 m depth. The field SPT N values were found to be 14,21,27,33 & 43 at 1.50 m, 4.50 m, 9.0 m, 15.0 m & 21.0 m depth.

2. From 24.0 m to 40.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist from which four UDS sample were collected at 24.0 m,30.0 m,36.0 m & 40.0 m depth. The field SPT N values were found to be 58, 72 & 89 at 27.0 m, 33.0 m & 39.0 m depth respectively.

BH NO- 25

1. From N.G.L to 40.0 m (max. explored) depth, medium-plastic, stiff to hard consistency silt & clay with low compressibility stratum exist from which one DS & eight UDS sample were collected at 0.5 m,3.0 m,6.0 m,12.0 m,18.0 m,24.0 m,30.0 m,36.0 m & 40.0 m depth. T
2. The field SPT N values were found to be 13,20,30,31,33,48,68 & 81 at 1.50 m,4.50 m,9.0 m,15.0 m,21.0 m,27.0 m, 33.0 m & 39.0 m depth respectively.

BH NO- 26

1. From N.G.L to 35.0 m (max. explored) depth, medium-plastic, stiff to hard consistency silt & clay with low compressibility stratum exist from which one DS & seven UDS sample were collected at 3.0 m,6.0 m,12.0 m,18.0 m,24.0 m,30.0 m & 35.0 m depth.
2. The field SPT N values were found to be 11,19,28,34,41,53 & 65 at 1.50 m,4.50 m,9.0 m,15.0 m,21.0 m,27.0 m & 33.0 m depth respectively.

BH NO- 27

1. From N.G.L to 6.0 m depth, a medium-plastic, stiff to very stiff consistency, silt and clay with low compressibility stratum exists from which one DS & one UDS were collected at 0.5 m & 3.0 m, depth. The field SPT N values were found to be 14 & 24 at 1.50 m, & 4.50 m depth.
2. From 6.0 m to 9.0 m depth, non-plastic, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 6.0 m depth,
3. From 9.0 m to 18.0 m depth, a medium-plastic, very stiff to hard consistency, silt and clay with low compressibility stratum exists from which one UDS was collected at 12.0 m, depth. The field SPT N values were found to be 27 & 36 & 9.0 m, & 15.0 m depth.
4. From 18.0 m to 21.0 m depth, non-plastic, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 18.0 m depth,

5. From 21.0 m to 30.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist from which two UDS sample were collected at 24.0 m & 30.0 m depth. The field SPT N values were found to be 45 & 54 at 21.0 m & 27.0 m depth respectively.

BH NO- 28

1. From N.G.L to 1.50 m depth, non-plastic, clayey silts with none to low plasticity stratum exists from which one DS was collected at 0.5 m depth,
2. From 1.50 m to 3.0 m depth, a medium-plastic, medium consistency, silt and clay with low compressibility stratum exists. The field SPT N values was found to be 12 at 1.5 m depth.
3. From 3.0 to 6.0 m depth, non-plastic, medium compacted clayey silts with none to low plasticity stratum exists from which one UDS was collected at 3.0 m depth. The field SPT N Values Was found to be 21 & 4.50 m depth.
4. From 6.0 to 9.0 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 6.0 m depth.
5. From 9.0 to 18.0 m depth, non-plastic, medium to dense compacted clayey silts with none to low plasticity stratum exists from which one UDS was collected at 12.0 m depth. The field SPT N Values Was found to be 28 & 38 at 9.0 & 15.0 m depth.
6. From 18.0 m to 30.0 m depth, a medium-plastic, hard consistency, silt and clay with low compressibility stratum exists from which two UDS were collected at 18.0 m & 24.0 m depth. The field SPT N values were found to be 47 & 53 at 21.0 m & 27.0 m depth.
7. From 30.0 to 33.0 m depth, non-plastic, very dense compacted clayey silts with none to low plasticity stratum exists from which one UDS was collected at 30.0 m depth.
8. From 33.0 m to 39.0 m depth, a medium-plastic, hard consistency, silt and clay with low compressibility stratum exists from which one UDS was collected at 36.0 m depth. The field SPT N values were found to be 70 at 33.0 m depth.
9. From 39.0 m to 45.0 m (max. explored) depth, non-plastic very dense compacted clayey silts with none to low plasticity stratum exist from which one UDS sample was collected at 39.0 m depth. The field SPT N values were found to be 81 & 92 at 39.0 m & 45.0 m depth respectively.

BH NO- 29

1. From N.G.L to 3.0 m depth, non-plastic, medium compacted, clayey silts with none to low plasticity stratum exists from which one DS was collected at 0.5 m depth. The field SPT N value was found to be 12 at 1.5 m depth.
2. From 3.0 m to 12.0 m depth, a low-plastic, very stiff consistency, consistency Inorganic silty clayey stratum exists from which two UDS were collected at 3.0 m & 6.0 m depth. The field SPT N values were found to be 14 & 27 at 4.5 m & 9.0 m depth.
3. From 12.0 to 15.0 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 12.0 m depth.
4. From 15.0 to 24.0 m depth, non-plastic, dense compacted, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 18.0 m depth. The field SPT N Values were found to be 38 & 47 at 15.0 m & 21.0 m depth respectively.
5. From 24.0 to 27.0 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 24.0 m depth.
6. From 27.0 m to 30.0 m (max. explored) depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists from which one UDS was collected at 27.0 m depth. The field SPT N values was found to be 61 at 27.0 m depth.

BH NO- 30

1. From N.G.L to 4.5 m depth, non-plastic, medium compacted, clayey silts with none to low plasticity stratum exists from which one DS and one UDS was collected at 0.5 m & 3.0 m depth. The field SPT N value was found to be 17 at 1.5 m depth.
2. From 4.50 m to 12.0 m depth, a low-plastic, very stiff consistency, Inorganic silty clayey stratum exists from which two UDS were collected at 3.0 m & 6.0 m depth. The field SPT N values were found to be 22 & 30 at 4.5 m & 9.0 m depth.
3. From 12.0 to 18.0 m depth, medium-plastic, hard consistency, silt & clay with low compressibility stratum exists from which one UDS was collected at 12.0 m depth. The field SPT N values was found to be 38 at 15.0 m depth.
4. From 18.0 to 21.0 m depth, non-plastic, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 18.0 m depth.

5. From 21.0 to 24.0 m depth, medium-plastic, hard consistency, silt & clay with low compressibility stratum exists. The field SPT N values were found to be 44 at 21.0 m depth.
6. From 24.0 to 27.0 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 24.0 m depth.
7. From 27.0 to 45.0 m depth, non-plastic, very dense compacted, clayey silts with none to low plasticity stratum exists from which three UDS were collected at 30.0 m,36.0 m & 42.0 m depth respectively.
8. From 45.0 m (max. explored) depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists. The field SPT N values were found to be 84 at 45.0 m depth.

BH NO- 31

1. From N.G.L to 3.0 m depth, medium-plastic, stiff consistency, silt and clay with low compressibility stratum exists from which one DS was collected at 0.5 m depth. The field SPT N value was found to be 16 at 1.5 m depth.
2. From 3.0 to 4.50 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 3.0 m depth.
3. From 4.50 m to 12.0 m depth, a non-plastic, medium to dense compacted, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 6.0 m depth. The field SPT N values were found to be 23 & 32 at 4.5 m & 9.0 m depth.
4. From 12.0 m to 20.0 m (max. explored) depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists from which two UDS were collected at 12.0 m & 18.0 m The field SPT N values were found to be 40 & 51 at 15.0 m & 20.0 m depth respectively.

BH NO-32

1. From N.G.L to 30 m depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists from which one DS was collected at 0.5 m depth and six UDS were collected at 3.0 m, 6.0 m, 12.0 m, 18.0 m, 24.0m & 30.0m.
2. The field SPT N values were found to be 17, 27, 35, 44, 54 & 63 at 1.5m, 4.5m, 9.0m, 15.0m, 21.0m & 27.0 m depth respectively.
3. The plasticity index of the soil throughout the borehole is ranging between 10% – 12 %.
4. The plastic limit of the soil throughout the borehole is ranging between 19% – 22 %.

BH NO-33

1. From N.G.L to 30 m depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists from which one DS was collected at 0.5 m depth and four UDS were collected at 3.0 m, 6.0 m, 12.0 m & 18.0 m.
2. The field SPT N values were found to be 11, 28, 39, 50 & 63 at 1.5m, 4.5m, 9.0m, 15.0m & 20.0m depth respectively.
3. The plasticity index of the soil throughout the borehole is ranging between 9% – 13 %.
4. The plastic limit of the soil throughout the borehole is ranging between 18% – 20 %.

4.2 Permeability Test in Bed Rock

The packer test method was carried out as per IS 5529 (Part 2): 2006 to determine the permeability of the rock strata at site.

4.2.1 Packer test method:

In the packer method, water is pumped under pressure into the test section of bedrock through drill hole. The single and double packer methods are normally conducted in exploratory holes.

Single packer method:

In this method, one packer is used in the drill hole. The test section is between the bottom of the bore hole and the packer.

Double packer method:

In this method, two packers are used in the drill hole. The test section is between the two packers.

Procedure:

The procedure adopted consists of pumping water into the 'test section' and is therefore called 'pumping-in type'. Packers are employed for conducting these tests and depending upon the use of one packer or two packers the method is designated as single or double packer method respectively. Examination of the drill cores and the results of water tests, obtained during drilling will usually indicate whether a double packer test in any isolated section or sections of the drill hole is required. The tests are based on measuring the amount of water accepted by the 'test section' (of the hole) confined by a packer/packer while water is pumped into it.

After completion of the full arrangement for the test, the water pumped in to the section under pressure. The pressure should be maintained until the readings of water intake at intervals of 5 min show a nearly constant reading of water intake for one particular pressure at the collar. The constant rate of water intake should be noted. It is recommended that the tests to be commenced with a low pressure at the collar and increased limited to the availability of suitable rock cover to prevent uplift or till a maximum pressure equivalent to H + x (where H is the hydraulic head to which the strata would be subjected to due to the contemplated structure and x is the loss due to the friction) is achieved. In our case, 1, 2 and 3 kg/cm2 pressure were applied in every case.

The water loss (due to permeability inside the rock) is expressed in Lugeons. A Lugeon is defined as the water loss in litre/min./m of the drill hole under is pressure of 10 atmospheres maintained for 10 min in a drill hole of 46 mm to 76 mm diameter.

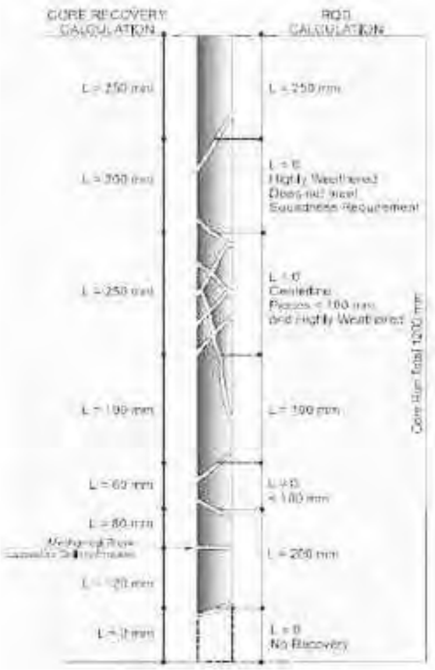
Table 5 Parker test results

BH No.	**Packer test section 1**		**Lugeon Value**	**Packer test section 2**		**Lugeon Value**
	Upper part (m)	**Lower part (m)**		**Upper part (m)**	**Lower part (m)**	
BH-13	**36**	**39**	**30.20**	**48**	**51**	**25.62**
BH-14	**54**	**57**	**24.46**	**63**	**66**	**21.88**
BG-15	**55**	**58**	**24.34**	**64**	**67**	**18.42**
BH-16	**44**	**47**	**27.38**	**56**	**59**	**21.14**
BH-17	**41**	**44**	**24.52**	**50**	**53**	**22.78**

5 CHAPTER: GEOMECHANICAL CLASSIFICATION OF GEOLOGICAL UNITS

5.1 Rock Quality Designation (RQD)

Rock Quality Designation (RQD) is a measure of quality of rock core taken from a borehole. RQD signifies the degree of jointing or fracture in a rock mass measured in percentage, where RQD of 75% or more shows good quality hard rock and less than 50% show low quality weathered rocks. RFQ is calculated by taking a rock core sample from a borehole and lengths of all sound rock pieces which are minimum 100 mm long are summed up and are divided by the length of the core run. Only those pieces of rocks are considered which are hard and good quality. Weathered rocks which do not meet soundness requirements and whose lengths are not greater than 100mm are not considered for calculation of RQD. The length of core pieces is measured along center line of the pieces. RFQ test provides assessment of soundness of the rock and damages caused due to weathering.



Rock Quality	RQD (%)
Very poor (Completely weathered rock)	<25%
Poor (weathered rocks)	25 to 50%
Fair (Moderately weathered rocks)	51 to 75%
Good (Hard Rock)	76 to 90%
Very Good (Fresh rocks)	91 to 100%

Table 6: Categories of rock with respect to their RQD value

5.1.1 Rocks Core Recovery and RQD Calculations:

Core recovery (CR) is calculated by following formula:

$$CR = \left[\frac{total\ length\ of\ rock\ recovered}{Total\ core\ run\ length} \times 100\right]\%$$

$$RQD = \left[\frac{Length\ of\ core\ pieces > 10cm}{Total\ core\ run\ length} \times 100\right]\%$$

ROCK CLASSIFICATION BASED ON RQD		Joint Frequency	RQD (%)
A	VERY POOR ROCK	>27 joints per m^3	0-25
B	POOR	20-27 joints per m^3	25-50
C	FAIR	13-19 joints per m^3	50-75
D	GOOD	8-12 joints per m^3	75-90
E	EXCELLENT	0-7 joints per m^3	90-100

Note:

i) Where RQD is reported or measured as ≤ 10 (including 0) the value 10 is used to evaluate the Q-value

ii) RQD-intervals of 5, i.e. 100, 95, 90, etc., are sufficiently accurate.

5.1.2 Methodology:

The drill cores (NX & NQ size) were properly logged and stored in the GI core boxes specifically designed as per the standard specifications. The cores are aligned systematically according to the core run and all the relevant information regarding the core recovery, Rock Quality Designation (RQD), fracture pattern was observed from the geotechnical logging of the drilled holes. The details of the rock type obtained from each drill hole runs were systematically recorded and summarized in the standard Geotechnical logging format. Table, given below, summarized the percentage of RQD as obtained during the drilling of bore holes. For detail table refer Annexure.

Table 7: Average, Minimum & Maximum Value of RQD.

BH NO.	AVERAGE RQD, %	MINIMUM RQD, %	MAXIMUM RQD, %
BH-13	6.5	0	28.6
BH-14	5.9	0	24.0
BH-15	5.9	0	27.0
BH-15A	10.7	0	32.0
BH-16	16.0	0	51.3
BH-17	10.9	0	41.5

Core samples were collected from the drill holes at different depth intervals to represent the envisaged strata conditions of the proposed crown and invert portion of different tunnel types. These samples were sent to IIT, Banaras Hindu University (BHU) and NABL accredited Laboratory at New Delhi for testing the Physico-mechanical properties.

The assessment of rock mass has been carried out based on the geotechnical investigation, observation of the core logs, joint orientation with reference to the proposed tunnel orientation and physico -mechanical properties of rock cores. The rock mass is classified in to Q-classification system (Q tunnelling index) developed by Barton. N. (1976), Norwegian Geotechnical Institute and RMR Geo-mechanics Classification system.

The data, thus obtained from geotechnical inputs has been analysed by using both the standard Rock Mass Classification systems. Pre-investigations for underground excavations often include core-logging. The Q-parameters were evaluated with a relatively high degree of accuracy.

However, special attention has been addressed to the following aspects:

Only a small section of each joint surface will usually be available, particularly for joints intersecting the borehole at an obtuse angle. Evaluation of the roughness coefficient (Jr) may therefore be difficult. Particularly the large and medium scale undulation may be difficult to estimate. As water is used during drilling, fillings like clay minerals may be washed out, making it difficult to evaluate in some cases.

The drilling direction of the borehole influences the number of joints that are intersected by the borehole. Sub-parallel joints to the borehole will be under represented in the cores, and this will give too high RQD-values and too low Jn values. Whereas, RQD is often calculated for every meter, Jn must usually be estimated for sections of several meters.

In massive rock it is impossible to estimate SRF (Stress Reduction Factor) from drill cores. However, in rock intersected by weakness zones, it may be possible to give some suggestions about SRF. In massive rock, SRF can be estimated partially based on the overburden, height of a mountain side, stress measurements carried out in the borehole, or experiences from nearby construction sites.

In general, a core log should only contain data obtained from the cores or measurements carried out in the borehole itself. However, by using the log data combined with estimates of J_w and SRF, it will be possible to get a rough impression of the Q-values of the cores, and these could be helpful during planning phase. Water-loss tests are often carried out during core drilling. The results are normally given in Lugeon (Lugeon = the loss of water in litters per minute and per meter borehole at an over-pressure of 1 MPa), and form the basis for evaluation of the J_w-value. One also has to take into account whether the rock mass is going to be grouted or not in order to estimate the Q-value as a basis for rock support after excavation.

It is always important to evaluate how representative the cores are. Boreholes are often drilled just in order to investigate particular zones. It is then imperative to consider how much of the total rock masses these zones represent. If a borehole is orientated along a fracture zone, the parameter values for this zone will be determined.

5.2 Rock Mass Rating Index (RMR):

Bieniawski (1976) published the details of a rock mass classification called the Geomechanics Classification or the Rock Mass Rating (RMR) system. Over the years, this system has been successively re- fined as more case records have been examined and the reader should be aware that Bieniawski has made significant changes in the ratings assigned to different parameters. The discussion which follows is based upon the 1989 version of the classification (Bieniawski, 1989). The following six parameters are used to classify a rock mass using the RMR system:

i) Uniaxial compressive strength of rock material.

ii) Rock Quality Designation (RQD).

iii) Spacing of discontinuities.

iv) Condition of discontinuities.

 a) Length, persistence

 b) Separation

 c) Smoothness

 d) Infilling

 e) Alteration / weathering

v) Groundwater conditions.

vi) Orientation of discontinuities.

All of these are measurable in the field and can also be obtained from borehole data. The rating of each of these parameters is summarized to give a value of RMR. All parameters are measurable in the field and some of them may also be obtained from borehole data.

To apply the RMR classification, the rock mass along a tunnel route is divided into a number of structural regions, i.e., zones in which certain geological feature are more or less uniform. The above six classification parameters are determined for each structural region from measurements in the field. Once the classification parameters are determined, the ratings are assigned to each parameter according to Table 7.

Table 8: RMR Classification Parameters and Their Ratings

PARAMETER			Range of values // ratings						
1	Strength of intact rock material	Point-load strength index	> 10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range Uniaxial compr. strength is preferred		
		Uniaxial com- pressive strength	> 250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 -5 MPa	< 1 MPa
	RATING		**15**	**12**	**7**	**4**	**2**	**1**	**0**
2	Drill core quality RQD		90 - 100%	75 - 90%	50 - 75%	25 - 50%	< 25%		
	RATING		**20**	**17**	**13**	**8**	**5**		
3	Spacing of discontinuities		> 2 m	0.6 - 2 m	200 - 600 mm	60 - 200 mm	< 60 mm		
	RATING		**20**	**15**	**10**	**8**	**5**		
4	Condition of discontinuities	Length, persistence	< 1 m	1 - 3 m	3 - 10 m	10 - 20 m	> 20 m		
		Rating	**6**	**4**	**2**	**1**	**0**		
		Separation	None	< 0.1 mm	0.1 - 1 mm	1 - 5 mm	> 5 mm		
		Rating	**6**	**5**	**4**	**1**	**0**		
		Roughness	very rough	Rough	slightly rough	smooth	Slickensided		
		Rating	**6**	**5**	**3**	**1**	**0**		
		Infilling (gouge)	None	Hard filling		Soft filling			
			-	< 5 mm	> 5 mm	< 5 mm	> 5 mm		
		Rating	**6**	**4**	**2**	**2**	**0**		
		Weathering	unweathered	slightly w.	moderately w.	highly w.	Decomposed		
		Rating	**6**	**5**	**3**	**1**	**0**		
5	Ground water	Inflow per 10 m tunnel length	None	< 10 litres/min	10 - 25 litres/min	25 - 125 litres/min	> 125 litres /min		
		p_w / l	0	0 - 0.1	0.1 - 0.2	0.2 - 0.5	> 0.5		
		General conditions	completely dry	Damp	Wet	dripping	Flowing		
	RATING		**15**	**10**	**7**	**4**	**0**		
p_w = joint water pressure; l = major principal stress									

In this respect the typical, rather than the worst conditions, are evaluated. Furthermore, it should be noted that the ratings, which are given for discontinuity spacing, apply to rock masses having three sets of discontinuities. Thus, when only two sets of discontinuities are present, a conservative assessment is obtained.

Table 9: Rating Adjustment for Discontinuity Orientations

		Very favorable	Favorable	Fair	Unfavorable	Very unfavorable
RATINGS	Tunnels	**0**	**-2**	**-5**	**-10**	**-12**
	Foundations	**0**	**-2**	**-7**	**-15**	**-25**
	Slopes	**0**	**-5**	**-25**	**-50**	**-60**

Table 10: Rock Mass Classes Determined from Total Ratings

Rating	100 - 81	80 – 61	60 – 41	40 - 21	< 20
Class No.	I	II	III	IV	V
Description	VERY GOOD	GOOD	FAIR	POOR	VERY POOR

Table 10: Significance of Rock Mass Classes

Class No.	I	II	III	IV	V
Average stand-up time	10 years for 15 m span	6 months for 8 m span	1 week for 5 m span	10 hours for 2.5 m span	30 minutes for 1 m span
Cohesion of the rock mass	> 400 kPa	300 - 400 kPa	200 - 300 kPa	100 - 200 kPa	< 100 kPa
Friction angle of the rock mass	< 45°	35 - 45°	25 - 35°	15 - 25°	< 15°

Table 11: RMR Classification Guide for Excavation and Support in Rock Tunnels

Rock mass class	**Excavation**	**Support**		
		Rock bolts (20 mm diam., fully bonded)	Shotcrete	Steel sets
1. Very good rock RMR: 81-100	Full face: 3 m advance	Generally, no support required except for occasional spot bolting		
2. Good rock RMR: 61-80	Full face: 1.0-1.5 m advance; Complete support 20 m from face	Locally bolts in crown, 3 m long, spaced 2.5 m with occasional wire mesh	50 mm in crown where required	None
3. Fair rock RMR: 41-60	Top heading and bench: 1.5-3 m advance in top heading; Commence support after each blast; Commence support 10 m from face	Systematic bolts 4 m long, spaced 1.5-2 m in crown and walls with wire mesh in crown	50-100 mm in crown, and 30 mm in sides	None

Rock mass class	**Excavation**	**Support**		
		Rock bolts (20 mm diam., fully bonded)	Shotcrete	Steel sets
4. Poor rock RMR: 21-40	Top heading and bench: 1.0-1.5 m advance in top heading; Install support concurrently with excavation - 10 m from face	Systematic bolts 4-5 m long, spaced 1-1.5 m in crown and walls with wire mesh	100-150 mm in crown and 100 mm in sides	Light ribs spaced 1.5 m where required
5. Very poor rock RMR < 21	Multiple drifts: 0.5-1.5 m advance in top heading; Install support concurrently with excavation; shotcrete as soon as possible after blasting	Systematic bolts 5-6 m long, spaced 1-1.5 m in crown and walls with wire mesh. Bolt invert	150-200 mm in crown, 150 mm in sides, and 50 mm on face	Medium to heavy ribs spaced 0.75 m with steel lagging and fore poling if required. Close invert

In applying this classification system, the rock mass is divided into a number of structural regions and each region is classified separately. The boundaries of the structural regions usually coincide with a major structural feature such as a fault or with a change in rock type. In some cases, significant changes in discontinuity spacing or characteristics, within the same rock type, may necessitate the division of the rock mass into a number of small structural regions or domains. The Rock Mass Rating system is presented in Table 12, giving the ratings for each of the six parameters listed above. These ratings are summed to give a value of RMR.

For detail table refer Annexure

Table 12 Average, Maximum, Minimum RMR of borehole (Follow Annexure -A for detailed information)

BH NO.	AVERAGE RMR VALUE	MAXIMUM RMR VALUE	MINIMUM RMR VALUE
BH-13	34.95	40	31
BH-14	34.18	38	31
BG-15	33.23404	40	24
BH-15A	29.47059	43	27
BH-16	37.61905	48	30
BH-17	41.2	47	32

Based on the average RMR value of the rock mass it falls into “Poor” category

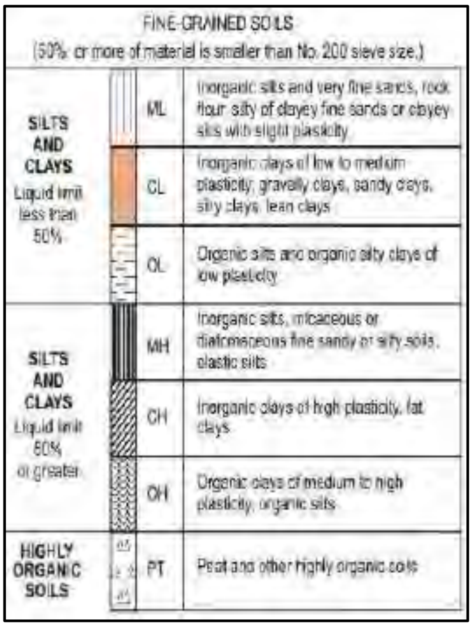
5.3 The Unified Soil Classification System (USCS) :

Though RMR classification provide great insight to classify the different types hard rocks of with reference to the tunnel designing, but it loses its reliability in classification soil or highly weathered rock. The main problem with using RMR for weak rock mass classification is that ratings are not sensitive to changes in rock quality designation (RQD) when RQD <25% and and fracture spacing is <2.4 inch (60 mm). For example, the RQD and fracture frequency ratings for sound rock with 24 % RQD and fracture spacing of 2.3 in. (59 mm) would receive the same Bin-RMR89 ratings as clay, 3 and 5, respectively. Hence classification of soil is provided using The Unified Soil Classification System (USCS) [ASTM (2011, 2009) D2487 and D2488].

The USCS provides good insight into behavior of material especially in the presence of water; however, it gives no indication of the relative strength of the material. In addition to USCS soil classification, civil-geotechnical engineering investigations usually include relative density or consistency estimates which are considered in the design process. (Parker 1996). However, in contrast to RMR system, USCS system uses letters to classify soil like material for general engineering purposes.

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)		
	Clean Gravels (Less than 5% fines)	
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
	Clean Sands (Less than 5% fines)	
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures

Figure 23: USCS Classification of coarse-grained soil.



FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)		
SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour silty of clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

Figure 24: USCS Classification of fine-grained soil

Soils are broadly classified into three divisions:

i. **Coarse grained soils:** 50% or more of the total material by weight is larger than 75 micron IS sieve size.
ii. **Fine grained soils:** 50% or more of the total material by weight is smaller than 75 micron IS sieve size.
iii. **Highly organic soils and other miscellaneous soil materials:** These soils contain large percentage of fibrous organic matter, such as peat, and the particles of decomposed vegetation. In addition, certain soils containing shells, cinders and other non-soil materials in sufficient quantities are also grouped in this division.

5.3.1 Coarse grained Soils

Coarse grained soils are further divided into two sub-divisions:

a) **Gravels (G)**: In these soils more than 50% of the coarse fraction (+75 micron) is larger than 4.75 mm sieve size. This sub-division includes gravels and gravelly soil, and is designated by symbol G.
b) **Sands (S)**: In these soils, more than 50% of the coarse fraction is smaller than 4.75mm IS sieve size. This sub-division includes sands and sandy soils.

Each of the above sub-divisions are further divided into four groups depending upon grading and inclusion of other materials.

1. W : Well Graded
2. C : Clay binder
3. P : Poorly graded
4. M : Containing fine materials not covered in other groups.

These symbols used in combination to designate the type of grained soils.

Example, GC: **C**layey **G**ravels.

5.3.2 Fine grained soils

Fine grained soils are further divided into three sub-divisions:

a) Inorganic silts and very fine sands: M

b) Inorganic clays: C

c) Organic silts and clays and organic matter: O.

The fine-grained soils are further divided into the following groups on the basis of the following arbitrarily selected values of liquid limit which is a good index of compressibility:

i) Silts and clays of low compressibility:

Having a liquid limit less than 35 and represented by symbol L.

ii) Silts and clays of medium compressibility:

Having a liquid limit greater than 35 and less than 50 and represented by symbol I.

iii) Silts and clays of high compressibility:

Having a liquid limit greater than 50 and represented by a symbol H.

Combination of these symbols indicates the type of fine-grained soil. For example, ML means inorganic silt with low to medium compressibility.

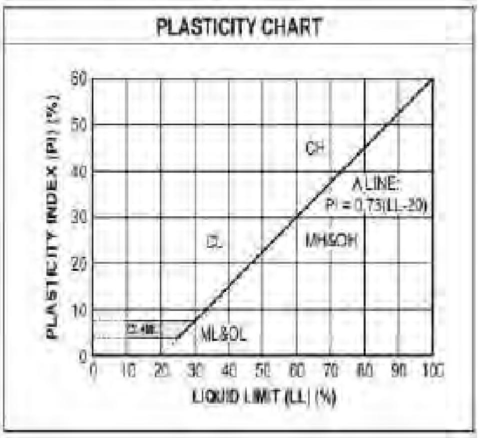


Figure 25 Relation between Liquid Limit and Plasticity Index of soil for USCS

5.4 USCS & RMR Correlation:

In spite of being an advantageous classification system, USCS also have some disadvantages due to its descriptive format of classification using letters. Any numerical and statistical analysis of materials classified in USCS using spreadsheets are really

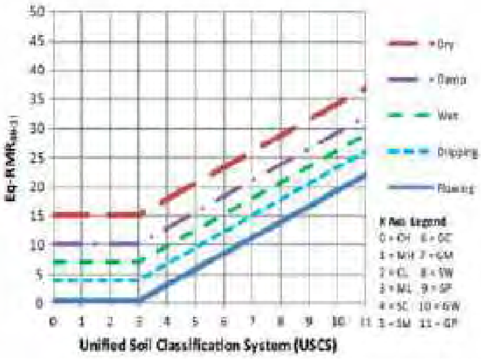


Figure 26 Graph showing correlation between USCS classification and RMR Classification. (Warren,2016)

difficult. Warren (2016) gives a numerical correlation between USCS and RMR which have been used to calculate equivalent RMR of soil in this report. Equivalent RMR is determined only by taking USCS Classification and ground water conditions of the soil material.

Table 11: Avg., Maximum, minimum of Eq-RMR for soil.

BH NO.	Average Eq-RMR value	Maximum Eq-RMR value	Minimum Eq-RMR value
BH-18	16.5	20	15
BH-19	16.75	20	15
BH-20	15.26	20	15
BH-21	15.6	20	15
BH-22	15.64	20	15
BH-23	15.789	20	15
BH-24	15	15	15
BH-25	15	15	15
BH-26	15	15	15
BH-27	15	15	15
BH-28	15.34	20	15
BH-29	15	15	15
BH-30	15	15	15
BH-31	15.34	20	15
BH-32	15	15	15
BH-33	15	15	15

Figure 26 Graph showing correlation between USCS classification and RMR Classification. (Warren,2016)

For other detailed soil properties like S.P.T N Value, Atterberg's Limit, Field Moisture Content, Natural density, Dry density, Cohesion, Angle of shearing resistance, Specific gravity, Void ratio along with results of Hydrometer Analysis, Grain size analysis, Triaxial test, Consolidation test please refer ANNEXURE –G.

5.5 Q System (NGI Tunneling Index):

The Q-system is developed to classify rock masses around an underground opening, as well as for field mapping. Based on estimation of six rock mass parameters, a Q-value for a rock mass can be calculated. This value gives a description of the rock mass quality. The Q-value depends on the underground opening and its geometry, and is therefore not an independent characterization of the rock mass. The Q-value in an undisturbed rock mass may be different.

The different Q-values are related to different types of permanent support by means of a schematic support chart. This means that by calculating the Q-value it is possible to find the type and quantity of support that has been applied previously in rock masses of the similar qualities. The Q-system can therefore be used as a guideline in rock support design decisions and for documentation of rock mass quality.

The Q-system was developed at NGI between 1971 and `74 (Barton et al. 1974). Since the introduction of the Q-system in 1974 there has been a considerable development within support philosophy and technology in underground excavations. Several new types of rock bolts have been introduced, and the continuous development of fibre reinforced technology has in many ways changed the support procedure. Application of sprayed concrete has gained acceptance even for good quality rocks masses due to demands for a higher level of safety during the recent years. Reinforced ribs of sprayed concrete have replaced cast concrete structures to a large extent.

Since the introduction of the system in 1974, two revisions of the support chart have been carried out and published in conference proceedings. An extensive updating in 1993 was based on 1050 examples mainly from Norwegian underground excavations (Grimstad and Barton, 1993). In 2002, an updating was made based on more than 900 new examples from underground excavations in Norway, Switzerland and India. This update also included analytical research with respect to the thickness, spacing and reinforcement of reinforced ribs of sprayed concrete (RRS) as a function of the load and the rock mass quality (Grimstad et al. 2002).

Calculation of Q value:

Q index value can be calculated from RMR using different empirical equation proposed by different author (Bieniawski;1984, Rutledge and Preston;1978, Moreno Tallon; 1980, Cameron-Clarke and Budavari;1981, Abad J et all;1987). These equations provide rapid determination of Q index from RMR index of corresponding rock. In reference with these equations, Q index shares logarithmic relation with RMR index value

$$\text{"}\boldsymbol{RMR = a\,.\,LnQ + b}\text{"}$$

The value of *'a'* and *'b'* are different for different equation purposed by different author and they vary over a range of value.

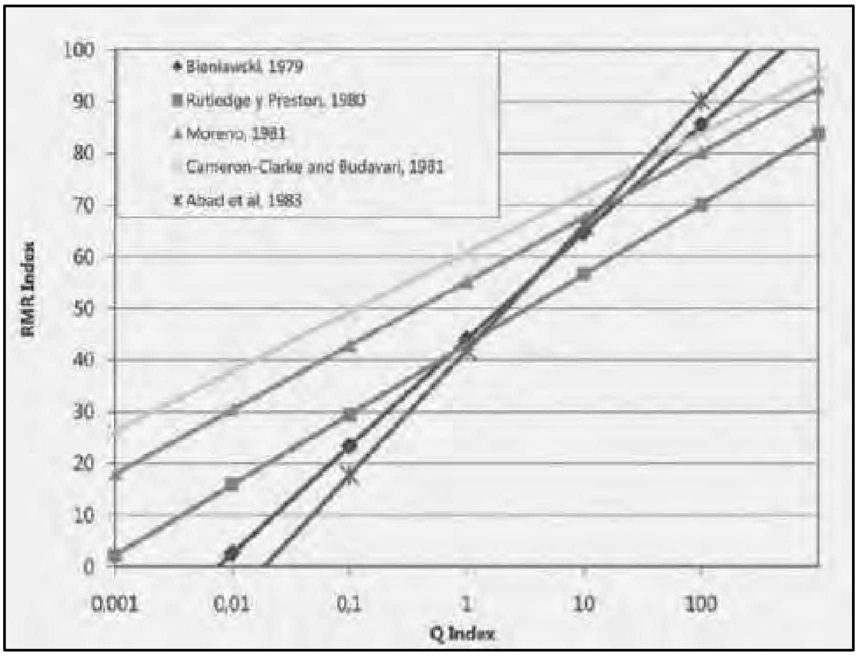


Figure 27: Graph showing correlation between different empirical equation for conversion between Q Index and RMR Index (adopted from Castro-fresno)

$\text{"}\boldsymbol{RMR = 9\,LnQ + 44}\text{"}$ Bieniawski;1984

"$\boldsymbol{RMR = 5.9\,LnQ + 43}$" Rutledge and Preston;1978

"$\boldsymbol{RMR = 5.4\,LnQ + 55.2}$" Moreno Tallon; 1980

"$\boldsymbol{RMR = 10.5\,LnQ + 41}$" Cameron-Clarke and Budavari;1981

"$\boldsymbol{RMR = 5\,LnQ + 60.8}$" Abad J et all;1987

All of these equations tend to give similar result for conversion between Q and RMR for a median value of respective indexes, but at extreme end of the values of indexes, the conversion by these empirical equations is not reliable due to variation.

The true Q-value at the level of underground excavation can only be observed in the excavation itself, and Q-values obtained by above methods will be more uncertain. The number of joint sets may be underestimated from drill cores and estimations of the parameters Jw and SRF may be cumbersome without actual observations on site. From surface mapping it may be uncertain as joint filling may be washed out at the surface, and other joint parameters may be difficult to observe. In such cases it may be an advantage to use histograms to visualize variations in the data by using maximum and minimum values for each parameter.

LnQ	Classification
0-0.01	Exceptionally Poor
0.01-0.1	Extremely Poor
0.1-1	Very Poor
1-7	Poor
7-10	Fair
10-70	Good
70-100	Very Good
100-700	Extremely Good
700-1000	Exceptionally Good

Table 12: Rock Mass classification based on their Q Value on logarithm scale (after Bieniawski,1976)

Absolute value of Q index is determined based on a numerical assessment of the rock mass quality using six different parameters;

1. RQD.
2. Number of joint sets.
3. Roughness of the most unfavorable joint or discontinuity.
4. Degree of alteration or filling along the weakest joint.
5. Water inflow.
6. Stress condition.

These six parameters are grouped into three quotients to give the overall rock mass quality Q as follows:

$$Q = \frac{RQD}{j_n} \times \frac{j_r}{j_a} \times \frac{j_w}{SRF}$$

Where:

RQD = Rock Quality Designation

j_n = Joint set number

j_r = Joint roughness number

j_a = Joint alteration number

RQD/J_n= Degree of jointing (or block size)

J_r/J_a=Joint Friction (inter block shear strength)

J_w/SRF=Active Stress

The rock quality can range from Q = 0.001 to Q = 1000 on a logarithmic rock mass quality scale. The above equation gives absolute value of Q index for a rock mass by taking abovesaid 6 parameters in account.

Table 13: Description & Rating for Jn

	2. Joint Set Number (J_n)	Rating
A	Massive, no or few joints	0.5-1.0
B	One joint set	2
C	One joint set plus random joint	3
D	Two joint sets	4
E	Two joint sets plus random joints	6
F	Three joint sets	9
G	Three joint sets plus random joints	12
H	Four or more joint sets, random heavily jointed "sugar cube", etc	15
J	Crushed rock, earth like	20
Note: i) For tunnel intersections, use 3 x Jn ii) For portals, use 2 x Jn		

Table 14 Description &Rating for J_r

	3. Joint Roughness Number (J_r)	Rating
Rock-wall contact, and Rock-wall contact before 10 cm of shear movement		
A	Discontinuous joints	4
B	Rough or irregular, undulating	3
C	Smooth, undulating	2
D	Slickensided, undulating	1.5
E	Rough, irregular, planar	1.5

F	Smooth, planar	1
G	Slickensided, planar	0.5
Note: i) Description refers to small scale features and intermediate scale features, in that order		
No rock-wall contact when sheared		
H	Zone containing clay minerals thick enough to prevent rock-wall contact when sheared	1
Note: ii) Add 1 if the mean spacing of the relevant joint set is greater than 3 m (dependent on the size of the underground opening) iii) Jr = 0.5 can be used for planar slickensided joints having lineation, provided the lineation are oriented in the estimated sliding direction		

Table 15 Description & Rating for J_a

Joint Alteration Number J_a		Rating
a) Rock-wall contact (no mineral fillings, only coatings)		
A	Tightly healed, hard, non-softening, impermeable filling, i.e., quartz or epidote.	0.75
B	Unaltered joint walls, surface staining only.	1
C	Slightly altered joint walls. Non-softening mineral coatings; sandy particles, clay-free disintegrated rock, etc.	2
D	Silty or sandy clay coatings, small clay fraction (non-softening).	3
E	Softening or low friction clay mineral coatings, i.e., kaolinite or mica. Also chlorite, talc gypsum, graphite, etc., and small quantities of swelling clays.	4
b) Rock-wall contact before 10 cm shear (thin mineral fillings)		

Joint Alteration Number J_a		**Rating**
F	Sandy particles, clay-free disintegrated rock, etc.	4
G	Strongly over-consolidated, non-softening, clay mineral fillings (continuous, but <5 mm thickness).	6
H	Medium or low over-consolidation, softening, clay mineral fillings (continuous, but <5 mm thickness).	8
J	Swelling-clay fillings, i.e., montmorillonite (continuous, but <5 mm thickness). Value of Ja depends on percent of swelling clay-size particles.	8-12
c) No rock-wall contact when sheared (thick mineral fillings)		
K	Zones or bands of disintegrated or crushed rock. Strongly over-consolidated.	6
L	Zones or bands of clay, disintegrated or crushed rock. Medium or low over-consolidation or softening fillings.	8
M	Zones or bands of clay, disintegrated or crushed rock. Swelling clay. Ja depends on percent of swelling clay-size particles.	8-12
N	Thick continuous zones or bands of clay. Strongly over-consolidated.	10
O	Thick, continuous zones or bands of clay. Medium to low over-consolidation.	13

Table 16 Description & Rating for J_w

Joint Water Reduction Factor J_w		Rating
A	Dry excavations or minor inflow (humid or a few drips)	1.0

B	Medium inflow, occasional out wash of joint fillings (many drips/"rain")	0.66
C	Jet inflow or high pressure in competent rock with unfilled joints	0.5
D	Large inflow or high pressure, considerable out wash of joint fillings	0.33
E	Exceptionally high inflow or water pressure decaying with time. Causes out wash of material and perhaps cave in.	0.2-0.1
F	Exceptionally high inflow or water pressure continuing without noticeable decay. Causes out wash of material and perhaps cave in.	0.1-0.05
Note: i) Factors C to F are crude estimates. Increase Jw if the rock is drained or grouting is carried out ii) Special problems caused by ice formation are not considered		

Table 17 Description & Rating for Stress Reducing Factor (SRF)

Stress Reduction Factor		SRF
a) Weak zones intersecting the underground opening, which may cause loosening of rock mass		
A	Multiple occurrences of weak zones within a short section containing clay or chemically disintegrated, very loose surrounding rock (any depth), or long sections within competent (weak) rock (any depth). For Squeezing conditions,	10
B	Multiple shear zones within a short section in competent clay-free rock with loose surrounding rock (any depth)	7.5
C	Single weak zones with or without clay or chemical disintegrated rock (depth ≤ 50m)	5
D	Loose, open joints, heavily jointed or "sugar cube", etc. (any depth)	5
E	Single weak zones with or without clay or chemical disintegrated rock (depth > 50m)	2.5
Note: i) Reduce these values of SRF by 25-50% if the weak zones only influence but do not intersect		

the underground opening.				
b) Competent, mainly massive rock, stress problems		σ_c/σ_1	σ_c/σ_2	SRF
F	Low stress, near surface, open joints	>200	<0.01	2.5
G	Medium stress, favourable stress condition	200-10	0.01-0.3	1
H	High stress, very tight structure. Usually favourable to stability. May also be unfavorable to stability dependent on the orientation of stresses compared to jointing / weakness planes*	10-5	0.3-0.4	0.5-2 2-5*
J	Moderate spalling and/or slabbing after > 1 hour in massive rock	5-3	0.5-0.65	5-50
K	Spalling or rock burst after a few minutes in massive rock	3-2	0.65-1	50-200
L	Heavy rock burst and immediate dynamic deformation in massive rock	<2	>1	200-400
Note: For strongly anisotropic virgin stress field (if measured): when 5 ≤σ1 /σ3 ≤ 10, reduce σc to 0.75 σc. When σ1 /σ3 > 10, reduce σc to 0.5 σ_c, where σ_c = unconfined compression strength, σ1 and σ3 are the major and minor principal stresses, and σ1σ2= maximum tangential stress (estimated from elastic theory) When the depth of the crown below the surface is less than the span; suggest SRF increase from 2.5 to 5 for such cases (see F)				
c) Squeezing rock: plastic deformation in incompetent rock under the influence of high pressure			σc	SRF
M	Mild squeezing rock pressure		1-5	5-10
N	Heavy squeezing rock pressure		>5	10-20
Note: iv) Determination of squeezing rock conditions must be made according to relevant literature (i.e., Singh et al., 1992 and Bhasin and Grimstad, 1996)				

d) Swelling rock: chemical swelling activity depending on the presence of water		SRF
O	Mild swelling rock pressure	5-10
P	Heavy swelling rock pressure	10-15

The individual parameters are determined during geological mapping using tables that give numerical values to be assigned to a described situation. Paired, the six parameters express the three main factors which describe the stability in underground openings

The Q values for the samples are given in table below. For detail table refer Annexure.

Table 18 Average, Maximum, and Minimum Q-Value from Borehole (Follow annexure A for detailed information)

BH NO.	AVERAGE Q VALUE	MAXIMUM Q VALUE	MINIMUM Q VALUE
BH-13	4.54	6.69	1.5
BH-14	1.74	3.6	1.5
BG-15	1.7	4.05	1.5
BH-15A	2.17	4.8	1.5
BH-16	2.7	7.69	1.5
BH-17	0.2	0.83	0.2

Based on the average Q value of the rock mass it falls into “Very Poor” to “Poor” category

6 CHAPTER: Engineering properties of the rock / soil

6.1 Laboratory Testing of Rock Mass

Laboratory tests were also carried out on rock samples, the details of different laboratory tests conducted as part of the project are given in the table below

Table 19: The laboratory tests conducted for rock.

Laboratory tests conducted for rock	1. Unconfined Compressive Strength,
	2. Point Load Index Test
	3. Tensile Strength
	4. Specific Gravity
	5. Modulus of elasticity
	6. Water absorption
	7. Poisons' ratio
	8. Triaxial Test
	9. Hardness test
	10. Abrasive test

6.1.1 Selection of Core Sample

Representative core samples (NX and NQ size) are collected for covering the crown and invert section and other portions above the crown. The samples were properly labelled and packed carefully and sent NABL accredited Bhubaneswar laboratory for determining the physico-mechanical properties.

The physico-mechanical properties like unit weight, water absorption, porosity, specific gravity, point load index, uniaxial compressive strength (UCS), tri-axial compressive strength, tensile strength (TS), modulus of elasticity, Poisson's ratio is determined. Simultaneously, the specific heat, thermal diffusivity, thermal conductivity, hydraulic conductivity and petrography tests are also conducted on the rock samples representing to the tunnel influence zone. The following laboratory tests have been conducted to determine intact rock properties.

6.1.2 Tensile Strength

Brazilian test is intended to measure the tensile strength of a rock sample in the form of specimens of regular geometry. The test is mainly intended for strength classification and characterization of intact rock. The test specimens are right circular cylinders having a length to diameter (L: D) ratio approximately equal to 0.5 and a diameter shall not be less than 45 mm. This method of determining tensile strength is an indirect method, and is popularly known as Brazilian method. The indirect tensile strength is calculated as follows:

$$\sigma_t = \frac{2P}{\pi D t}$$

Where:

σ_t = Brazilian tensile strength (MPa); D = Diameter of the core sample (mm);

P = Maximum failure load (N); t = Thickness or Length of the sample (mm)

Figure 28 and Table 20 below provides a summary of Tensile strength for the all the core samples from different boreholes.

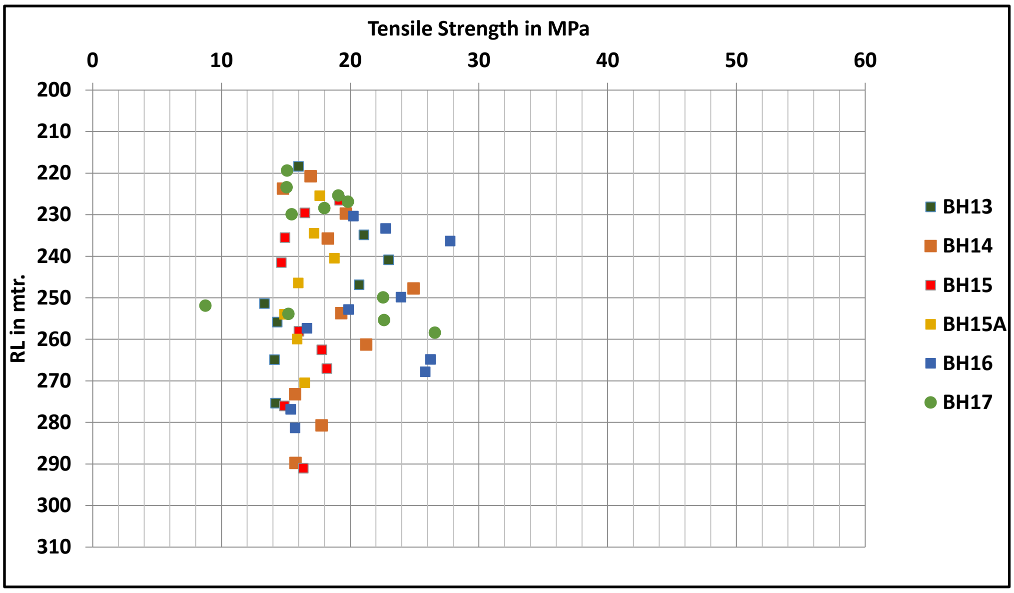


Figure 28: Tensile Strength of rock mass from entire borehole length vs RL. (Refer to Annexure B in Geotechnical Report for detail).

Table 20: Result of Tensile strength (Follow annexure B for detailed information)

BH NO.	Minimum tensile strength value (MPa)	Maximum tensile strength value (MPa)	Average tensile strength value (MPa)
BH-13	13.34	22.99	17.10
BH-14	14.78	24.93	18.44
BG-15	14.66	19.2	16.51
BH-15A	14.91	18.78	16.70
BH-16	15.39	27.77	21.67
BH-17	8.77	26.58	18.03

6.1.3 Unconfined Compressive Strength

UCS test is intended to determine the unconfined compressive strength of a rock sample in the form of specimens of regular geometry. The length to diameter ratio of cylindrical specimen shall preferably be 2 to 3. If the ratio is less than 2, usual correction shall be applied taking standard slenderness ratio as 2. Load on the specimen shall be applied continuously at a constant stress rate such that failure will take place in about 5 to 15 minutes of loading. Alternatively, the stress rate shall be within the limits of 0.5 MPa/s to 1 MPa/s. The unconfined compressive strength of the specimen has been calculated by dividing the maximum load carried by the specimen during the test, by the average original cross-sectional area.

Figure 29 and Table 21 below provides a summary of UCS values for the all the samples. For detail table refer Annexure.

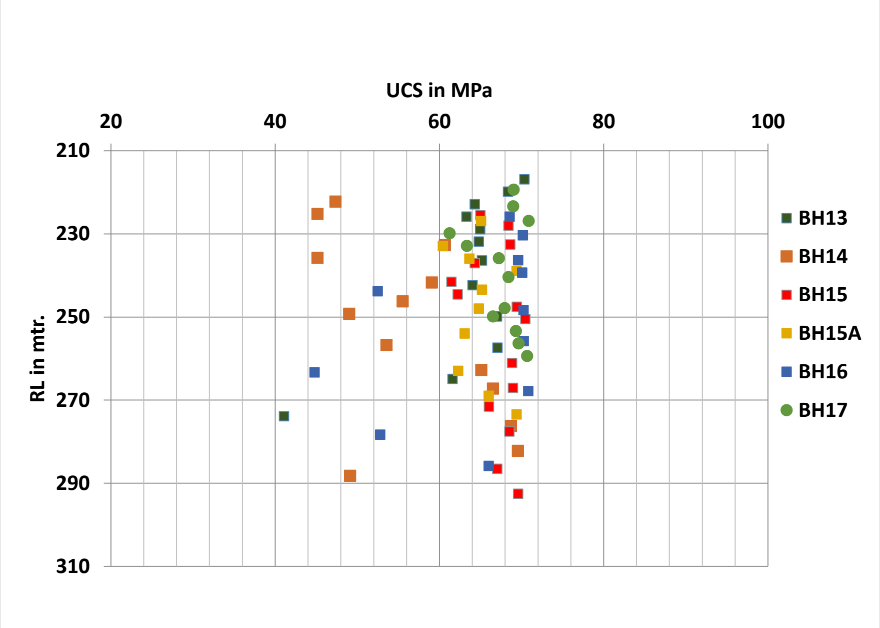


Figure 29: Unconfined Compressive Strength (UCS) of rock mass from entire borehole length vs RL (Refer to Annexure C in Geotechnical Report for detail).

Table 21: Result of UCS Test (Follow annexure C for detailed information)

BH NO.	Minimum UCS value (MPa)	Maximum UCS value (MPa)	Average UCS value (MPa)
BH-13	41.06	70.33	63.49
BH-14	45.15	69.54	56.49
BG-15	61.45	70.44	67.05
BH-15A	60.42	69.38	65.12
BH-16	44.8	70.8	64.16
BH-17	61.24	70.85	67.76

6.1.4 Density, Specific Gravity, Water Absorption

These tests are performed as per relevant standard. The Bulk volume is obtained by buoyancy technique and the pore volume is obtained by water saturation. It may also be applied to a sample in the form of specimen of irregular geometry.

Based on the tests conducted, the unit weight has been calculated

Specific gravity has been estimated for core samples picked up from different borehole. The true specific gravity has been expressed as a numerical value and shall be based on average of three determinations.

The table below provides set of values calculated for Density, specific gravity, water absorption. For detail table refer Annexure.

Table 22: Result of Density, Specific Gravity, Water absorption (Follow annexure D for detailed information).

BH NO.	Minimum Density value (kN/m^3)	Maximum Density value (kN/m^3)	Average Density value (kN/m^3)
BH-13	24.31	25.73	25.31
BH-14	25.67	26.09	25.88
BG-15	25.07	25.74	25.43
BH-15A	24.81	25.69	25.30
BH-16	25.3	26.52	25.97
BH-17	24.23	26.21	25.42

Table 23: Result of Specific Gravity (Follow annexure D for detailed information).

BH NO.	Minimum Specific gravity value	Maximum Specific gravity value	Average Specific gravity value
BH-13	2.47	2.61	2.57
BH-14	2.61	2.65	2.63

BH NO.	Minimum Specific gravity value	Maximum Specific gravity value	Average Specific gravity value
BG-15	2.54	2.61	2.58
BH-15A	2.52	2.60	2.57
BH-16	2.56	2.69	2.64
BH-17	2.45	2.67	2.58

Table 24: Result of Water absorption (Follow annexure D for detailed information).

BH NO.	Minimum Water absorption value %	Maximum Water absorption value %	Average Water absorption value %
BH-13	0.14	0.51	0.39
BH-14	0.15	0.57	0.32
BG-15	0.46	0.63	0.52
BH-15A	0.16	0.75	0.47
BH-16	0.25	0.70	0.50
BH-17	0	1.18	0.56

6.1.5 Point Load Strength Index

Point Load test is intended to determine the diametrical and axial point load strength index of rock core. The core specimens with length to diameter ratio of 0.3 to 1 are suitable for axial testing. The point load strength index shall be calculated from the following formula:

$$I_l(50) = \frac{P}{(Dd)^{0.75} \times \sqrt{D_{50}}}$$

Where: $I_l(50)$ = Point Load strength Index (MPa); D = Distance between the platen (mm);

P = Maximum failure load (N); d = Diameter of test specimen (mm);

D_{50} = Standard core diameter (mm)

Figure 30 and table below provides point load index value, for detail table refer Annexure.

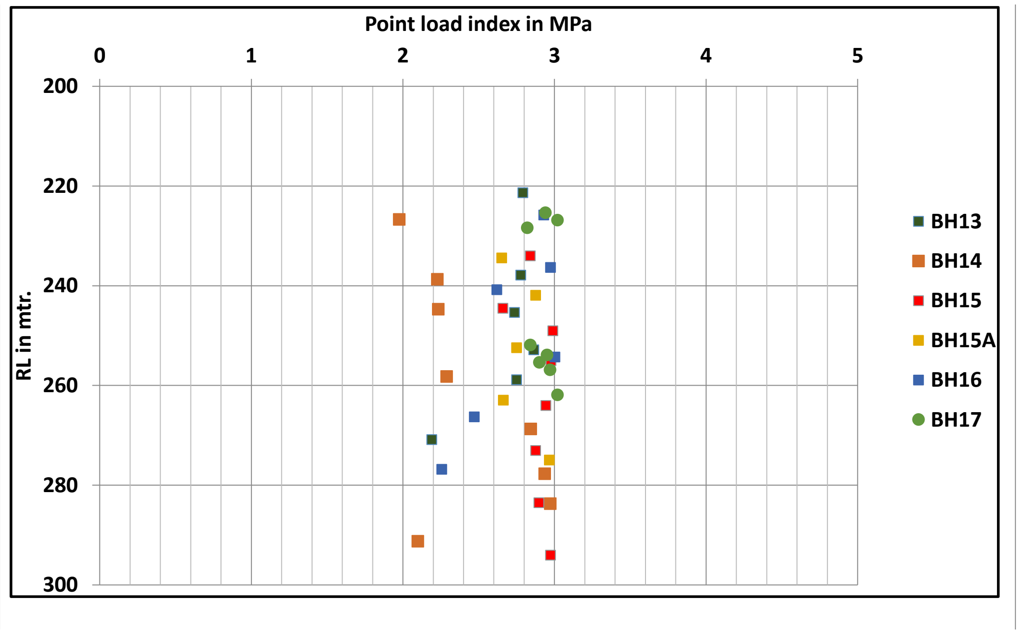


Figure 30: Point Load Index (PLI) of rock mass from entire borehole length vs RL. (Refer to Annexure E in Geotechnical Report for detail).

Table 25: Result of point load index test (Follow annexure E for detailed information).

BH NO.	**Minimum Point load index value (MPa)**	**Maximum Point load index value (MPa)**	**Average Point load index value (MPa)**
BH-13	1.01	3.20	2.18
BH-14	2.27	3.62	2.99
BG-15	2.53	3.85	3.37
BH-15A	2.86	3.40	3.14
BH-16	2.06	3.84	3.07

BH NO.	Minimum Point load index value (MPa)	Maximum Point load index value (MPa)	Average Point load index value (MPa)
BH-17	2.82	3.02	2.93

6.1.6 Modulus of Elasticity and Poisson's Ratio

This test is intended to determine the Modulus of Elasticity & Poisson's Ratio of cylindrical rock specimen in compression. Circumferential and axial deformations or strains may be determined from data obtained by electrical resistance strain gauges, compress meters, optical devices or other suitable means. The design of the measuring device shall be such that the average of at least two circumferential and two axial strain measurements can be determined for each increment of load. Measuring positions shall be equally spaced around the circumference of the specimens close to the mid height. They should not fall within D/2 of the specimen ends, where D is the diameter.

6.1.6.1 Calculation

The axial strain (Ɛa) and the diametric strain (Ɛd) may be recorded directly from strain indicating equipment or may be calculated from the measured deformation depending upon the type of apparatus or instrument used.

The axial (Ɛa) and diametric (Ɛd) strains shall be calculated as follows:

$$\varepsilon a = \Delta l / l$$

$$\varepsilon d = \Delta d / d$$

Where l = original axial length before deformation,

d = original diameter before the deformation,

Δl = change in measured axial length (positive for a decrease in length), and

Δd = change in diameter (positive for an in increase in diameter).

*NOTE - It may be noted that circumferentially applied electrical resistance strain gauges also reflect diametric strain, the value necessary for computing Poisson's ratio.

Since,

$$C = \pi d$$

$$\Delta c = \pi \Delta d$$

The circumferential and diametric strains are related as follows:

$$\varepsilon c = \Delta c / c$$

$$= \pi \Delta \mathrm{d} / \pi \mathrm{d}$$

$$= \Delta d / d$$

$$= \varepsilon d$$

Where, *c* and d are circumference and diameter of the specimen respectively. The compressive stress in the test specimen σ shall be calculated from compressive load P and the θ initially computed cross-sectional area A, as follows:

$$\sigma = \frac{P}{A}$$

The stress versus axial and lateral strain shall be plotted as a curve.

Figure 31 and table below shows Modulus of Elasticity values for all samples from boreholes.

Figure 31

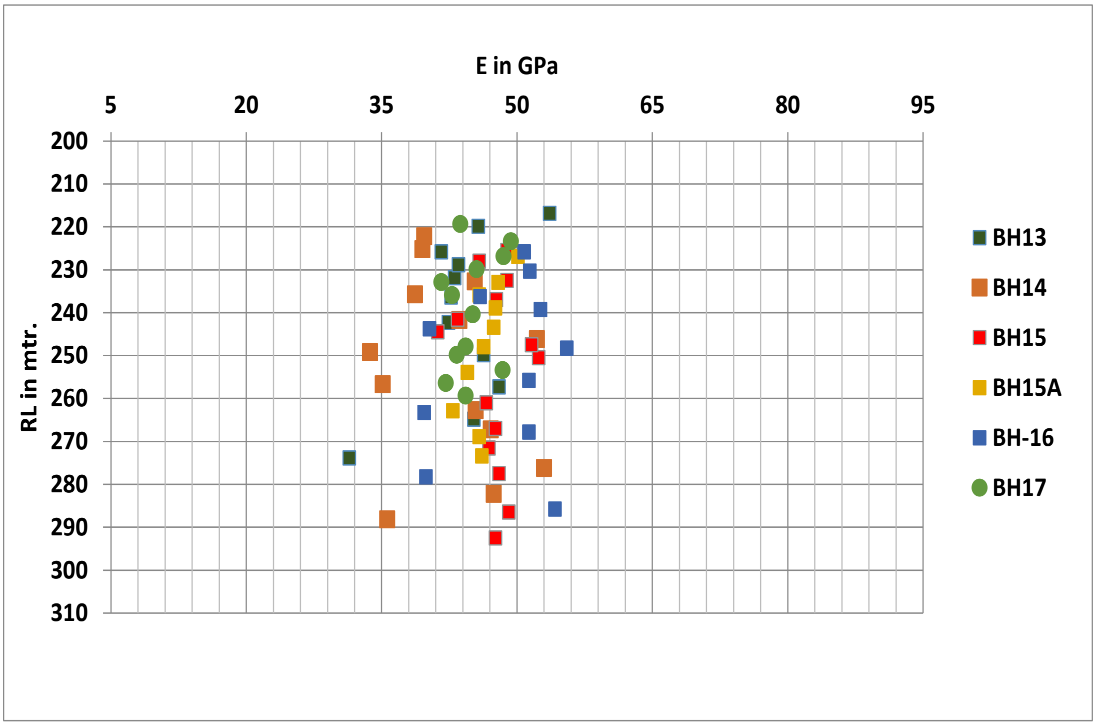


Figure 31: Modulus of Elasticity (E) of rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).

Table 26: Modulus of elasticity (Follow annexure F for detailed information).

BH NO.	Minimum Modulus of elasticity value (GPa)	Maximum Modulus of elasticity value (GPa)	Average Modulus of elasticity value (GPa)
BH-13	31.4	53.6	43.9
BH-14	33.7	53.0	42.8
BG-15	41.2	52.4	47.5
BH-15A	42.9	50.1	46.7
BH-16	39.7	55.5	48.4
BH-17	41.6	49.3	44.9

Poisson’s Ratio (v) –

Poisson’s ratio shall be calculated as the ratio of the total diametric strain εd to the total axial strain εa at any given stress level.

NOTE - When the terms ‘Modulus’ and ‘Poisson’s Ratio’ are used without any qualification, they shall be taken to mean as the tangent modulus and the Poisson’s ratio at 50percent of the ultimate stress.

Based on the tests conducted on core samples, the average Poisson’s Ratio and Modulus of Elasticity has been estimated to be 0.13 and 45.89 GPa. Figure 32 and table below shows Poisson’s ratio values for all samples, for detail table refer Annexure

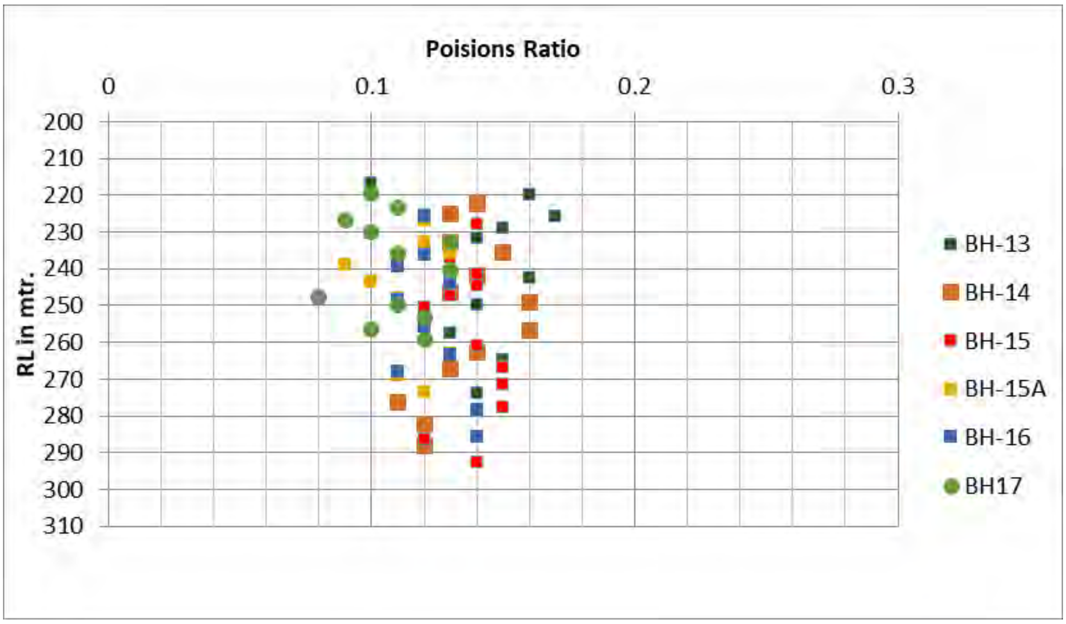


Figure 32: Poisson's Ratio distribution for the entire rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).

Table 27: Poisson's ratio (Follow annexure E for detailed information).

BH NO.	Minimum Poisson's ratio value	Maximum Poisson's ratio value	Average Poisson's ratio value
BH-13	0.10	0.17	0.14
BH-14	0.11	0.16	0.14
BG-15	0.12	0.15	0.14
BH-15A	0.09	0.13	0.11
BH-16	0.10	0.14	0.12
BH-17	0.08	0.13	0.11

6.1.7 Triaxial Test

Triaxial test is intended to determine the Cohesion and angle of internal friction of a rock sample in the form of specimens of regular geometry. The length to diameter ratio of cylindrical specimen shall preferably be 2 to 3. Load on the specimen shall be applied continuously at a constant stress rate such that failure will take place in about 5 to 15 minutes of loading. Alternatively, the stress rate shall be within the limits of 0.5 MPa/s to 1 MPa/s.

6.1.7.1 Calculation

Using Parameter m and b, the angle of internal friction Ø and a value for the apparent cohesion C may be calculated using following formula.

$$\emptyset = \sin^{-1}\frac{m-1}{m+1}$$

$$C = b \times \frac{1-\sin\emptyset}{2\cos\emptyset}$$

Figure 33 and Table 28 below provides a summary of Triaxial Cohesion values for the all the samples. Figure 34 and Table 29 below provides a summary of phi values.

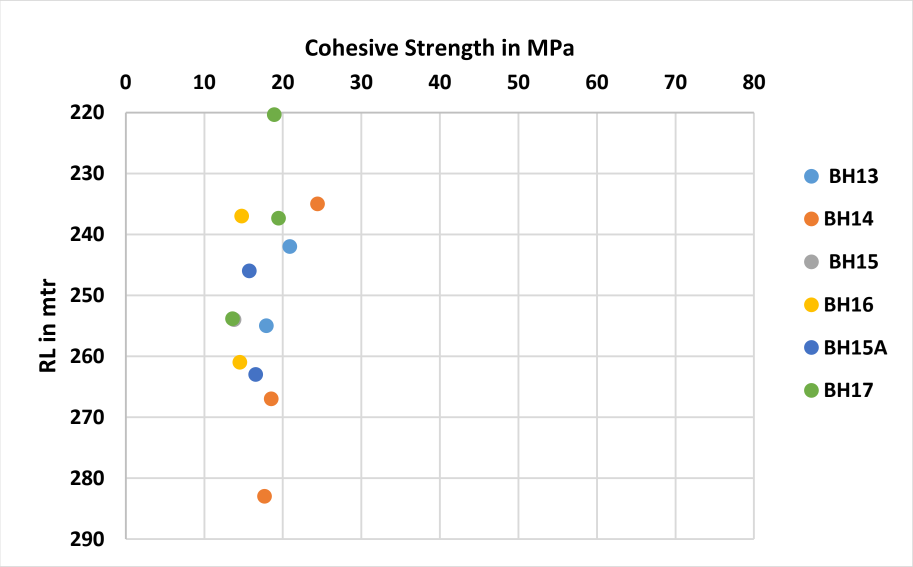


Figure 33: Cohesive strength of rock mass from entire borehole length vs RL (Refer to Annexure F in Geotechnical Report for detail).

Table 28: Result of Cohesive Strength test (Follow annexure F for detailed information)

BH NO.	**Minimum C value (MPa)**	**Maximum C value (MPa)**	**Average C value (MPa)**
BH-13	15.13	20.88	17.97
BH-14	17.66	24.39	20.19
BH-15	13.78	13.78	13.78
BH-15A	15.71	16.54	16.13
BH-16	14.50	14.75	14.63
BH-17	13.58	19.44	17.30

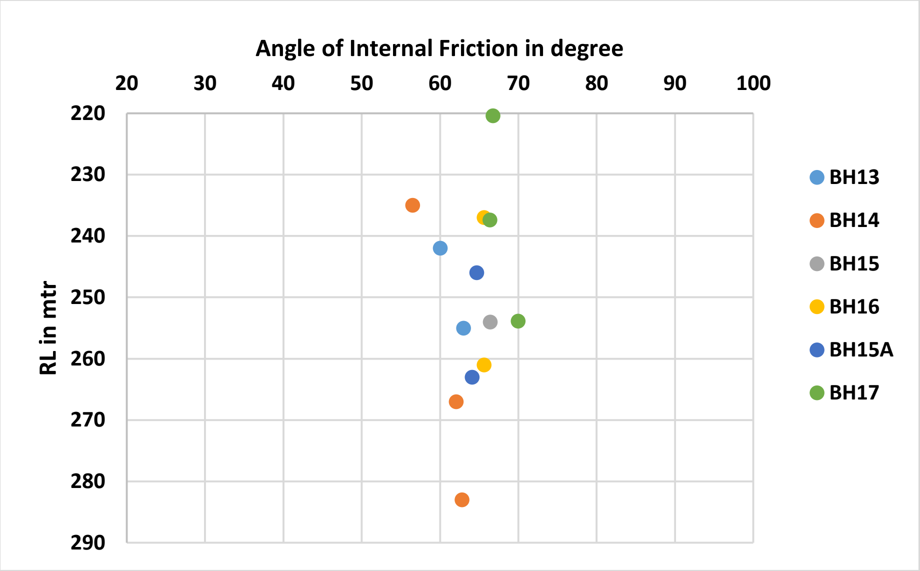


Figure 34: Angle of internal friction of rock mass from entire borehole length vs RL (Refer to Annexure G in Geotechnical Report for detail).

Table 29: Result of angle of internal friction (∅) Test (Follow annexure F for detailed information)

BH NO.	Minimum ∅ value in degree	Maximum ∅ value in degree	Average ∅ value in degree
BH-13	60.02	65.23	62.75
BH-14	56.48	62.80	60.45
BH-15	66.39	66.39	66.39
BH-15A	64.08	64.67	64.38
BH-16	65.63	65.63	65.63
BH-17	66.36	69.96	67.69

6.1.8 Hardness Test

Hardness test is intended to determine the hardness number of a rock sample. The length of the sample should be at least 60 mm. Test locations shall be separated by at least twice the diameter of the plunger.

6.1.8.1 Calculation

The correction factor is calculated as: Correction factor=

$$\frac{Specified\ standard\ value\ of\ the\ anvil}{Average\ of\ 10\ reading\ on\ calibration\ anvil}$$

The measured test values for the sample should be tabulated in descending order. The lower 50 percent of the values should be discarded and the average obtained of the upper 50 percent values. This average shall be multiplied by the correction factor

Figure 35 and Table 30 below provides a summary of Triaxial Cohesion values for the all the samples.

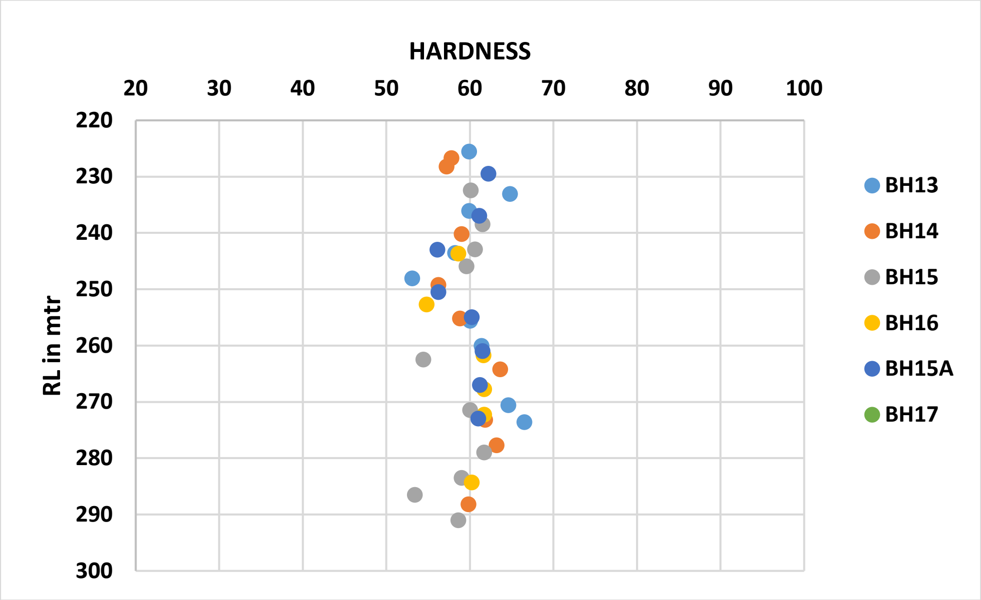


Figure 35: Hardness of rock mass from entire borehole length vs RL. (Refer to Annexure H in Geotechnical Report for detail).

Table 30: Result of Hardness Test (Follow Annexure G for detailed information).

BH NO.	Minimum Hardness value in Numbers	Maximum Hardness value in Numbers	Average Hardness value in Numbers
BH-13	53.1	66.5	60.9
BH-14	56.2	63.6	59.7
BH-15	53.4	61.7	58.9
BH-15A	56.1	62.2	59.9
BH-16	54.8	61.7	59.8
BH-17	22.1	50.6	32.6

6.1.9 Abrasiveness Test

Abrasiveness test is intended to determine the wear or loss of material which the rock produces on contact with another material.

6.1.9.1 Calculation

Abrasiveness is calculated by following formula

$$\text{CAI or CAIs}=\frac{1}{10\in}\sum_{1}^{10} di$$

CAI or CAIs = Cerchar index for natural or saw cut surface respectively and d_i is diameter of the abraded flat area measured in units of 0.1 mm.

If Saw cut specimen is tested, then calculated CAIs of Eq. 1 it is advised to be normalized using Eq.2

$$CAI= 0.99\ CAIs + 0.48$$

CAI = Cerchar index for natural surface; CAIs= Cerchar index for smooth surface

Table 31 and Figure 36below provides a summary of Triaxial Cohesion values for the all the samples

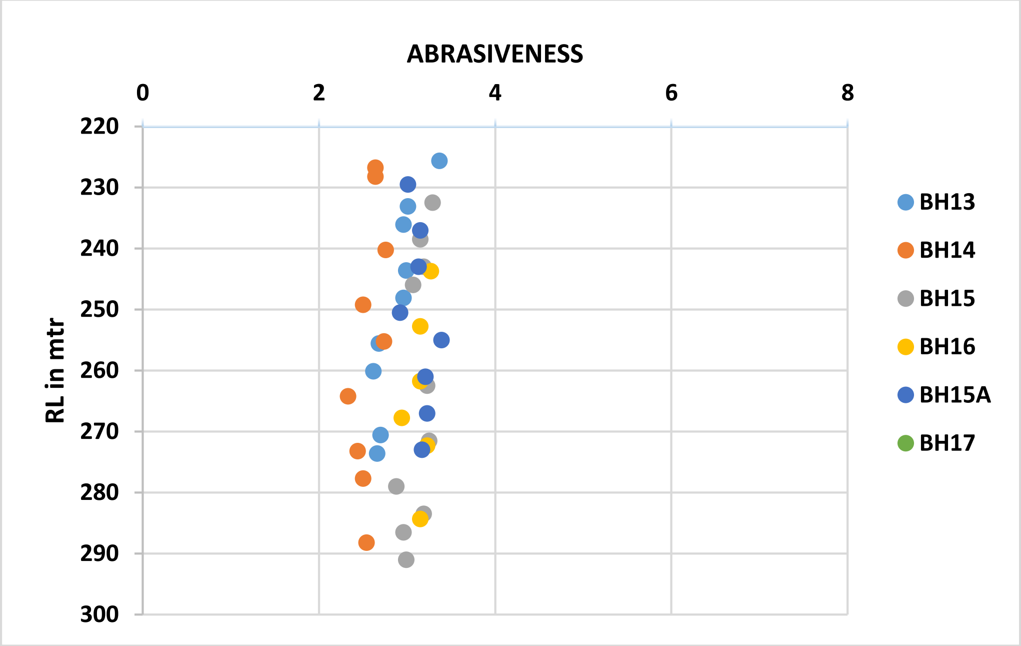


Figure 36: Abrasiveness of rock mass from entire borehole length vs RL. (Refer to Annexure I in Geotechnical Report for detail).

Table 31: Result of Abrasiveness test (Follow annexure G for detailed information)

BH NO.	Minimum Abrasiveness	Maximum Minimum Abrasiveness	Average Minimum Abrasiveness	Classification (HRC=55)
BH-13	2.62	3.37	2.88	High Abrasiveness
BH-14	2.33	2.76	2.55	High Abrasiveness
BH-15	2.88	3.43	3.15	High Abrasiveness
BH-15A	2.92	3.39	3.15	High Abrasiveness
BH-16	2.94	3.31	3.17	High Abrasiveness
BH-17	1.91	2.58	2.21	High Abrasiveness

6.1.10 Petrography Test

This test is performed to study the mineralogical, textural and micro-structural property of rock. The rock samples are cut up to 30-micron size and their optical properties are observed.

In the present test Grain size analysis is done to study the textural property of rock and the relative abundance of minerals are calculated to study the chemical and mineralogical property of the rock.

In order to get a holistic view, the samples are collected from different depth from each borehole as follows:

Table 32: Borehole wise details of collected sample for thin section.

BH ID	DEPTH
BH13	6
	10.5
	18
	24
	31.5
	39
	46.5
	52.5
	55.5
BH14	3
	10.5
	16.5
	25.5
	36
	49
	55.5

BH ID	DEPTH
	67.5
BH15	1.5
	12
	22.5
	31.5
	40.5
	51
	61.5
	67.5
BH15A	6
	10.5
	18
	22.5
	27
	33
	34.5
	45
BH16	10.5
	21
	33
	40.5
	46.5
	52
BH17	20.5
	25.0
	30.0
	31.5

BH ID	DEPTH
	45.5
	51.5
	53.0
	61.0
	62.0

As per the grain size analysis of the rock the entire strata was found to be formed of Quartzite containing 80-90% quartz, only ≥20% of feldspar and very little mica, representing a mineralogically matured parent rock. This rock is almost equigranular with an average grain diameter of 0.25mm, indicating the textural maturity of its provenance. Only in BH16 at below 40m a very small amount of mica rich garnetiferrous phyllite was found. Photomicrographs of the thin sections and the results of the respective grain size and mineralogical analyses are presented below.

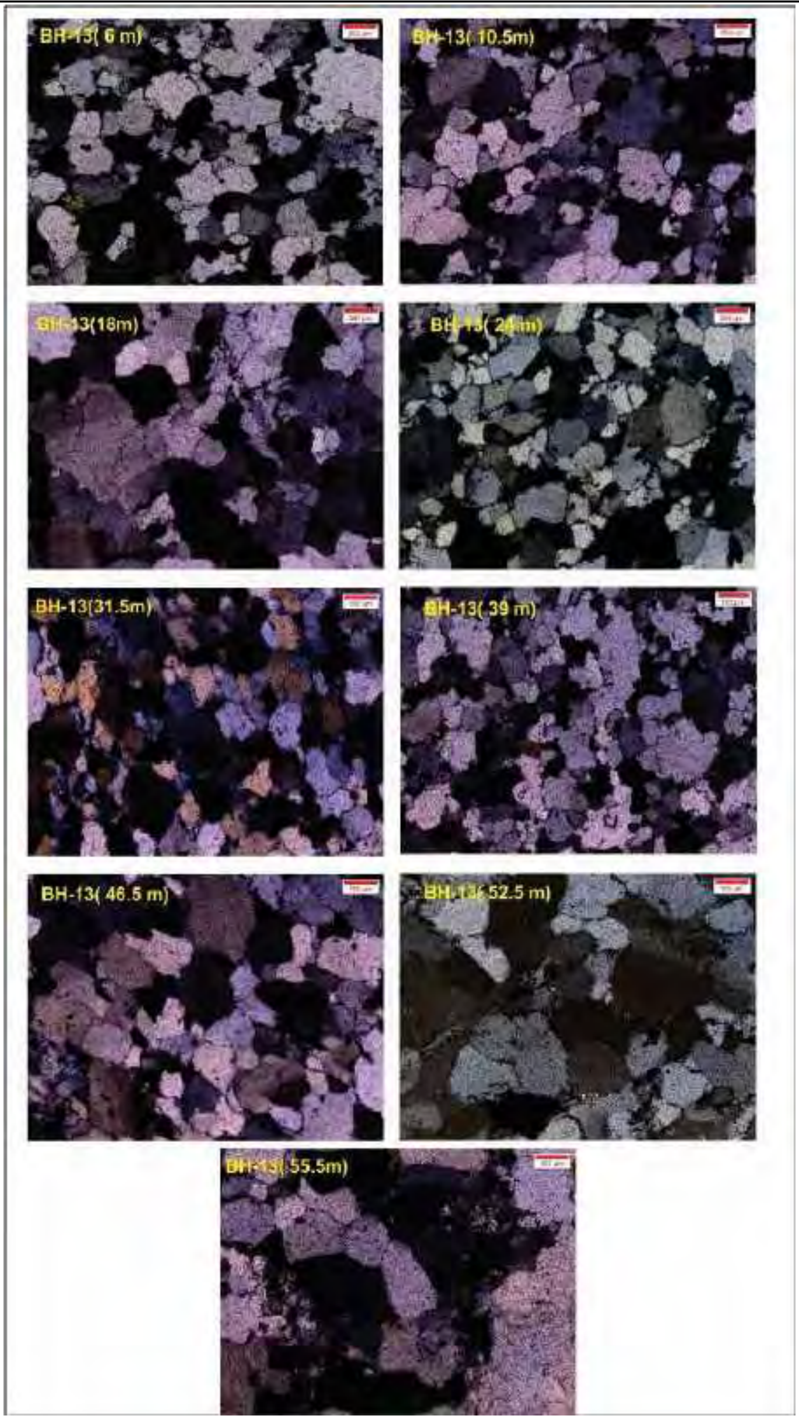


Figure 37: Borehole 13 sample under optical microscope (Cross polarized 5X)

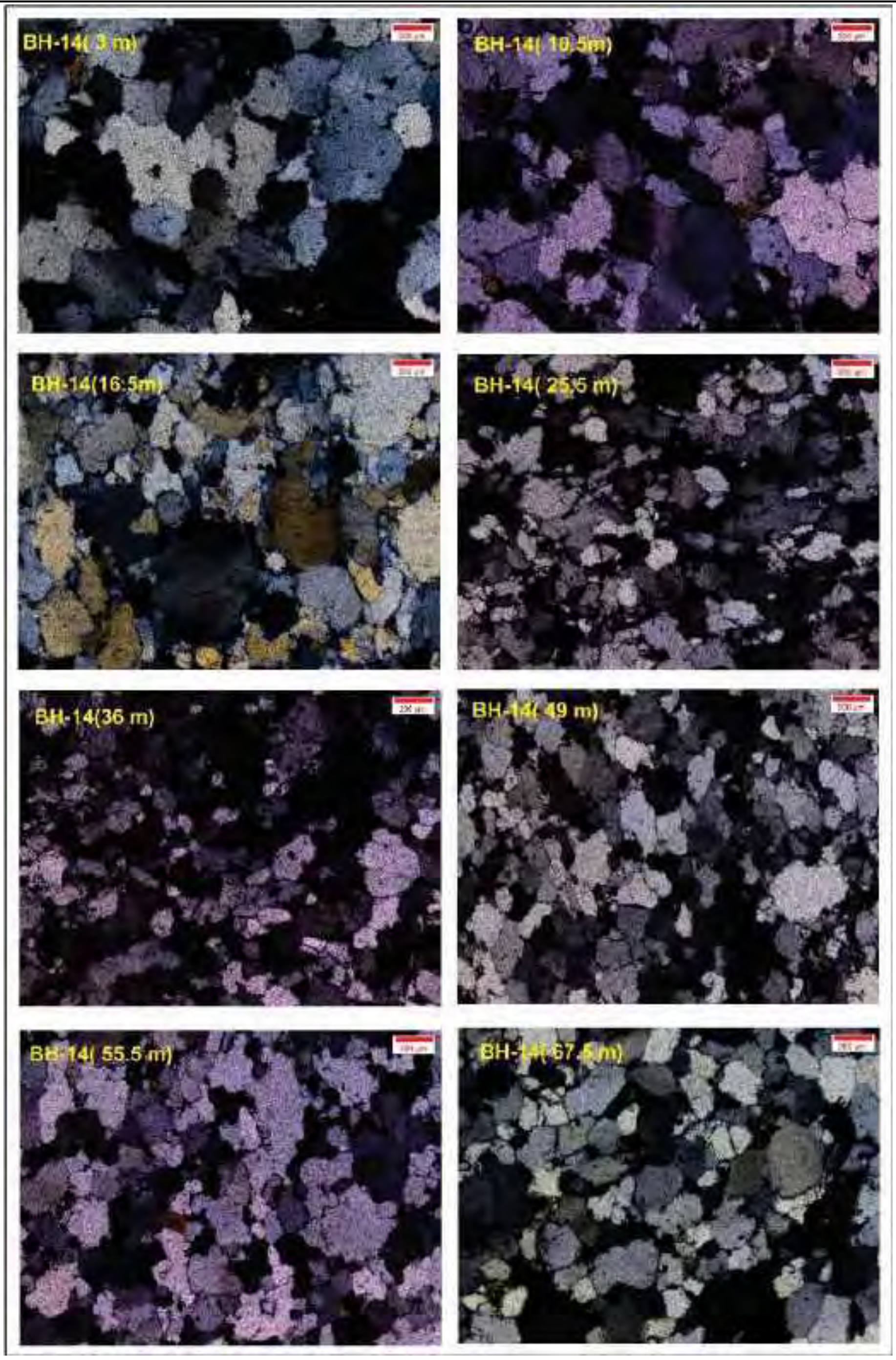


Figure 38: Borehole 14 samples under optical microscope (Cross polarized 5X)

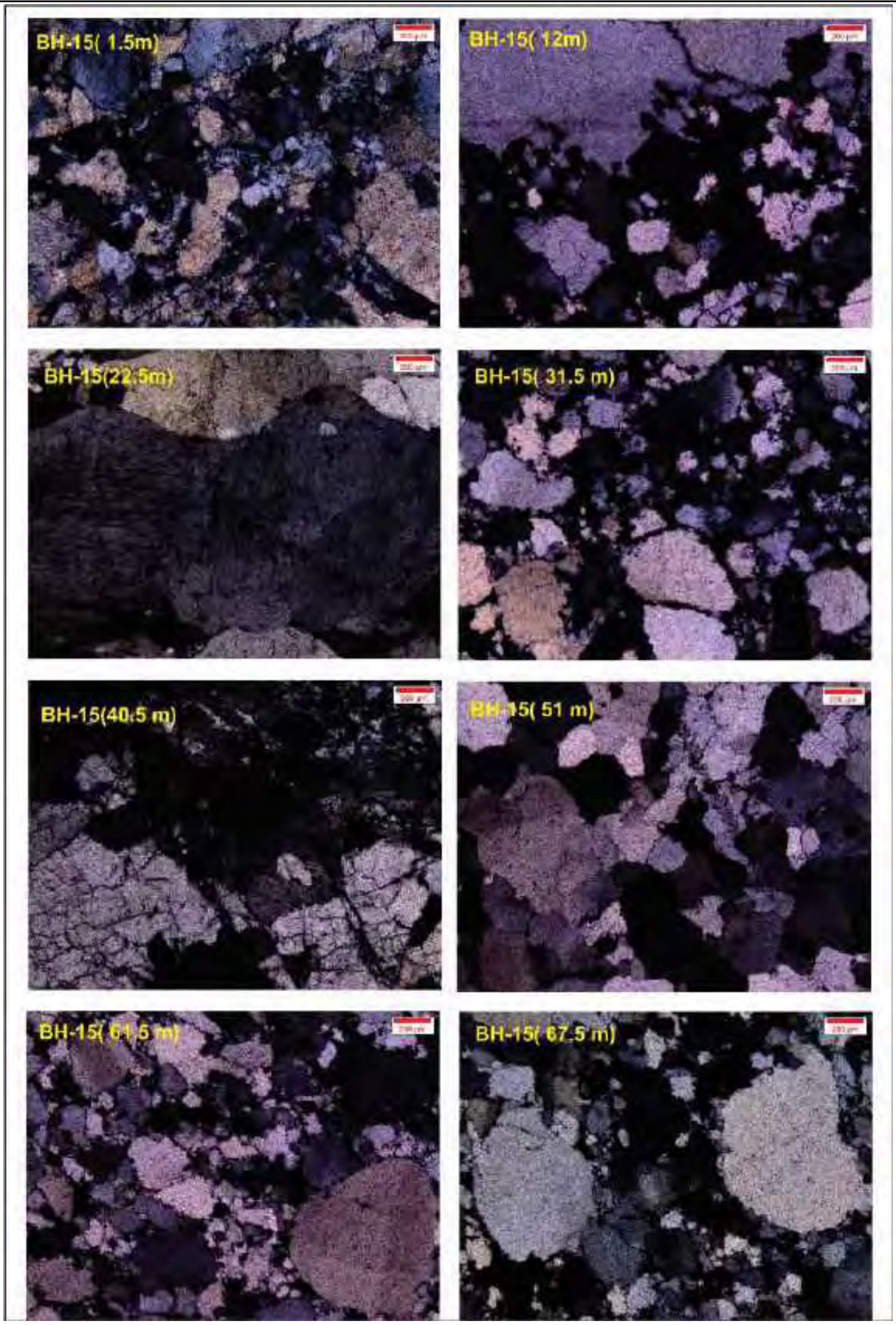


Figure 39: Borehole 15 Samples under optical microscope (cross polarized 5X).

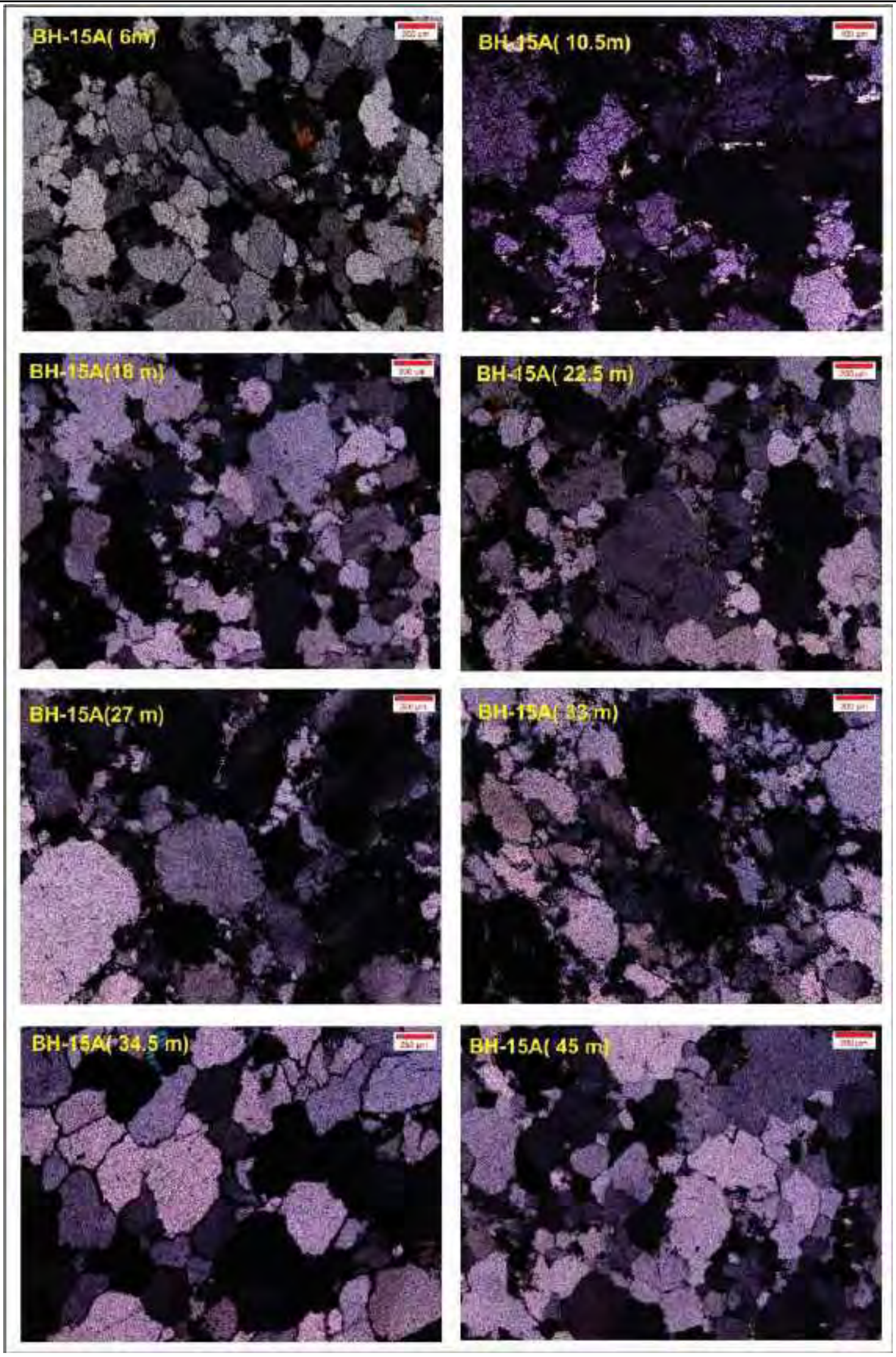


Figure 40: Borehole 15(A) Samples under optical microscope (cross polarized 5X).

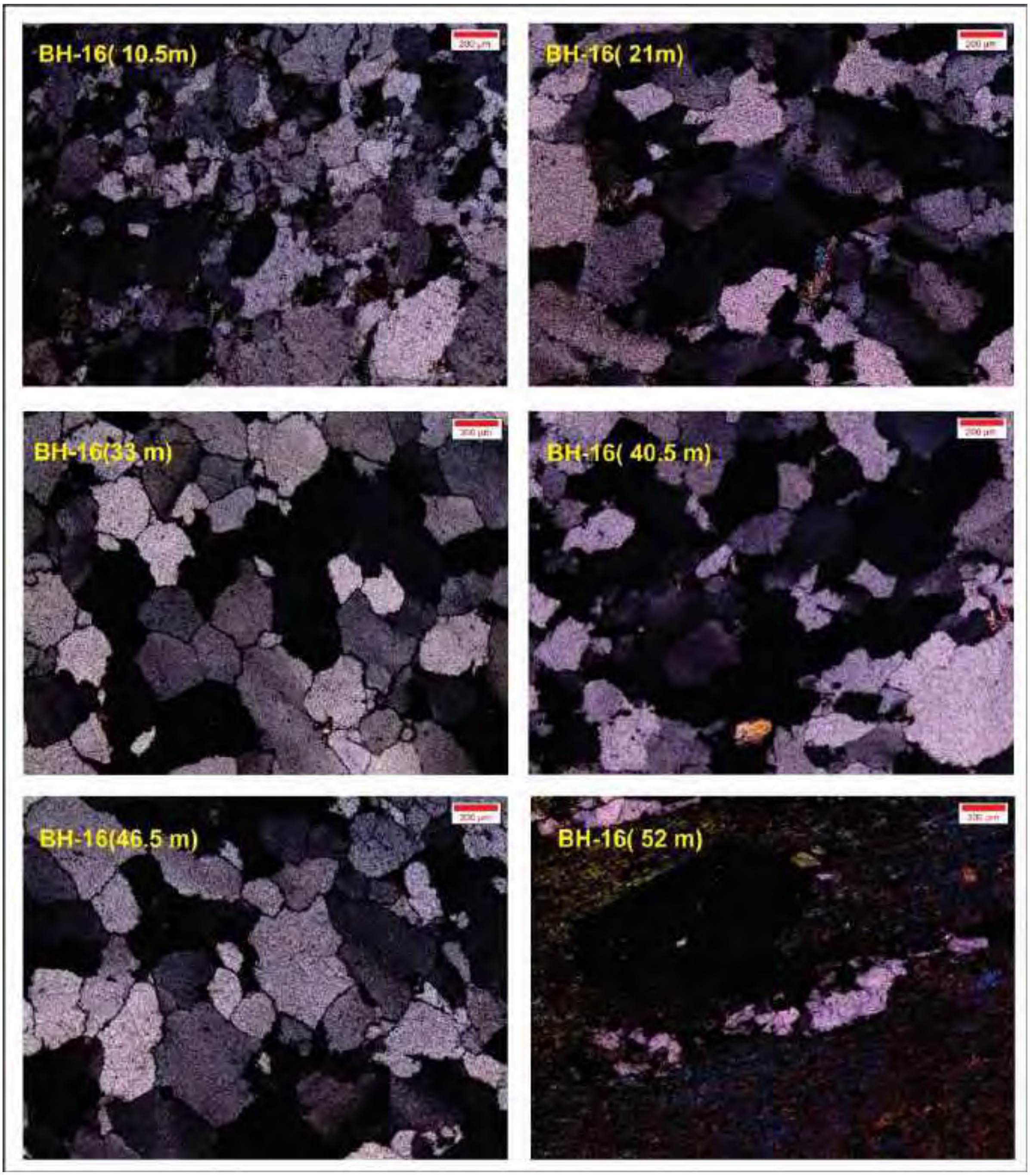


Figure 41: Borehole 16 sample under optical microscope (cross polarized 5X).

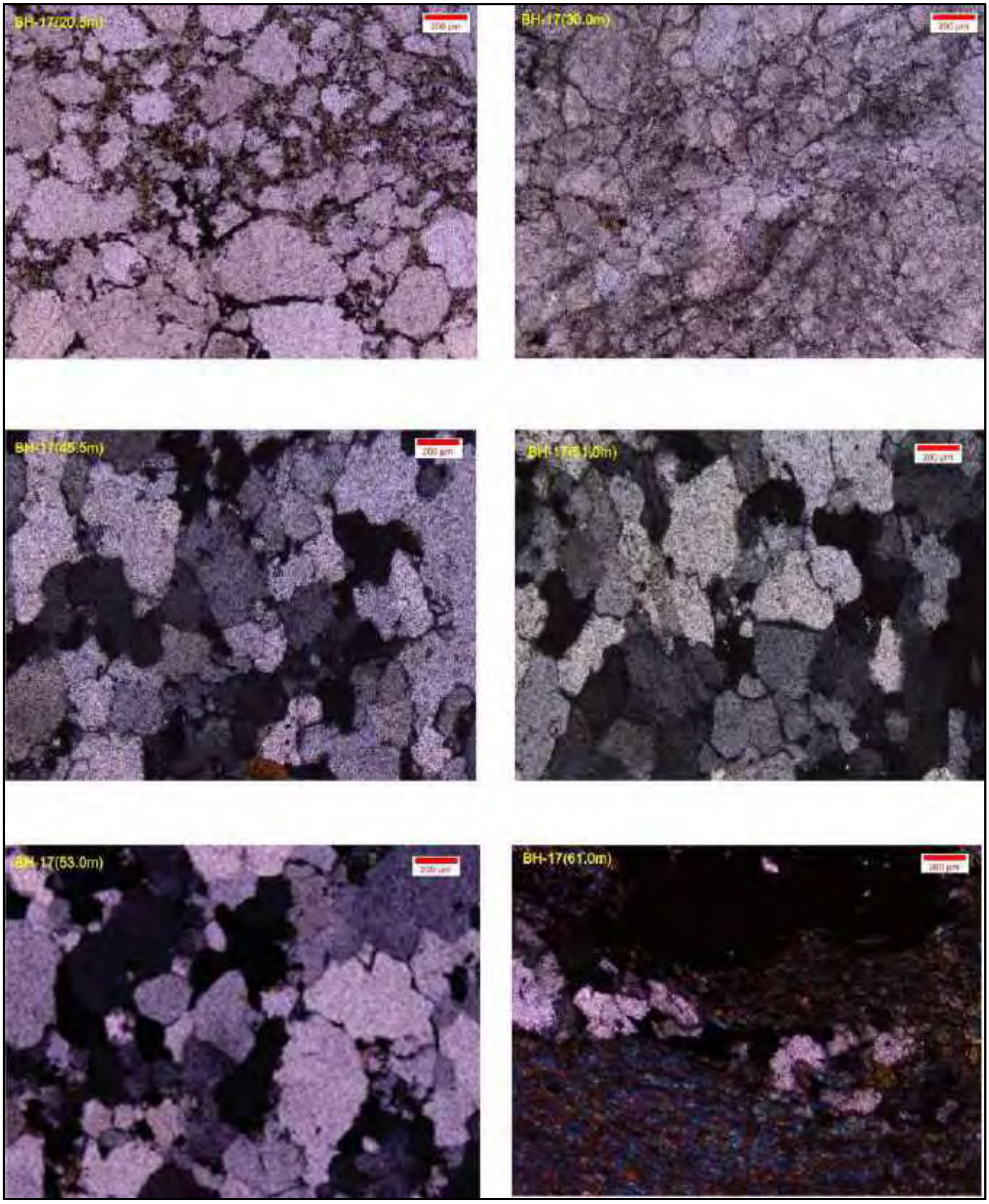


Figure 42: Borehole 17 sample under optical microscope

6.1.11 Grain size analysis

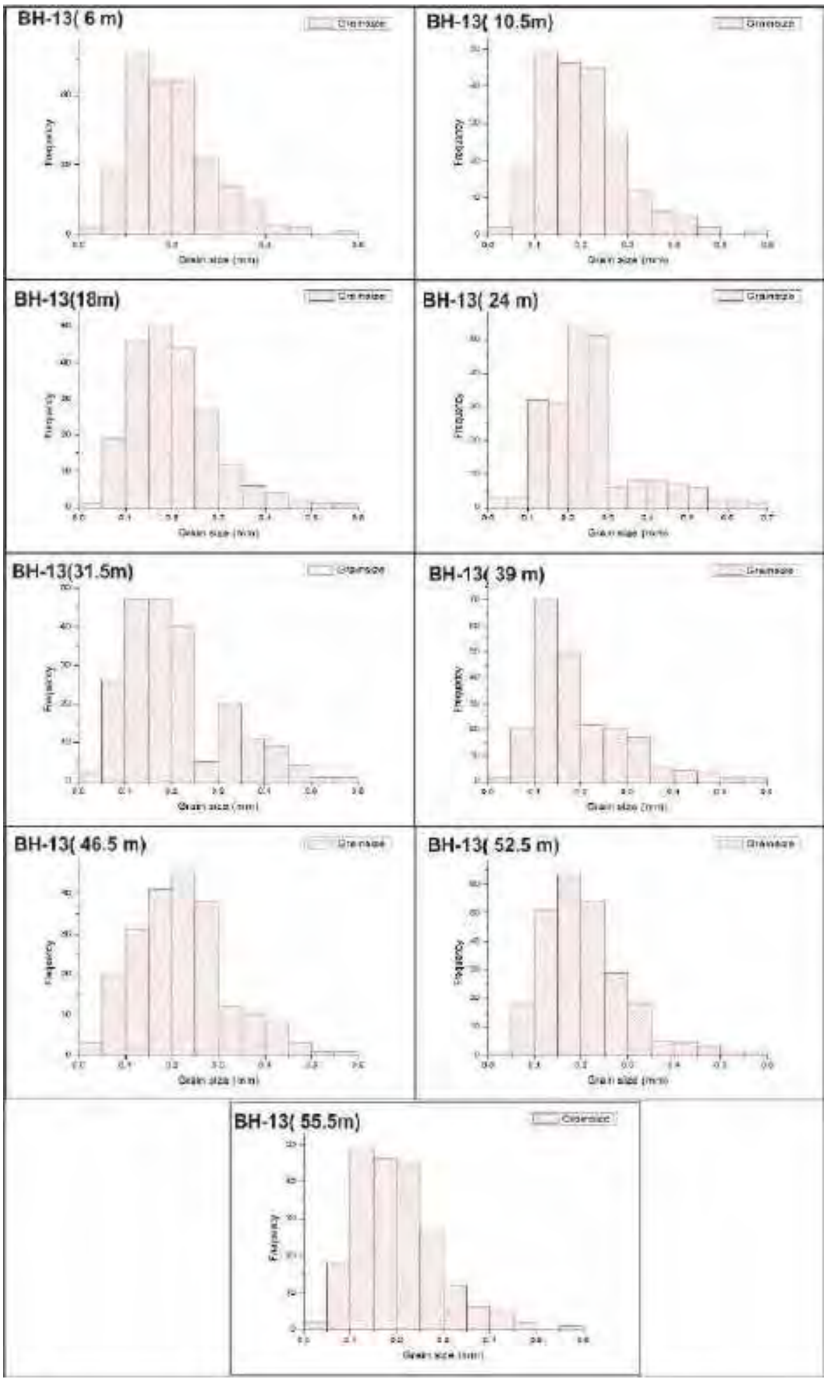


Figure 43: Borehole 13 Grain size analysis histogram.

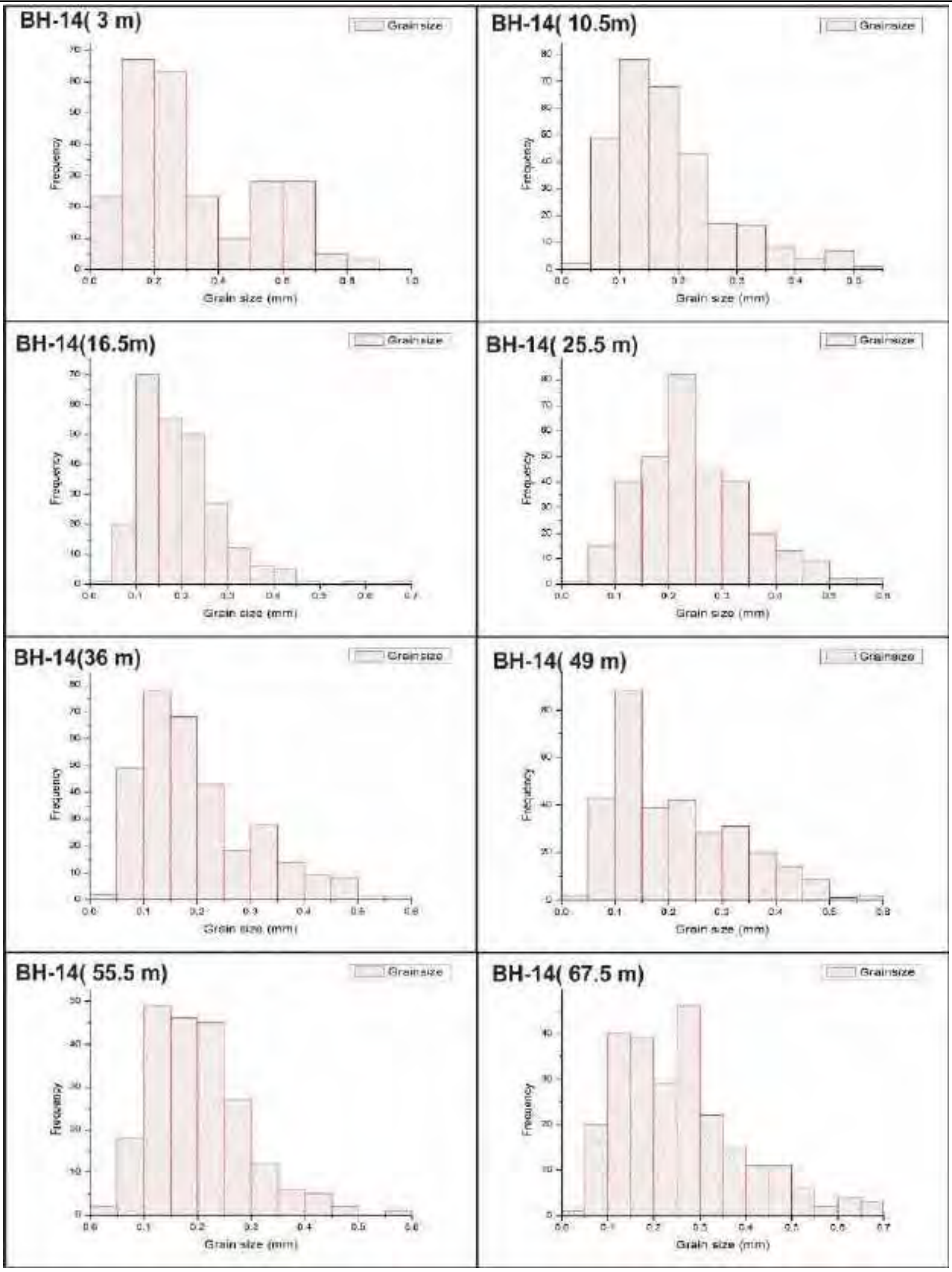


Figure 44: Borehole 14 Grain size analysis histogram

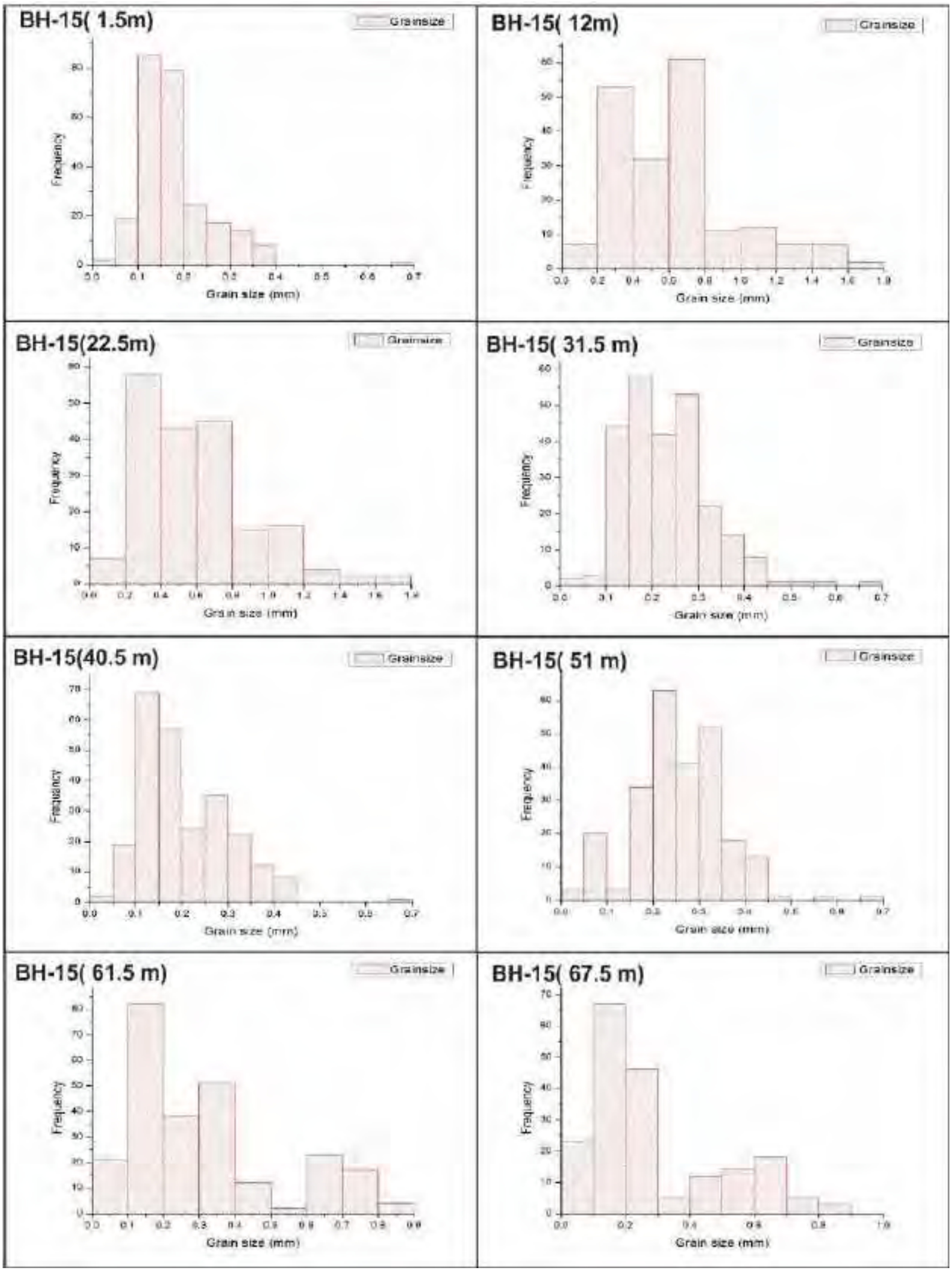


Figure 45: Borehole 15 Grain size analysis histogram

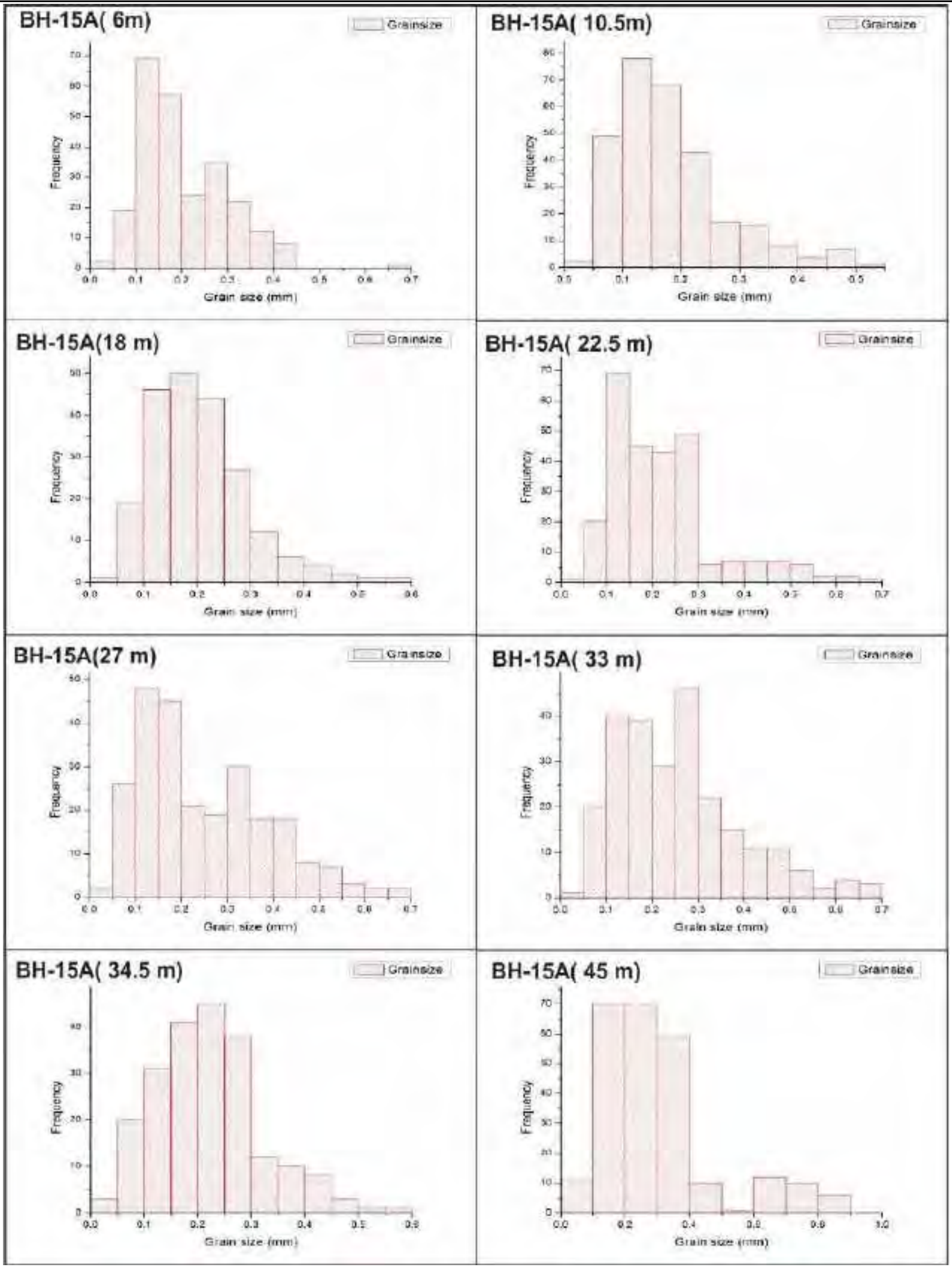


Figure 46: Borehole 15(A) Grain size analysis histogram.

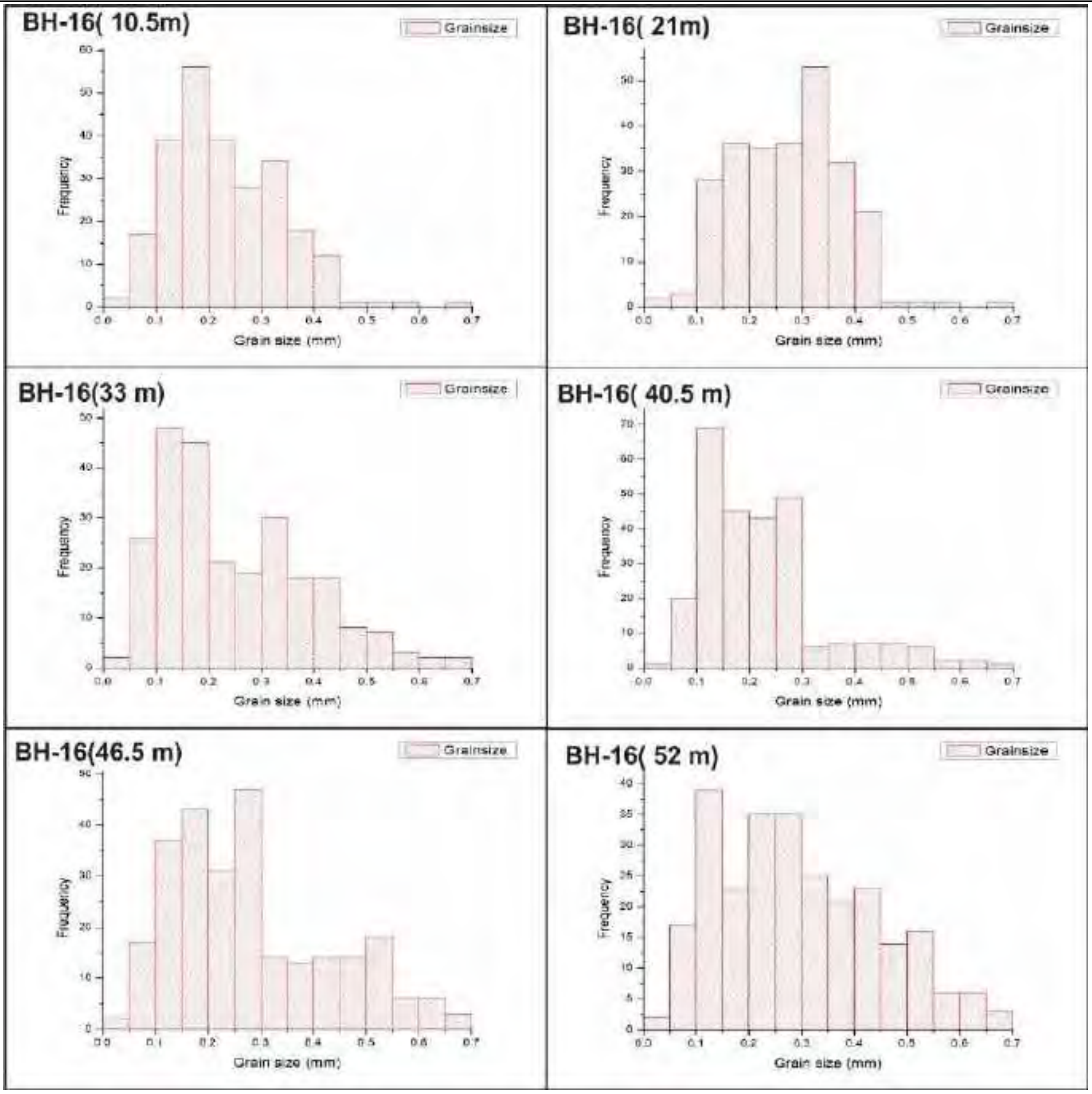


Figure 47: Borehole 16 Grain size analysis histogram.

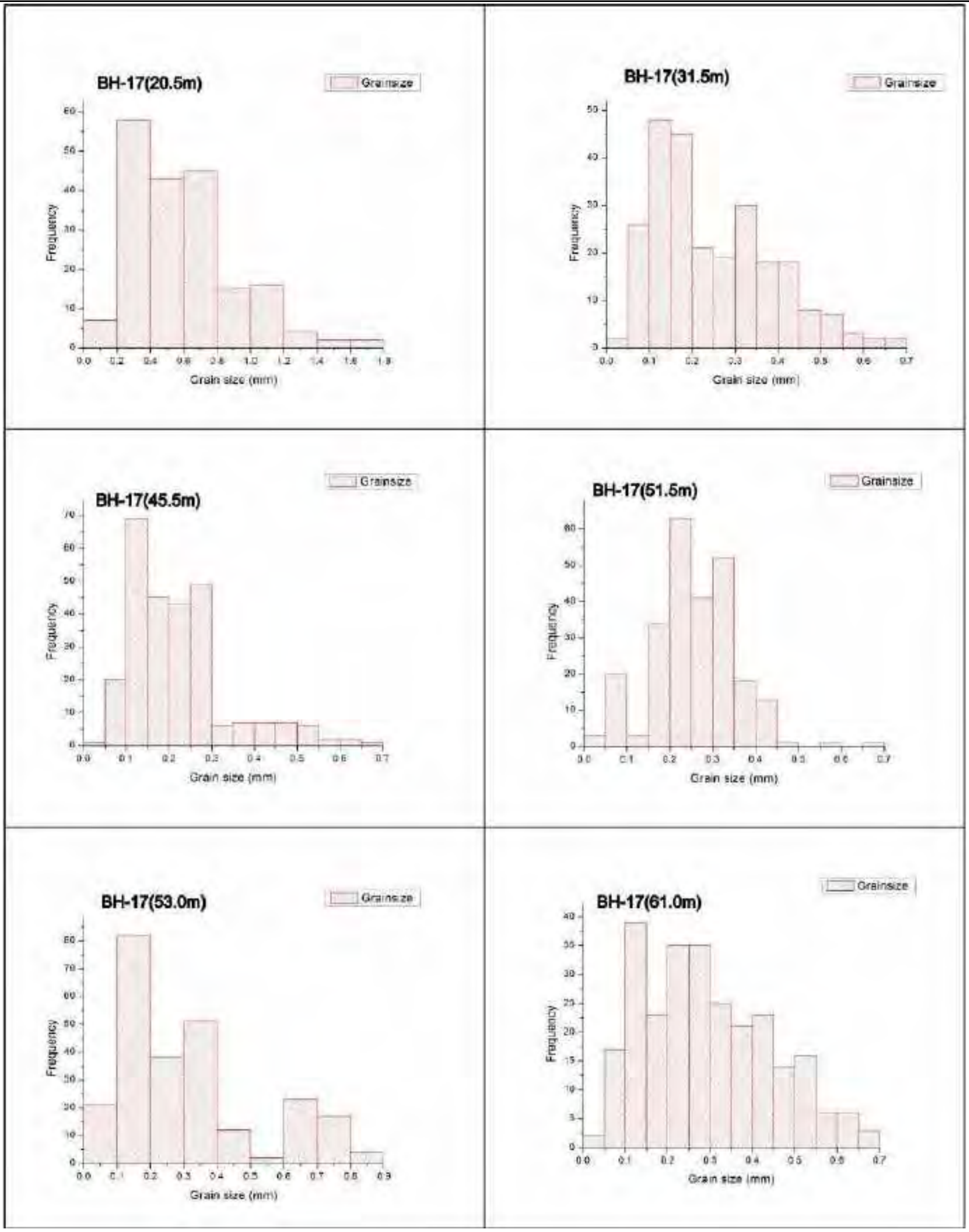


Figure 48: Borehole 17 Grain size analysis histogram.

Table 33: Mean, Median, Mode value of grain size analysis

BH.ID	Depth(m)	Grain size(mm)		
		Mean	Median	Mode
BH13	4.50-6.00	0.199803	0.19	0.12
	9.00-10.50	0.201959	0.193	0.085
	16.50-18.00	0.205468	0.1915	0.129
	22.50-24.00	0.258223	0.241	0.273
	30.00-31.50	0.206205	0.182	0.093
	37.50-39.00	0.16483	0.1515	0.129
	45.00-46.50	0.206281	0.205	0.203
	51.00-52.50	0.212493	0.209	0.273
	54.00-52.50	0.201959	0.205	0.273
BH14	1.50-3.00	0.18256	0.17	0.12
	9.00-10.50	0.2053	0.193	0.128
	15.00-16.50	0.203155	0.183	0.12
	24.00-25.50	0.256	0.239	0.23
	34.50-36.00	0.26	0.23	0.129
	48.00-49.50	0.21	0.25	0.129
	54.00-55.50	0.25	0.26	0.11
	66.00-67.50	0.316289	0.26	0.26
BH15	0-1.5	0.177933	0.16	0.12
	10.50-12.0	0.708647	0.6635	0.203
	21.00-22.50	0.568245	0.436	0.375
	30.00-31.50	0.246856	0.25	0.273
	39.00-40.50	0.203155	0.183	0.12
	49.50-51.00	0.236961	0.23	0.191
	60.00-61.50	0.316289	0.1835	0.12
	66.00-67.50	0.311211	0.246	0.252
BH15A	4.50-6.00	0.201959	0.193	0.1

BH.ID	Depth(m)	Grain size(mm)		
		Mean	Median	Mode
	9.00-10.50	0.203155	0.183	0.12
	16.50-18.00	0.204089	0.2	0.23
	21.00-22.50	0.238725	0.222	0.129
	25.50-27.00	0.25	0.26	0.15
	31.50-33.00	0.213	0.224	0.23
	33.00-34.50	0.246253	0.243	0.222
	43.50-45.00	0.266062	0.2245	0.129
BH16	9.00-10.50	0.204089	0.1915	0.085
	19.50-21.00	0.238725	0.222	0.129
	31.50-33.00	0.219092	0.184	0.093
	39.00-40.50	0.218842	0.197	0.129
	45.00-46.50	0.246253	0.2	0.222
	52.00-53.50	0.316289	0.26	0.16
BH-17	20.50-22.00	0.238725	0.224	0.23
	25.00-26.50	0.21	0.25	0.129
	30.00-31.50	0.2456	0.23	0.191
	45.50-47.00	0.236961	0.23	0.191
	51.50-53.00	0.389	0.286	0.146
	61.00-62.00	0.311211	0.26	0.252

6.1.12 Mineralogical analysis

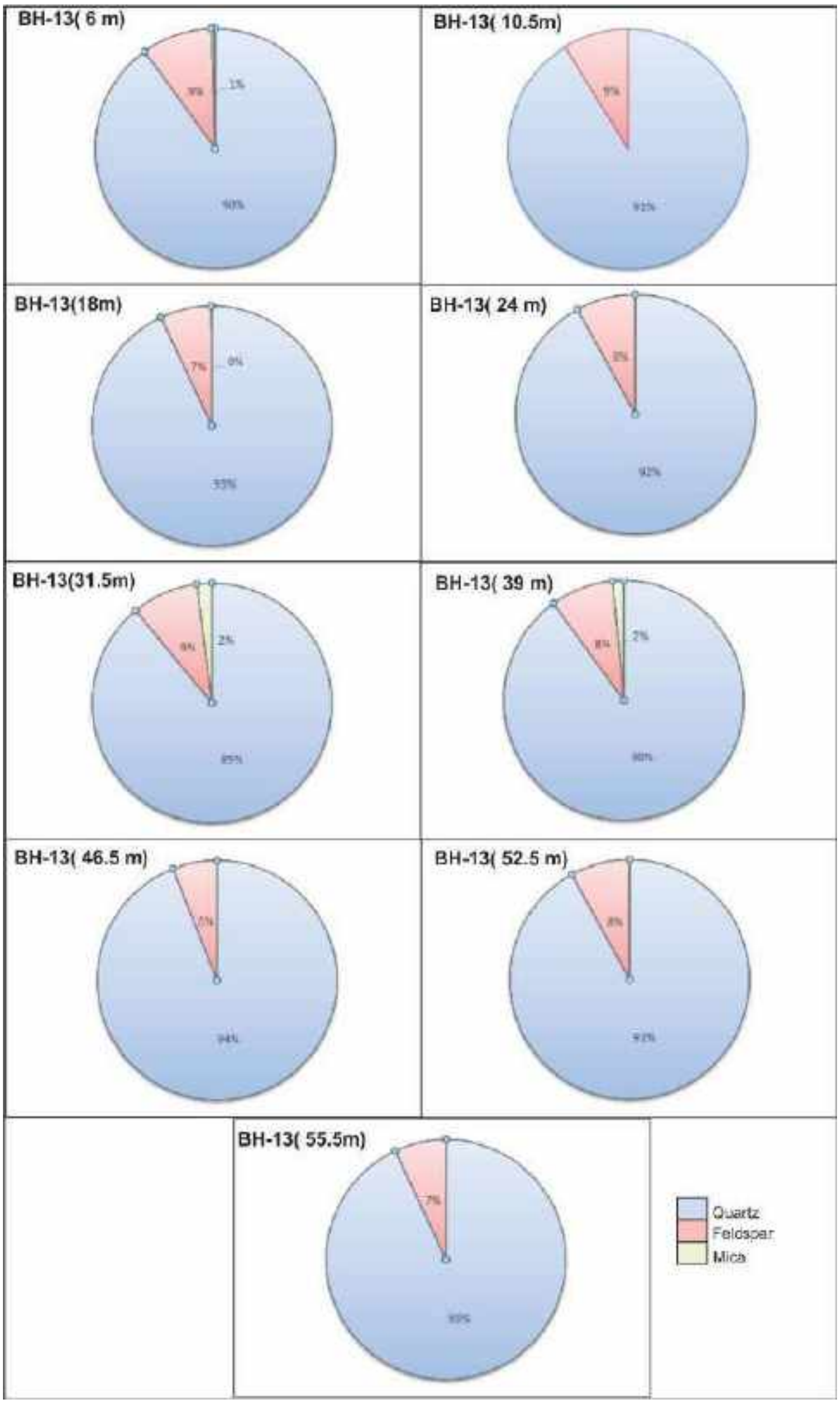


Figure 49: Borehole 13 Mineral percentage

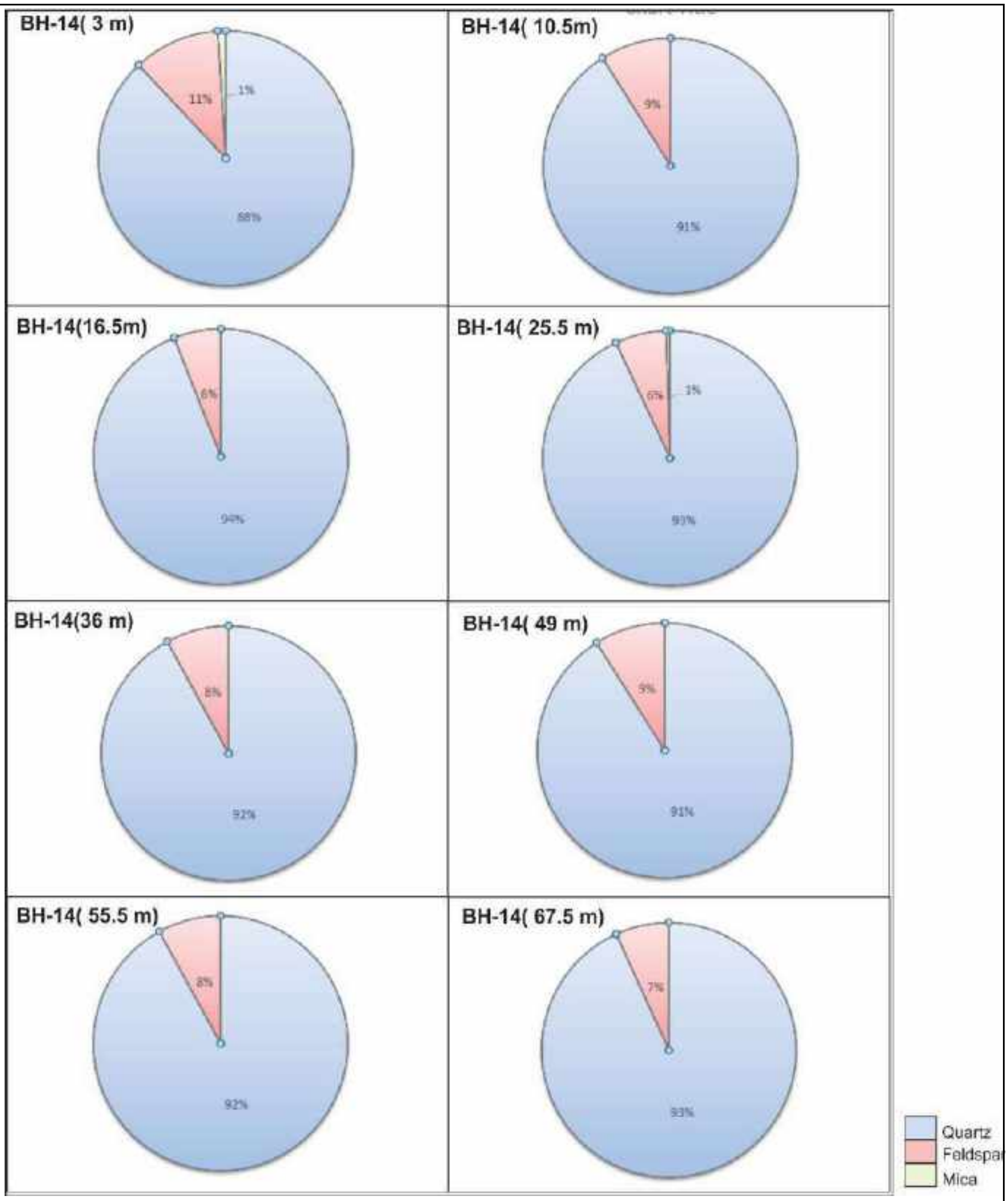


Figure 50: Borehole 14 Mineral percentage.

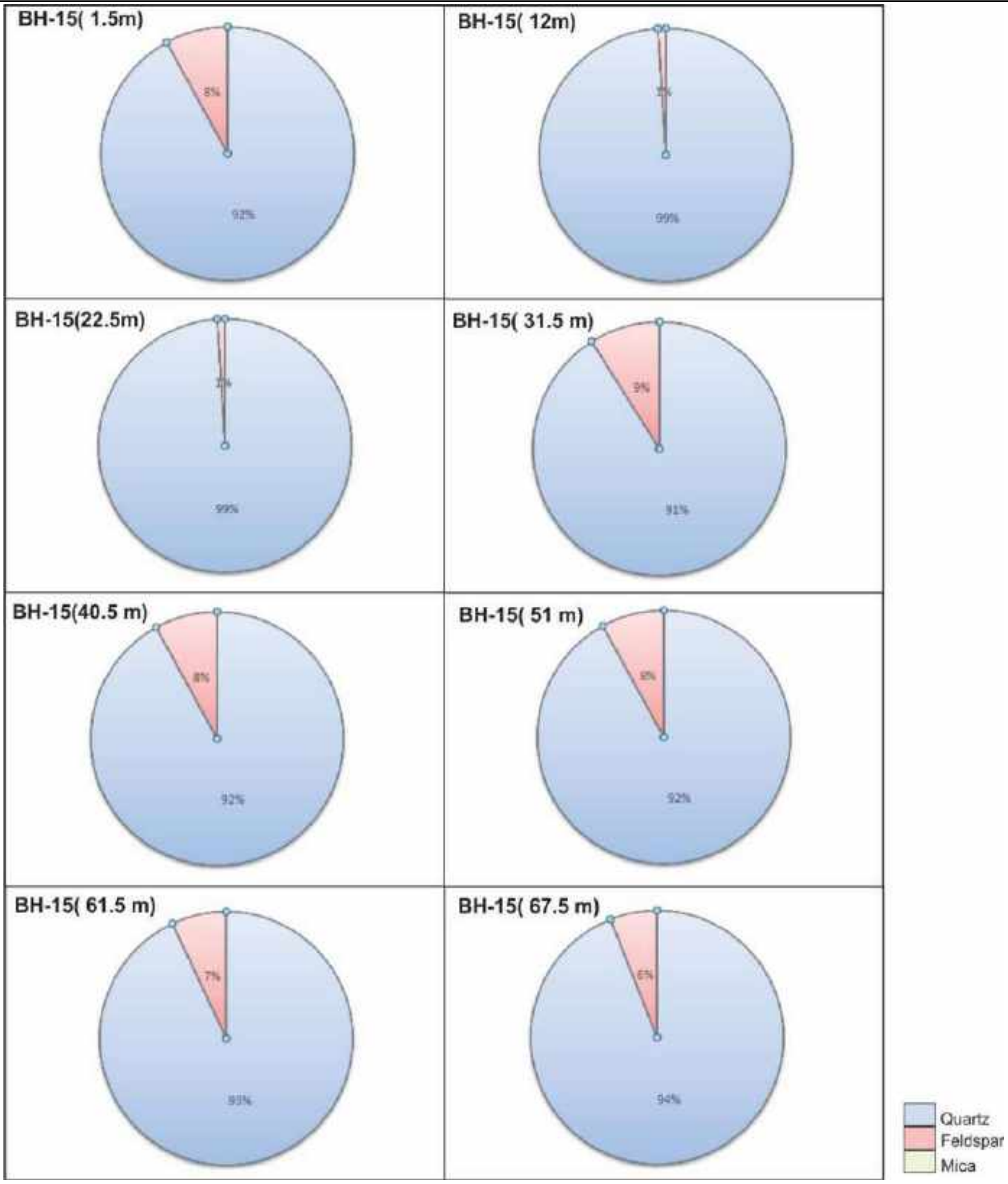


Figure 51: Borehole 15 Mineral percentage.

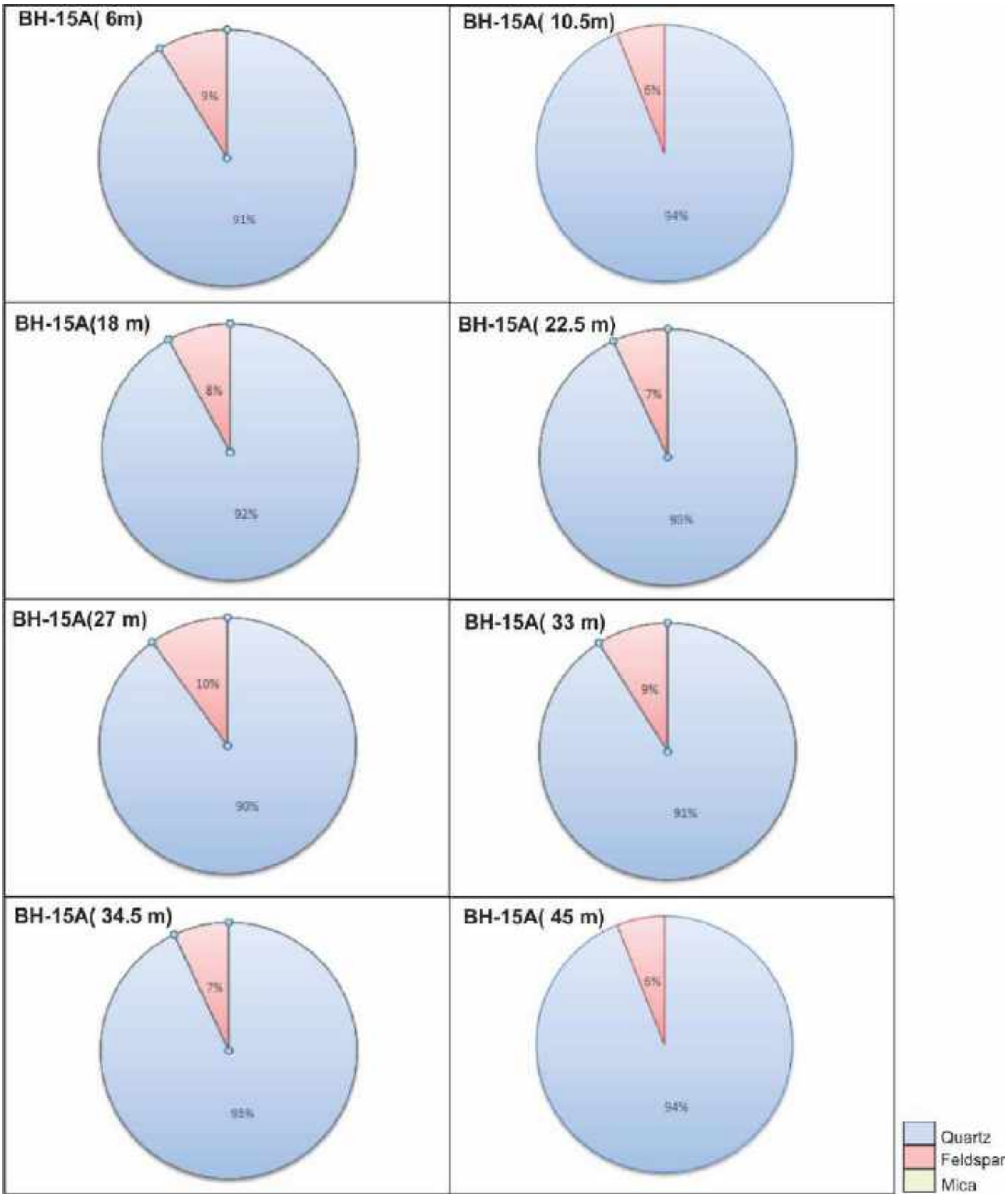


Figure 52: Borehole 15(A) Mineral percentage.

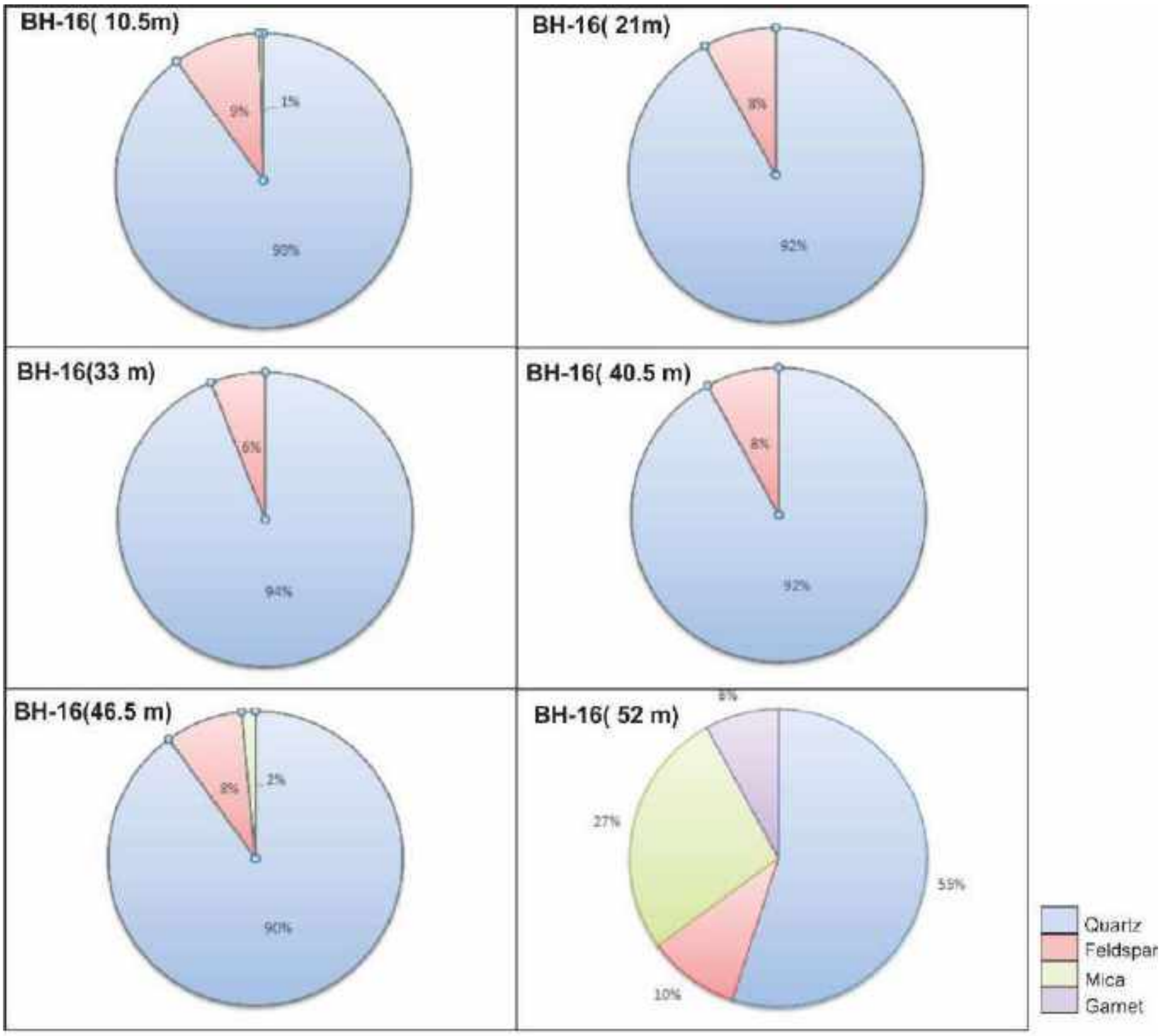


Figure 53: Borehole 16 Mineral percentage.

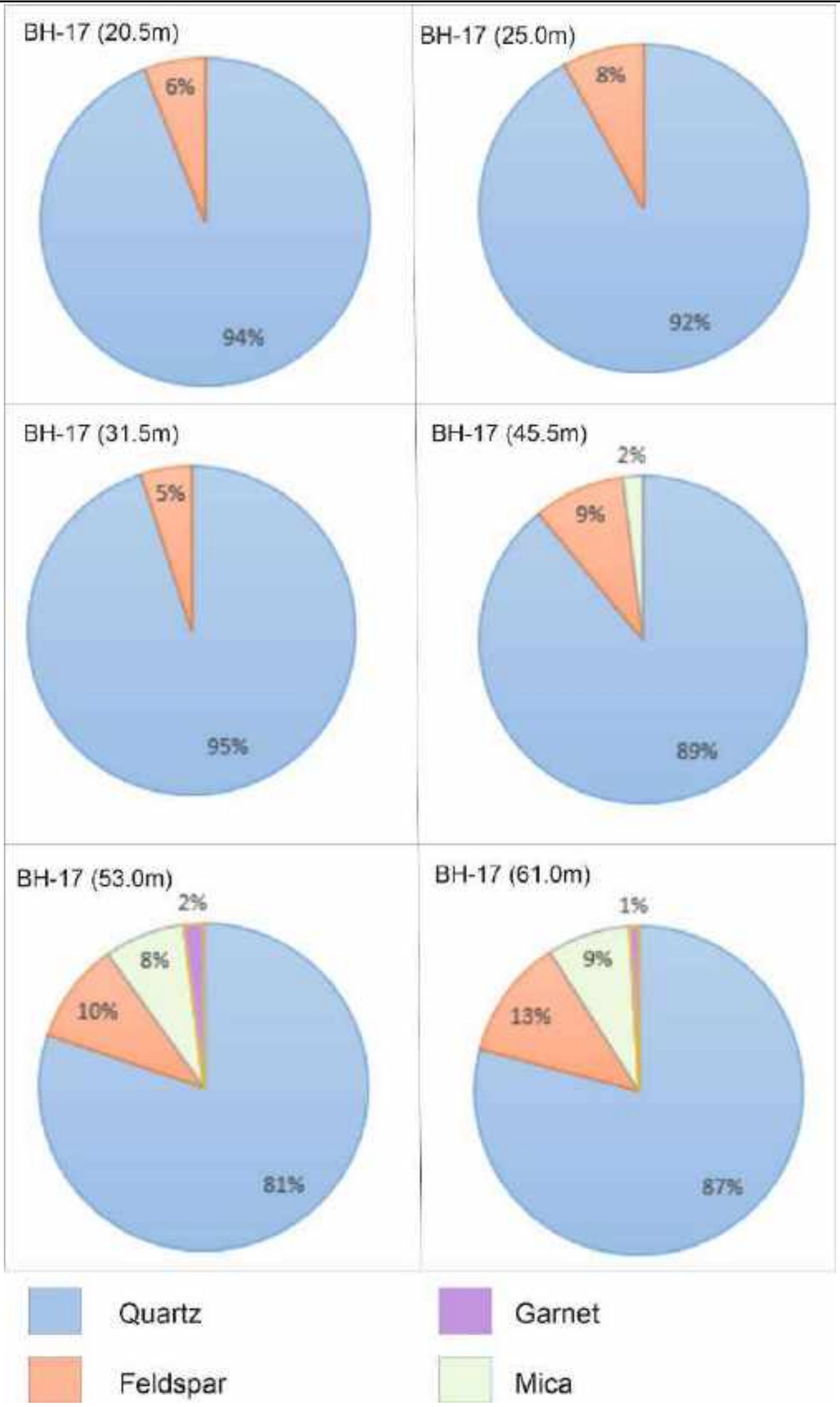


Figure 54: Borehole 17 Mineral percentage.

6.2 Soil Laboratory Test:

Laboratory tests were also carried out on soil samples taken from borehole BH18-BH33, the details of different laboratory tests conducted as part of the project are given in the table below.

Sl. No.	**Laboratory tests**	**IS Codes**
1	Preparation of soil sample	IS: 2720(part-1)-1983 (Reaffirmed 2015)
2	Moisture Content	IS: 2720(part-2)-1973 (Reaffirmed 2015)
3	Specific Gravity	IS: 2720(part-3)(sec-1)-1980 (Reaffirmed 2016)
4	Grain Size Analysis	IS: 2720(part-4)-1985 (Reaffirmed 2015)
5	Atterberg's Limits	IS: 2720(part-5)-1985 (Reaffirmed 2015)
6	Bulk Density	----
7	Triaxial Shear Strength	IS: 2720(part-11)-1993 (Reaffirmed 2016)
8	Direct Shear Strength	IS: 2720(part-13)-1986 (Reaffirmed 2016)
9	Consolidation Test	IS: 2720(part-15)-1986 (Reaffirmed 2016)

6.2.1 Soil Types:

Soil mass encountered along the tunnel alignment has been categorised in two group i.e., 1) Noncohesive Soil comprising Silty Sand (SM) and Inorganic Silt (ML) and 2) Cohesive Soil comprising Inorganic clay (CL).

6.2.2 Cohesion Test:

Cohesion values from all the all kinds of soil are found to 2 group. As shown in Figure 55 CL type soil mass has higher cohesion value (clustered green dots in graph) ranging between 25-35 kPa and other 3 types of soil are comprised of another group with values ranging from 4-12 kPa.

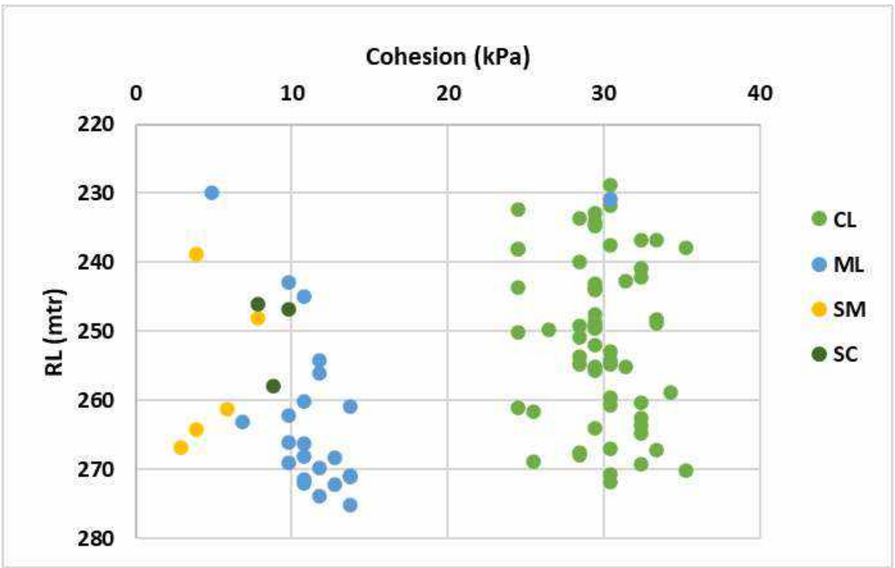


Figure 55: Variation in cohesion value of soil with RL.

Table 34: Summery of cohesion test results for soil.

Soil Types	Minimum Cohesion value	Maximum Cohesion value	Average Cohesion value
CL	23.54 kPa	35.30 kPa	25 kPa
ML	1.96 kPa	18.63 kPa	3 kPa
SC	7.85 kPa	19.61 kPa	3 kPa
SM	1.96 kPa	3.92 kPa	3 kPa

6.2.3 Angle of Internal Friction:

The figure below provides the summarized results of test conducted to determine the angle of internal friction of the soil sample taken from the boreholes.

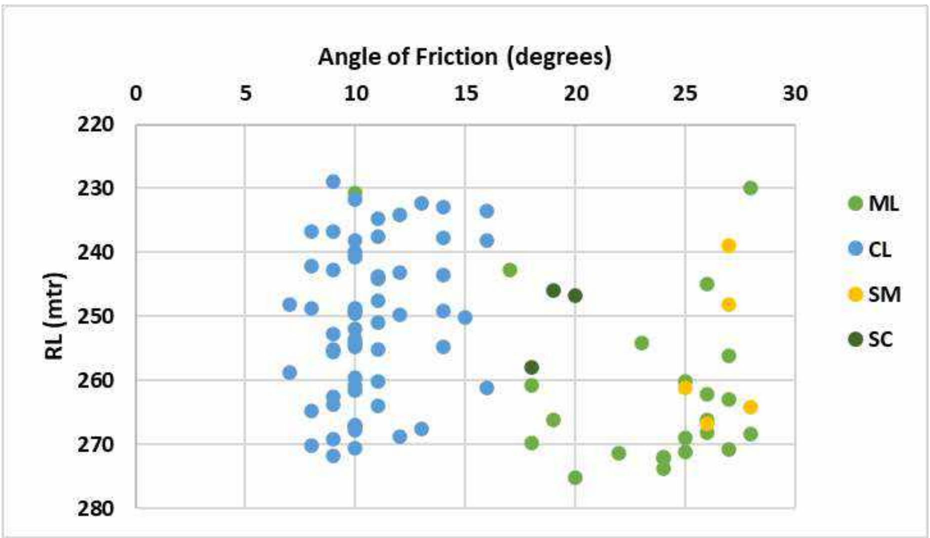


Figure 56: Variation in phi value of soil with RL

Table 35: Summery of angle of internal friction test results for soil.

Soil Types	Minimum Phi value	Maximum Phi value	Average Phi value
CL	9°	16°	12°
ML	28°	36°	32°
SC	29°	34°	32°
SM	29°	32°	32°

6.2.4 Natural Weight:

Density of all kind of soil found to be linearly increasing with depth. The trend of variation with depth is shown below in Figure 57.

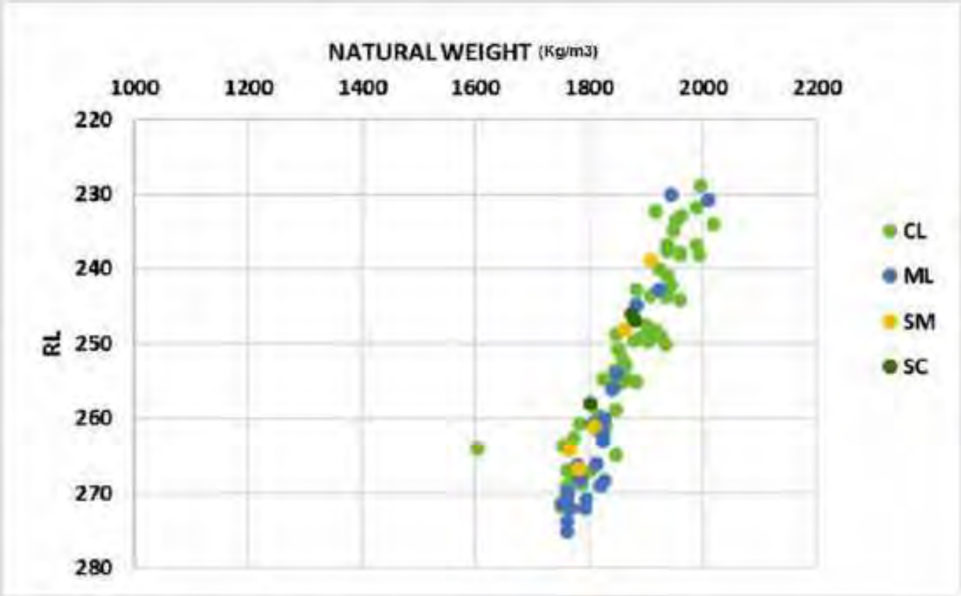


Figure 57: Variation in density value of soil with RL

Table 36: Summery of density test results for soil

Soil Types	Minimum Density value	Maximum Density value	Average Density value
CL	1604 kg/m^3	2018 kg/m^3	1852 kg/m^3
ML	1752 kg/m^3	2009 kg/m^3	1765 kg/m^3
SC	1802 kg/m^3	1879 kg/m^3	1851 kg/m^3
SM	1765 kg/m^3	1906 kg/m^3	1824 kg/m^3

6.2.5 Modulus of Elasticity (E):

The drained modulus (E’) values are determined based on the corrected SPT N value –N_{60} as per CIRIA Report 143 for granular as well as cohesive soils. For cohesive soil– **$E' = 1.2\times N_{60}$ (MPa)**, and for cohesionless soil– **$E' = 1.0\times N_{60}$ (MPa). Modulus of elasticity** was found to be increasing from 10 MPa to 15 MPa with depth up-to first 15 meter from the surface, after which it falls within a constant range of value around 30±1 MPa up-to the floor of the tunnel.

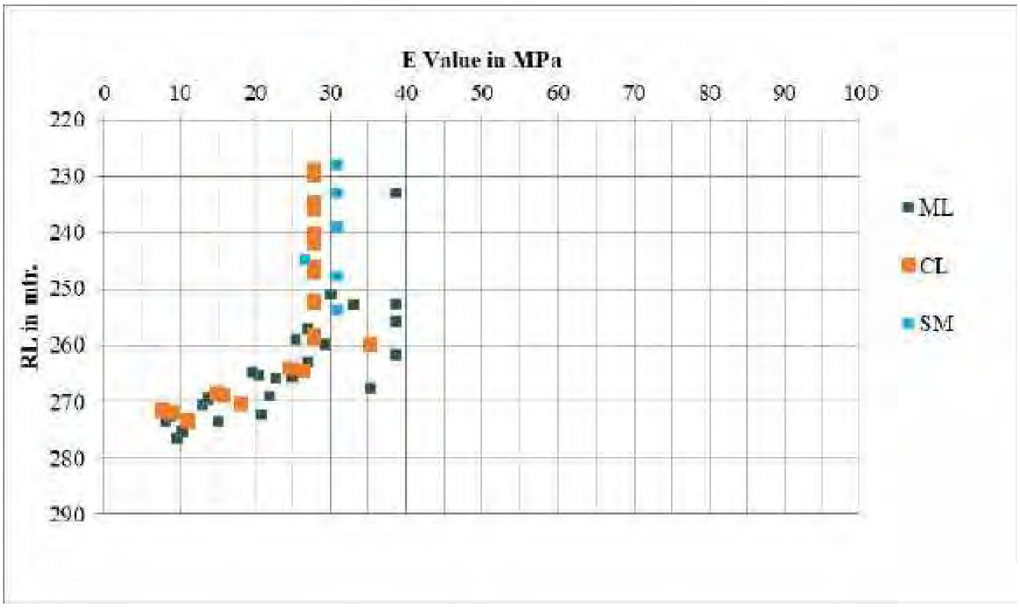


Figure 58: graph for Modulus of elasticity for soil vs RL.

Table 37: Summery of Modulus of E values for soil

Soil Types	Minimum E value	Maximum E value	Average E value
CL	7.64 MPa	35.19 MPa	24.10 MPa
ML	6.94 MPa	38.58 MPa	24.67 MPa
SM	26.54 MPa	30.87 MPa	30.14 MPa

7 CHAPTER: SUMMARY

The Geotechnical investigation is an integral part of the assessment of subsurface strata conditions before the commencement of underground excavation and design methodology. For this purpose, 20 nos. of bore holes (BH-13 to BH-33) were drilled at the site covering the entire area. The bore holes were planned in such a way to intersect the proposed tunnel layouts throughout its proposed alignment. Geological mapping has been carried out based on the surface exposure of different rock types. The attitude (strike and dip) of these different formations were measured in the field at appropriate places.

7.1 Structure

Based on the available surface information and close observation of the drilled cores from the litho-logs, it has been observed that after crossing the soil the tunnel will enter into a folded rock mass where the axis of the tunnel will be perpendicular to the fold axis, thus favourably oriented with respect to the folded bedding planes. However, the folded rock layer has suffered extreme level of later brittle fracturing, which has been testified by the presence of 6 sets of joints of different orientation and a few late brittle discrete shear zones (which is certainly not active in nature). These joints and the fractures have significantly reduced the strength of the otherwise sufficiently cohesive metamorphic rock mass.

7.2 Lithology

Out of 4.26 km length of the tunnel it was found that 1.1 km of tunnel will be within the quartzite rock mass of Delhi Supergroup and rest of the 3.16 km will run through soil.

7.2.1 Rock Mass

The rock core samples extracted from the drilled holes, at regular intervals along depth, were utilized for the estimation of strength parameters, rock mass characterization, basic support design, and prediction of envisaged strata conditions. The testing of cores for the determination of strength properties performed at NABL recognized laboratories. The tests include uniaxial compressive test, triaxial strength test, tensile strength, permeability, porosity, Point Load strength index, hardness, abrasiveness, petrographic analysis. The test results regarding the engineering properties for the rock mass are given in Annexures.

7.2.2 Soil

Geotechnical Investigation were carried out by drilling 15 no of boreholes i.e., BH No-18 to 33. The subsoil predominantly consists of silt of low plasticity to clay of low plasticity. The ranges of engineering properties such as, cohesive strength, phi value, natural weight, Modulus of elasticity for **CL** type soil is 23.54-35.30 kPa, 9°-16°, 1604-2018 kg/m3, 7.64 MPa; for **ML** type Soil is 1.96-18.36 kPa, 28°-36°, 1752-2009 kg/m3, 6,94-38.58 MPa; for **SM** type soil is 1.96-3.92 kPa, 29°-32°, 1765-1906 kg/m3, 26.54-30.87 MPa respectively

7.3 Hydrogeological Conditions

None of the boreholes reached the ground water table. Therefore, based on the preliminary survey, it can be predicted that the tunnel will not face any difficulty due to encounter of ground water table during the construction. However, the overlying rock strata having significant nos. of joint set is quite capable of percolating rain waters during the rainy seasons. There is also a ditch around CH 24800, which is situated almost 31.87m above the roof of the tunnel. This ditch may be connected to a perched water table with a limited water resource. The joint sets and the ditch could act as efficient path ways of rainwater recharge into the tunnel during the rainy season. Therefore, it is recommended that suitable drainage system should be designed along with the tunnel to drain out that percolated water to avoid water logging during and after the construction of the tunnel.

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9 ANNEXURES

ANNEXURE –A
Geological Log, RQD, Q value

BH No.	**Chainage No.**	**Ground Elevation, RL (m)**	**Total Depth (m)**
BH-13	25000	276.867	60
BH-14	25195	294.218	75
BH-15	25380	295.532	70
BH-15A	25488	276.442	50
BH-16	25586	287.324	62
BH-17	25785	282.461	62
BH-18	25990	280.253	55
BH-19	26210	278.116	50
BH-20	26387	276.795	48
BH-21	26587	274.993	45
BH-22	26787	274.321	45
BH-23	26980	274.85	45
BH-24	27187	274.075	40
BH-25	27410	273.565	40
BH-26	27550	273.112	35
BH-27	28050	272.210	30
BH-28	28350	272.799	45
BH-29	28550	269.964	30
BH-30	28750	270.808	45
BH-31	29050	267.159	20
BH-32	29550	266.684	30
BH-33	30125	265.581	20

project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**13**	**LONGITUDE**	**77°2'41.397"E**	**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25000**	**LATTITUDE**	**28°12'25.991"N**	**TOTAL DEPTH:**	**60m**		
START DATE	**25-08-2021**	**GROUND ELEVATION MSL :**	**276.867**	**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**06-09-2021**	**ANGLE WITH HORIZONT: 90^{0}**		**DEPTH OF WATER TABLE**	**Not Found**	**CASING**	**NX up to 3.0 m**
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**		**WATER TABLE RECORD DATE**	**07-09-2021**		
				NAME OF GEOLOGIST	**Gaurav Chunekar**		

Bh-13; Total Depth 60m

Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
280	0	1.5	Slightly Weathered, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	18	0	33	CLASS 3(FAIR ROCK)	0.00-1.50	Core Rock	1.5
278	1.5	3	Slightly Weathered,Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Moderately Fractured and Jointed	28.6	0	33	CLASS 3(FAIR ROCK)	1.50-3.00	Core Rock	1.5

Bh-13; Total Depth 60m											
Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
277	3	4.5	Slightly Weathered, Light Grey to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	44.6	0	33	CLASS 3(FAIR ROCK)	3.00-4.50	Core Rock	6.69
275	4.5	6	Highly Weathered, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	21.33	0	31	CLASS 3(FAIR ROCK)	4.50-6.00	Core Rock	3.1995
274	6	7.5	Slightly Weathered, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	25.33	10	35	CLASS 3(FAIR ROCK)	6.00-7.50	Core Rock	3.7995
272	7.5	9	Highly Weathered, Highly Fractured, Highly Jointed, White to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	37.33	0	31	CLASS 3(FAIR ROCK)	7.50-9.00	Core Rock	5.5995
271	9	11		Highly Fractured and Jointed	34	0	31	CLASS 3(FAIR ROCK)	9.00-10.50	Core Rock	5.1

Bh-13; Total Depth 60m

Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
269	11	12	Moderately Weathered, Highly Fractured, Highly Jointed, Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	28	17	33	CLASS 3(FAIR ROCK)	10.50-12.00	Core Rock	4.2
268	12	14	Highly Weathered, White to Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	21.33	0	33	CLASS 3(FAIR ROCK)	12.00-13.50	Core Rock	3.1995
266	14	15		Highly Fractured and Jointed	34	0	35	CLASS 3(FAIR ROCK)	13.50-15.00	Core Rock	5.1
265	15	17	Slightly Weathered, Reddish Brown to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	32	0	35	CLASS 3(FAIR ROCK)	15.00-16.50	Core Rock	4.2
263	17	18	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	32.85	0	35	CLASS 3(FAIR ROCK)	16.50-18.00	Core Rock	3.1995
262	18	20	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron	Highly Fractured and Jointed	30	9	35	CLASS 3(FAIR ROCK)	18.00-19.50	Core Rock	5.1

Bh-13; Total Depth 60m

Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
260	20	21	Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	39.33	0	35	CLASS 3(FAIR ROCK)	19.50-21.00	Core Rock	4.8
259	21	23		Highly Fractured and Jointed	33.33	0	35	CLASS 3(FAIR ROCK)	21.00-22.50	Core Rock	4.9275
257	23	24		Highly Fractured and Jointed	39.33	0	38	CLASS 3(FAIR ROCK)	22.50-24.00	Core Rock	4.5
256	24	26	Slightly Weathered,Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	28.66	9	38	CLASS 3(FAIR ROCK)	24.00-25.50	Core Rock	5.8995
254	26	27		Highly Fractured and Jointed	34	18	38	CLASS 3(FAIR ROCK)	25.50-27.00	Core Rock	4.9995
253	27	29		Highly Fractured and Jointed	34	24	38	CLASS 3(FAIR ROCK)	27.00-28.50	Core Rock	5.8995
251	29	30		Highly Fractured and Jointed	40	20	38	CLASS 3(FAIR ROCK)	28.50-30.00	Core Rock	4.299
250	30	32		Highly Fractured and Jointed	31.33	0	35	CLASS 3(FAIR ROCK)	30.00-31.50	Core Rock	5.1

Bh-13; Total Depth 60m

Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
248	32	33		Highly Fractured and Jointed	33.33	9	35	CLASS 3(FAIR ROCK)	31.50-33.00	Core Rock	5.1
247	33	35		Highly Fractured and Jointed	24	11	35	CLASS 3(FAIR ROCK)	33.00-34.50	Core Rock	6
245	35	36	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	35.33	8	35	CLASS 3(FAIR ROCK)	34.50-36.00	Core Rock	4.6995
244	36	38		Highly Fractured and Jointed	32.6	8	35	CLASS 3(FAIR ROCK)	36.00-37.50	Core Rock	4.9995
242	38	39	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	26.66	0	35	CLASS 3(FAIR ROCK)	37.50-39.00	Core Rock	3.6
241	39	41		Highly Fractured and Jointed	32	9	35	CLASS 3(FAIR ROCK)	39.00-40.50	Core Rock	5.2995
239	41	42		Highly Fractured and Jointed	43.33	9	35	CLASS 3(FAIR ROCK)	40.50-42.00	Core Rock	4.89
238	42	44		Highly Fractured and Jointed	26	8	35	CLASS 3(FAIR ROCK)	42.00-43.50	Core Rock	3.999

Bh-13; Total Depth 60m

Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
236	44	45	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	33.33	16	35	CLASS 3(FAIR ROCK)	43.50-45.00	Core Rock	4.8
235	45	47		Highly Fractured and Jointed	30	0	35	CLASS 3(FAIR ROCK)	45.00-46.50	Core Rock	6.4995
233	47	48		Highly Fractured and Jointed	22.66	19	35	CLASS 3(FAIR ROCK)	46.50-48.00	Core Rock	3.9
232	48	50		Highly Fractured and Jointed	34	29	40	CLASS 3(FAIR ROCK)	48.00-49.50	Core Rock	4.9995
230	50	51		Highly Fractured and Jointed	27.33	0	35	CLASS 3(FAIR ROCK)	49.50-51.00	Core Rock	4.5
229	51	53		Highly Fractured and Jointed	26	0	35	CLASS 3(FAIR ROCK)	51.00-52.50	Core Rock	3.399
227	53	54		Highly Fractured and Jointed	34	0	35	CLASS 3(FAIR ROCK)	52.50-54.00	Core Rock	5.1
226	54	56		Highly Fractured and Jointed	34	0	35	CLASS 3(FAIR ROCK)	54.00-55.50	Core Rock	4.0995

Bh-13; Total Depth 60m											
Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
224	56	57	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	26.66	9	35	CLASS 3(FAIR ROCK)	55.50-57.00	Core Rock	3.9
223	57	59		Highly Fractured and Jointed	28	8	35	CLASS 3(FAIR ROCK)	57.00-58.50	Core Rock	5.1
221	59	60		Highly Fractured and Jointed	22	13	35	CLASS 3(FAIR ROCK)	58.50-60.00	Core Rock	5.1

Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**14**	**LONGITUDE**	**77°2'37.427"E**		**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25195**	**LATTITUDE**	**28°12'31.483"N**		**TOTAL DEPTH:**	**75m**		
START DATE	**11-08-2021**	**GROUND ELEVATION MSL :**	**294.218**		**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**23-08-2021**	**ANGLE WITH HORIZONT: 90°**			**DEPTH OF WATER TABLE**	**Not found**	**CASING**	**NX up to 3.0 m**
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**			**WATER TABLE RECORD DATE**	**24-08-2021**		
					NAME OF GEOLOGIST	**Gaurav Chunekar**		

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
294.218	0.0	1.5	Moderately Weathered, , Light Grey, Fine Grained, Interlocking Texture, Iron Leaching , Very Hard Quartzite	Highly Fractured and Jointed	30	0	33	CLASS 3(FAIR ROCK)	0.00-1.50	Core Rock	1.5
292.718	1.5	3.0		Highly Fractured and Jointed	48	0	33	CLASS 3(FAIR ROCK)	1.50-3.00	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
291.218	3.0	4.5	Highly Weathered Light Grey, Fine Grained, Interlocking Texture, Iron Leaching , Very Hard Quartzite	Moderately Fractured and Jointed	38	0	33	CLASS 3(FAIR ROCK)	3.00-4.50	Core Rock	1.5
289.718	4.5	6.0	Quartz vein Slightly Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching , Very Hard Quartzite	Highly Fractured and Jointed	66	24	33	CLASS 3(FAIR ROCK)	4.50-6.00	Core Rock	3.6
288.218	6.0	7.5	Highly Weathered Light Grey, Fine Grained, Interlocking Texture, Iron Leaching , Very Hard Quartzite	Moderatley Fractured and Jointed	45	0	35	CLASS 3(FAIR ROCK)	6.00-7.50	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
286.718	7.5	9.0	Slightly Weatherd, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (fine grain muscovite)	Highly Fractured and Jointed	50	18	35	CLASS 3(FAIR ROCK)	7.50-9.00	Core Rock	2.7
285.218	9.0	10.5	Slightly to Moderately Weatherd, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Moderately Fractured and Jointed	51	0	33	CLASS 3(FAIR ROCK)	9.00-10.50	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
283.718	10.5	12.0	Moderately Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	40	21	38	CLASS 3(FAIR ROCK)	10.50-12.00	Core Rock	3.15
282.218	12.0	13.5		Highly Fractured and Jointed	34	15	33	CLASS 3(FAIR ROCK)	12.00-13.50	Core Rock	2.25
280.718	13.5	15.0		Highly Fractured and Jointed	21	0	31	CLASS 3(FAIR ROCK)	13.50-15.00	Core Rock	1.5
279.218	15.0	16.5		Highly Fractured and Jointed	29	0	31	CLASS 3(FAIR ROCK)	15.00-16.50	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
277.718	16.5	18.0	Moderately Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	28	9	31	CLASS 3(FAIR ROCK)	16.50-18.00	Core Rock	1.5
276.218	18.0	19.5	Slightly Weathered, Light Grey, Fine Grained, Interlocking Texture,	Highly Fractured and Jointed	34	6	35	CLASS 3(FAIR ROCK)	18.00-19.50	Core Rock	1.5
274.718	19.5	21.0		Highly Fractured and Jointed	23	0	35	CLASS 3(FAIR ROCK)	19.50-21.00	Core Rock	1.5
273.218	21.0	22.5		Highly Fractured and Jointed	28	13	35	CLASS 3(FAIR ROCK)	21.00-22.50	Core Rock	1.95

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
271.718	22.5	24.0	Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	23	6	35	CLASS 3(FAIR ROCK)	22.50-24.00	Core Rock	1.5
270.218	24.0	25.5		Highly Fractured and Jointed	20	0	35	CLASS 3(FAIR ROCK)	24.00-25.50	Core Rock	1.5
268.718	25.5	27.0		Highly Fractured and Jointed	25	9	35	CLASS 3(FAIR ROCK)	25.50-27.00	Core Rock	1.5
267.218	27.0	28.5		Highly Fractured and Jointed	28	0	38	CLASS 3(FAIR ROCK)	27.00-28.50	Core Rock	1.5
265.718	28.5	30.0		Highly Fractured and Jointed	25	18	35	CLASS 3(FAIR ROCK)	28.50-30.00	Core Rock	2.7
264.218	30.0	31.5	Slightly Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	28	14	35	CLASS 3(FAIR ROCK)	30.00-31.50	Core Rock	2.1

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
262.718	31.5	33.0	Moderately Weathered, , Gery, Fine Grained, Interlocking Texture, Iron Leaching , Very Hard Quartzite	Moderately Fractured and Jointed	28	18	33	CLASS 3(FAIR ROCK)	31.50-33.00	Core Rock	2.7
261.218	33.0	34.5	Moderately Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching , Very Hard Quartzite	Highly Fractured and Jointed	22	6	31	CLASS 3(FAIR ROCK)	33.00-34.50	Core Rock	1.5
259.718	34.5	36.0		Highly Fractured and Jointed	25	0	31	CLASS 3(FAIR ROCK)	34.50-36.00	Core Rock	1.5
258.218	36.0	37.5		Highly Fractured and Jointed	29	10	31	CLASS 3(FAIR ROCK)	36.00-37.50	Core Rock	1.5
256.718	37.5	39.0		Highly Fractured and Jointed	28	7	31	CLASS 3(FAIR ROCK)	37.50-39.00	Core Rock	1.5
255.218	39.0	40.5		Highly Fractured and Jointed	30	0	31	CLASS 3(FAIR ROCK)	39.00-40.50	Core Rock	1.5
253.718	40.5	42.0	Moderately	Highly Fractured and Jointed	28	7	31	CLASS 3(FAIR ROCK)	40.50-42.00	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
252.218	42.0	43.5	Weathered, Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	25	0	35	CLASS 3(FAIR ROCK)	42.00-43.50	Core Rock	1.5
250.718	43.5	45.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	26	6	35	CLASS 3(FAIR ROCK)	43.50-45.00	Core Rock	1.5
249.218	45.0	46.5		Highly Fractured and Jointed	24	0	35	CLASS 3(FAIR ROCK)	45.00-46.50	Core Rock	1.5
247.718	46.5	48.0		Highly Fractured and Jointed	26	0	35	CLASS 3(FAIR ROCK)	46.50-48.00	Core Rock	1.5
246.218	48.0	49.5		Highly Fractured and Jointed	27	18	35	CLASS 3(FAIR ROCK)	48.00-49.50	Core Rock	2.7
244.718	49.5	51.0		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	49.50-51.00	Core Rock	1.5
243.218	51.0	52.5		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	51.00-52.50	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
241.718	52.5	54.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	52.50-54.00	Core Rock	1.5
240.218	54.0	55.5		Highly Fractured and Jointed	26	0	35	CLASS 3(FAIR ROCK)	54.00-55.50	Core Rock	1.5
238.718	55.5	57.0		Highly Fractured and Jointed	26	0	35	CLASS 3(FAIR ROCK)	55.50-57.00	Core Rock	1.5
237.218	57.0	58.5		Highly Fractured and Jointed	22	10	35	CLASS 3(FAIR ROCK)	57.00-58.50	Core Rock	1.5
235.718	58.5	60.0		Highly Fractured and Jointed	21	0	35	CLASS 3(FAIR ROCK)	58.50-60.00	Core Rock	1.5
234.218	60.0	61.5		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	60.00-61.50		1.5
232.718	61.5	63.0		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	61.50-63.00		1.5
231.218	63.0	64.5		Highly Fractured and Jointed	25	13	35	CLASS 3(FAIR ROCK)	63.05-64.55		1.95
229.718	64.5	66.0		Highly Fractured and Jointed	28	11	35	CLASS 3(FAIR ROCK)	64.50-66.00		1.65

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
228.218	66.0	67.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	28	0	35	CLASS 3(FAIR ROCK)	66.05-67.55		1.5
226.718	67.5	69.0		Highly Fractured and Jointed	28	0	35	CLASS 3(FAIR ROCK)	67.50-69.00		1.5
225.218	69.0	70.5		Highly Fractured and Jointed	26	8	35	CLASS 3(FAIR ROCK)	69.05-70.55		1.5
223.718	70.5	72.0		Highly Fractured and Jointed	27	14	35	CLASS 3(FAIR ROCK)	70.50-72.00		2.1
222.218	72.0	73.5		Highly Fractured and Jointed	26	14	38	CLASS 3(FAIR ROCK)	72.05-73.55		2.1
220.718	73.5	75.0		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	73.50-75.00		1.5

Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**15**	**LONGITUDE**	**77°2'32.878"E**		**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25380**	**LATTITUDE**	**28°12'36.141"N**		**TOTAL DEPTH:**	**70m**		
START DATE	**12-08-2021**	**GROUND ELEVATION MSL :**	**295.532**		**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**28-08-2021**	**ANGLE WITH HORIZONT: 90º**			**DEPTH OF WATER TABLE**	**61.0m**	**CASING**	**NX up to 3.0 m**
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**			**WATER TABLE RECORD DATE**	**29-08-2021**		
					NAME OF GEOLOGIST	**Gaurav Chunekar**		

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Sample Collected	
295.532	0.0	1.5	HighlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	26	0	33	CLASS 4 (POOR ROCK)	0.00-1.50	Core Rock	1.5
294.03	1.5	3.0		Highly Fractured and Jointed	28	7	33	CLASS 4 (POOR ROCK)	1.50-3.00	Core Rock	1.5
292.528	3.0	4.5		Highly Fractured and Jointed	42	7	33	CLASS 4 (POOR ROCK)	3.00-4.50	Core Rock	1.5
291.026	4.5	6.0	SightlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	36	0	33	CLASS 4 (POOR ROCK)	4.50-6.00	Core Rock	1.5
289.524	6.0	7.5		Highly Fractured and Jointed	46	0	33	CLASS 4 (POOR ROCK)	6.00-7.50	Core Rock	1.5

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Sample Collected	
288.022	7.5	9.0		Highly Fractured and Jointed	24	7	33	CLASS 4 (POOR ROCK)	7.50-9.00	Core Rock	1.5
286.52	9.0	10.5		Highly Fractured and Jointed	34	14	33	CLASS 4 (POOR ROCK)	9.00-10.50	Core Rock	2.1
285.018	10.5	12.0	SightlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite (Quartz vein)	Highly Fractured and Jointed	20	0	33	CLASS 4 (POOR ROCK)	10.50-12.00	Core Rock	1.5
283.516	12.0	13.5	HighlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	23	0	33	CLASS 4 (POOR ROCK)	12.00-13.50	Core Rock	1.5
282.014	13.5	15.0		Highly Fractured and Jointed	16	0	33	CLASS 4 (POOR ROCK)	13.50-15.00	Core Rock	1.5

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Sample Collected	
280.512	15.0	16.5	SightlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite (Quartz vein)	Highly Fractured and Jointed	16	0	35	CLASS 4 (POOR ROCK)	15.00-16.50	Core Rock	1.5
279.01	16.5	18.0	HighlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	22	0	35	CLASS 4 (POOR ROCK)	16.50-18.00	Core Rock	1.5
277.508	18.0	19.5	HighlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	41	17	35	CLASS 4 (POOR ROCK)	18.00-19.50	Core Rock	2.55

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Sample Collected	
276.006	19.5	21.0	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	28	0	35	CLASS 4 (POOR ROCK)	19.50-21.00	Core Rock	1.5
274.504	21.0	22.5	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	26	0	35	CLASS 4 (POOR ROCK)	21.00-22.50	Core Rock	1.5
273.002	22.5	24.0		Highly Fractured and Jointed	36	18	35	CLASS 4 (POOR ROCK)	22.50-24.00	Core Rock	2.7
271.5	24.0	25.5		Highly Fractured and Jointed	27	0	35	CLASS 4 (POOR ROCK)	24.00-25.50	Core Rock	1.5
269.998	25.5	27.0		Highly Fractured and Jointed	36	0	35	CLASS 4 (POOR ROCK)	25.50-27.00	Core Rock	1.5
268.496	27.0	28.5		Highly Fractured and Jointed	33	8	35	CLASS 4 (POOR ROCK)	27.00-28.50	Core Rock	1.5
266.994	28.5	30.0		Highly Fractured and Jointed	20	0	35	CLASS 4 (POOR ROCK)	28.50-30.00	Core Rock	1.5
265.492	30.0	31.5		Highly Fractured and Jointed	23	0	35	CLASS 4 (POOR ROCK)	30.00-31.50	Core Rock	1.5

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Sample Collected	
263.99	31.5	33.0	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Moderately Fractured and Jointed	21	0	35	CLASS 4 (POOR ROCK)	31.50-33.00	Core Rock	1.5
262.488	33.0	34.5		Highly Fractured and Jointed	30	7	35	CLASS 4 (POOR ROCK)	33.00-34.50	Core Rock	1.5
260.986	34.5	36.0		Highly Fractured and Jointed	32	0	35	CLASS 4 (POOR ROCK)	34.50-36.00	Core Rock	1.5
259.484	36.0	37.5		Highly Fractured and Jointed	31	0	35	CLASS 4 (POOR ROCK)	36.00-37.50	Core Rock	1.5
257.982	37.5	39.0		Highly Fractured and Jointed	30	6	35	CLASS 4 (POOR ROCK)	37.50-39.00	Core Rock	1.5
256.48	39.0	40.5		Highly Fractured and Jointed	25	0	38	CLASS 4 (POOR ROCK)	39.00-40.50	Core Rock	1.5
254.978	40.5	42.0		Highly Fractured and Jointed	40	22	38	CLASS 4 (POOR ROCK)	40.50-42.00	Core Rock	3.3
253.476	42.0	43.5		Highly Fractured and Jointed	28	8	38	CLASS 4 (POOR ROCK)	42.00-43.50	Core Rock	1.5
251.974	43.5	45.0		Highly Fractured and Jointed	30	6	35	CLASS 4 (POOR ROCK)	43.50-45.00	Core Rock	1.5

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Sample Collected	
250.472	45.0	46.5	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	26	0	35	CLASS 4 (POOR ROCK)	45.00-46.50	Core Rock	1.5
248.97	46.5	48.0		Highly Fractured and Jointed	38	27	40	CLASS 4 (POOR ROCK)	46.50-48.00	Core Rock	4.05
247.468	48.0	49.5		Highly Fractured and Jointed	29	10	35	CLASS 4 (POOR ROCK)	48.00-49.50	Core Rock	1.5
245.966	49.5	51.0		Highly Fractured and Jointed	22	0	35	CLASS 4 (POOR ROCK)	49.50-51.00	Core Rock	1.5
244.464	51.0	52.5		Highly Fractured and Jointed	26	15	35	CLASS 4 (POOR ROCK)	51.00-52.50	Core Rock	2.25
242.962	52.5	54.0		Highly Fractured and Jointed	20	10	35	CLASS 4 (POOR ROCK)	52.50-54.00	Core Rock	1.5
241.46	54.0	55.5		Highly Fractured and Jointed	26	0	35	CLASS 4 (POOR ROCK)	54.00-55.50	Core Rock	1.5
239.958	55.5	57.0		Highly Fractured and Jointed	20	0	35	CLASS 4 (POOR ROCK)	55.50-57.00	Core Rock	1.5
238.456	57.0	58.5		Highly Fractured and Jointed	25	0	35	CLASS 4 (POOR ROCK)	57.00-58.50	Core Rock	1.5

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Sample Collected	
236.954	58.5	60.0	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	34	0	35	CLASS 4 (POOR ROCK)	58.50-60.00	Core Rock	1.5
235.452	60.0	61.5		Highly Fractured and Jointed	28	24	24	CLASS 4 (POOR ROCK)	60.00-61.50		3.6
233.95	61.5	63.0		Highly Fractured and Jointed	20	8	24	CLASS 4 (POOR ROCK)	61.50-63.00		1.5
232.448	63.0	64.5		Highly Fractured and Jointed	32	16	24	CLASS 4 (POOR ROCK)	63.00-64.50		2.4
230.946	64.5	66.0		Highly Fractured and Jointed	31	14	24	CLASS 4 (POOR ROCK)	64.50-66.00		2.1
229.444	66.0	67.5		Highly Fractured and Jointed	27	9	24	CLASS 4 (POOR ROCK)	66.00-67.50		1.5
227.942	67.5	69.0		Highly Fractured and Jointed	28	8	24	CLASS 4 (POOR ROCK)	67.50-69.00		1.5
226.44	69.0	70.0		Highly Fractured and Jointed	57	10	24	CLASS 4 (POOR ROCK)	69.00-70.00		1.5

Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**15(A)**	**LONGITUDE**	**77°2'30.032"E**		**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25488**	**LATTITUDE**	**28°12'38.555"N**		**TOTAL DEPTH:**	**50.0m**		
START DATE	**15-09-2021**	**GROUND ELEVATION MSL :**	**276.442**		**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**01-10-2021**	**ANGLE WITH HORIZONT: 90º**			**DEPTH OF WATER TABLE**	**10.0 m**	**CASING**	
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**			**WATER TABLE RECORD DATE**	**02-10-2021**		
					NAME OF GEOLOGIST	**Gaurav Chunekar**		

Bh-15(A) Ch. No. 24820 Total Depth 50m

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of sample Collected	
276.442	0.0	1.5	Moderately Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	28	0	36	CLASS 3(FAIR ROCK)	0.00-1.50	Core Rock	1.5
274.94	1.5	3.0		Highly Fractured and Jointed	39	10	36	CLASS 3(FAIR ROCK)	1.50-3.00	Core Rock	1.5
273.438	3.0	4.5		Highly Fractured and Jointed	32	21	36	CLASS 3(FAIR ROCK)	3.00-4.50	Core Rock	3.15
271.936	4.5	6.0		Highly Fractured and Jointed	35	0	36	CLASS 3(FAIR ROCK)	4.50-6.00	Core Rock	1.5

Bh-15(A) Ch. No. 24820 Total Depth 50m

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of sample Collected	
270.434	6.0	7.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	45	28	43	CLASS 3(FAIR ROCK)	6.00-7.50	Core Rock	4.2
268.932	7.5	9.0		Highly Fractured and Jointed	21	0	38	CLASS 3(FAIR ROCK)	7.50-9.00	Core Rock	1.5
267.43	9.0	10.5		Highly Fractured and Jointed	50	30	43	CLASS 3(FAIR ROCK)	9.00-10.50	Core Rock	4.5
265.928	10.5	12.0		Highly Fractured and Jointed	35	22	27	CLASS 3(FAIR ROCK)	10.50-12.00	Core Rock	3.3
264.426	12.0	13.5		Highly Fractured and Jointed	32	8	27	CLASS 3(FAIR ROCK)	12.00-13.50	Core Rock	1.5
262.924	13.5	15.0		Highly Fractured and Jointed	47	32	32	CLASS 3(FAIR ROCK)	13.50-15.00	Core Rock	4.8
261.422	15.0	16.5		Highly Fractured and Jointed	28	8	27	CLASS 3(FAIR ROCK)	15.00-16.50	Core Rock	1.5
259.92	16.5	18.0		Highly Fractured and Jointed	41	7	27	CLASS 3(FAIR ROCK)	16.50-18.00	Core Rock	1.5

Bh-15(A) Ch. No. 24820 Total Depth 50m

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of sample Collected	
258.418	18.0	19.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	36	16	27	CLASS 3(FAIR ROCK)	18.00-19.50	Core Rock	2.4
256.916	19.5	21.0		Highly Fractured and Jointed	45	20	27	CLASS 3(FAIR ROCK)	19.50-21.00	Core Rock	3
255.414	21.0	22.5		Highly Fractured and Jointed	30	15	27	CLASS 3(FAIR ROCK)	21.00-22.50	Core Rock	2.25
253.912	22.5	24.0		Highly Fractured and Jointed	36	0	27	CLASS 3(FAIR ROCK)	22.50-24.00	Core Rock	1.5
252.41	24.0	25.5		Highly Fractured and Jointed	27	0	27	CLASS 3(FAIR ROCK)	24.00-25.50	Core Rock	1.5
250.908	25.5	27.0		Highly Fractured and Jointed	40	15	27	CLASS 3(FAIR ROCK)	25.50-27.00	Core Rock	2.25
249.406	27.0	28.5		Highly Fractured and Jointed	32	23	27	CLASS 3(FAIR ROCK)	27.00-28.50	Core Rock	3.45
247.904	28.5	30.0		Highly Fractured and Jointed	34	0	27	CLASS 3(FAIR ROCK)	28.50-30.00	Core Rock	1.5

Bh-15(A) Ch. No. 24820 Total Depth 50m											
Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of sample Collected	
246.402	30.0	31.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	34	22	27	CLASS 3(FAIR ROCK)	30.00-31.50	Core Rock	3.3
244.9	31.5	33.0		Highly Fractured and Jointed	30	15	27	CLASS 3(FAIR ROCK)	31.50-33.00	Core Rock	2.25
243.398	33.0	34.5		Highly Fractured and Jointed	30	8	27	CLASS 3(FAIR ROCK)	33.00-34.50	Core Rock	1.5
241.896	34.5	36.0		Highly Fractured and Jointed	36	0	27	CLASS 3(FAIR ROCK)	34.50-36.00	Core Rock	1.5
240.394	36.0	37.5		Highly Fractured and Jointed	37	23	27	CLASS 3(FAIR ROCK)	36.00-37.50	Core Rock	3.45
238.892	37.5	39.0		Highly Fractured and Jointed	40	7	27	CLASS 3(FAIR ROCK)	37.50-39.00	Core Rock	1.5
237.39	39.0	40.5		Highly Fractured and Jointed	50	10	27	CLASS 3(FAIR ROCK)	39.00-40.50	Core Rock	1.5
235.888	40.5	42.0		Highly Fractured and Jointed	34	0	27	CLASS 3(FAIR ROCK)	40.50-42.00	Core Rock	1.5

Bh-15(A) Ch. No. 24820 Total Depth 50m

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	ype of sample Collected	
234.386	42.0	43.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	32	8	27	CLASS 3(FAIR ROCK)	42.00-43.50	Core Rock	1.5
232.884	43.5	45.0		Highly Fractured and Jointed	35	0	27	CLASS 3(FAIR ROCK)	43.50-45.00	Core Rock	1.5
231.382	45.0	46.5		Highly Fractured and Jointed	30	0	27	CLASS 3(FAIR ROCK)	45.00-46.50	Core Rock	1.5
229.88	46.5	48.0		Highly Fractured and Jointed	36	7	27	CLASS 3(FAIR ROCK)	46.50-48.00	Core Rock	1.5
228.378	48.0	49.5		Highly Fractured and Jointed	40	8	27	CLASS 3(FAIR ROCK)	48.00-49.50	Core Rock	1.5
226.876	49.5	50.0		Highly Fractured and Jointed	40	0	27	CLASS 3(FAIR ROCK)	49.50-50.00	Core Rock	1.5

nments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**16**	**LONGITUDE**	**77°2'27.239"E**		**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25586**	**LATTITUDE**	**28°12'40.66"N**		**TOTAL DEPTH:**	**62m**		
START DATE	**26-08-2021**	**GROUND ELEVATION MSL :**	**287.324**		**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**10-09-2021**	**ANGLE WITH HORIZONT: 90º**			**DEPTH OF WATER TABLE**	**50.0m**	**CASING**	**NX up to 3.0 m**
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**			**WATER TABLE RECORD DATE**	**11-09-2021**		
					NAME OF GEOLOGIST	**Gaurav Chunekar**		

Bh-16 ;Total Depth 62m

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
287.324	0.0	1.5	Moderately Weathered, , Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite (DS and DS Wash Collected)	Highly Fractured and Jointed	16	0	33	CLASS 3(FAIR ROCK)	0.00-1.50	Core Rock	1.5
285.82	1.5	3.0	Moderately Weathered, , Grey , Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	25	0	33	CLASS 3(FAIR ROCK)	1.50-3.00	Core Rock	1.5
284.316	3.0	4.5		Highly Fractured and Jointed	32	0	33	CLASS 3(FAIR ROCK)	3.00-4.50	Core Rock	1.5
282.812	4.5	6.0		Highly Fractured and Jointed	32	0	33	CLASS 3(FAIR ROCK)	4.50-6.00	Core Rock	1.5

Bh-16 ;Total Depth 62m

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
281.308	6.0	7.5	Moderately Weathered, , Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	30	0	33	CLASS 3(FAIR ROCK)	6.00-7.50	Core Rock	1.5
279.804	7.5	9.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	31	10	35	CLASS 3(FAIR ROCK)	7.50-9.00	Core Rock	1.5
278.3	9.0	10.5		Highly Fractured and Jointed	30	0	35	CLASS 3(FAIR ROCK)	9.00-10.50	Core Rock	1.5
276.796	10.5	12.0		Highly Fractured and Jointed	34	0	35	CLASS 3(FAIR ROCK)	10.50-12.00	Core Rock	1.5
275.292	12.0	13.5		Highly Fractured and Jointed	31	15	38	CLASS 3(FAIR ROCK)	12.00-13.50	Core Rock	2.2995
273.788	13.5	15.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	27	10	38	CLASS 3(FAIR ROCK)	13.50-15.00	Core Rock	1.5
272.284	15.0	16.5		Highly Fractured and Jointed	36	19	38	CLASS 3(FAIR ROCK)	15.00-16.50	Core Rock	2.85
270.78	16.5	18.0		Highly Fractured and Jointed	28	15	38	CLASS 3(FAIR ROCK)	16.50-18.00	Core Rock	2.295

Bh-16 ;Total Depth 62m

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
269.276	18.0	19.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	46	36	43	CLASS 3(FAIR ROCK)	18.00-19.50	Core Rock	5.445
267.772	19.5	21.0		Highly Fractured and Jointed	48	0	38	CLASS 3(FAIR ROCK)	19.50-21.00	Core Rock	1.5
266.268	21.0	22.5		Highly Fractured and Jointed	44	14	38	CLASS 3(FAIR ROCK)	21.00-22.50	Core Rock	2.1
264.764	22.5	24.0		Highly Fractured and Jointed	43	11	38	CLASS 3(FAIR ROCK)	22.50-24.00	Core Rock	1.65
263.26	24.0	25.5		Highly Fractured and Jointed	42	28	43	CLASS 3(FAIR ROCK)	24.00-25.50	Core Rock	4.2
261.756	25.5	27.0		Highly Fractured and Jointed	34	15	38	CLASS 3(FAIR ROCK)	25.50-27.00	Core Rock	2.25
260.252	27.0	28.5		Highly Fractured and Jointed	53	47	43	CLASS 3(FAIR ROCK)	27.00-28.50	Core Rock	7.05
258.748	28.5	30.0		Highly Fractured and Jointed	31	8	38	CLASS 3(FAIR ROCK)	28.50-30.00	Core Rock	1.5

Bh-16 ;Total Depth 62m

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
257.244	30.0	31.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	39	34	43	CLASS 3(FAIR ROCK)	30.00-31.50	Core Rock	5.1
255.74	31.5	33.0		Highly Fractured and Jointed	30	14	38	CLASS 3(FAIR ROCK)	31.50-33.00	Core Rock	2.1
254.236	33.0	34.5		Highly Fractured and Jointed	36	25	43	CLASS 3(FAIR ROCK)	33.00-34.50	Core Rock	3.75
252.732	34.5	36.0		Highly Fractured and Jointed	30	22	38	CLASS 3(FAIR ROCK)	34.50-36.00	Core Rock	3.3
251.228	36.0	37.5		Highly Fractured and Jointed	37	22	38	CLASS 3(FAIR ROCK)	36.00-37.50	Core Rock	3.3
249.724	37.5	39.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	30	8	38	CLASS 3(FAIR ROCK)	37.50-39.00	Core Rock	1.5
248.22	39.0	40.5		Highly Fractured and Jointed	34	20	38	CLASS 3(FAIR ROCK)	39.00-40.50	Core Rock	3
246.716	40.5	42.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	36	0	38	CLASS 3(FAIR ROCK)	40.50-42.00	Core Rock	1.5

Bh-16 ;Total Depth 62m

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
245.212	42.0	43.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	42	17	38	CLASS 3(FAIR ROCK)	42.00-43.50	Core Rock	2.49
243.708	43.5	45.0		Highly Fractured and Jointed	44	44	43	CLASS 3(FAIR ROCK)	43.50-45.00	Core Rock	6.6
242.204	45.0	46.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	37	0	38	CLASS 3(FAIR ROCK)	45.00-46.50	Core Rock	1.5
240.7	46.5	48.0	Slightly Weathered, , Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	53	51	48	CLASS 3(FAIR ROCK)	46.50-48.00	Core Rock	7.695
239.196	48.0	49.5		Highly Fractured and Jointed	45	15	38	CLASS 3(FAIR ROCK)	48.00-49.50	Core Rock	2.295
237.692	49.5	51.0		Highly Fractured and Jointed	38	27	43	CLASS 3(FAIR ROCK)	49.50-51.00	Core Rock	3.99
236.188	51.0	52.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very	Highly Fractured and Jointed	40	29	43	CLASS 3(FAIR ROCK)	51.00-52.50		4.395

Bh-16 ;Total Depth 62m											
Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
234.684	52.5	54.0	Hard, Quartzite (Weathered Medium Grained Garnet Grains, Contact of Phyllite Band Noticed)	Highly Fractured and Jointed	43	16	38	CLASS 3(FAIR ROCK)	52.50-54.00		2.445
233.18	54.0	55.5	Slightly Weathered, , Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	43	21	38	CLASS 3(FAIR ROCK)	54.00-55.50		3.15
231.676	55.5	57.0		Highly Fractured and Jointed	31	8	38	CLASS 3(FAIR ROCK)	55.50-57.00		1.5
230.172	57.0	58.5		Highly Fractured and Jointed	30	18	30	CLASS 3(FAIR ROCK)	57.00-58.50		2.64
228.668	58.5	60.0		Highly Fractured and Jointed	25	20	30	CLASS 3(FAIR ROCK)	58.50-60.00		3
227.164	60.0	61.5		Highly Fractured and Jointed	32	24	30	CLASS 3(FAIR ROCK)	60.00-61.50		3.645
225.66	61.5	62.0		Highly Fractured and Jointed	66	9	30	CLASS 3(FAIR ROCK)	61.50-62.00		1.5

Consultant:	**Geotechnical Investigation Report**		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**BH 17**	**LONGITUDE**	**77°2'30.032"E**		**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25785**	**LATTITUDE**	**28°12'38.555"N**		**TOTAL DEPTH:**	**50.0m**		
START DATE	**15-09-2021**	**GROUND ELEVATION MSL :**	**276.442**		**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**01-10-2021**	**ANGLE WITH HORIZONT: 90º**			**DEPTH OF WATER TABLE**	**10.0 m**	**CASING**	
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**			**WATER TABLE RECORD DATE**	**02-10-2021**		
					NAME OF GEOLOGIST	**Gaurav Chunekar**		

Bh-17 ;Total Depth 75m

Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
282.46	0			0	0	NA	NA		0
280.961	1.5	Brown colour, very fine to fine grained, clayey silt deposit	very fine to fine grained, clayey silt deposit	0	0	NA	NA		0
279.461	3	Brown colour, very fine to fine grained, clayey silt deposit	very fine to fine grained, clayey silt deposit	0	0	NA	NA		0
277.96	4.5			0	0	NA	NA		0
276.46	6			0	0	NA	NA		0
274.96	9			0	0	NA	NA		0
273.461	12	Brown colour, very fine to fine grained, clayey silt with gravels..	very fine to fine grained, clayey silt with gravels..	0	0	NA	NA		0

Bh-17 ;Total Depth 75m									
Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
271.96	15			0	0	NA	NA		0
270.46	16.5			0	0	NA	NA		0
268.961	18	Brown colour, very fine to fine grained, sub angular to sub rounded pebbels with clayey silt.	It shows very fine to fine grained, sub angular to sub rounded pebbels clayey silt.	0	0	NA	NA		0
267.461	19.5	Highly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Hard Quartzite.	Joints of 0°,45°	17	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
265.961	20.5		Closed Joint of 10°	22	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
264.461	22		It shows highly fractured weathered rock	25	11.6	47	CLASS 3(FAIR ROCK)	Core Rock	0
262.961	23			32	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
261.461	24.5			33	0	40	CLASS 4 (POOR ROCK)	Core Rock	0

Bh-17 ;Total Depth 75m

Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
259.961	25	Moderately Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite.	Joints of 0°,10°,15°	48	25	47	CLASS 3(FAIR ROCK)	Core Rock	1
258.461	26		Joints of 0°, 15°,80°	59	32.6	43	CLASS 3(FAIR ROCK)	Core Rock	1
256.961	27.5		Joints of 0°,10°,15°,20°	44	12.66	40	CLASS 4 (POOR ROCK)	Core Rock	0
255.461	28			68	25.8	43	CLASS 3(FAIR ROCK)	Core Rock	1
253.961	29.5	Highly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Hard Quartzite.	It shows highly fractured weathered rock	58	7.6	40	CLASS 4 (POOR ROCK)	Core Rock	0
252.461	30	Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Joints of 0°,10°,15°, 70°	70	0	47	CLASS 3(FAIR ROCK)	Core Rock	0
250.961	31		It shows highly angular fractured and jointed, weak strength	47	17.13	40	CLASS 4 (POOR ROCK)	Core Rock	0

Bh-17 ;Total Depth 75m									
Elevation (m)	Depth (m)		Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
		Lithology				Rating	Class	Type of Sample Collected	
249.461	32.5			64	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
247.961	33.5	Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite		54	15.53	40	CLASS 4 (POOR ROCK)		0
246.461	35	Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite.(crushed zone)		34.66	0	40	CLASS 4 (POOR ROCK)		0
244.961	36.5	Light Brown colour, Coarse grained, Sand. (SPT Rebounded)	Coarse grained, Sand. (SPT Rebounded)	0	0	0	CLASS 5 (VERY POOR ROCK)		0
243.461	38			0	0	0	CLASS 5 (VERY POOR ROCK)	Core Rock	0
241.961	39.5			0	0	0	CLASS 5 (VERY POOR ROCK)	Core Rock	0

Bh-17 ;Total Depth 75m										
Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
240.461	41	Moderatey to Slightly Weathered, Moderately to Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite		32	11	47	CLASS 3(FAIR ROCK)	Core Rock	0
238.961	42.5			41.33	19.33	40	CLASS 4 (POOR ROCK)	Core Rock	0
237.461	44			54	41.53	43	CLASS 3(FAIR ROCK)	Core Rock	1
235.961	45.5			30	16.66	47	CLASS 3(FAIR ROCK)	Core Rock	0
234.461	47			37.33	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
232.961	48.5			41.33	21.06	47	CLASS 3(FAIR ROCK)	Core Rock	0
231.461	50			30	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
229.961	51.5			36.66	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
228.461	53			34.66	12	40	CLASS 4 (POOR ROCK)	Core Rock	0
226.961	54.5			33.33	6.8	47	CLASS 3(FAIR ROCK)	Core Rock	0

Bh-17 ;Total Depth 75m

Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
225.461	56			28	6.73	32	CLASS 4 (POOR ROCK)	Core Rock	0
223.961	58			38	8	32	CLASS 4 (POOR ROCK)	Core Rock	0
222.461	59.5			38.33	0	39	CLASS 4 (POOR ROCK)	Core Rock	0
220.961	61			40.6	27.66	35	CLASS 4 (POOR ROCK)	Core Rock	1

ANNEXURE –B
Tensile Strength

Tensile Strength

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
1	BH-13	0.50	1.50	14.21
2		1.50	3.00	
3		3.00	4.50	
4		4.50	6.00	
5		6.00	7.50	
6		7.50	9.00	
7		9.00	10.50	
8		10.50	12.00	14.12
9		15.00	16.50	
10		16.50	18.00	
11		18.00	19.50	
12		19.50	21.00	14.34
13		21.00	22.50	
14		22.50	24.00	
15		24.00	25.50	13.34
16		25.50	27.00	
17		27.00	28.50	
18		28.50	30.00	20.71
19		30.00	31.50	
20		31.50	33.00	
21		33.00	34.50	
22		34.50	36.00	22.99
23		36.00	37.50	
24		37.50	39.00	
25		39.00	40.50	
26		40.50	42.00	21.08
27		42.00	43.50	
28		43.50	45.00	
29		45.00	46.50	
30		46.50	48.00	
31		48.00	49.50	
32		49.50	51.00	
33		51.00	52.50	

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
34		52.50	54.00	
35		54.00	55.50	
36		55.50	57.00	
37		57.00	58.50	16
38		58.50	60.00	
	Min.			13.34
	Max.			22.99
	Avg.			17.10
39	BH-14	1.50	3.00	
40		3.00	4.50	15.77
41		4.50	6.00	
42		6.00	7.50	
43		7.50	9.00	
44		9.00	10.50	
45		10.50	12.00	
46		12.00	13.50	17.78
47		15.00	16.50	
48		16.50	18.00	
49		18.00	19.50	
50		19.50	21.00	15.72
51		21.00	22.50	
52		22.50	24.00	
53		24.00	25.50	
54		25.50	27.00	
55		27.00	28.50	
56		28.50	30.00	
57		30.00	31.50	
58		31.50	33.00	21.25
59		33.00	34.50	
60		34.50	36.00	
61		36.00	37.50	
62		37.50	39.00	
63		39.00	40.50	19.31
64		40.50	42.00	
65		42.00	43.50	
66		43.50	45.00	
67		45.00	46.50	24.93

Sr.No.	**BH NO.**	**Depth**		**Tensile Strength Test**
		From	**To**	**(MPa)**
68		**46.50**	**48.00**	
69		**48.00**	**49.50**	
70		**49.50**	**51.00**	
71		**51.00**	**52.50**	
72		**52.50**	**54.00**	
73		**54.00**	**55.50**	
74		**57.00**	**58.50**	**18.27**
75		**58.50**	**60.00**	
76		**60.00**	**61.50**	
77		**63.00**	**64.50**	**19.68**
78		**64.50**	**66.00**	
79		**66.00**	**67.50**	
80		**67.50**	**69.00**	
81		**69.00**	**70.50**	**14.78**
82		**70.50**	**72.00**	
83		**72.00**	**73.50**	**16.94**
	Min.			**14.78**
	Max.			**24.93**
	Avg.			**18.44**
84	**BH-15**	**0.00**	**1.50**	
85		**1.50**	**3.00**	
86		**3.00**	**4.50**	**16.36**
87		**4.50**	**6.00**	
88		**6.00**	**7.50**	
89		**7.50**	**9.00**	
90		**9.00**	**10.50**	
91		**10.50**	**12.00**	
92		**12.00**	**13.50**	
93		**15.00**	**16.50**	
94		**16.50**	**18.00**	
95		**18.00**	**19.50**	**14.89**
96		**19.50**	**21.00**	
97		**21.00**	**22.50**	
98		**22.50**	**24.00**	
99		**24.00**	**25.50**	
100		**25.50**	**27.00**	
101		**27.00**	**28.50**	**18.2**

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
102		28.50	30.00	
103		30.00	31.50	
104		31.50	33.00	17.81
105		33.00	34.50	
106		34.50	36.00	
107		36.00	37.50	16.03
108		37.50	39.00	
109		39.00	40.50	
110		40.50	42.00	
111		42.00	43.50	
112		43.50	45.00	
113		45.00	46.50	
114		46.50	48.00	
115		48.00	49.50	
116		49.50	51.00	
117		51.00	52.50	
118		52.50	54.00	14.66
119		54.00	55.50	
120		57.00	58.50	
121		58.50	60.00	14.94
122		60.00	61.50	
123		61.50	63.00	
124		64.50	66.00	16.49
125		66.00	67.50	
126		67.50	69.00	19.2
127		69.00	70.00	
	Min.			14.66
	Max.			19.2
	Avg.			16.51
128	BH-15A	0.00	1.50	
129		1.50	3.00	
130		3.00	4.50	
131		4.50	6.00	
				16.47
132		6.00	7.50	

Sr.No.	**BH NO.**	**Depth**		**Tensile Strength Test**
		From	**To**	**(MPa)**
133		**7.50**	**9.00**	
138		**9.00**	**10.50**	
139		**10.50**	**12.00**	
140		**12.00**	**13.50**	
141		**13.50**	**15.00**	
142		**15.00**	**16.50**	**15.89**
143		**16.50**	**18.00**	
144		**18.00**	**19.50**	
145		**19.50**	**21.00**	
146		**21.00**	**22.50**	**14.91**
147		**22.50**	**24.00**	
148		**25.50**	**27.00**	
149		**27.00**	**28.50**	
150		**28.50**	**30.00**	**15.97**
151		**30.00**	**31.50**	
152		**31.50**	**33.00**	
153		**33.00**	**34.50**	
154		**34.50**	**36.00**	**18.78**
155		**36.00**	**37.50**	

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
156		37.50	39.00	
157		39.00	40.50	
158		40.50	42.00	17.21
159		42.00	43.50	
160		43.50	45.00	
161		46.50	48.00	
162		48.00	49.50	
163		49.50	51.00	17.64
	Min.			14.91
	Max.			18.78
	Avg.			16.70
164	BH-16	0.00	1.50	
165		1.50	3.00	
166		3.00	4.50	
167		4.50	6.00	15.72
168		4.50	6.00	
169		7.50	9.00	
170		9.00	10.50	15.39
171		10.50	12.00	
172		12.00	13.50	
173		13.50	15.00	
174		18.00	19.50	25.83
175		19.50	21.00	
176		21.00	22.50	26.24
177		22.50	24.00	
178		24.00	25.50	
179		25.50	27.00	
180		27.00	28.50	
181		28.50	30.00	16.65
182		30.00	31.50	
183		31.50	33.00	

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
184		33.00	34.50	19.89
185		33.00	34.50	
186		36.00	37.50	23.96
187		37.50	39.00	
188		39.00	40.50	
189		40.50	42.00	23.86
190		42.00	43.50	
191		45.00	46.50	
192		46.50	48.00	
193		48.00	49.50	
194		49.50	51.00	27.77
195		52.50	54.00	22.76
196		54.00	55.50	
197		55.50	57.00	20.25
198		58.50	60.00	
199		60.00	61.50	
200		61.50	62.00	
	Min.			15.39
	Max.			27.77
	Avg.			21.67

BH 17		
Depth	Sample Number	Tensile Strength Test
		(Mpa)
19.50	BH17/1221/R/01	
20.50	BH17/1221/R/03	
22.00	BH17/1221/R/05	
23.00	BH17/1221/R/06	26.58
24.50	BH17/1221/R/07	

BH 17		
Depth	**Sample Number**	**Tensile Strength Test**
	BH17/1221/R/08	
25.00	BH17/0122/R/09	
	BH17/0122/R/10	
26.00	BH17/0122/R/11	22.64
	BH17/0122/R/12	
	BH17/0122/R/13	
27.50	BH17/0122/R/14	
	BH17/0122/R/15	
	BH17/0122/R/16	
	BH17/0122/R/17	15.21
28.00	BH17/0122/R/18	
	BH17/0122/R/19	
	BH17/0122/R/20	
29.50	BH17/0122/R/21	8.77
	BH17/0122/R/22	
	BH17/0122/R/23	
30.00	BH17/0122/R/24	
	BH17/0122/R/25	
31.50	BH17/0122/R/26	
	BH17/0122/R/27	
	BH17/0122/R/28	
	BH17/0122/R/29	22.57
32.50	BH17/0122/R/30	
	BH17/0122/R/31	
33.50	BH17/0122/R/32	
	BH17/0122/R/33	

BH 17

Depth	**Sample Number**	**Tensile Strength Test**
	BH17/0122/R/34	
	BH17/0122/R/35	
35.00	BH17/0122/R/37	
	BH17/0122/R/38	
41.00	BH17/0122/R/40	
	BH17/0122/R/41	
42.50	BH17/0122/R/42	
	BH17/0122/R/43	
44.00	BH17/0122/R/44	
	BH17/0122/R/45	
	BH17/0122/R/46	
	BH17/0122/R/47	
45.50	BH17/1221/R/48	
	BH17/1221/R/49	
	BH17/1221/R/50	
	BH17/1221/R/51	
47.00	BH17/1221/R/52	
	BH17/1221/R/53	
48.50	BH17/1221/R/54	
	BH17/1221/R/55	
	BH17/1221/R/56	
	BH17/1221/R/57	
50.00	BH17/1221/R/58	
	BH17/1221/R/59	
	BH17/1221/R/60	
	BH17/1221/R/61	

BH 17		
Depth	**Sample Number**	**Tensile Strength Test**
	BH17/1221/R/65	15.46
53.00	BH17/1221/R/69	18.01
54.50	BH17/1221/R/74	
	BH17/1221/R/75	
	BH17/1221/R/76	19.83
	BH17/1221/R/77	
56.00	BH17/1221/R/78	
	BH17/1221/R/79	19.09
58.00	BH17/1221/R/80	
	BH17/1221/R/81	15.07
59.50	BH17/1221/R/82	
62.00	BH17/1221/R/87	
	BH17/1221/R/88	
	BH17/1221/R/89	15.1
	BH17/1221/R/90	
	BH17/1221/R/91	
	BH17/1221/R/92	
	Min.	**8.77**
	Max.	**26.58**
	Average.	**18.03**

ANNEXURE –C
Unconfined Compressive strength

Unconfined Compressive Strength

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
1	BH-13	0.50	1.50	
2		1.50	3.00	41.06
3		3.00	4.50	
4		4.50	6.00	
5		6.00	7.50	
6		7.50	9.00	
7		9.00	10.50	
8		10.50	12.00	61.6
9		15.00	16.50	
10		16.50	18.00	
11		18.00	19.50	67.07
12		19.50	21.00	
13		21.00	22.50	
14		22.50	24.00	
15		24.00	25.50	
16		25.50	27.00	67.01
17		27.00	28.50	
18		28.50	30.00	
19		30.00	31.50	
20		31.50	33.00	
21		33.00	34.50	64.01
22		34.50	36.00	
23		36.00	37.50	
24		37.50	39.00	
25		39.00	40.50	65.17
26		40.50	42.00	
27		42.00	43.50	
28		43.50	45.00	64.79
29		45.00	46.50	
30		46.50	48.00	64.94
31		48.00	49.50	
32		49.50	51.00	63.23
33		51.00	52.50	

Sr.No.	**BH NO.**	**Depth**		**UCS Test**
		From	**To**	**(MPa)**
34		**52.50**	**54.00**	64.29
35		**54.00**	**55.50**	
36		**55.50**	**57.00**	68.34
37		**57.00**	**58.50**	
38		**58.50**	**60.00**	70.33
	Min.			41.06
	Max.			70.33
	Avg.			63.49
39	**BH-14**	**1.50**	**3.00**	
40		**3.00**	**4.50**	
41		**4.50**	**6.00**	49.1
42		**6.00**	**7.50**	
43		**7.50**	**9.00**	
44		**9.00**	**10.50**	
45		**10.50**	**12.00**	69.54
46		**12.00**	**13.50**	
47		**15.00**	**16.50**	
48		**16.50**	**18.00**	68.69
49		**18.00**	**19.50**	
50		**19.50**	**21.00**	
51		**21.00**	**22.50**	
52		**22.50**	**24.00**	
53		**24.00**	**25.50**	
54		**25.50**	**27.00**	66.51
55		**27.00**	**28.50**	
56		**28.50**	**30.00**	
57		**30.00**	**31.50**	65.1
58		**31.50**	**33.00**	
59		**33.00**	**34.50**	
60		**34.50**	**36.00**	
61		**36.00**	**37.50**	53.54
62		**37.50**	**39.00**	
63		**39.00**	**40.50**	
64		**40.50**	**42.00**	
65		**42.00**	**43.50**	
66		**43.50**	**45.00**	49.01
67		**45.00**	**46.50**	

Sr.No.	**BH NO.**	**Depth**		**UCS Test**
		From	**To**	**(MPa)**
68		**46.50**	**48.00**	55.52
69		**48.00**	**49.50**	
70		**49.50**	**51.00**	
71		**51.00**	**52.50**	59.06
72		**52.50**	**54.00**	
73		**54.00**	**55.50**	
74		**57.00**	**58.50**	45.15
75		**58.50**	**60.00**	
76		**60.00**	**61.50**	60.66
77		**63.00**	**64.50**	
78		**64.50**	**66.00**	
79		**66.00**	**67.50**	
80		**67.50**	**69.00**	45.15
81		**69.00**	**70.50**	
82		**70.50**	**72.00**	47.33
83		**72.00**	**73.50**	
	Min.			45.15
	Max.			69.54
	Avg.			56.49
84	**BH-15**	**0.00**	**1.50**	
85		**1.50**	**3.00**	69.58
86		**3.00**	**4.50**	
87		**4.50**	**6.00**	
88		**6.00**	**7.50**	
89		**7.50**	**9.00**	67.04
90		**9.00**	**10.50**	
91		**10.50**	**12.00**	
92		**12.00**	**13.50**	
93		**15.00**	**16.50**	
94		**16.50**	**18.00**	68.52
95		**18.00**	**19.50**	
96		**19.50**	**21.00**	
97		**21.00**	**22.50**	
98		**22.50**	**24.00**	66.01
99		**24.00**	**25.50**	
100		**25.50**	**27.00**	
101		**27.00**	**28.50**	68.94

Sr.No.	**BH NO.**	**Depth**		**UCS Test**
		From	**To**	**(MPa)**
102		**28.50**	**30.00**	
103		**30.00**	**31.50**	
104		**31.50**	**33.00**	
105		**33.00**	**34.50**	68.84
106		**34.50**	**36.00**	
107		**36.00**	**37.50**	
108		**37.50**	**39.00**	
109		**39.00**	**40.50**	
110		**40.50**	**42.00**	
111		**42.00**	**43.50**	
112		**43.50**	**45.00**	70.44
113		**45.00**	**46.50**	
114		**46.50**	**48.00**	69.4
115		**48.00**	**49.50**	
116		**49.50**	**51.00**	62.21
117		**51.00**	**52.50**	
118		**52.50**	**54.00**	61.45
119		**54.00**	**55.50**	
120		**57.00**	**58.50**	64.29
121		**58.50**	**60.00**	
122		**60.00**	**61.50**	
123		**61.50**	**63.00**	68.63
124		**64.50**	**66.00**	
125		**66.00**	**67.50**	68.41
126		**67.50**	**69.00**	
127		**69.00**	**70.00**	64.97
	Min.			61.45
	Max.			70.44
	Avg.			67.05
128	**BH-15A**	**0.00**	**1.50**	
129		**1.50**	**3.00**	69.38
130		**3.00**	**4.50**	
131		**4.50**	**6.00**	
132		**6.00**	**7.50**	

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
				66
133		7.50	9.00	
138		9.00	10.50	
139		10.50	12.00	
140		12.00	13.50	
				62.28
141		13.50	15.00	
142		15.00	16.50	
143		16.50	18.00	
144		18.00	19.50	
145		19.50	21.00	
146		21.00	22.50	
				63.06
147		22.50	24.00	
148		25.50	27.00	
149		27.00	28.50	
				64.78
150		28.50	30.00	
151		30.00	31.50	
152		31.50	33.00	65.17
				67.2
153		33.00	34.50	

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
154		34.50	36.00	
155		36.00	37.50	69.38
156		37.50	39.00	
157		39.00	40.50	63.64
158		40.50	42.00	
159		42.00	43.50	60.42
160		43.50	45.00	
161		46.50	48.00	
162		48.00	49.50	65.05
163		49.50	51.00	
	Min.			60.42
	Max.			69.38
	Avg.			65.12
164	BH-16	0.00	1.50	66
165		1.50	3.00	
166		3.00	4.50	
167		4.50	6.00	
168		4.50	6.00	
169		7.50	9.00	52.79
170		9.00	10.50	
171		10.50	12.00	
172		12.00	13.50	
173		13.50	15.00	
174		18.00	19.50	70.8
175		19.50	21.00	
176		21.00	22.50	
177		22.50	24.00	44.8
178		24.00	25.50	
179		25.50	27.00	
180		27.00	28.50	

Sr.No.	**BH NO.**	**Depth**		**UCS Test**
		From	**To**	**(MPa)**
181		**28.50**	**30.00**	
182		**30.00**	**31.50**	70.27
183		**31.50**	**33.00**	
184		**33.00**	**34.50**	
185		**33.00**	**34.50**	
186		**36.00**	**37.50**	
187		**37.50**	**39.00**	70.23
188		**39.00**	**40.50**	
189		**40.50**	**42.00**	
190		**42.00**	**43.50**	52.49
191		**45.00**	**46.50**	
192		**46.50**	**48.00**	70.08
193		**48.00**	**49.50**	
194		**49.50**	**51.00**	69.57
195		**52.50**	**54.00**	
196		**54.00**	**55.50**	
197		**55.50**	**57.00**	70.16
198		**58.50**	**60.00**	
199		**60.00**	**61.50**	68.55
200		**61.50**	**62.00**	
	Min.			44.8
	Max.			70.8
	Avg.			64.16

BH 17

Depth	**Sample Number**	**UCS (Mpa)**
19.50	BH17/1221/R/01	
20.50	BH17/1221/R/03	
22.00	BH17/1221/R/05	70.68
23.00	BH17/1221/R/06	
24.50	BH17/1221/R/07	
	BH17/1221/R/08	
25.00	BH17/0122/R/09	69.63
	BH17/0122/R/10	
26.00	BH17/0122/R/11	
	BH17/0122/R/12	
	BH17/0122/R/13	
27.50	BH17/0122/R/14	
	BH17/0122/R/15	
	BH17/0122/R/16	
	BH17/0122/R/17	
28.00	BH17/0122/R/18	69.31
	BH17/0122/R/19	
	BH17/0122/R/20	
29.50	BH17/0122/R/21	
	BH17/0122/R/22	
	BH17/0122/R/23	
30.00	BH17/0122/R/24	
	BH17/0122/R/25	
31.50	BH17/0122/R/26	
	BH17/0122/R/27	66.51
	BH17/0122/R/28	
	BH17/0122/R/29	
32.50	BH17/0122/R/30	
	BH17/0122/R/31	
33.50	BH17/0122/R/32	
	BH17/0122/R/33	
	BH17/0122/R/34	
	BH17/0122/R/35	
	BH17/0122/R/36	67.94
35.00	BH17/0122/R/37	
	BH17/0122/R/38	

BH 17		
Depth	**Sample Number**	**UCS (Mpa)**
41.00	BH17/0122/R/40	
	BH17/0122/R/41	68.41
42.50	BH17/0122/R/42	
	BH17/0122/R/43	
44.00	BH17/0122/R/44	
	BH17/0122/R/45	
	BH17/0122/R/46	
	BH17/0122/R/47	
45.50	BH17/1221/R/49	67.23
47.00	BH17/1221/R/52	
	BH17/1221/R/53	
48.50	BH17/1221/R/54	
	BH17/1221/R/55	
	BH17/1221/R/56	
	BH17/1221/R/57	63.34
50.00	BH17/1221/R/58	
51.50	BH17/1221/R/62	
	BH17/1221/R/63	
	BH17/1221/R/64	
	BH17/1221/R/65	
	BH17/1221/R/66	61.24
	BH17/1221/R/67	
53.00	BH17/1221/R/69	
	BH17/1221/R/70	
	BH17/1221/R/71	
	BH17/1221/R/72	
	BH17/1221/R/73	
54.50	BH17/1221/R/74	
	BH17/1221/R/75	70.85
	BH17/1221/R/76	
	BH17/1221/R/77	
56.00	BH17/1221/R/78	
	BH17/1221/R/79	
58.00	BH17/1221/R/80	68.97
	BH17/1221/R/81	
59.50	BH17/1221/R/82	
62.00	BH17/1221/R/87	69.04
	BH17/1221/R/88	

BH 17		
Depth	**Sample Number**	**UCS (Mpa)**
	BH17/1221/R/89	
	BH17/1221/R/90	
	BH17/1221/R/91	
	BH17/1221/R/92	
Min.		**61.24**
Max.		**70.85**
Average.		**67.76**

ANNEXURE –D

Specific Gravity, Water absorption, Density

Specific Gravity, Water absorption, Density

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
1	BH-13	0.50	1.50	24.31	2.47	0.4
2		1.50	3.00			
3		3.00	4.50			
4		4.50	6.00			
5		6.00	7.50	25.15	2.55	0.45
6		7.50	9.00			
7		9.00	10.50			
8		10.50	12.00			
9		15.00	16.50	25.26	2.57	0.32
10		16.50	18.00			
11		18.00	19.50			
12		19.50	21.00			
13		21.00	22.50	25.65	2.6	0.44
14		22.50	24.00			
15		24.00	25.50			
16		25.50	27.00			
17		27.00	28.50			
18		28.50	30.00	25.08	2.55	0.4
19		30.00	31.50			
20		31.50	33.00			
21		33.00	34.50			
22		34.50	36.00	25.35	2.58	0.14
23		36.00	37.50			
24		37.50	39.00	25.47	2.58	0.47
25		39.00	40.50			
26		40.50	42.00	25.23	2.56	0.3
27		42.00	43.50			
28		43.50	45.00	25.47	2.58	0.47
29		45.00	46.50			
30		46.50	48.00	25.73	2.61	0.39
31		48.00	49.50			
32		49.50	51.00	25.43	2.58	0.38
33		51.00	52.50			
34		52.50	54.00			

Sr.No.	**BH NO.**	**Depth**		**Weight Density**	**Specific Gravity**	**Water Absorption**
		From	**To**	**(kN/m³)**		**(%)**
35		**54.00**	**55.50**	25.64	2.6	0.51
36		**55.50**	**57.00**			
37		**57.00**	**58.50**			
38		**58.50**	**60.00**			
	Min.			24.31	2.47	0.14
	Max.			25.73	2.61	0.51
	Avg.			25.31	2.57	0.39
39	**BH-14**	**1.50**	**3.00**			
40		**3.00**	**4.50**			
41		**4.50**	**6.00**			
42		**6.00**	**7.50**	25.67	2.61	0.41
43		**7.50**	**9.00**			
44		**9.00**	**10.50**			
45		**10.50**	**12.00**			
46		**12.00**	**13.50**	25.8	2.63	0.16
47		**15.00**	**16.50**			
48		**16.50**	**18.00**			
49		**18.00**	**19.50**	25.83	2.62	0.35
50		**19.50**	**21.00**			
51		**21.00**	**22.50**			
52		**22.50**	**24.00**	25.78	2.62	0.3
53		**24.00**	**25.50**			
54		**25.50**	**27.00**			
55		**27.00**	**28.50**			
56		**28.50**	**30.00**			
57		**30.00**	**31.50**			
58		**31.50**	**33.00**			
59		**33.00**	**34.50**	26.09	2.65	0.43
60		**34.50**	**36.00**			
61		**36.00**	**37.50**			
62		**37.50**	**39.00**	25.99	2.65	0.15
63		**39.00**	**40.50**			
64		**40.50**	**42.00**			
65		**42.00**	**43.50**	25.92	2.63	0.41
66		**43.50**	**45.00**			
67		**45.00**	**46.50**			
68		**46.50**	**48.00**			

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
69		48.00	49.50			
70		49.50	51.00	25.82	2.62	0.57
71		51.00	52.50			
72		52.50	54.00			
73		54.00	55.50			
74		57.00	58.50	25.96	2.64	0.23
75		58.50	60.00			
76		60.00	61.50			
77		63.00	64.50			
78		64.50	66.00	25.94	2.64	0.28
79		66.00	67.50			
80		67.50	69.00	25.82	2.63	0.23
81		69.00	70.50	25.91	2.63	0.29
82		70.50	72.00			
83		72.00	73.50			
	Min.			25.67	2.61	0.15
	Max.			26.09	2.65	0.57
	Avg.			25.88	2.63	0.32
84	BH-15	0.00	1.50			
85		1.50	3.00			
86		3.00	4.50			
87		4.50	6.00	25.66	2.6	0.51
88		6.00	7.50			
89		7.50	9.00			
90		9.00	10.50			
91		10.50	12.00			
92		12.00	13.50			
93		15.00	16.50	25.33	2.57	0.51
94		16.50	18.00			
95		18.00	19.50			
96		19.50	21.00	25.53	2.59	0.5
97		21.00	22.50			
98		22.50	24.00			
99		24.00	25.50			
100		25.50	27.00	25.38	2.57	0.63
101		27.00	28.50			
102		28.50	30.00			

Sr.No.	**BH NO.**	**Depth**		**Weight Density**	**Specific Gravity**	**Water Absorption**
		From	**To**	**(kN/m^3)**		**(%)**
103		**30.00**	**31.50**			
104		**31.50**	**33.00**	25.5	2.59	0.49
105		**33.00**	**34.50**			
106		**34.50**	**36.00**			
107		**36.00**	**37.50**			
108		**37.50**	**39.00**			
109		**39.00**	**40.50**			
110		**40.50**	**42.00**			
111		**42.00**	**43.50**	25.2	2.55	0.6
112		**43.50**	**45.00**			
113		**45.00**	**46.50**			
114		**46.50**	**48.00**			
115		**48.00**	**49.50**	25.36	2.57	0.47
116		**49.50**	**51.00**			
117		**51.00**	**52.50**			
118		**52.50**	**54.00**			
119		**54.00**	**55.50**	25.5	2.59	0.47
120		**57.00**	**58.50**			
121		**58.50**	**60.00**			
122		**60.00**	**61.50**			
123		**61.50**	**63.00**			
124		**64.50**	**66.00**	25.74	2.61	0.53
125		**66.00**	**67.50**			
126		**67.50**	**69.00**			
127		**69.00**	**70.00**	25.07	2.54	0.46
	Min.			25.07	2.54	0.46
	Max.			25.74	2.61	0.63
	Avg.			25.43	2.58	0.52
128	**BH-15A**	**0.00**	**1.50**			
129		**1.50**	**3.00**			
130		**3.00**	**4.50**	25.44	2.59	0.16
131		**4.50**	**6.00**			
132		**6.00**	**7.50**			

Sr.No.	**BH NO.**	**Depth**		**Weight Density**	**Specific Gravity**	**Water Absorption**
		From	**To**	**(kN/m³)**		**(%)**
133		**7.50**	**9.00**			
138		**9.00**	**10.50**	25.55	2.59	0.47
139		**10.50**	**12.00**			
140		**12.00**	**13.50**			
141		**13.50**	**15.00**			
142		**15.00**	**16.50**			
143		**16.50**	**18.00**			
144		**18.00**	**19.50**	25.35	2.57	0.75
145		**19.50**	**21.00**			
146		**21.00**	**22.50**			
147		**22.50**	**24.00**	25.69	2.6	0.55
148		**25.50**	**27.00**			
149		**27.00**	**28.50**			
150		**28.50**	**30.00**	25.17	2.56	0.2
151		**30.00**	**31.50**			
152		**31.50**	**33.00**	25.45	2.58	0.72
153		**33.00**	**34.50**			
154		**34.50**	**36.00**			
155		**36.00**	**37.50**	24.81	2.52	0.46

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
156		37.50	39.00			
157		39.00	40.50	25.01	2.54	0.45
158		40.50	42.00			
159		42.00	43.50	25.58	2.6	0.38
160		43.50	45.00	25.02	2.54	0.57
161		46.50	48.00			
162		48.00	49.50			
163		49.50	51.00			
	Min.			24.81	2.52	0.16
	Max.			25.69	2.6	0.75
	Avg.			25.307	2.57	0.47
164	BH-16	0.00	1.50			
165		1.50	3.00	25.43	2.59	0.25
166		3.00	4.50			
167		4.50	6.00			
168		4.50	6.00			
169		7.50	9.00			
170		9.00	10.50			
171		10.50	12.00	25.3	2.56	0.62
172		12.00	13.50			
173		13.50	15.00	25.51	2.58	0.7
174		18.00	19.50			
175		19.50	21.00			
176		21.00	22.50			
177		22.50	24.00	26.39	2.68	0.57
178		24.00	25.50			
179		25.50	27.00			
180		27.00	28.50			
181		28.50	30.00			
182		30.00	31.50	26.33	2.67	0.48
183		31.50	33.00			

Sr.No.	**BH NO.**	**Depth**		**Weight Density**	**Specific Gravity**	**Water Absorption**
		From	**To**	**(kN/m³)**		**(%)**
184		**33.00**	**34.50**			
185		**33.00**	**34.50**			
186		**36.00**	**37.50**			
187		**37.50**	**39.00**	26.52	2.69	0.51
188		**39.00**	**40.50**			
189		**40.50**	**42.00**			
190		**42.00**	**43.50**			
191		**45.00**	**46.50**			
192		**46.50**	**48.00**	25.54	2.63	0.63
193		**48.00**	**49.50**	26.24	2.67	0.3
194		**49.50**	**51.00**			
195		**52.50**	**54.00**			
196		**54.00**	**55.50**			
197		**55.50**	**57.00**			
198		**58.50**	**60.00**	26.36	2.67	0.46
199		**60.00**	**61.50**	26.1	2.65	0.51
200		**61.50**	**62.00**			
	Min.			25.3	2.56	0.25
	Max.			26.52	2.69	0.7
	Avg.			25.97	2.64	0.50

BH 17				
Depth	**Sample Number**	**Weight Density**	**Specific Gravity**	**Water Absorption**
		(kN/m³)		**(%)**
19.50	BH17/1221/R/01	26.21	2.67	0
20.50	BH17/1221/R/03			
22.00	BH17/1221/R/05			
23.00	BH17/1221/R/06	25.73	2.61	0.36
24.50	BH17/1221/R/07			
	BH17/1221/R/08			
25.00	BH17/0122/R/09			
	BH17/0122/R/10			
26.00	BH17/0122/R/11	25.7	2.61	0.38

BH 17				
Depth	**Sample Number**	**Weight Density**	**Specific Gravity**	**Water Absorption**
	BH17/0122/R/12			
	BH17/0122/R/13			
27.50	BH17/0122/R/14			
	BH17/0122/R/15			
	BH17/0122/R/16	24.79	2.5	0.95
	BH17/0122/R/17			
28.00	BH17/0122/R/18			
	BH17/0122/R/19			
	BH17/0122/R/20			
29.50	BH17/0122/R/21	25.21	2.54	1.18
	BH17/0122/R/22			
	BH17/0122/R/23			
30.00	BH17/0122/R/24			
	BH17/0122/R/25	25.79	2.63	0.16
31.50	BH17/0122/R/26			
	BH17/0122/R/27			
	BH17/0122/R/28			
	BH17/0122/R/29	25.82	2.62	0.36
32.50	BH17/0122/R/30			
	BH17/0122/R/31			
33.50	BH17/0122/R/32			
	BH17/0122/R/33			
	BH17/0122/R/34			
	BH17/0122/R/35	26.2	2.66	0.21
	BH17/0122/R/36			
35.00	BH17/0122/R/37			
	BH17/0122/R/38			
41.00	BH17/0122/R/40	24.96	2.52	1.1
	BH17/0122/R/41			
42.50	BH17/0122/R/42			
	BH17/0122/R/43			
45.50	BH17/1221/R/48	25.48	2.59	0.39
	BH17/1221/R/49			
	BH17/1221/R/50			
	BH17/1221/R/51			
47.00	BH17/1221/R/52			
	BH17/1221/R/53			
48.50	BH17/1221/R/54	24.23	2.45	0.9

BH 17				
Depth	**Sample Number**	**Weight Density**	**Specific Gravity**	**Water Absorption**
	BH17/1221/R/55			
	BH17/1221/R/56			
	BH17/1221/R/57			
50.00	BH17/1221/R/58			
	BH17/1221/R/59			
51.50	BH17/1221/R/62			
	BH17/1221/R/63	25.13	2.54	0.81
	BH17/1221/R/64			
	BH17/1221/R/65			
	BH17/1221/R/66			
	BH17/1221/R/67			
53.00	BH17/1221/R/69			
	BH17/1221/R/70			
	BH17/1221/R/71	25.73	2.62	0.2
	BH17/1221/R/72			
	BH17/1221/R/73			
54.50	BH17/1221/R/74			
	BH17/1221/R/75			
	BH17/1221/R/76			
	BH17/1221/R/77	25.51	2.59	0.21
56.00	BH17/1221/R/78			
	BH17/1221/R/79			
58.00	BH17/1221/R/80			
	BH17/1221/R/81	25.54	2.58	0.72
59.50	BH17/1221/R/82	25.25	2.55	0.78
61.00	BH17/1221/R/83			
	BH17/1221/R/84			
	BH17/1221/R/85	25.31	2.57	0.45
	BH17/1221/R/86			
62.00	BH17/1221/R/87			
	BH17/1221/R/88	25.68	2.61	0.42
	BH17/1221/R/89			
	BH17/1221/R/90			
	BH17/1221/R/91			
	BH17/1221/R/92			
Min.		**24.23**	**2.45**	**0**
Max.		**26.21**	**2.67**	**1.18**
Average.		**25.42**	**2.58**	**0.56**

ANNEXURE –E
Point load index

Point load index Test

Sr.No.	**BH NO.**	**Depth**		**Point load index**
		From	**To**	**(MPa)**
1	**BH-13**	**0.50**	**1.50**	
2		**1.50**	**3.00**	
3		**3.00**	**4.50**	
4		**4.50**	**6.00**	3.73
5		**6.00**	**7.50**	
6		**7.50**	**9.00**	
7		**9.00**	**10.50**	
8		**10.50**	**12.00**	
9		**15.00**	**16.50**	
10		**16.50**	**18.00**	2.61
11		**18.00**	**19.50**	
12		**19.50**	**21.00**	
13		**21.00**	**22.50**	
14		**22.50**	**24.00**	2.39
15		**24.00**	**25.50**	
16		**25.50**	**27.00**	
17		**27.00**	**28.50**	
18		**28.50**	**30.00**	
19		**30.00**	**31.50**	1.01
20		**31.50**	**33.00**	
21		**33.00**	**34.50**	
22		**34.50**	**36.00**	
23		**36.00**	**37.50**	
24		**37.50**	**39.00**	2.30
25		**39.00**	**40.50**	
26		**40.50**	**42.00**	
27		**42.00**	**43.50**	
28		**43.50**	**45.00**	
29		**45.00**	**46.50**	
30		**46.50**	**48.00**	
31		**48.00**	**49.50**	
32		**49.50**	**51.00**	
33		**51.00**	**52.50**	
34		**52.50**	**54.00**	

Sr.No.	BH NO.	Depth		Point load index
		From	To	(MPa)
35		54.00	55.50	1.6
36		55.50	57.00	
37		57.00	58.50	
38		58.50	60.00	
	Min.			1.01
	Max.			3.20
	Avg.			2.18
39	BH-14	1.50	3.00	21.83
40		3.00	4.50	
41		4.50	6.00	
42		6.00	7.50	
43		7.50	9.00	
44		9.00	10.50	3.2
45		10.50	12.00	
46		12.00	13.50	
47		15.00	16.50	3.23
48		16.50	18.00	
49		18.00	19.50	
50		19.50	21.00	
51		21.00	22.50	
52		22.50	24.00	
53		24.00	25.50	3.62
54		25.50	27.00	
55		27.00	28.50	
56		28.50	30.00	
57		30.00	31.50	
58		31.50	33.00	
59		33.00	34.50	
60		34.50	36.00	3.08
61		36.00	37.50	
62		37.50	39.00	
63		39.00	40.50	
64		40.50	42.00	
65		42.00	43.50	
66		43.50	45.00	
67		45.00	46.50	
68		46.50	48.00	

Sr.No.	**BH NO.**	**Depth**		**Point load index**
		From	**To**	**(MPa)**
69		**48.00**	**49.50**	3.16
70		**49.50**	**51.00**	
71		**51.00**	**52.50**	
72		**52.50**	**54.00**	
73		**54.00**	**55.50**	2.37
74		**57.00**	**58.50**	
75		**58.50**	**60.00**	
76		**60.00**	**61.50**	
77		**63.00**	**64.50**	
78		**64.50**	**66.00**	
79		**66.00**	**67.50**	2.26
80		**67.50**	**69.00**	
81		**69.00**	**70.50**	
82		**70.50**	**72.00**	
83		**72.00**	**73.50**	
	Min.			2.27
	Max.			3.62
	Avg.			2.99
84	**BH-15**	**0.00**	**1.50**	3.15
85		**1.50**	**3.00**	
86		**3.00**	**4.50**	
87		**4.50**	**6.00**	
88		**6.00**	**7.50**	
89		**7.50**	**9.00**	
90		**9.00**	**10.50**	
91		**10.50**	**12.00**	3.66
92		**12.00**	**13.50**	
93		**15.00**	**16.50**	
94		**16.50**	**18.00**	
95		**18.00**	**19.50**	
96		**19.50**	**21.00**	
97		**21.00**	**22.50**	2.53
98		**22.50**	**24.00**	
99		**24.00**	**25.50**	
100		**25.50**	**27.00**	
101		**27.00**	**28.50**	
102		**28.50**	**30.00**	

Sr.No.	**BH NO.**	**Depth**		**Point load index**
		From	**To**	**(MPa)**
103		**30.00**	**31.50**	3.21
104		**31.50**	**33.00**	
105		**33.00**	**34.50**	
106		**34.50**	**36.00**	
107		**36.00**	**37.50**	
108		**37.50**	**39.00**	
109		**39.00**	**40.50**	3.66
110		**40.50**	**42.00**	
111		**42.00**	**43.50**	
112		**43.50**	**45.00**	
113		**45.00**	**46.50**	3.35
114		**46.50**	**48.00**	
115		**48.00**	**49.50**	
116		**49.50**	**51.00**	3.53
117		**51.00**	**52.50**	
118		**52.50**	**54.00**	
119		**54.00**	**55.50**	
120		**57.00**	**58.50**	
121		**58.50**	**60.00**	
122		**60.00**	**61.50**	3.85
123		**61.50**	**63.00**	
124		**64.50**	**66.00**	
125		**66.00**	**67.50**	
126		**67.50**	**69.00**	
127		**69.00**	**70.00**	
	Min.			2.5
	Max.			3.8
	Avg.			3.37
128	**BH-15A**	**0.00**	**1.50**	2.86
129		**1.50**	**3.00**	
130		**3.00**	**4.50**	
131		**4.50**	**6.00**	
132		**6.00**	**7.50**	

Sr.No.	BH NO.	Depth		Point load index
		From	To	(MPa)
133		7.50	9.00	
138		9.00	10.50	
139		10.50	12.00	
140		12.00	13.50	3.02
141		13.50	15.00	
142		15.00	16.50	
143		16.50	18.00	
144		18.00	19.50	
145		19.50	21.00	
146		21.00	22.50	
147		22.50	24.00	3.15
148		25.50	27.00	
149		27.00	28.50	
150		28.50	30.00	
151		30.00	31.50	
152		31.50	33.00	
153		33.00	34.50	3.4
154		34.50	36.00	

Sr.No.	**BH NO.**	**Depth**		**Point load index**
		From	**To**	**(MPa)**
155		**36.00**	**37.50**	
156		**37.50**	**39.00**	
157		**39.00**	**40.50**	
158		**40.50**	**42.00**	3.3
159		**42.00**	**43.50**	
160		**43.50**	**45.00**	
161		**46.50**	**48.00**	
162		**48.00**	**49.50**	
163		**49.50**	**51.00**	
	Min.			2.86
	Max.			3.4
	Avg.			3.14
164	**BH-16**	**0.00**	**1.50**	
165		**1.50**	**3.00**	
166		**3.00**	**4.50**	
167		**4.50**	**6.00**	
168		**4.50**	**6.00**	
169		**7.50**	**9.00**	
170		**9.00**	**10.50**	2.16
171		**10.50**	**12.00**	
172		**12.00**	**13.50**	
173		**13.50**	**15.00**	
174		**18.00**	**19.50**	
175		**19.50**	**21.00**	2.06
176		**21.00**	**22.50**	
177		**22.50**	**24.00**	
178		**24.00**	**25.50**	
179		**25.50**	**27.00**	
180		**27.00**	**28.50**	
181		**28.50**	**30.00**	
182		**30.00**	**31.50**	

Sr.No.	**BH NO.**	**Depth**		**Point load index**
		From	**To**	**(MPa)**
183		**31.50**	**33.00**	3.47
184		**33.00**	**34.50**	
185		**33.00**	**34.50**	
186		**36.00**	**37.50**	
187		**37.50**	**39.00**	
188		**39.00**	**40.50**	
189		**40.50**	**42.00**	
190		**42.00**	**43.50**	
191		**45.00**	**46.50**	3.84
192		**46.50**	**48.00**	
193		**48.00**	**49.50**	
194		**49.50**	**51.00**	3.32
195		**52.50**	**54.00**	
196		**54.00**	**55.50**	
197		**55.50**	**57.00**	
198		**58.50**	**60.00**	
199		**60.00**	**61.50**	3.60
200		**61.50**	**62.00**	
	Min.			2.06
	Max.			3.84
	Avg.			3.07

BH 17		
Depth	**Sample Number**	**Point load index (Mpa)**
19.50	BH17/1221/R/01	3.02
20.50	BH17/1221/R/03	
22.00	BH17/1221/R/05	
23.00	BH17/1221/R/06	
24.50	BH17/1221/R/07	
	BH17/1221/R/08	2.97
25.00	BH17/0122/R/09	
	BH17/0122/R/10	
26.00	BH17/0122/R/11	

BH 17		
Depth	**Sample Number**	**Point load index (Mpa)**
	BH17/0122/R/12	2.9
	BH17/0122/R/13	
27.50	BH17/0122/R/14	
	BH17/0122/R/15	2.95
	BH17/0122/R/16	
	BH17/0122/R/17	
28.00	BH17/0122/R/18	
	BH17/0122/R/19	
	BH17/0122/R/20	
29.50	BH17/0122/R/21	
	BH17/0122/R/22	
	BH17/0122/R/23	2.84
30.00	BH17/0122/R/24	
	BH17/0122/R/25	
31.50	BH17/0122/R/26	
	BH17/0122/R/27	
	BH17/0122/R/28	
	BH17/0122/R/29	
32.50	BH17/0122/R/30	
	BH17/0122/R/31	
33.50	BH17/0122/R/32	
	BH17/0122/R/33	
	BH17/0122/R/34	
	BH17/0122/R/35	
	BH17/0122/R/36	
35.00	BH17/0122/R/37	
	BH17/0122/R/38	
41.00	BH17/0122/R/40	
	BH17/0122/R/41	
42.50	BH17/0122/R/42	
	BH17/0122/R/43	
44.00	BH17/0122/R/44	
	BH17/0122/R/45	
	BH17/0122/R/46	
	BH17/0122/R/47	
45.50	BH17/1221/R/48	
	BH17/1221/R/49	
	BH17/1221/R/50	
	BH17/1221/R/51	
47.00	BH17/1221/R/52	
	BH17/1221/R/53	

BH 17		
Depth	**Sample Number**	**Point load index (Mpa)**
48.50	BH17/1221/R/54	
	BH17/1221/R/55	
	BH17/1221/R/56	
	BH17/1221/R/57	
50.00	BH17/1221/R/58	
	BH17/1221/R/59	
	BH17/1221/R/60	
	BH17/1221/R/61	
51.50	BH17/1221/R/62	
	BH17/1221/R/63	
	BH17/1221/R/64	
	BH17/1221/R/65	
	BH17/1221/R/66	
	BH17/1221/R/67	
53.00	BH17/1221/R/69	
	BH17/1221/R/70	
	BH17/1221/R/71	
	BH17/1221/R/72	
	BH17/1221/R/73	2.82
54.50	BH17/1221/R/74	
	BH17/1221/R/75	
	BH17/1221/R/76	
	BH17/1221/R/77	3.02
56.00	BH17/1221/R/78	
	BH17/1221/R/79	2.94
58.00	BH17/1221/R/80	
	BH17/1221/R/81	
59.50	BH17/1221/R/82	
61.00	BH17/1221/R/83	
	BH17/1221/R/84	
	BH17/1221/R/85	
	BH17/1221/R/86	
Min.		**2.82**
Max.		**3.02**
Average.		**2.9325**

ANNEXURE –F

Modulus of elasticity and Poisson's ratio

Modulus of elasticity and Poisson’s ratio

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
1	BH-13	0.50	1.50		
2		1.50	3.00	31.4	0.14
3		3.00	4.50		
4		4.50	6.00		
5		6.00	7.50		
6		7.50	9.00		
7		9.00	10.50		
8		10.50	12.00	45.2	0.15
9		15.00	16.50		
10		16.50	18.00		
11		18.00	19.50	48	0.13
12		19.50	21.00		
13		21.00	22.50		
14		22.50	24.00		
15		24.00	25.50		
16		25.50	27.00	46.3	0.14
17		27.00	28.50		
18		28.50	30.00		
19		30.00	31.50		
20		31.50	33.00		
21		33.00	34.50	42.4	0.16
22		34.50	36.00		
23		36.00	37.50		
24		37.50	39.00		
25		39.00	40.50	42.7	0.15
26		40.50	42.00		
27		42.00	43.50		
28		43.50	45.00	43.1	0.14
29		45.00	46.50		
30		46.50	48.00	43.5	0.15
31		48.00	49.50		
32		49.50	51.00	41.6	0.17
33		51.00	52.50		
34		52.50	54.00		

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
35		54.00	55.50		
36		55.50	57.00	45.7	0.16
37		57.00	58.50		
38		58.50	60.00	53.6	0.1
			Min.	31.4	0.1
			Max.	53.6	0.17
			Avg.	43.95	0.14
39	BH-14	1.50	3.00		
40		3.00	4.50		
41		4.50	6.00	35.6	0.12
42		6.00	7.50		
43		7.50	9.00		
44		9.00	10.50		
45		10.50	12.00	47.4	0.12
46		12.00	13.50		
47		15.00	16.50		
48		16.50	18.00	53	0.11
49		18.00	19.50		
50		19.50	21.00		
51		21.00	22.50		
52		22.50	24.00		
53		24.00	25.50		
54		25.50	27.00	47.1	0.13
55		27.00	28.50		
56		28.50	30.00		
57		30.00	31.50	45.4	0.14
58		31.50	33.00		
59		33.00	34.50		
60		34.50	36.00		
61		36.00	37.50	35.1	0.16
62		37.50	39.00		
63		39.00	40.50		
64		40.50	42.00		
65		42.00	43.50		
66		43.50	45.00	33.7	0.16
67		45.00	46.50		

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
68		46.50	48.00	52.2	0.13
69		48.00	49.50		
70		49.50	51.00		
71		51.00	52.50	43.6	0.14
72		52.50	54.00		
73		54.00	55.50		
74		57.00	58.50	38.7	0.15
75		58.50	60.00		
76		60.00	61.50	45.3	0.13
77		63.00	64.50		
78		64.50	66.00		
79		66.00	67.50		
80		67.50	69.00	39.5	0.13
81		69.00	70.50		
82		70.50	72.00	39.7	0.14
83		72.00	73.50		
	Min.			33.7	0.11
	Max.			53	0.16
	Avg.			42.79	0.14
84	BH-15	0.00	1.50		
85		1.50	3.00	47.6	0.14
86		3.00	4.50		
87		4.50	6.00		
88		6.00	7.50		
89		7.50	9.00	49.1	0.12
90		9.00	10.50		
91		10.50	12.00		
92		12.00	13.50		
93		15.00	16.50		
94		16.50	18.00	48	0.15
95		18.00	19.50		
96		19.50	21.00		
97		21.00	22.50		
98		22.50	24.00	46.9	0.15
99		24.00	25.50		
100		25.50	27.00		

Sr.No.	**BH NO.**	**Depth**		**Modulus of Elasticity (GPa)**	**Poisson's Ratio**
		From	**To**		
101		**27.00**	**28.50**	47.6	0.15
102		**28.50**	**30.00**		
103		**30.00**	**31.50**		
104		**31.50**	**33.00**		
105		**33.00**	**34.50**	46.6	0.14
106		**34.50**	**36.00**		
107		**36.00**	**37.50**		
108		**37.50**	**39.00**		
109		**39.00**	**40.50**		
110		**40.50**	**42.00**		
111		**42.00**	**43.50**		
112		**43.50**	**45.00**	52.4	0.12
113		**45.00**	**46.50**		
114		**46.50**	**48.00**	51.6	0.13
115		**48.00**	**49.50**		
116		**49.50**	**51.00**	41.2	0.14
117		**51.00**	**52.50**		
118		**52.50**	**54.00**	43.4	0.14
119		**54.00**	**55.50**		
120		**57.00**	**58.50**	47.7	0.13
121		**58.50**	**60.00**		
122		**60.00**	**61.50**		
123		**61.50**	**63.00**	48.9	0.13
124		**64.50**	**66.00**		
125		**66.00**	**67.50**	45.8	0.14
126		**67.50**	**69.00**		
127		**69.00**	**70.00**	48.9	0.12
	Min.			41.2	0.12
	Max.			52.4	0.15
	Avg.			47.55	0.14
128	**BH-15A**	**0.00**	**1.50**		
129		**1.50**	**3.00**	46.1	0.12
130		**3.00**	**4.50**		
131		**4.50**	**6.00**		

Sr.No.	**BH NO.**	**Depth**		**Modulus of Elasticity (GPa)**	**Poisson's Ratio**
		From	**To**		
132		**6.00**	**7.50**	45.8	0.11
133		**7.50**	**9.00**		
138		**9.00**	**10.50**		
139		**10.50**	**12.00**		
140		**12.00**	**13.50**	42.9	0.13
141		**13.50**	**15.00**		
142		**15.00**	**16.50**		
143		**16.50**	**18.00**		
144		**18.00**	**19.50**		
145		**19.50**	**21.00**		
146		**21.00**	**22.50**	44.5	0.12
147		**22.50**	**24.00**		
148		**25.50**	**27.00**		
149		**27.00**	**28.50**	46.3	0.11
150		**28.50**	**30.00**		
151		**30.00**	**31.50**		
152		**31.50**	**33.00**	47.4 49.8	0.11 0.1

Sr.No.	**BH NO.**	**Depth**		**Modulus of Elasticity (GPa)**	**Poisson's Ratio**
		From	**To**		
153		**33.00**	**34.50**		
154		**34.50**	**36.00**		
155		**36.00**	**37.50**	47.6	0.09
156		**37.50**	**39.00**		
157		**39.00**	**40.50**	45.8	0.13
158		**40.50**	**42.00**		
159		**42.00**	**43.50**	47.9	0.12
160		**43.50**	**45.00**		
161		**46.50**	**48.00**		
162		**48.00**	**49.50**	50.1	0.12
163		**49.50**	**51.00**		
	Min.			42.9	0.09
	Max.			50.1	0.13
	Avg.			46.75	0.11
164	**BH-16**	**0.00**	**1.50**	54.2	0.14
165		**1.50**	**3.00**		
166		**3.00**	**4.50**		
167		**4.50**	**6.00**		
168		**4.50**	**6.00**		
169		**7.50**	**9.00**	39.9	0.14
170		**9.00**	**10.50**		
171		**10.50**	**12.00**		
172		**12.00**	**13.50**		
173		**13.50**	**15.00**		
174		**18.00**	**19.50**	51.3	0.11
175		**19.50**	**21.00**		
176		**21.00**	**22.50**		
177		**22.50**	**24.00**	39.7	0.13
178		**24.00**	**25.50**		
179		**25.50**	**27.00**		

Sr.No.	**BH NO.**	**Depth**		**Modulus of Elasticity (GPa)**	**Poisson's Ratio**
		From	**To**		
180		**27.00**	**28.50**		
181		**28.50**	**30.00**		
182		**30.00**	**31.50**	51.3	0.12
183		**31.50**	**33.00**		
184		**33.00**	**34.50**		
185		**33.00**	**34.50**		
186		**36.00**	**37.50**		
187		**37.50**	**39.00**	55.5	0.11
188		**39.00**	**40.50**		
189		**40.50**	**42.00**		
190		**42.00**	**43.50**	40.3	0.13
191		**45.00**	**46.50**		
192		**46.50**	**48.00**	52.6	0.11
193		**48.00**	**49.50**		
194		**49.50**	**51.00**	45.9	0.12
195		**52.50**	**54.00**		
196		**54.00**	**55.50**		
197		**55.50**	**57.00**	51.4	0.1
198		**58.50**	**60.00**		
199		**60.00**	**61.50**	50.8	0.12
200		**61.50**	**62.00**		
	Min.			39.7	0.1
	Max.			55.5	0.14
	Avg.			48.45	0.12

	BH 17		
Depth	**Sample Number**	**Modulus of Elasticity (GPa)**	**Poisson's Ratio**
19.50	BH17/1221/R/01		
20.50	BH17/1221/R/03		
22.00	BH17/1221/R/05	44.3	0.12
23.00	BH17/1221/R/06		

	BH 17		
Depth	**Sample Number**	**Modulus of**	**Poisson's Ratio**
24.50	BH17/1221/R/07		
	BH17/1221/R/08		
25.00	BH17/0122/R/09	42.1	0.1
	BH17/0122/R/10		
26.00	BH17/0122/R/11		
	BH17/0122/R/12		
	BH17/0122/R/13		
27.50	BH17/0122/R/14		
	BH17/0122/R/15		
	BH17/0122/R/16		
	BH17/0122/R/17		
28.00	BH17/0122/R/18	48.4	0.12
	BH17/0122/R/19		
	BH17/0122/R/20		
29.50	BH17/0122/R/21		
	BH17/0122/R/22		
	BH17/0122/R/23		
30.00	BH17/0122/R/24		
	BH17/0122/R/25		
31.50	BH17/0122/R/26		
	BH17/0122/R/27	43.3	0.11
	BH17/0122/R/28		
	BH17/0122/R/29		
32.50	BH17/0122/R/30		
	BH17/0122/R/31		
33.50	BH17/0122/R/32		
	BH17/0122/R/33		
	BH17/0122/R/34		
	BH17/0122/R/35		
	BH17/0122/R/36	44.3	0.08
35.00	BH17/0122/R/37		
	BH17/0122/R/38		
41.00	BH17/0122/R/40		
	BH17/0122/R/41	45.1	0.13
42.50	BH17/0122/R/42		
	BH17/0122/R/43		
44.00	BH17/0122/R/44		
	BH17/0122/R/45		
	BH17/0122/R/46		
	BH17/0122/R/47		
45.50	BH17/1221/R/48		
	BH17/1221/R/49	42.8	0.11
	BH17/1221/R/50		
	BH17/1221/R/51		

	BH 17		
Depth	**Sample Number**	**Modulus of**	**Poisson's Ratio**
47.00	BH17/1221/R/52		
	BH17/1221/R/53		
48.50	BH17/1221/R/54		
	BH17/1221/R/55		
	BH17/1221/R/56		
	BH17/1221/R/57	41.6	0.13
50.00	BH17/1221/R/58		
	BH17/1221/R/59		
	BH17/1221/R/60		
	BH17/1221/R/61		
51.50	BH17/1221/R/62		
	BH17/1221/R/63		
	BH17/1221/R/64		
	BH17/1221/R/65		
	BH17/1221/R/66	45.5	0.1
	BH17/1221/R/67		
54.50	BH17/1221/R/74		
	BH17/1221/R/75	48.5	0.09
	BH17/1221/R/76		
	BH17/1221/R/77		
56.00	BH17/1221/R/78		
	BH17/1221/R/79		
58.00	BH17/1221/R/80	49.3	0.11
	BH17/1221/R/81		
59.50	BH17/1221/R/82		
61.00	BH17/1221/R/83		
	BH17/1221/R/84		
	BH17/1221/R/85		
	BH17/1221/R/86		
62.00	BH17/1221/R/87	43.7	0.1
	BH17/1221/R/88		
Min.		**41.6**	**0.08**
Max.		**49.3**	**0.13**
Average.		**44.91**	**0.11**

ANNEXURE –G
Triaxial Test

Sr No.	BH No.	Depth		Triaxial Test	
		From	To	Cohesion	Angle of Internal Friction
1	**BH-13**	**27.00**	**30.00**	**17.9**	**63**
2		**40.50**	**43.50**	**20.88**	**60.02**
3		**48.00**	**49.50**	**15.13**	**65.23**
	Min.			**15.13**	**60.02**
	Max.			**20.88**	**65.23**
	Avg.			**17.97**	**62.75**
4	**BH-14**	**10.50**	**13.50**	**17.66**	**62.8**
5		**28.50**	**31.50**	**18.53**	**62.06**
6		**63.00**	**66.00**	**24.39**	**56.48**
	Min.			**17.66**	**56.48**
	Max.			**24.39**	**62.8**
	Avg.			**20.19**	**60.45**
7	**BH-15**	**40.50**	**43.50**	**13.78**	**66.39**
	Min.			**13.78**	**66.39**
	Max.			**13.78**	**66.39**
	Avg.			**13.78**	**66.39**

Sr No.	BH No.	Depth		Triaxial Test	
		From	To	Cohesion	Angle of Internal Friction
8	**BH-15A**	**13.50**	**15.00**	**16.54**	**64.08**
9		**30.00**	**31.50**	**15.71**	**64.67**
	Min.			**15.71**	**64.08**
	Max.			**16.54**	**64.67**
	Avg.			**16.13**	**64.38**
10	**BH-16**	**27.00**	**30.00**	**14.50**	**65.63**
11		**52.50**	**54.00**	**14.75**	**65.63**
	Min.			**14.50**	**65.63**
	Max.			**14.75**	**65.63**
	Avg.			**14.63**	**65.63**
12	**BH-17**	**25.0**	**27.5**	**13.58**	**69.96**
13		**42.5**	**44.0**	**19.44**	**66.36**
14		**59.5**	**61.0**	**18.89**	**66.76**
	Min.			**13.58**	**66.36**
	Max.			**19.44**	**69.96**
	Avg.			**17.30**	**67.69**

ANNEXURE –H
Hardness

Sr No.	BH No.	Depth		Hardness Number
		From	To	
1	**BH-13**	**3.00**	**4.50**	**66.5**
2		**6.00**	**7.50**	**64.6**
3		**19.50**	**21.00**	**61.4**
4		**24.00**	**25.50**	**60**
5		**31.50**	**33.00**	**53.1**
6		**36.00**	**37.50**	**58.2**
7		**43.50**	**45.00**	**59.9**
8		**46.50**	**48.00**	**64.8**
9		**57.00**	**58.50**	**59.9**
	Min.			**53.1**
	Max.			**66.5**
	Avg.			**60.93**
10	**BH-14**	**6.00**	**7.50**	**59.8**
11		**18.00**	**19.50**	**63.2**
12		**22.50**	**24.00**	**61.8**
13		**31.50**	**33.00**	**63.6**
14		**40.50**	**42.00**	**58.8**
15		**46.50**	**48.00**	**56.2**
16		**57.00**	**58.50**	**59.00**
17		**70.50**	**72.00**	**57.2**
18		**72.00**	**73.50**	**57.8**
	Min.			**56.2**
	Max.			**63.6**
	Avg.			**59.71**

Sr No.	BH No.	Depth		Hardness Number
		From	To	
19	**BH-15**	**4.50**	**6.00**	**58.6**
20		**9.00**	**10.50**	**53.4**
21		**12.00**	**13.50**	**59**
22		**18.00**	**19.50**	**61.7**
23		**25.50**	**27.00**	**60**
24		**34.50**	**36.00**	**54.4**
25		**51.00**	**52.50**	**59.6**
26		**54.00**	**55.50**	**60.6**
27		**60.00**	**61.50**	**61.5**
28		**67.50**	**69.00**	**60.1**
	Min.			**53.4**
	Max.			**61.7**
	Avg.			**58.89**
29	**BH-15A**	**3.00**	**4.50**	**61**
30		**9.00**	**10.50**	**61.2**
31		**15.00**	**16.50**	**61.5**
32		**21.00**	**22.50**	**60.2**
33		**25.50**	**27.00**	**56.2**
34		**33.00**	**34.50**	**56.1**
35		**39.00**	**40.50**	**61.1**
36		**46.50**	**48.00**	**62.2**
	Min.			**56.1**
	Max.			**62.2**
	Avg.			**59.94**

Sr No.	BH No.	Depth		Hardness Number
		From	To	
37	**BH-16**	**3.00**	**4.50**	**60.2**
38		**13.50**	**15.00**	**61.7**
39		**21.00**	**22.50**	**61.7**
40		**27.00**	**28.50**	**61.6**
41		**36.00**	**37.50**	**54.8**
42		**46.50**	**48.00**	**58.6**
43		**55.50**	**57.00**	**60.2**
		Min.		**54.8**
		Max.		**61.7**
		Avg.		**59.83**
44	**BH-17**	**20.5**	**22.0**	**27.4**
45		**26.0**	**27.5**	**25.5**
46		**27.5**	**28.0**	**30.2**
47		**29.5**	**30.0**	**31.8**
48		**31.5**	**32.5**	**22.1**
49		**32.5**	**33.5**	**50.6**
50		**33.5**	**35.0**	**34.5**
51		**41.0**	**42.5**	**34.1**
52		**44.0**	**45.5**	**40.0**
53		**47**	**48.5**	**24.5**
54		**51.5**	**53.0**	**28.6**
55		**54.5**	**56**	**33.9**
56		**61.0**	**62.0**	**36.3**
	Min.			**22.1**
	Max.			**50.6**
	Avg.			**32.65**

ANNEXURE –I
Abrasiveness Test

Sr No.	BH No.	Depth		Abrasiveness	Classification
		From	To		(HRC=55)
1	**BH-13**	**3.00**	**4.50**	**2.66**	**High Abrasiveness**
2		**6.00**	**7.50**	**2.7**	**High Abrasiveness**
3		**19.50**	**21.00**	**2.62**	**High Abrasiveness**
4		**24.00**	**25.50**	**2.68**	**High Abrasiveness**
5		**31.50**	**33.00**	**2.96**	**High Abrasiveness**
6		**36.00**	**37.50**	**2.99**	**High Abrasiveness**
7		**43.50**	**45.00**	**2.96**	**High Abrasiveness**
8		**46.50**	**48.00**	**3.01**	**High Abrasiveness**
9		**57.00**	**58.50**	**3.37**	**High Abrasiveness**
	Min.			**2.62**	**High Abrasiveness**
	Max.			**3.37**	**High Abrasiveness**
	Avg.			**2.88**	**High Abrasiveness**
10	**BH-14**	**6.00**	**7.50**	**2.54**	**High Abrasiveness**
		10.50	**12.00**	**2.38**	**High Abrasiveness**
11		**18.00**	**19.50**	**2.5**	**High Abrasiveness**
12		**22.50**	**24.00**	**2.44**	**High Abrasiveness**
13		**31.50**	**33.00**	**2.33**	**High Abrasiveness**
14		**40.50**	**42.00**	**2.74**	**High Abrasiveness**
15		**46.50**	**48.00**	**2.5**	**High Abrasiveness**
16		**57.00**	**58.50**	**2.76**	**High Abrasiveness**
17		**70.50**	**72.00**	**2.64**	**High Abrasiveness**
18		**72.00**	**73.50**	**2.64**	**High Abrasiveness**
	Min.			**2.33**	**High Abrasiveness**
	Max.			**2.76**	**High Abrasiveness**
	Avg.			**2.55**	**High Abrasiveness**

Sr No.	BH No.	Depth		Abrasiveness	Classification
		From	To		(HRC=55)
19	**BH-15**	**4.50**	**6.00**	**2.99**	**High Abrasiveness**
20		**9.00**	**10.50**	**2.96**	**High Abrasiveness**
21		**12.00**	**13.50**	**3.19**	**High Abrasiveness**
22		**18.00**	**19.50**	**2.88**	**High Abrasiveness**
23		**25.50**	**27.00**	**3.25**	**High Abrasiveness**
24		**34.50**	**36.00**	**3.23**	**High Abrasiveness**
		43.50	**45.00**	**3.43**	**High Abrasiveness**
25		**51.00**	**52.50**	**3.07**	**High Abrasiveness**
26		**54.00**	**55.50**	**3.19**	**High Abrasiveness**
27		**60.00**	**61.50**	**3.15**	**High Abrasiveness**
28		**67.50**	**69.00**	**3.29**	**High Abrasiveness**
	Min.			**2.88**	**High Abrasiveness**
	Max.			**3.43**	**High Abrasiveness**
	Avg.			**3.15**	**High Abrasiveness**
29	**BH-15A**	**3.00**	**4.50**	**3.17**	**High Abrasiveness**
30		**9.00**	**10.50**	**3.23**	**High Abrasiveness**
31		**15.00**	**16.50**	**3.21**	**High Abrasiveness**
32		**21.00**	**22.50**	**3.39**	**High Abrasiveness**
33		**25.50**	**27.00**	**2.92**	**High Abrasiveness**
34		**33.00**	**34.50**	**3.13**	**High Abrasiveness**
35		**39.00**	**40.50**	**3.15**	**High Abrasiveness**
36		**46.50**	**48.00**	**3.01**	**High Abrasiveness**
	Min.			**2.92**	**High Abrasiveness**
	Max.			**3.39**	**High Abrasiveness**
	Avg.			**3.15**	**High Abrasiveness**

Sr No.	BH No.	Depth		Abrasiveness	Classification
		From	To		(HRC=55)
37	**BH-16**	**3.00**	**4.50**	**3.15**	**High Abrasiveness**
38		**13.50**	**15.00**	**3.23**	**High Abrasiveness**
39		**21.00**	**22.50**	**2.94**	**High Abrasiveness**
40		**27.00**	**28.50**	**3.15**	**High Abrasiveness**
41		**36.00**	**37.50**	**3.15**	**High Abrasiveness**
42		**46.50**	**48.00**	**3.27**	**High Abrasiveness**
43		**55.50**	**57.00**	**3.31**	**High Abrasiveness**
	Min.			**2.94**	
	Max.			**3.31**	
	Avg.			**3.17**	
44	**BH-17**	**20.5**	**22.0**	**1.95**	**Medium Abrasiveness**
45		**26.0**	**27.5**	**1.91**	**Medium Abrasiveness**
46		**27.5**	**28.0**	**2.38**	**High Abrasiveness**
47		**29.5**	**30.0**	**2.58**	**High Abrasiveness**
48		**31.5**	**32.5**	**2.18**	**High Abrasiveness**
49		**32.5**	**33.5**	**2.36**	**High Abrasiveness**
50		**33.5**	**35.0**	**2.46**	**High Abrasiveness**
51		**41.0**	**42.5**	**2.12**	**High Abrasiveness**
52		**44.0**	**45.5**	**2.28**	**High Abrasiveness**
53		**47**	**48.5**	**2.16**	**High Abrasiveness**
54		**51.5**	**53.0**	**2.08**	**High Abrasiveness**
55		**54.5**	**56**	**2.24**	**High Abrasiveness**
56		**61.0**	**62.0**	**1.97**	**Medium Abrasiveness**
	Min.			**1.91**	
	Max.			**2.58**	
	Avg.			**2.21**	

ANNEXURE –G
SOIL TEST Results

*** The SPT N values illustrated in the tables below are raw values (without correction factor) collected directly from field.**
*** The phi values represented in the tables are measured in laboratory, they do not illustrate the phi values in the insitu condition.**

Consultant:	**Geotechnical Investigation Report**		*Client:*
S.M. CONSULTANTS **BHUBANESWAR**	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**From 0.0 m to 1.50 m depth**	UDS		6.23	1.87	4.63	37.26	37.56	12.45	25	19	6	10.56	1.754	1.586	0.09	27	DS	2.66	0.68	0.136	ML-CL
2	**From 1.50 m to 3.0 m depth**	SPT	12	11.53	2.21	5.3	29.63	38.70	12.63	25	20	5	---	---	---	---	---	---	2.66		---	ML-CL
3	**From 3.0 m to 4.50 m depth**	UDS	---	5.23	3.14	4.87	6.85	65.06	14.85	26	20	6	12.45	1.816	1.615	0.15	14	UU	2.67	0.65	0.129	ML-CL
4	**From 4.50 m to 6.0 m depth**	SPT	16	4.21	1.35	4.58	7.59	65.88	16.39	27	20	7	---	---	---	---	---	---	2.67		---	ML-CL
5	**From 6.0 m to 9.0 m depth**	UDS	---	3.15	2.84	6.47	9.66	63.26	14.62	25	20	5	13.82	1.853	1.628	0.15	12	UU	2.66	0.63	0.139	ML-CL
6	**From 9.0 m to 12.0 m depth**	SPT	26	7.14	0.73	1.12	5.69	68.56	16.76	26	19	7	---	---	---	---	---	---	2.68	---	---	ML-CL
7	**From 12.0 m to 15.0 m depth**	SPT	21	6.02	1.06	2.48	7.03	67.55	15.86	25	19	6	---	---	---	---	---	---	2.67	---	---	ML-CL

Contd… BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear test Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
8	**From 15.0 m to 16.50 m depth**	SPT	37	6.97	3.25	2.28	3.29	68.29	15.92	25	20	5	---	---	---	---	---	---	2.67	---	---	ML-CL
9	**From 16.50 m to 18.00 m depth**	SPT	>50	26	0.87	0.9	3.67	56.10	12.46	24	18	6	---	---	---	---	---	---	2.66	---	---	ML-CL
10	**From 18.0 m to 19.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=17%, R.Q.D=NIL)																		
11	**From 19.50 m to 20.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=22%, R.Q.D=NIL)																		
12	**From 20.50m to 22.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=25%, R.Q.D=11.6%)																		
13	**From 22.0 m to 23.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=32%, R.Q.D=NIL)																		
14	**From 23.0 m to 24.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=33%, R.Q.D=NIL)																		
15	**From 24.50 m to 25.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=48%, R.Q.D=25%)																		

TEST RESULTSHEET

Contd… BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
16	**From 25.00 m to 26.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=59%, R.Q.D=32.6%)																		
17	**From 26.00 m to 27.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=44%, R.Q.D=12.66%)																		
18	**From 27.50 m to 28.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=68%, R.Q.D=25.8%)																		
19	**From 28.0 m to 29.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=58%, R.Q.D=7.6%)																		
20	**From 29.50 m to 30.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=70%, R.Q.D=NIL)																		
21	**From 30.00m to 31.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=47%, R.Q.D=17.13%)																		
22	**From 31.0 m to 32.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=64%, R.Q.D=NIL)																		

Contd… BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				ine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
23	**From 32.50 m to 33.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=54%, R.Q.D=15.53%)																		
24	**From 33.50 m to 35.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=34.66%, R.Q.D=NIL)																		
25	**From 35.00 m to 36.50 m depth**	SPT	>50	2.16	1.51	3.55	67.09	25.69	0.00	21	---	NP	---	---	---	---	---	---	2.65	---	---	SM
26	**From 36.50 m to 38.00 m depth**	SPT	>50	3.41	1.61	9.75	71.60	13.63	0.00	20	---	NP	---	---	---	---	---	---	2.64	---	---	SM
27	**From 38.00 m to 39.50 m depth**	SPT	>50	4.10	1.37	2.57	5.31	71.41	15.24	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
28	**From 39.50 m to 41.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=32%, R.Q.D=11%)																		
29	**From 41.00 m to 42.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=41.33%, R.Q.D=19.33%)																		

TEST RESULTSHEET

Contd… BH-17, (CH-25785 M)

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
30	**From 42.50m to 44.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=54%, R.Q.D=41.53%)																		
31	**From 44.0 m to 45.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=30%, R.Q.D=NIL)																		
32	**From 45.50 m to 47.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=37.33%, R.Q.D=NIL)																		
33	**From 47.00 m to 48.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=41.33%, R.Q.D=21.06%)																		
34	**From 48.50 m to 50.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=30%, R.Q.D=NIL)																		
35	**From 50.00 m to 51.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=36.66%, R.Q.D=NIL)																		
36	**From 51.50 m to 53.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=34.66%, R.Q.D=12%)																		

Contd… BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
37	**From 53.00 m to 54.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=33.33%, R.Q.D=6.8%)																		
38	**From 54.50 m to 56.00m depth**	ROCK	---	ROCK (CORE RECOVERY=28%, R.Q.D=6.73%)																		
39	**From 56.00m to 58.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=38%, R.Q.D=8%)																		
40	**From 58.00 m to 59.50m depth**	ROCK	---	ROCK (CORE RECOVERY=38.33%, R.Q.D=NIL)																		
41	**From 59.50 m to 61.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=40.6%, R.Q.D=27.66%)																		
42	**From 61.00 m to 62.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=70%, R.Q.D=12.66%)																		

***Note: From 35.0 m to 39.5m depth, highly weathered soft rock stratum exists from which core sample couldn't be collected only washed out sample has been collected.**

TEST RESULTSHEET

BH-18, (CH-25990)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear test Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	2.77	21.85	66.69	8.69	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
2	**At 1.5 m depth**	UDS	---	0	0.09	0.54	34.22	58.61	6.54	24	---	NP	11.42	1.765	1.584	0.13	17	UU	2.66	0.68	0.132	ML
3	**At 3.0 m depth**	SPT	11	1.21	0.16	1.49	7.87	80.01	9.26	25	---	NP				---	---	---	2.68	---	---	ML
4	**At 4.5 m depth**	UDS	---	0	0.13	0.53	35.77	55.94	7.63	25	---	NP	12.63	1.803	1.601	0.12	19	UU	2.66	0.66	0.128	ML
5	**At 6.0 m depth**	SPT	20	0.75	1.12	1.02	11.01	76.63	9.47	26	---	NP				---	---	---	2.68	---	---	ML
6	**At 9.0 m depth**	UDS	---	0	0	0.64	22.85	67.82	8.69	26	---	NP	14.63	1.853	1.617	0.16	14	UU	2.67	0.65	0.125	ML
7	**At 12.0 m depth**	SPT	24	0	0	0.41	17.66	71.47	10.46	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
8	**At 15.0 m depth**	SPT	31	0	0	0.65	13.25	70.87	15.23	27	21	6	---	---	---	---	---	---	2.70	---	---	ML-CL
9	**At 18.0 m depth**	SPT	35	1.12	3.05	3.21	12.74	65.99	13.89	25	20	5	---	---	---	---	---	---	2.69	---	---	ML-CL

Contd… BH-18, (CH-25990)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear test Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	40	0	4.27	4.28	12.73	66.51	12.21	26	20	6	---	---	---	---	---	---	2.69	---	---	ML-CL
11	**At 24.0 m depth**	SPT	47	2.08	5.39	4.35	10.17	70.32	7.69	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
12	**At 27.00 m depth**	SPT	49	2.77	5.59	4.54	7.57	71.08	8.45	24	---	NP	---	---	---	---	---	---	2.67	---	---	ML
13	**At 30.00 m depth**	SPT	57	6.59	2.30	2.13	11.62	70.87	6.49	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
14	**At 33.00 m depth**	SPT	64	2.29	3.32	2.72	20.65	64.68	6.34	24	---	NP	---	---	---	---	---	---	2.65	---	---	ML
15	**At 36.00 m depth**	SPT	69	1.21	3.92	2.72	20.65	64.94	6.56	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML
16	**At 39.00 m depth**	SPT	77	1.21	3.92	5.48	13.20	68.82	7.37	26	---	NP	---	---	---	---	---	---	2.66	---	---	ML
17	**At 42.00 m depth**	SPT	84	0	0.29	4.69	14.85	70.53	9.64	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
18	**At 45.00 m depth**	SPT	>50	0.86	1.29	2.47	21.77	66.35	7.26	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
19	**At 47.00 m depth**	SPT	>50	1.01	0.95	1.68	21.22	67.29	7.85	25	---	NP	---	---	---	---	---	---	2.65	---	---	ML

Contd… BH-18, (CH-25990)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear test Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
20	**At 50.0 m depth**	SPT	>50	0	0	0.38	36.92	56.16	6.54	24	---	NP	---	---	---	---	---	---	2.68	---	---	ML
21	**At 53.0 m depth**	SPT	>50	5.50	1.11	0.98	17.76	66.76	7.89	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
22	**At 55.00 m depth**	SPT	>50	4.29	1.92	1.75	16.29	67.63	8.12	26	---	NP	---	---	---	---	---	---	2.66	---	---	ML

TEST RESULTSHEET

BH-19, (CH-26210 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 197

				Grain size analysis				Hydrometer Analysis		Atterberg's Limit												
Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %	Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
1	**At 0.5 m depth**	DS	---	0	0	0.52	31.8	46.32	21.36	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	17	0	0	0.35	29.33	47.89	22.43	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	0.78	33.46	45.28	20.48	24	---	NP	10.59	1.761	1.592	0.14	20	DS	2.66	0.67	0.123	ML
4	**At 4.5 m depth**	SPT	23	13.54	1.59	3.96	10.02	49.93	20.96	24	---	NP	---	---	---	---	---	---	2.65	---	---	ML
5	**At 6.0 m depth**	UDS	---	6.24	2.85	4.39	13.62	49.46	23.44	27	---	NP	11.36	1.792	1.609	0.13	24	DS	2.67	0.66	0.118	ML
6	**At 9.0 m depth**	SPT	30	5.8	0.24	3.24	9.08	54.79	26.85	26	---	NP	---	---	---	---	---	---	2.68	--	---	ML
7	**At 12.0 m depth**	UDS	---	3.15	0.46	1.79	13.63	56.03	24.94	26	---	NP	11.85	1.813	1.621	0.10	26	DS	2.68	0.65	0.114	ML
8	**At 15.0 m depth**	SPT	35	1.01	0.3	0.8	17.77	55.86	24.26	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML

Contd… BH-19, (CH-26210 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	5.26	0.96	1.45	14.96	54.50	22.87	26	---	NP	12.64	1.826	1.621	0.11	25	DS	2.66	0.64	0.111	ML
10	**At 21.0 m depth**	SPT	35	8.28	0.81	2.77	12.82	55.69	19.63	24	---	NP	---	---	---	---	---	---	2.65	---	---	ML
11	**At 24.0 m depth**	UDS	---	3.45	0.69	1.75	21.82	51.85	20.44	25	---	NP	13.76	1.849	1.625	0.12	23	DS	2.66	0.64	0.115	ML
12	**At 27.00 m depth**	SPT	39	0.55	0.29	1.08	27.15	51.39	19.54	24	---	NP	---	---	---	---	---	---	2.65	---	---	ML
13	**At 30.00 m depth**	UDS	---	0.63	0.45	1.69	24.85	50.75	21.63	25	---	NP	14.24	1.863	1.631	0.08	27	DS	2.66	0.63	0.116	ML
14	**At 33.00 m depth**	SPT	43	2.3	3.3	12.85	60.05	21.50	0.00	19	---	NP	---	---	---	---	---	---	2.65	---	---	SM
15	**At 36.00 m depth**	DS	---	0.53	3.24	13.83	62.42	19.98	0.00	18	---	NP	---	---	---	---	---	---	2.63	---	---	SM
16	**At 39.00 m depth**	SPT	52	0	0	11.29	43.73	44.98	0.00	21	---	NP	---	---	---	---	---	---	2.65	---	---	SM
17	**At 42.00 m depth**	DS	---	0.14	1.64	12.89	50.37	34.96	0.00	20	---	NP	---	---	---	---	---	---	2.64	---	---	SM
18	**At 45.00 m depth**	SPT	65	0.62	0.82	10.3	43.26	45.00	0.00	21	---	NP	---	---	---	---	---	---	2.65	---	---	SM

Contd… BH-19, (CH-26210 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
19	**At 48.00 m depth**	DS	---	1.01	2.08	12.23	52.69	31.99	0.00	20	---	NP	---	---	---	---	---	---	2.64	---	---	SM
20	**At 50.00 m depth**	SPT	80	0.22	0.92	11.98	51.54	35.34	0.00	21	---	NP	---	---	---	---	--	---	2.63	---	----	SM

TEST RESULTSHEET

BH-20, (CH-26387M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

				Grain size analysis				Hydrometer Analysis		Atterberg's Limit												
Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %	Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
1	**At 0.5 m depth**	DS	---	0	0	1.04	38.61	54.08	6.27	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
2	**At 1.5 m depth**	SPT	18	0	0	2.56	45.72	46.58	5.14	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
3	**At 3.0 m depth**	UDS	---	1.8	0.78	1.42	39.52	50.44	6.04	26	---	NP	11.58	1.761	1.578	0.12	24	DS	2.66	0.69	0.118	ML
4	**At 4.5 m depth**	SPT	32	0	0	1.13	39.71	53.23	5.93	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
5	**At 6.0 m depth**	UDS	---	0	0	0.67	40.58	52.93	5.82	25	---	NP	12.43	1.795	1.597	0.14	27	DS	2.66	0.67	0.112	ML
6	**At 9.0 m depth**	SPT	48	8.24	0.8	1.32	4.08	77.09	8.47	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	DS	---	14.74	5.96	3.44	37.78	38.08	0.00	21	---	NP	---	---	---	---	---	---	2.64	---	---	SM
8	**At 15.0 m depth**	SPT	60	13.83	3.05	4.49	14.01	57.77	6.85	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
9	**At 18.0 m depth**	DS	---	15.72	10.44	3.33	15.53	49.18	5.80	22	---	NP	---	---	---	---	---	---	2.65	---	---	ML

Contd… BH-20, (CH-26387 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	67	4.2	2.21	2.11	28.52	56.46	6.50	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML
11	**At 24.0 m depth**	SPT	76	0	0	1.81	13.06	76.83	8.30	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
12	**At 27.00 m depth**	UDS	---	3.38	2.51	7.06	7.7	64.85	14.50	31	20	11	14.21	1.902	1.665	0.27	12	UU	2.70	0.62	0.134	CL
13	**At 30.00 m depth**	SPT	58	0	0	0.21	11.23	71.36	17.20	33	21	12	---	---	---	---	---	---	2.71	---	---	CL
14	**At 33.00 m depth**	UDS	---	0.76	1.71	3.61	6.07	71.05	16.80	33	20	13	14.85	1.935	1.685	0.30	11	UU	2.71	0.61	0.136	CL
15	**At 36.00 m depth**	SPT	67	1.2	0.77	4.01	17.67	62.15	14.20	31	21	10	---	---	---	---	---	---	2.70	---	---	CL
16	**At 39.00 m depth**	UDS	---	0	0.63	1.08	7.44	72.35	18.50	34	22	12	15.38	1.958	1.697	0.36	14	UU	2.72	0.60	0.138	CL
17	**At 42.00 m depth**	SPT	75	3.12	1.63	3.72	9.71	64.92	16.90	32	21	11	---	---	---	---	---	---	2.71	---	---	CL
18	**At 45.00 m depth**	UDS	---	0	0	1.11	24.18	60.71	14.00	30	18	12	16.47	1.988	1.707	0.31	10	UU	2.70	0.58	0.133	CL
19	**At 48.00 m depth**	SPT	79	0	0.69	0.18	8.39	72.34	18.40	34	23	11	---	---	---	---	---	---	2.72	---	---	CL

TEST RESULTSHEET

BH-21, (CH-26587 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.98	29.34	63.28	6.40	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	14	0	0	0.8	27.92	64.38	6.90	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	0.78	23.87	67.85	7.50	27	---	NP	10.28	1.768	1.603	0.11	24	DS	2.67	0.67	0.112	ML
4	**At 4.5 m depth**	SPT	20	0	0	1.02	26.12	65.76	7.10	26	---	NP	---	---	---	---	---	---	2.66	---	---	ML
5	**At 6.0 m depth**	UDS	---	10.23	0.57	2.52	8.02	70.86	7.80	27	---	NP	11.47	1.819	1.632	0.10	25	DS	2.68	0.64	0.116	ML
6	**At 9.0 m depth**	SPT	31	8.31	1.47	2.56	10.42	69.94	7.30	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	UDS	---	22.85	4.06	2.15	19.18	45.06	6.70	25	---	NP	12.16	1.824	1.626	0.07	27	DS	2.64	0.62	0.109	ML
8	**At 15.0 m depth**	SPT	38	0	1.06	3.7	6.73	80.11	8.40	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
9	**At 18.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY = 6.0%, R.Q.D=4.5%)																		

Contd… BH-21, (CH-26587 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=3.5%, R.Q.D=NIL)																		
11	**At 24.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=4.0%, R.Q.D=NIL)																		
12	**At 27.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=6.0%, R.Q.D=NIL)																		
13	**At 30.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=9.0%, R.Q.D=NIL)																		
14	**At 33.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=6.0%, R.Q.D=NIL)																		
15	**At 36.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=4.6%, R.Q.D=NIL)																		
16	**At 39.00 m depth**	DS	---	1.59	1.05	1.79	9.41	77.76	8.40	28	---	NP	---	---	---	---	---	---	2.68	---	---	ML
17	**At 42.00 m depth**	SPT	77	0	0.12	2.98	19.55	69.85	7.50	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
18	**At 45.00 m depth**	26600	---	0	0	3.56	22.62	66.62	7.20	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML

TEST RESULTSHEET

BH-22, (CH-26787 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.2	20.81	60.79	18.20	31	20	11	---	---	---	---	---	---	2.70	---	---	CL
2	**At 1.5 m depth**	SPT	15	0	0	0.29	29.32	62.89	7.50	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0.39	0.16	0.32	29.83	63.00	6.30	26	---	NP	11.58	1.752	1.570	0.11	22	DS	2.66	0.69	0.116	ML
4	**At 4.5 m depth**	SPT	21	19.14	0.52	3.9	11.46	58.38	6.60	25	---	NP	---	---	---	---	---	---	2.65	---	---	ML
5	**At 6.0 m depth**	UDS	---	0	0.2	0.14	24.82	67.64	7.20	27	---	NP	13.57	1.826	1.608	0.13	28	DS	2.67	0.66	0.112	ML
6	**At 9.0 m depth**	SPT	28	16.76	2.29	7.05	8.02	59.08	6.80	26	---	NP	---	---	---	---	---	---	2.66	---	---	ML
7	**At 12.0 m depth**	PEBBLE	---	PEBBLE PIECES WERE COLLECTED																		
8	**At 15.0 m depth**	PEBBLE	---	PEBBLE PIECES WERE COLLECTED																		
9	**At 18.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=3.0%, R.Q.D=NIL)																		

Contd… BH-22, (CH-26787 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=2.3%, R.Q.D=NIL)																		
11	**At 24.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=3.0%, R.Q.D=NIL)																		
12	**At 27.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=2.0%, R.Q.D=NIL)																		
13	**At 30.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=3.0%, R.Q.D=NIL)																		
14	**At 33.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=2.3%, R.Q.D=NIL)																		
15	**At 36.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=4.0%, R.Q.D=NIL)																		
16	**At 39.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=4.0%, R.Q.D=NIL)																		
17	**At 42.00 m depth**	DS	---	0	0.3	1.58	33.52	44.10	20.50	30	20	10	---	---	---	---	---	---	2.71	---	---	CL
18	**At 45.00 m depth**	SPT	91	6.44	0.88	1.4	32.90	38.78	19.60	28	19	9	---	---	---	---	---	---	2.70	---	---	CL

TEST RESULTSHEET

BH-23, (CH-26980 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0	32.85	53.65	13.50	30	18	12	---	---	---	---	---	---	2.70	---	---	CL
2	**At 1.5 m depth**	SPT	16	0	0	0.2	20.45	64.55	14.80	32	19	13	---	---	---	---	---	---	2.71	---	---	CL
3	**At 3.0 m depth**	UDS	---	0	0	0.2	20.32	64.58	14.90	32	20	12	10.62	1.752	1.584	0.31	9	UU	2.71	0.71	0.130	CL
4	**At 4.5 m depth**	SPT	23	12.8	0.7	1.67	9.92	60.71	14.20	31	18	13	---	---	---	---	---	---	2.70	---	---	CL
5	**At 6.0 m depth**	UDS	---	0	0	1.37	15.52	67.91	15.20	33	20	13	11.35	1.785	1.603	0.26	12	UU	2.72	0.70	0.132	CL
6	**At 9.0 m depth**	SPT	34	0	0	0	23.15	70.65	6.20	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
7	**At 12.0 m depth**	DS	---	6.27	1.67	7.71	9.26	60.89	14.20	32	19	13	---	---	---	---	---	---	2.70	---	---	CL
8	**At 15.0 m depth**	SPT	38	2.31	2.23	15.61	8.32	57.63	13.90	30	17	13	---	---	---	---	---	---	2.69	---	---	CL
9	**At 18.0 m depth**	DS	---	0	0	0.2	19.19	65.81	14.80	33	19	14	---	---	---	---	---	---	2.71	---	---	CL

TEST RESULTSHEET

Contd… BH-23, (CH-26980 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	50	5.71	0.9	0.99	49.32	43.08	0.00	20	---	NP	---	---	---	---	---	---	2.65	---	---	SM
11	**At 24.0 m depth**	UDS	---	3.47	1.7	1.54	31.5	48.59	13.20	30	17	13	13.45	1.851	1.632	0.29	11	UU	2.69	0.65	0.126	CL
12	**At 27.00 m depth**	SPT	63	1.03	0.51	0.23	61.61	36.62	0.00	19	---	NP	---	---	---	---	---	---	2.64	---		SM
13	**At 30.00 m depth**	UDS	---	4.84	1.61	1.35	18.75	67.65	5.80	26	---	NP	14.62	1.883	1.643	0.11	26	DS	2.67	0.63	0.117	ML
14	**At 33.00 m depth**	SPT	73	2.64	1.21	1.95	10.36	68.54	15.30	33	19	14	---	---	---	---	---	---	2.72	---	---	CL
15	**At 36.00 m depth**	UDS	---	7.71	0.7	1.56	42.4	47.63	0.00	21	---	NP	15.48	1.906	1.651	0.04	27	DS	2.66	0.61	---	SM
16	**At 39.00 m depth**	SPT	77	0	0	0.2	1.39	79.11	19.30	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
17	**At 42.00 m depth**	UDS	---	0	2.74	7.74	11.98	62.64	14.90	31	20	11	16.21	1.961	1.687	0.30	14	UU	2.70	0.60	0.132	CL
18	**At 45.00 m depth**	SPT	85	0	0	0.49	1.74	78.57	19.20	34	22	12	---	---	---	---	---	---	2.72	---	---	CL

TEST RESULTSHEET

BH-24, (CH-27187 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.36	23.48	68.86	7.30	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
2	**At 1.5 m depth**	SPT	14	0	0	0.42	18.62	73.16	7.80	26	---	NP	---	---	---	---	---	---	2.68	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	0.82	13.57	77.41	8.20	27	---	NP	10.82	1.761	1.589	0.14	25	DS	2.68	0.69	0.113	ML
4	**At 4.5 m depth**	SPT	21	0	0	0.72	16.82	74.46	8.00	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
5	**At 6.0 m depth**	UDS	---	0.82	0.36	1.42	23.27	67.63	6.50	26	---	NP	11.48	1.784	1.600	0.11	26	DS	2.66	0.66	0.108	ML
6	**At 9.0 m depth**	SPT	27	0.34	0.68	0.95	17.43	72.9	7.70	26	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	UDS	---	0	0	0.17	25.49	67.74	6.60	25	---	NP	12.44	1.824	1.622	0.10	26	DS	2.67	0.65	0.109	ML
8	**At 15.0 m depth**	SPT	33	0	0	0.48	21.46	70.46	7.60	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
9	**At 18.0 m depth**	UDS	---	0.12	1.26	5.87	10.44	74.31	8.00	26	---	NP	13.28	1.839	1.623	0.12	27	DS	2.67	0.64	0.117	ML

Contd… BH-24, (CH-27187 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	43	0	0	12.62	15.87	65.21	6.30	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
11	**At 24.0 m depth**	UDS	---	0	0	8.47	11.49	64.44	15.60	32	20	12	15.47	1.935	1.676	0.25	15	UU	2.71	0.62	0.137	CL
12	**At 27.00 m depth**	SPT	58	0.43	0.82	5.44	8.79	68.32	16.20	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
13	**At 30.00 m depth**	UDS	---	0.29	0.45	3.28	16.74	64.14	15.10	30	20	10	15.89	1.958	1.690	0.30	11	UU	2.70	0.60	0.132	CL
14	**At 33.00 m depth**	SPT	72	0	0.17	2.62	21.53	60.88	14.80	30	19	11	---	---	---	---	---	---	2.70	---	---	CL
15	**At 36.00 m depth**	UDS	---	0	0	4.51	11.43	67.46	16.60	33	21	12	16.52	1.992	1.710	0.25	10	UU	2.72	0.59	0.136	CL
16	**At 39.00 m depth**	SPT	89	0	0	0.32	18.84	65.04	15.80	31	20	11	---	---	---	---	---	---	2.71	---	---	CL
17	**At 40.00 m depth**	UDS	---	1.23	4.62	7.38	12.56	59.61	14.60	30	21	9	17.24	2.018	1.721	0.30	12	UU	2.70	0.57	0.128	CL

TEST RESULTSHEET

BH-25, (CH-27410 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

				Grain size analysis				Hydrometer Analysis		Atterberg's Limit												
Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %	Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
1	**At 0.5 m depth**	DS	---	0	0	0.42	19.2	64.18	16.20	31	19	12	---	---	---	---	---	---	2.71	---	---	CL
2	**At 1.5 m depth**	SPT	13	0	0	0.28	5.96	74.26	19.50	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
3	**At 3.0 m depth**	UDS	---	9.16	1.88	10.4	7.00	56.36	15.20	29	17	12	12.14	1.758	1.568	0.31	10	UU	2.70	0.72	0.138	CL
4	**At 4.5 m depth**	SPT	20	0	0	0.56	20.8	62.64	16.00	30	17	13	---	---	---	---	---	---	2.70	---	---	CL
5	**At 6.0 m depth**	UDS	---	24.64	0.24	0.18	11.95	48.39	14.60	28	18	10	12.58	1.779	1.580	0.29	13	UU	2.69	0.70	0.134	CL
6	**At 9.0 m depth**	SPT	30	0	0	0.82	20.36	62.72	16.10	30	18	12	---	---	---	---	---	---	2.70	---	---	CL
7	**At 12.0 m depth**	UDS	---	0	0	0.08	21.46	62.66	15.80	30	17	13	13.42	1.816	1.601	0.26	10	UU	2.70	0.69	0.136	CL
8	**At 15.0 m depth**	SPT	31	18.06	0	0.42	18.4	48.42	14.70	29	18	11	---	---	---	---	---	---	2.69	---	---	CL
9	**At 18.0 m depth**	UDS	---	0	4.3	7.84	9.5	62.66	15.70	31	19	12	14.34	1.846	1.614	0.30	9	UU	2.70	0.67	0.134	CL

Contd… BH-25, (CH-27410 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	33	1.16	1.15	23.2	8.81	50.88	14.80	28	16	12	---	---	---	---	---	---	2.69	---	---	CL
11	**At 24.0 m depth**	UDS	---	0	0	26.28	5.92	52.9	14.90	29	17	12	15.32	1.878	1.629	0.30	10	UU	2.69	0.65	0.129	CL
12	**At 27.00 m depth**	SPT	48	9.1	1.82	18.91	7.42	48.25	14.50	28	17	11	---	---	---	---	---	---	2.69	---	---	CL
13	**At 30.00 m depth**	UDS	---	0	0	8.74	12.18	63.28	15.80	30	17	13	15.86	1.906	1.645	0.25	14	UU	2.70	0.64	0.131	CL
14	**At 33.00 m depth**	SPT	68	0	0	0.32	16.1	66.78	16.80	31	19	12	---	---	---	---	---	---	2.71	---	---	CL
15	**At 36.00 m depth**	UDS	---	4.24	5.46	10	5.02	59.98	15.30	30	17	13	16.38	1.936	1.664	0.31	11	UU	2.70	0.62	0.128	CL
16	**At 39.00 m depth**	SPT	81	0	0	0.54	14.4	68.36	16.70	32	20	12	---	---	---	---	---	---	2.71	---	---	CL
17	**At 40.00 m depth**	UDS	---	7	3.42	20.7	7.68	47.3	13.90	28	17	11	16.69	1.952	1.673	0.29	16	UU	2.69	0.61	0.125	CL

TEST RESULTSHEET

BH-26, (CH-27550)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0	1.17	79.33	19.50	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
2	**At 1.5 m depth**	SPT	11	0	0	0.10	1.20	79.50	19.20	34	22	12	---	---	---	---	---	---	2.72	---	---	CL
3	**At 3.0 m depth**	UDS	---	0	0	0	1.07	79.33	19.60	34	21	13	10.89	1.763	1.590	0.36	8	UU	2.72	0.71	0.140	CL
4	**At 4.5 m depth**	SPT	19	0	0	0.36	20.4	62.74	16.50	32	21	12	---	---	---	---	---	---	2.70	---	---	CL
5	**At 6.0 m depth**	UDS	---	0	0	0.46	16.4	65.94	17.20	33	22	11	11.62	1.801	1.614	0.34	10	UU	2.71	0.68	0.132	CL
6	**At 9.0 m depth**	SPT	28	0	0	0.42	14.4	67.58	17.60	33	23	10	---	---	---	---	---	---	2.71	---	---	CL
7	**At 12.0 m depth**	UDS	---	0	0.24	0.36	17.92	64.38	17.10	32	20	12	12.62	1.829	1.624	0.25	16	UU	2.70	0.66	0.130	CL
8	**At 15.0 m depth**	SPT	34	0	2.3	21.32	8.68	52.50	15.20	30	20	10	---	---	---	---	---	---	2.69	---	---	CL
9	**At 18.0 m depth**	UDS	---	1.6	1.13	8.97	7.83	63.67	16.80	31	21	10	13.54	1.859	1.637	0.30	11	UU	2.70	0.65	0.128	CL

Contd… BH-26, (CH-27550)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	41	2.2	5.4	9.62	3.64	62.64	16.50	31	21	10	---	---	---	---	---	---	2.71	---	---	CL
11	**At 24.0 m depth**	UDS	---	30.22	3.28	1.12	11.78	39.40	14.20	28	19	9	14.86	1.892	1.647	0.29	14	UU	2.69	0.63	0.125	CL
12	**At 27.00 m depth**	SPT	53	16.38	0	0.56	10.63	56.73	15.70	30	19	11	---	---	---	---	---	---	2.71	---	---	CL
13	**At 30.00 m depth**	UDS	---	11.84	0	0.24	9.2	62.42	16.30	31	20	11	15.42	1.936	1.677	0.30	12	UU	2.71	0.62	0.128	CL
14	**At 33.00 m depth**	SPT	65	28.78	0	0.22	13.00	43.60	14.40	29	19	10	---	---	---	---	---	---	2.69	---	---	CL
15	**At 35.00 m depth**	UDS	---	0	0	0.38	21.96	61.56	16.10	31	20	11	16.38	1.958	1.682	0.25	16	UU	2.70	0.60	0.127	CL

BH-27, (CH-28050m)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.7	21.45	57.65	20.20	31	20	11	---	---	---	---	---	---	2.70	---	---	CL
2	**At 1.5 m depth**	SPT	14	0	0	0.4	16.2	66.60	16.80	32	21	11	---	---	---	---	---	---	2.72	---	---	CL
3	**At 3.0 m depth**	UDS	---	0	0	0.4	36.03	49.97	13.60	30	18	12	11.45	1.758	1.577	0.26	10	UU	2.69	0.71	0.126	CL
4	**At 4.5 m depth**	SPT	24	0	0	1.52	18.64	64.24	15.60	31	19	12	---	---	---	---	---	---	2.70	---	---	CL
5	**At 6.0 m depth**	UDS	---	0	0	0.2	48.27	45.93	5.60	24	---	NP	12.63	1.779	1.580	0.16	14	UU	2.67	0.69	0.109	ML
6	**At 9.0 m depth**	SPT	27	6.66	0.51	1.88	6.69	66.96	17.30	31	19	12	---	---	---	---	---	---	2.72	---	---	CL
7	**At 12.0 m depth**	UDS	---	12.22	0.58	1.43	7.42	62.95	15.40	30	19	11	13.21	1.825	1.612	0.24	12	UU	2.70	0.67	0.132	CL
8	**At 15.0 m depth**	SPT	36	0	0	0.81	16.98	65.91	16.30	31	18	13	---	---	---	---	---	---	2.71	---	---	CL

Contd… BH-27, (CH-28050m)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	0	0	0.23	32.2	58.07	9.50	26	---	NP	14.45	1.854	1.620	0.18	13	UU	2.69	0.66	0.118	ML
10	**At 21.0 m depth**	SPT	45	0	0	4.68	4.92	71.80	18.60	33	20	13	---	---	---	---	---	---	2.72	---	---	CL
11	**At 24.0 m depth**	UDS	---	0	0.37	1.08	7.36	71.79	19.40	34	20	14	15.63	1.916	1.657	0.29	9	UU	2.72	0.64	0.136	CL
12	**At 27.00 m depth**	SPT	54	1.36	0.25	0.75	3.35	73.69	20.60	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
13	**At 30.00 m depth**	UDS	---	0	0	0.48	6.68	73.04	19.80	33	21	12	16.48	1.942	1.667	0.30	9	UU	2.72	0.63	0.138	CL

TEST RESULTSHEET

BH-28, (CH-28350)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.35	36.45	57.00	6.20	24	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	12	0	0.44	34.2	4.36	47.6	13.40	28	18	10	---	---	---	---	---	---	2.69	---	---	CL
3	**At 3.0 m depth**	UDS	---	0	0	0.66	27.56	65.18	6.60	25	---	NP	11.82	1.763	1.577	0.12	18	UU	2.67	0.69	0.108	ML
4	**At 4.5 m depth**	SPT	21	7.06	0.67	0.91	11.1	73.16	7.10	25	---	NP	---	---	---	---	---	---	2.68	---	---	ML
5	**At 6.0 m depth**	UDS	---	0	1.29	2.21	55.64	40.86	0.00	20	---	NP	12.47	1.782	1.584	0.03	26	DS	2.64	0.67	---	SM
6	**At 9.0 m depth**	SPT	28	0	0	1.6	8.52	82.08	7.80	25	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	UDS	---	16.98	0.76	1.3	6.54	67.62	6.80	25	---	NP	12.86	1.806	1.600	0.14	18	UU	2.66	0.66	0.110	ML
8	**At 15.0 m depth**	SPT	38	4.65	7.39	16.02	5.62	60.02	6.30	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
9	**At 18.0 m depth**	UDS	---	2.89	1.51	2.82	15.3	62.18	15.30	32	19	13	13.27	1.866	1.647	0.28	10	UU	2.70	0.64	0.136	CL

Contd… BH-28, (CH-28350)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	47	1.53	3.64	20.64	7.17	52.52	14.50	29	17	12	---	---	---	---	---	---	2.69	---	---	CL
11	**At 24.0 m depth**	UDS	---	1.52	0.39	1.78	2.39	74.32	19.60	34	20	14	14.43	1.901	1.661	0.25	10	UU	2.72	0.64	0.138	CL
12	**At 27.00 m depth**	SPT	53	0	0	2.72	3.54	74.44	19.30	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
13	**At 30.00 m depth**	UDS	---	0	0	0.68	22.58	68.94	7.80	25	---	NP	15.62	1.923	1.663	0.17	14	UU	2.66	0.60	0.109	ML
14	**At 33.00 m depth**	SPT	70	0	0.68	1.27	2.97	74.58	20.50	35	22	13	---	---	---	---	---	---	2.72	---	---	CL
15	**At 36.00 m depth**	UDS	---	0	0	3.74	3.44	73.42	19.40	33	21	12	16.45	1.987	1.706	0.26	9	UU	2.72	0.59	0.136	CL
16	**At 39.00 m depth**	SPT	81	33.16	1.42	2.18	10.64	48.00	4.60	24	---	NP	---	---	---	---	---	---	2.66	---	---	ML
17	**At 42.00 m depth**	UDS	---	0	0	2.2	16.4	73.20	8.20	25	---	NP	17.61	2.009	1.708	0.19	13	UU	2.66	0.56	0.112	ML
18	**At 45.00 m depth**	SPT	92	0	0	2.7	15.36	73.64	8.30	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML

TEST RESULTSHEET

BH-29, (CH-28550m)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	(ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.48	20.15	67.97	9.40	27	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	12	0	0	0.56	37.26	54.88	7.30	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	1.07	36.44	48.09	14.40	26	---	NP	11.45	1.761	1.580	0.20	11	UU	2.70	0.71	0.126	ML-CL
4	**At 4.5 m depth**	SPT	24	0	0	0.27	41.98	43.85	13.90	26	---	NP	---	---	---	---	---	---	2.69	---	---	ML-CL
5	**At 6.0 m depth**	UDS	---	8.04	17.4	7.97	3.10	48.89	14.60	27	20	7	11.89	1.795	1.604	0.18	14	UU	2.70	0.68	0.131	ML-CL
6	**At 9.0 m depth**	SPT	27	0	0	0.62	33.02	51.46	14.90	27	21	6	---	---	---	---	---	---	2.70	---	---	ML-CL
7	**At 12.0 m depth**	UDS	---	0	0.18	0.17	57.05	42.60	0.00	21	---	NP	12.63	1.802	1.600	0.02	25	DS	2.66	0.66	---	SM
8	**At 15.0 m depth**	SPT	38	3.91	14.98	8.17	3.37	60.77	8.80	26	---	NP	---	---	---	---	---	---	2.69	---	---	ML

Contd… BH-29, (CH-28550m)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial tes(UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	5.72	15.44	9.61	5.28	49.45	8.50	26	---	NP	13.48	1.857	1.636	0.14	19	UU	2.69	0.64	0.128	ML
10	**At 21.0 m depth**	SPT	47	0	0	0.34	23.87	65.69	10.10	27	---	NP	---	---	---	---	---	---	2.70	---	---	ML
11	**At 24.0 m depth**	UDS	---	0	0	0.98	56.73	42.29	0.00	19	---	NP	14.69	1.874	1.634	0.03	25	DS	2.66	0.63	---	SM
12	**At 27.00 m depth**	SPT	61	26.98	0.17	6.66	14.33	41.06	10.80	26	19	7	---	---	---	---	---	---	2.67	---	---	ML-CL
13	**At 30.00 m depth**	UDS	---	0	0	0.76	43.32	42.12	13.80	26	20	6	15.27	1.923	1.668	0.18	16	UU	2.69	0.61	0.127	ML-CL

Consultant:	Geotechnical Investigation Report		Client:
S.M. CONSULTANTS BHUBANESWAR	Job No.:	830	Haryana Rail Infrastructure Development Corporation Ltd
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

BH-30, (CH-28750)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.88	47.65	42.67	8.80	24	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	17	0	0	0.41	42.88	47.51	9.20	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	0.94	43.45	47.51	8.10	26	---	NP	12.62	1.768	1.570	0.17	19	UU	2.67	0.71	0.123	ML
4	**At 4.5 m depth**	SPT	22	0	1.05	2.58	8.25	68.52	19.60	27	22	5	---	---	---	---	---	---	2.69	---	---	ML-CL
5	**At 6.0 m depth**	UDS	---	0	0	0.27	11.1	69.73	18.90	28	22	6	13.47	1.816	1.600	0.19	14	UU	2.69	0.69	0.132	ML-CL
6	**At 9.0 m depth**	SPT	30	0	0	0.31	16.49	66.80	16.40	26	20	6	---	---	---	---	---	---	2.68	---	---	ML-CL
7	**At 12.0 m depth**	UDS	---	0	0.5	0.98	2.4	72.52	23.60	34	23	11	13.86	1.847	1.622	0.25	10	UU	2.72	0.68	0.146	CL
8	**At 15.0 m depth**	SPT	38	0	0	0.66	10.22	66.22	22.90	33	22	11	---	---	---	---	---	---	2.72	---	---	CL
9	**At 18.0 m depth**	UDS	---	0	0	1.69	24.57	64.54	10.20	25	---	NP	14.43	1.864	1.629	0.19	14	UU	2.68	0.66	0.125	ML

Contd… BH-30, (CH-28750)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear test Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	44	0	0	0.47	8.56	66.57	24.40	34	22	12	---	---	---	---	---	---	2.72	---	---	CL
11	**At 24.0 m depth**	UDS	---	2.75	10.44	31.23	7.20	48.38	0.00	22	---	NP	15.17	1.879	1.632	0.03	25	DS	2.67	0.64	---	SM
12	**At 27.00 m depth**	SPT	56	18.53	0.57	1.46	5.54	63.20	10.70	24	---	NP	---	---	---	---	---	---	2.70	---	---	ML
13	**At 30.00 m depth**	UDS	---	0	0	2.11	15.18	71.41	11.30	26	---	NP	16.21	1.936	1.666	0.18	15	UU	2.71	0.63	0.126	ML
14	**At 33.00 m depth**	SPT	64	0	0	0.47	35.50	54.83	9.20	25	---	NP	---	---	---	---	---	---	2.68	---	---	ML
15	**At 36.00 m depth**	UDS	---	0	0	1.72	36.52	52.16	9.60	24	---	NP	16.72	1.947	1.668	0.14	17	UU	2.69	0.61	0.128	ML
16	**At 39.00 m depth**	SPT	73	0	9.34	6.6	23.74	52.12	8.20	24	---	NP	---	---	---	---	---	---	2.67	---	---	ML
17	**At 42.00 m depth**	UDS	---	0	1.88	6.24	13.57	68.11	10.20	26	---	NP	17.62	1.995	1.696	0.16	13	UU	2.71	0.60	0.122	ML
18	**At 45.00 m depth**	SPT	84	10.2	14.44	7.44	13.61	38.31	16.00	27	20	7	---	---	---	---	---	---	2.69	---	---	ML-CL

TEST RESULTSHEET

BH-31, (CH-29050)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	(ϕ) in degree	Triaxial test (UU)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	4.09	1.33	3.53	31.98	45.07	14.00	29	18	11	---	---	---	---	---	---	2.69	---	---	CL
2	**At 1.5 m depth**	SPT	16	5.72	2.18	4.08	21.64	51.18	15.20	30	18	12	---	---	---	---	---	---	2.69	---	---	CL
3	**At 3.0 m depth**	UDS	---	27.54	2.16	2.2	37.7	30.40	0.00	21	---	NP	12.24	1.765	1.573	0.02	27	DS	2.65	0.69	---	SM
4	**At 4.5 m depth**	SPT	23	5.46	1.94	3.82	24.96	53.02	10.80	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
5	**At 6.0 m depth**	UDS	---	0	0	0.2	42.13	47.27	10.40	25	---	NP	13.47	1.808	1.593	0.04	29	DS	2.66	0.67	0.123	ML
6	**At 9.0 m depth**	SPT	32	0	0	0.86	45.22	40.02	13.90	26	---	NP	---	---	---	---	---	---	2.69	---	---	ML
7	**At 12.0 m depth**	UDS	---	0.92	1.86	11.96	5.42	63.64	16.20	26	20	6	14.61	1.882	1.642	0.17	12	UU	2.71	0.65	0.132	ML-CL
8	**At 15.0 m depth**	SPT	40	0	0	0.44	18.47	64.19	16.90	27	21	6	---	---	---	---	---	---	2.72	---	---	ML-CL

TEST RESULTSHEET

Contd… BH-31, (CH-29050)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	8.32	6.4	5.86	13.56	50.76	15.10	25	20	5	15.37	1.926	1.669	0.14	15	UU	2.70	0.62	0.130	ML-CL
10	**At 20.0 m depth**	SPT	51	1.65	2.91	6.1	11.29	61.95	16.10	27	20	7	---	---	---	---	---	---	2.69	---	---	ML-CL

TEST RESULTSHEET

BH-32, (CH-29550)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	2.18	0.46	3.88	17.28	61.30	14.90	26	20	6	---	---	---	---	---	---	2.69	---	---	ML-CL
2	**At 1.5 m depth**	SPT	17	1.56	2.2	1.92	17.08	61.94	15.30	27	21	6	---	---	---	---	---	---	2.68	---	---	ML-CL
3	**At 3.0 m depth**	UDS	---	0	0.24	0.32	29	56.14	14.30	25	20	5	10.69	1.754	1.585	0.16	15	UU	2.69	0.70	0.141	ML-CL
4	**At 4.5 m depth**	SPT	27	0	3.54	3.6	16.4	61.36	15.10	27	20	7	---	---	---	---	---	---	2.67	---	---	ML-CL
5	**At 6.0 m depth**	UDS	---	0	0	2.36	27.14	55.90	14.60	26	21	5	11.58	1.784	1.599	0.15	14	UU	2.69	0.68	0.136	ML-CL
6	**At 9.0 m depth**	SPT	35	0	0	0.26	18.4	72.54	8.80	25	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	UDS	---	25.98	8.4	6.38	8.46	43.28	7.50	24	---	NP	12.18	1.824	1.626	0.02	30	DS	2.68	0.65	0.118	ML
8	**At 15.0 m depth**	SPT	44	0	0	0.64	18.06	72.60	8.70	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML

Contd… BH-32, (CH-29550)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	0	0	1.36	33.9	57.24	7.50	25	---	NP	12.87	1.847	1.636	0.03	27	DS	2.68	0.64	0.122	ML
10	**At 21.0 m depth**	SPT	54	0	0	0.42	30.4	60.38	8.80	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
11	**At 24.0 m depth**	UDS	---	0	0	0.54	33.06	57.80	8.60	26	---	NP	13.68	1.882	1.656	0.04	26	DS	2.67	0.61	0.124	ML
12	**At 27.00 m depth**	SPT	63	0	0	1.22	16.54	72.84	9.40	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
13	**At 30.00 m depth**	UDS	---	0	0	0.82	17.96	72.02	9.20	27	---	NP	14.57	1.937	1.691	0.16	17	UU	2.68	0.59	0.132	ML

BH-33, (CH-30125)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	1.94	0.77	36.88	52.61	7.80	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML
2	**At 1.5 m depth**	SPT	11	0	0	1.94	33.44	50.42	14.20	26	20	6	---	---	---	---	---	---	2.68	---	---	ML-CL
3	**At 3.0 m depth**	UDS	---	0	0	0.79	9.79	73.02	16.40	28	22	6	11.62	1.772	1.588	0.16	14	UU	2.68	0.69	0.137	ML-CL
4	**At 4.5 m depth**	SPT	28	0	0	0.42	33.62	51.36	14.60	26	21	5	---	---	---			---	2.67	---	---	ML-CL
5	**At 6.0 m depth**	UDS	---	0	0	3.19	20.06	61.45	15.30	27	22	5	12.47	1.814	1.613	0.14	13	UU	2.68	0.66	0.131	ML-CL
6	**At 9.0 m depth**	SPT	39	0	0	0.25	24.59	60.06	15.10	27	21	6	---	---	---			---	2.67	---	---	ML-CL
7	**At 12.0 m depth**	UDS	---	0	0	0.42	25.78	59.00	14.80	26	20	6	13.27	1.843	1.627	0.09	27	DS	2.68	0.65	0.128	ML-CL
8	**At 15.0 m depth**	SPT	50	0	0	0.32	40.18	45.90	13.60	25	20	5	---	---	---	---	---	---	2.67	---	---	ML-CL

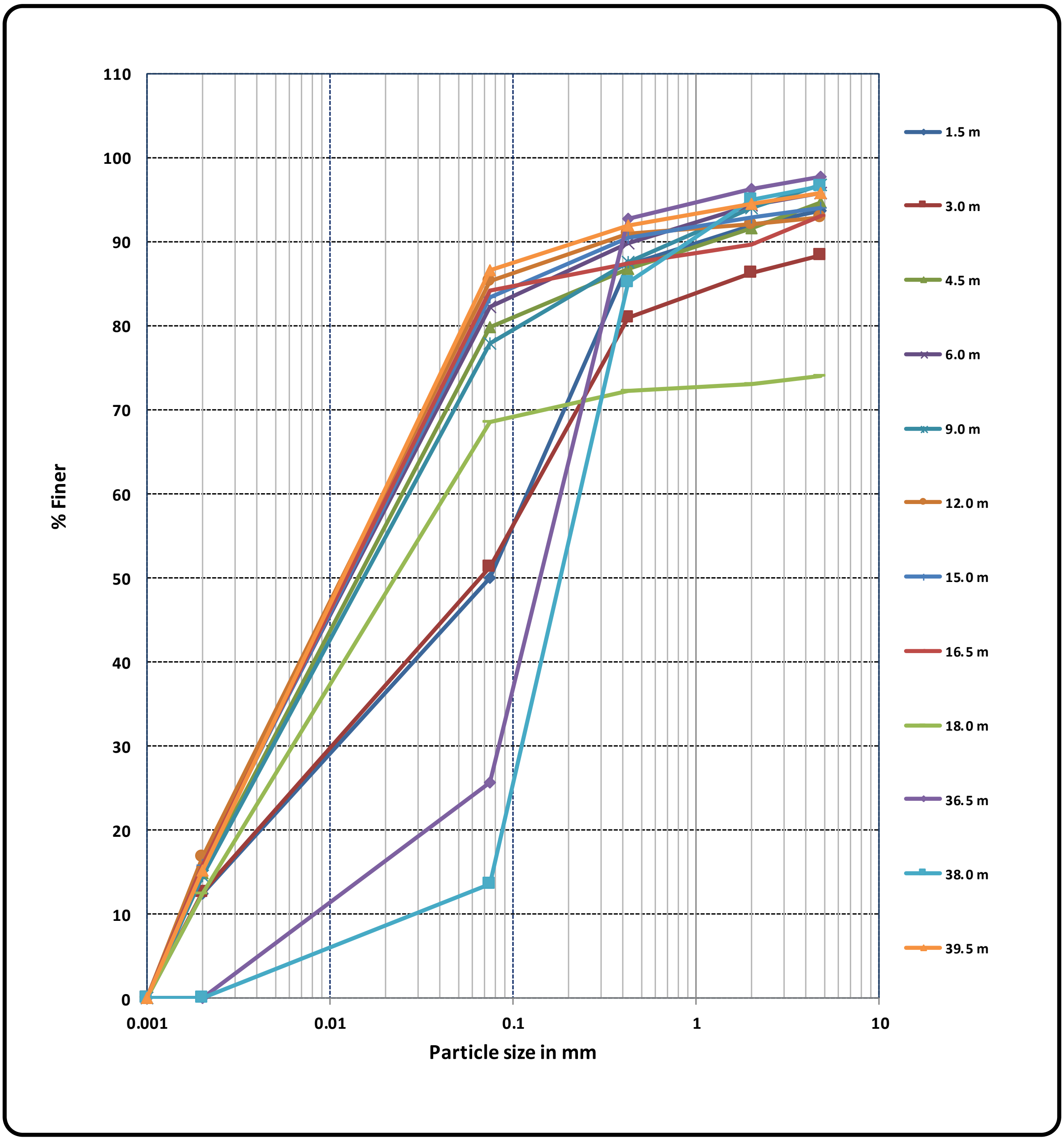
Contd… BH-33, (CH-30125)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

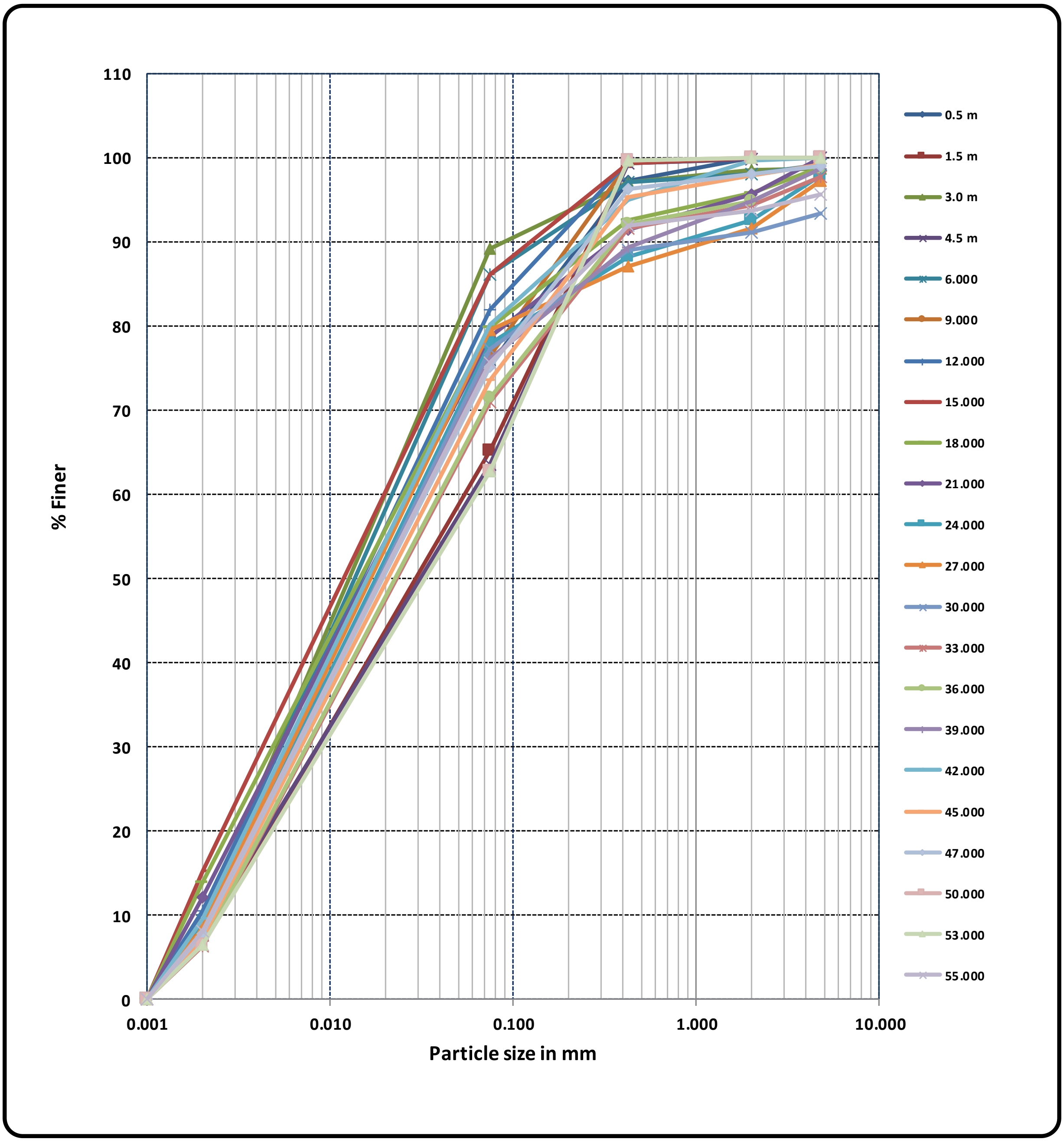
Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Medium Sand in % (4.75mm To 2.00 mm)	(2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	0	0	1.56	28.53	55.11	14.80	25	20	5	14.65	1.901	1.658	0.08	26	DS	2.68	0.62	0.126	ML-CL
10	**At 20.0 m depth**	SPT	63	0	0	3.23	20.48	61.29	15.00	26	21	5	---	---	---	---	---	---	2.67	---	---	ML-CL

ANNEXURE –H
GRAIN SIZE DISTRIBUTION CURVE

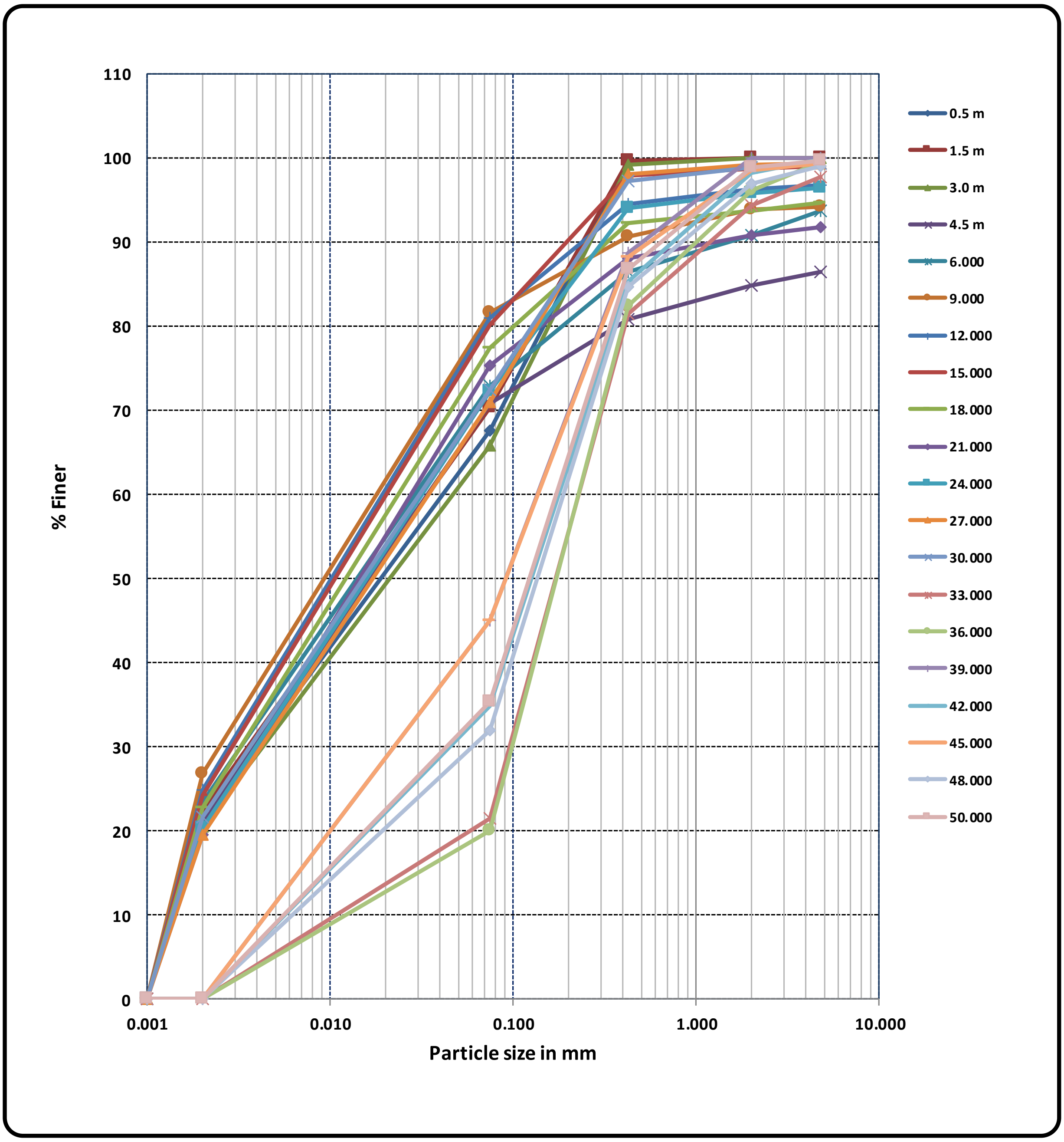
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-17



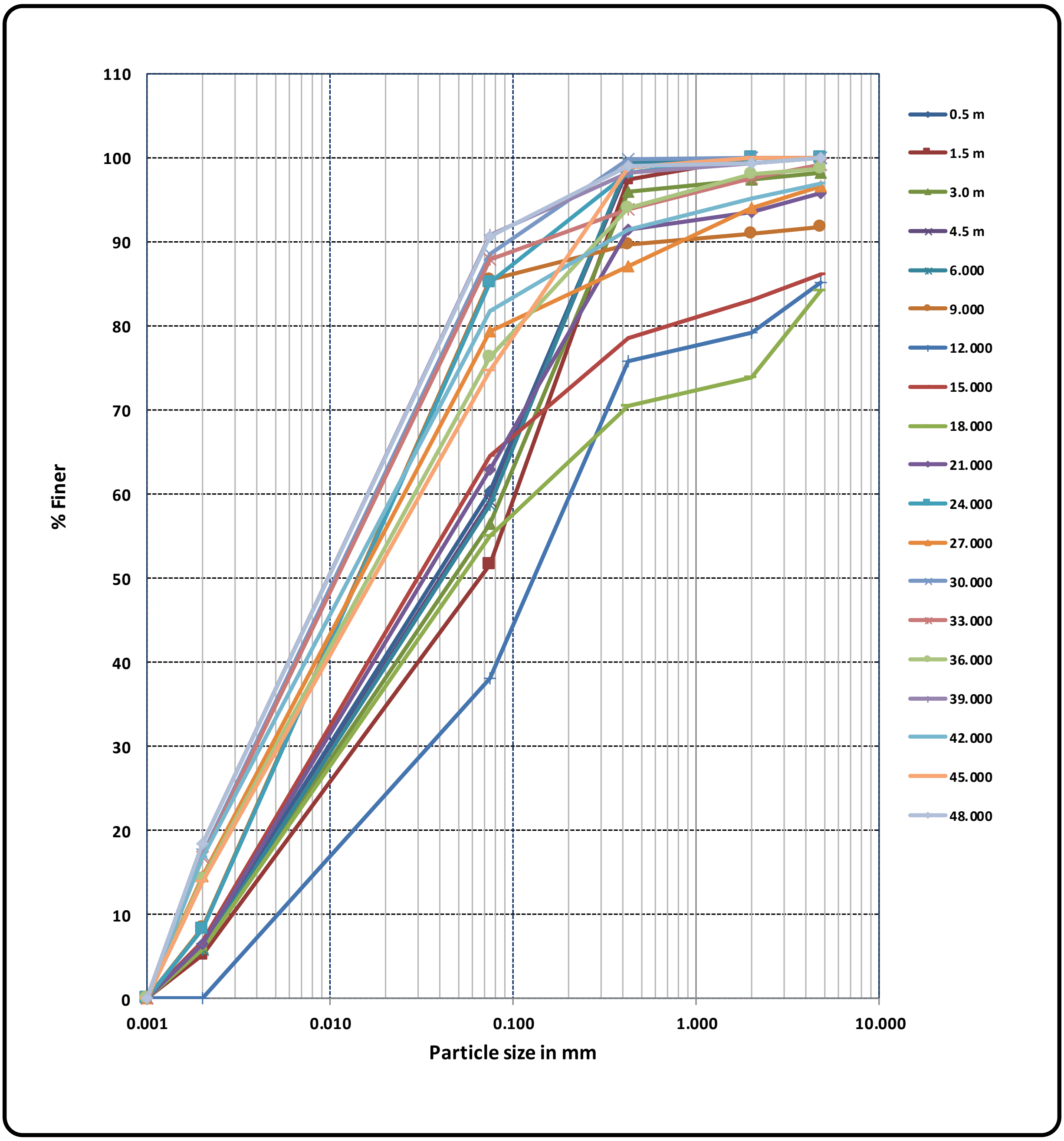
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-18



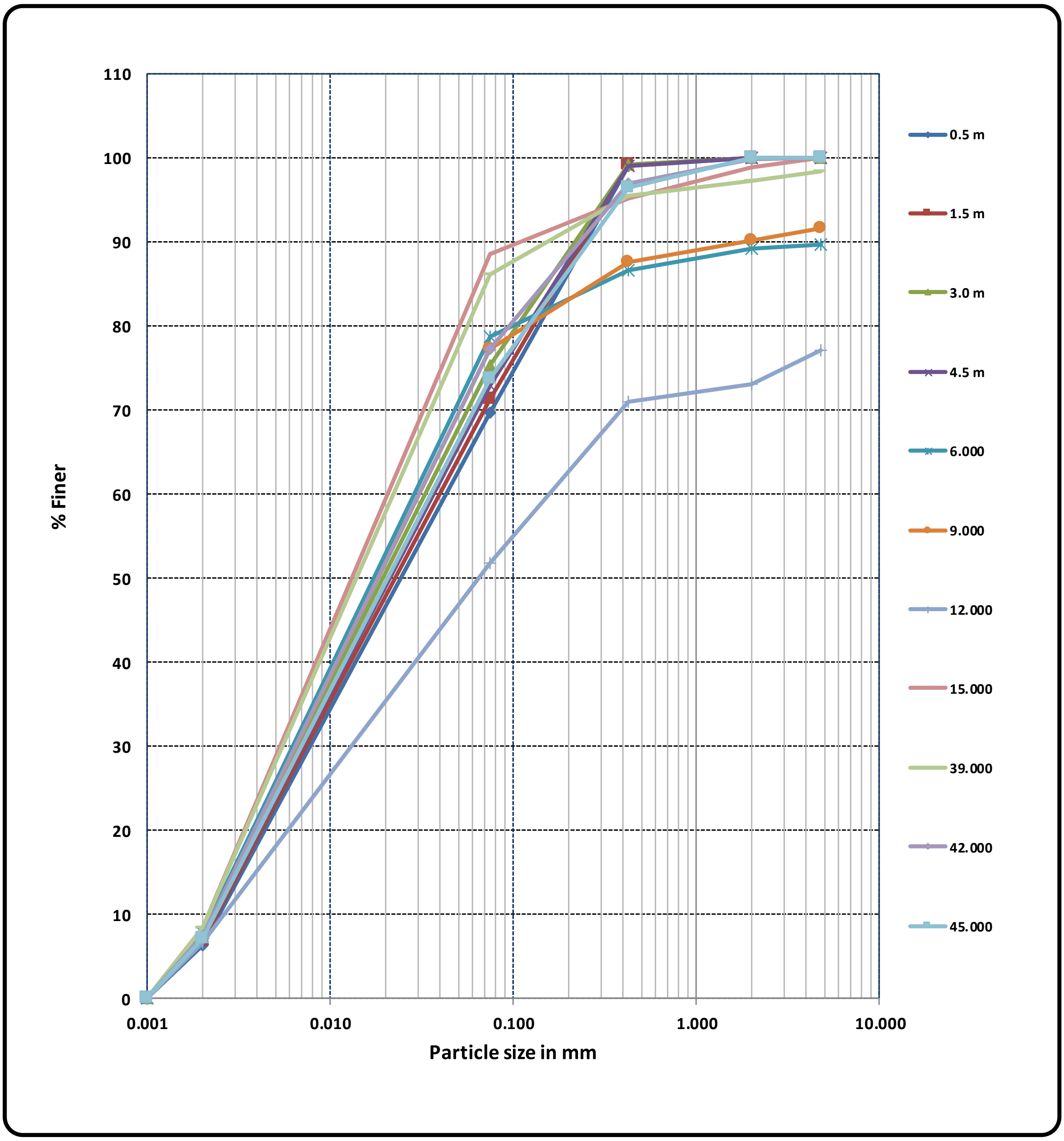
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-19



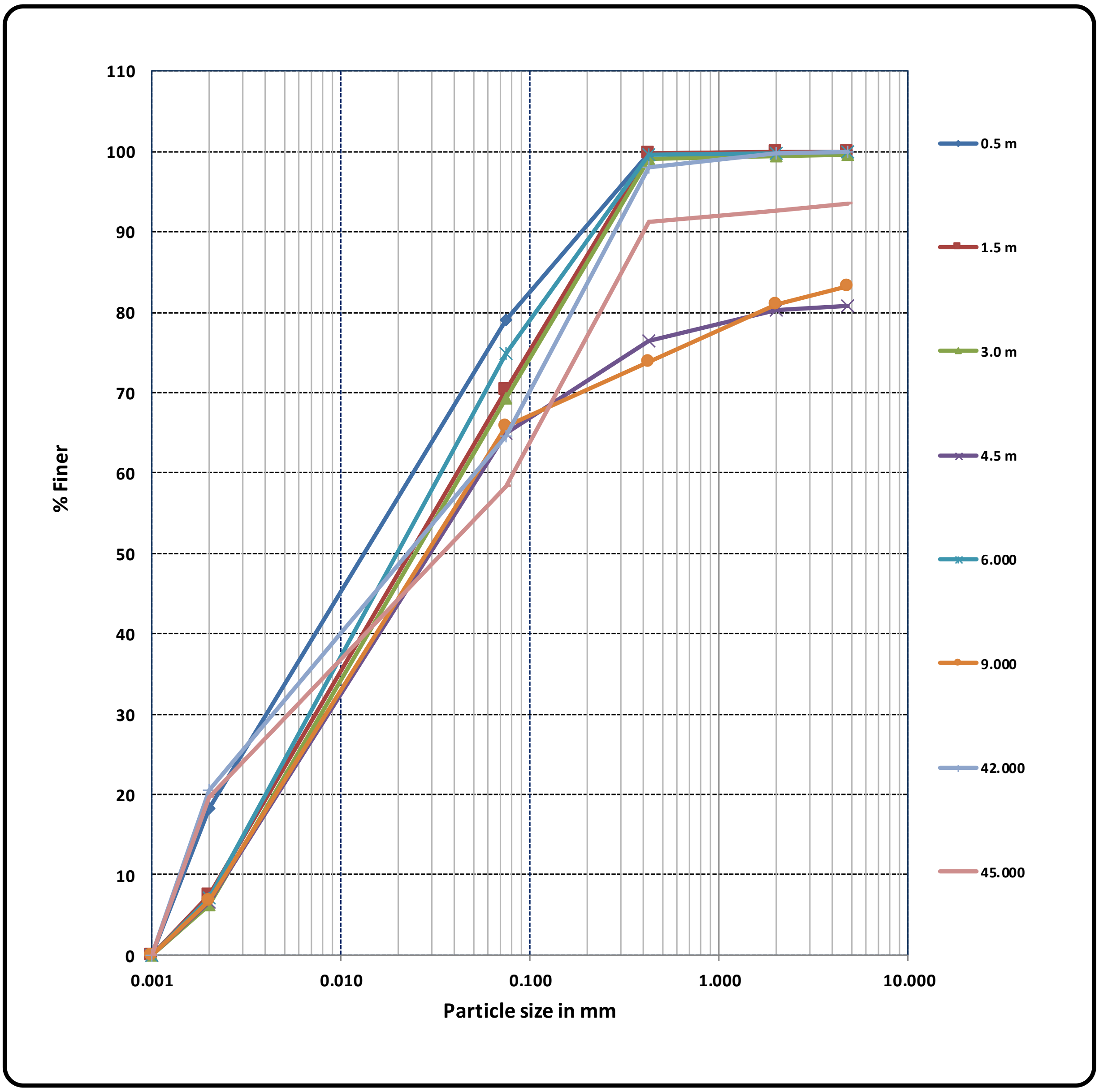
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-20



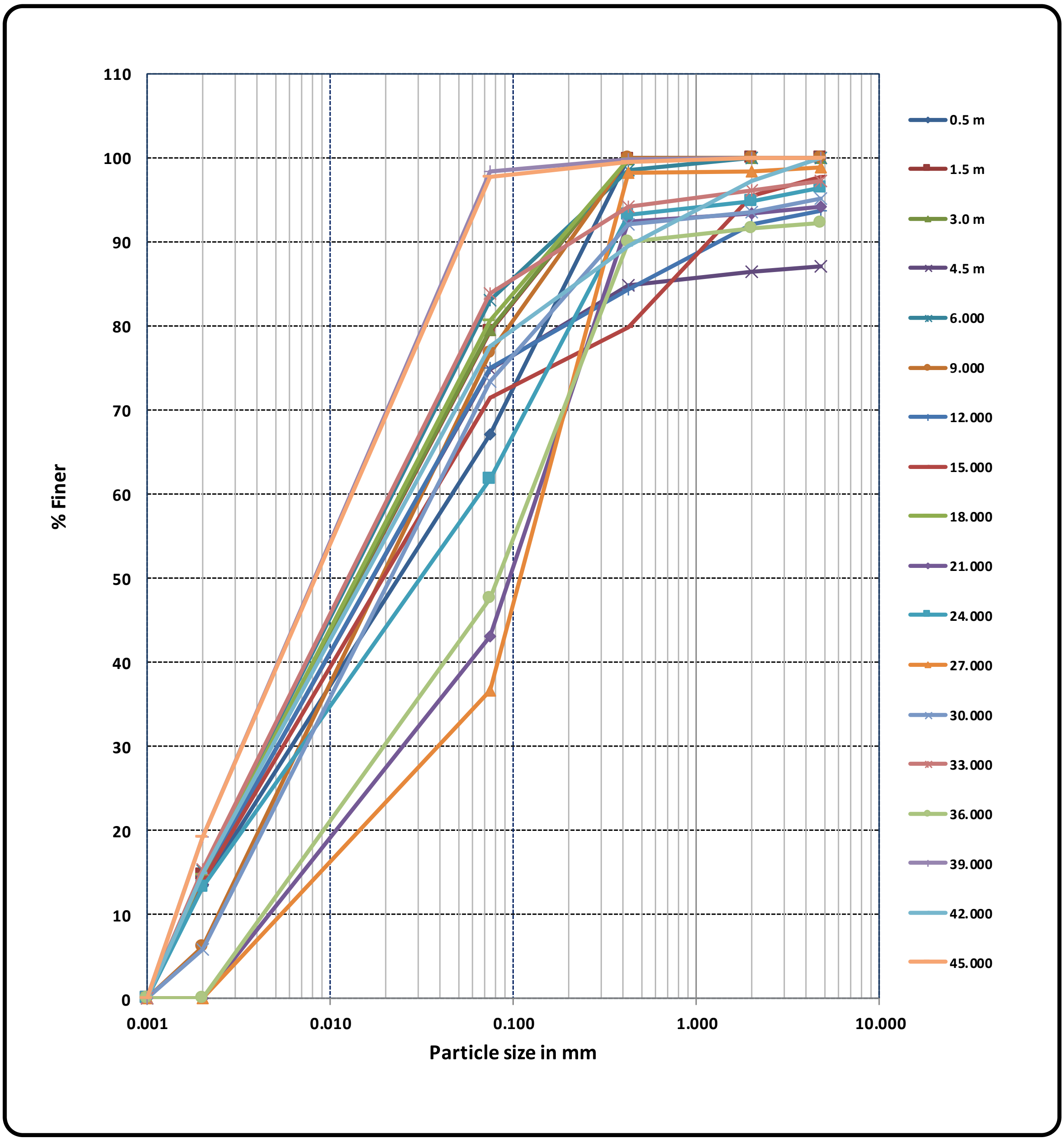
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-21



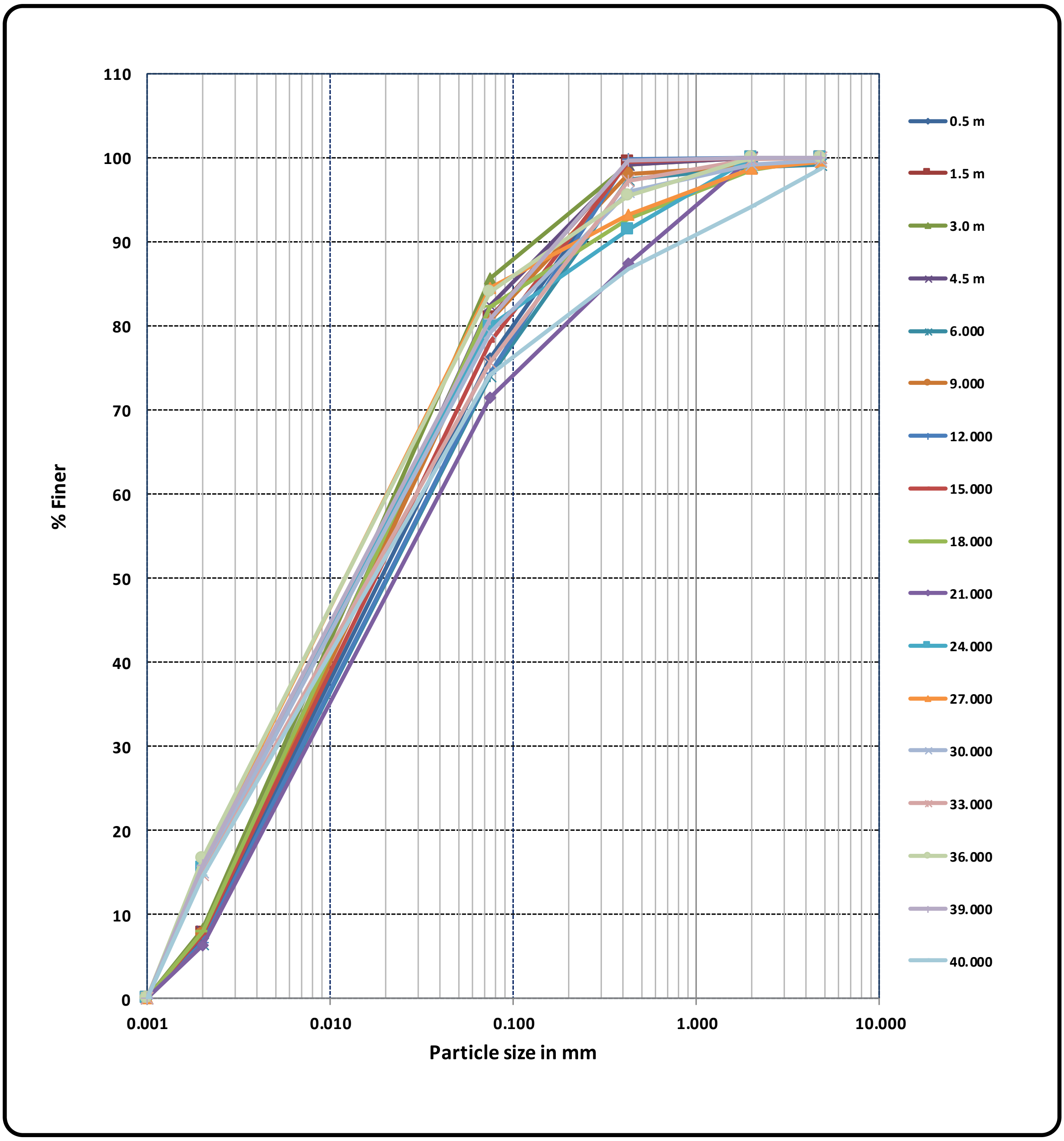
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-22



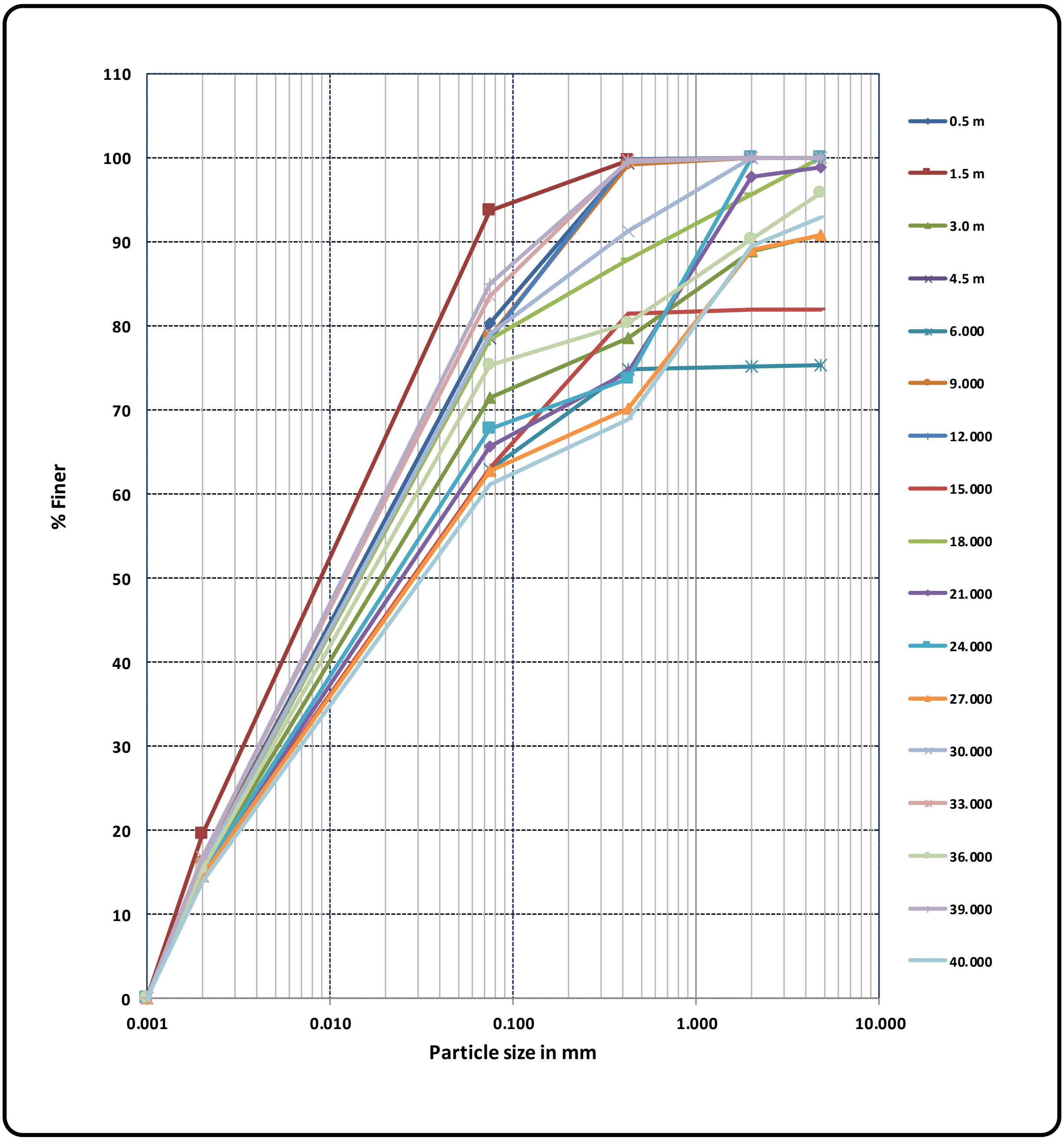
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-23



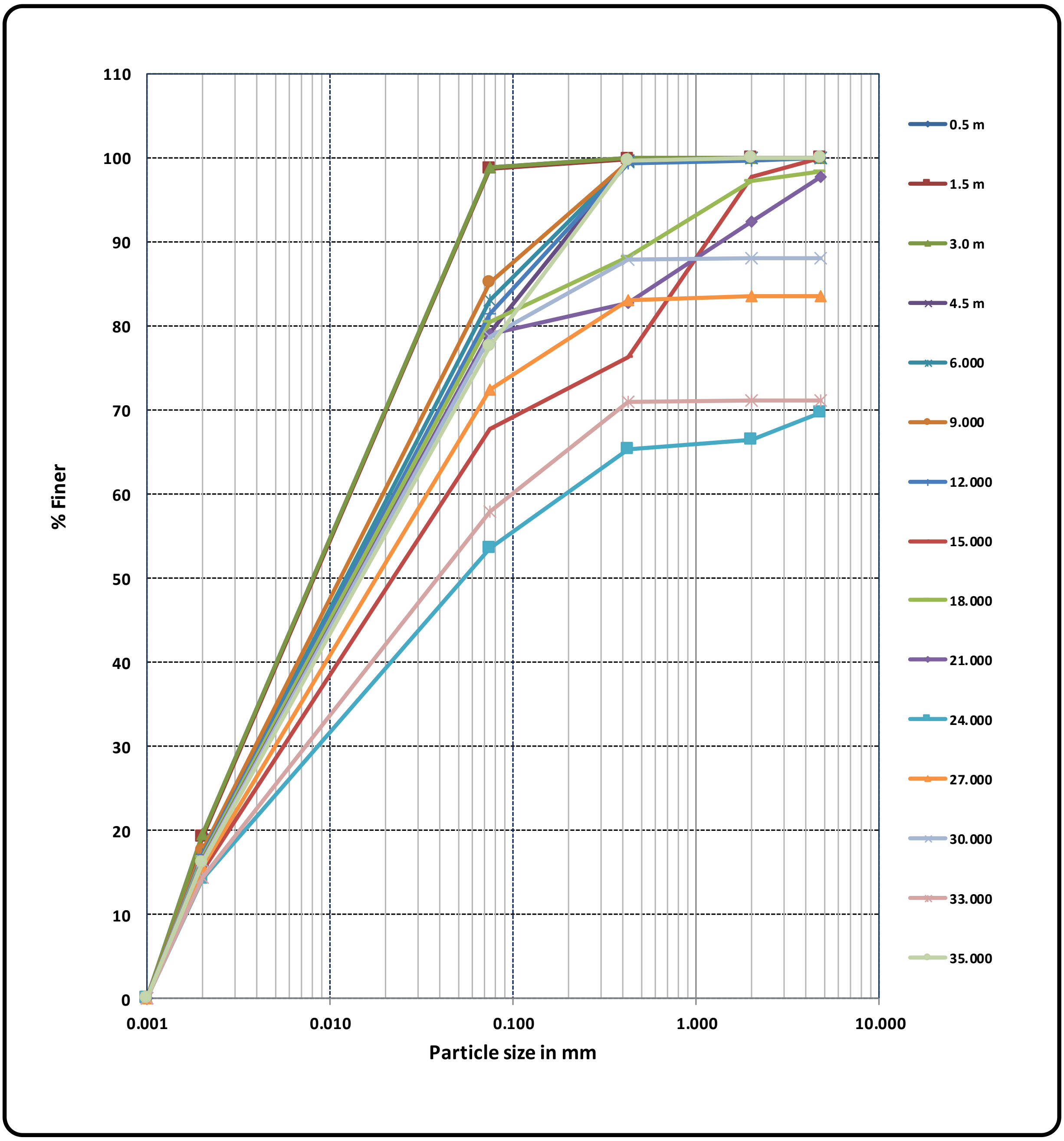
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-24



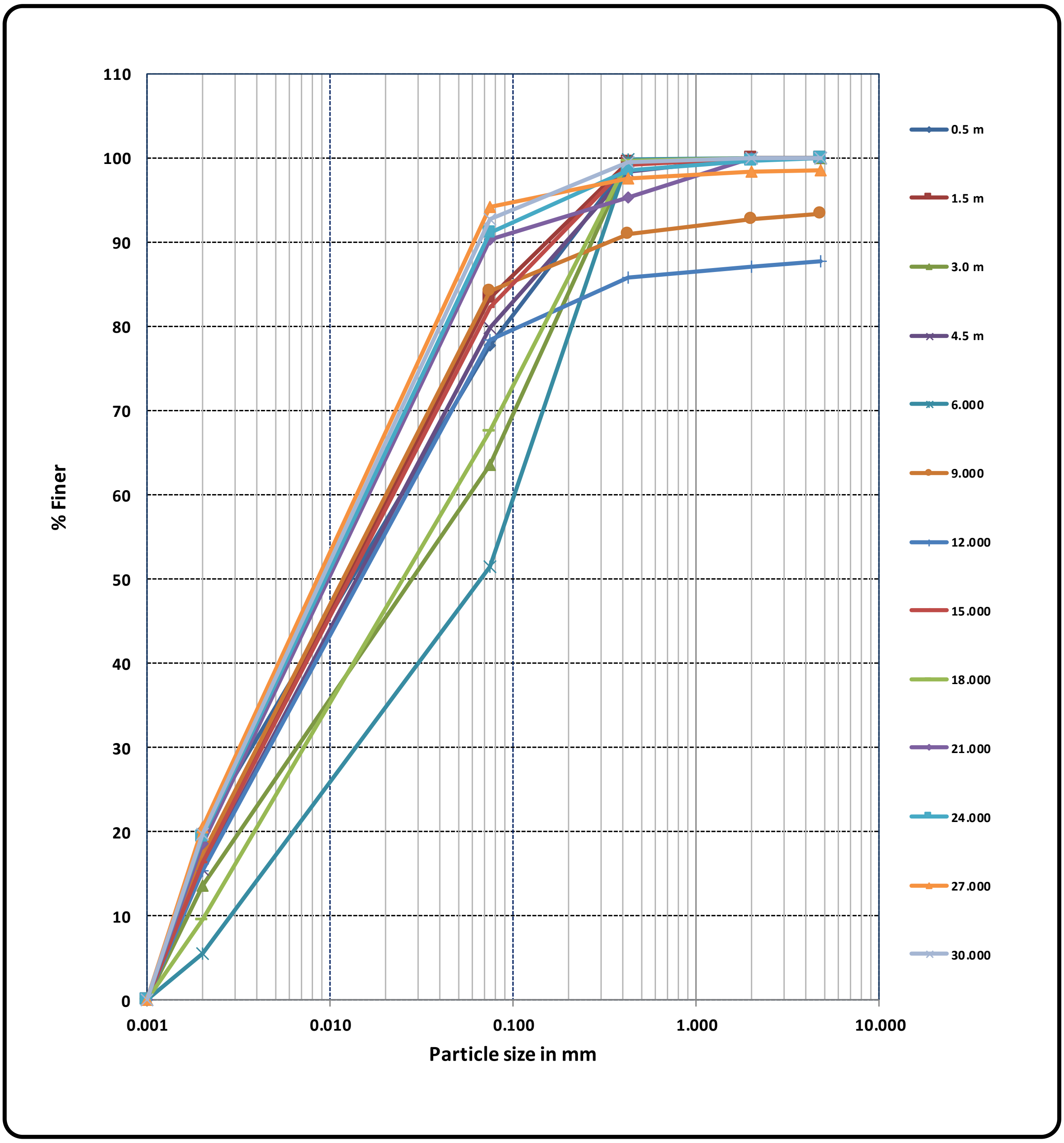
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-25



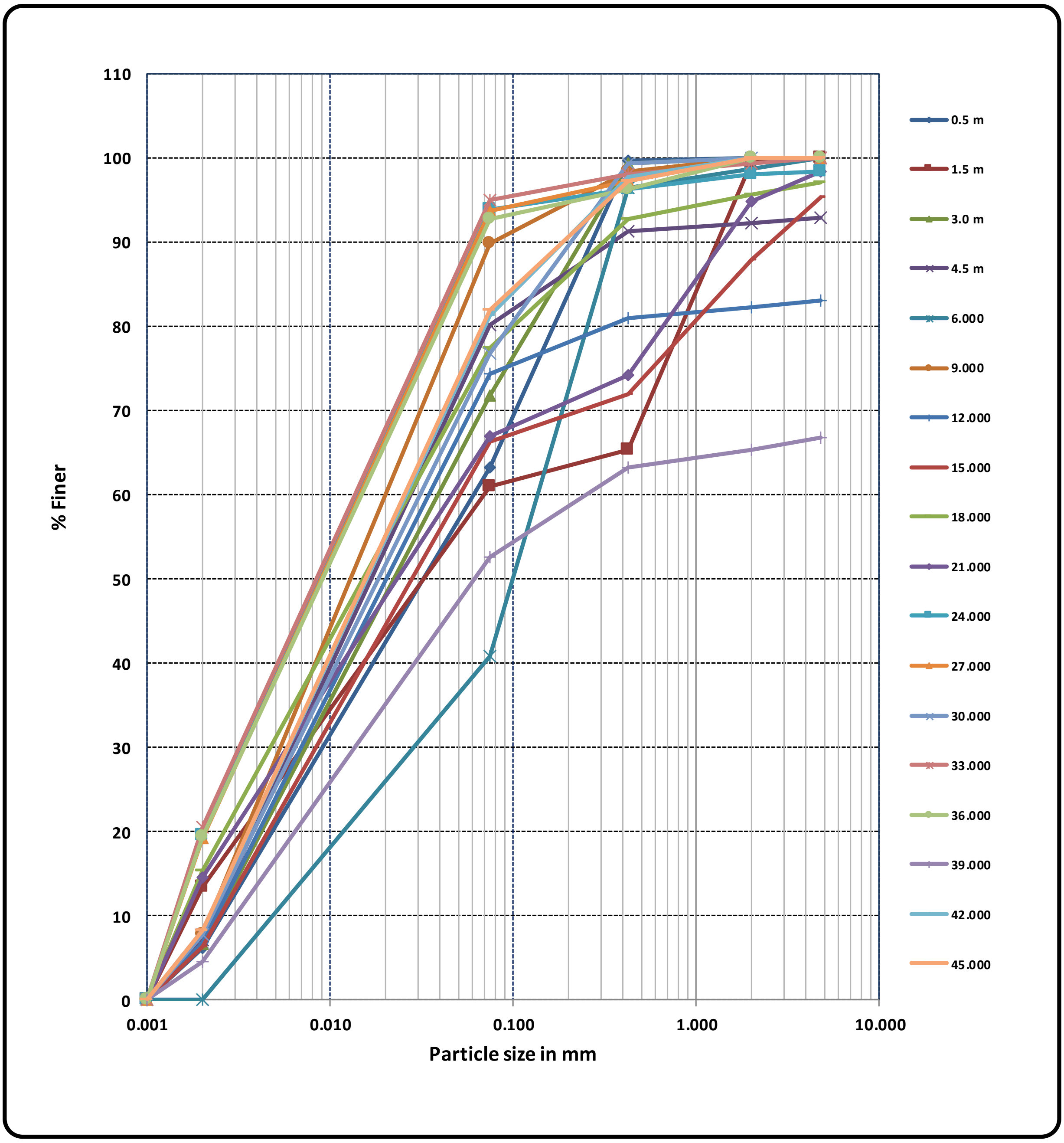
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-26



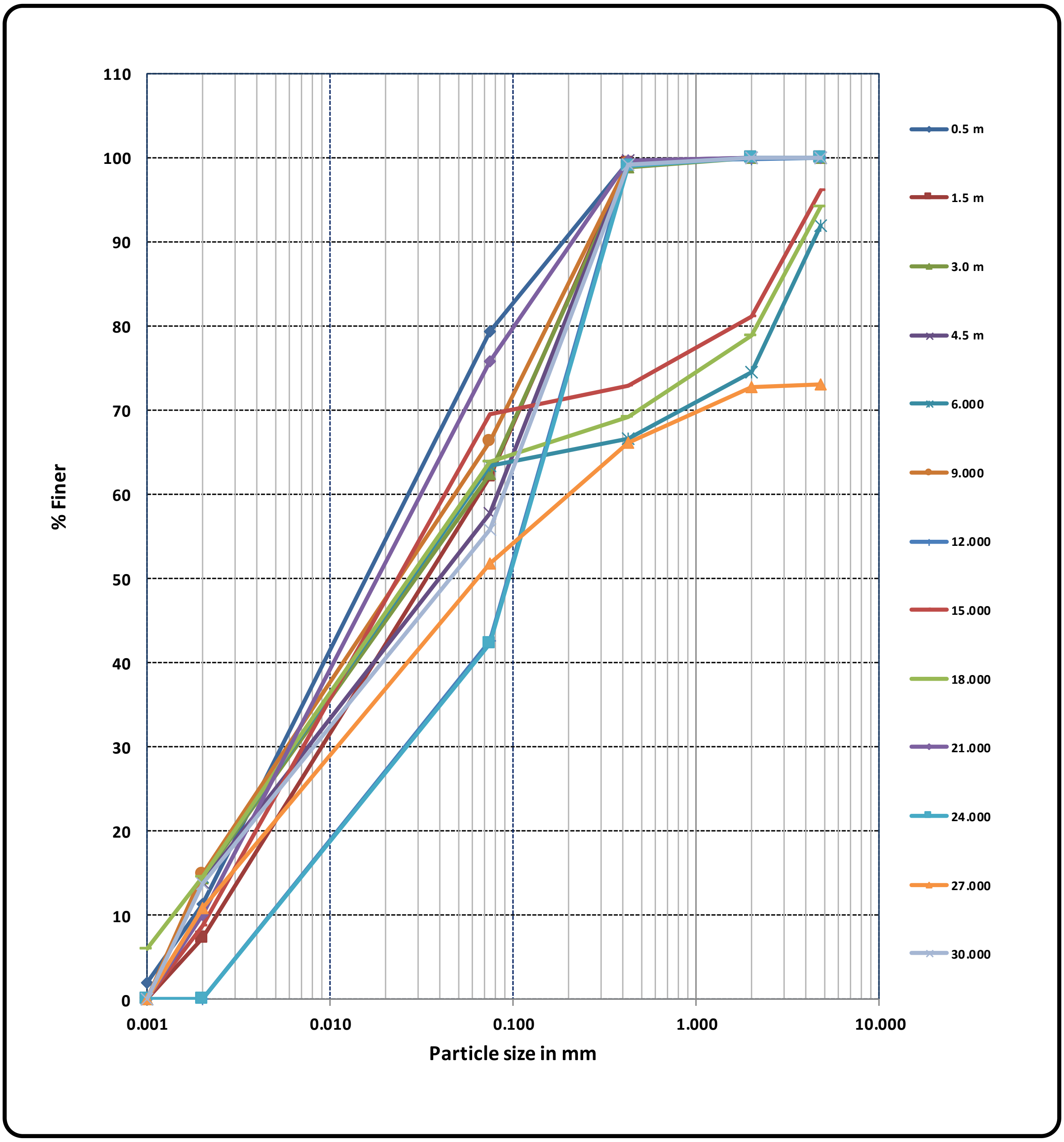
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-27



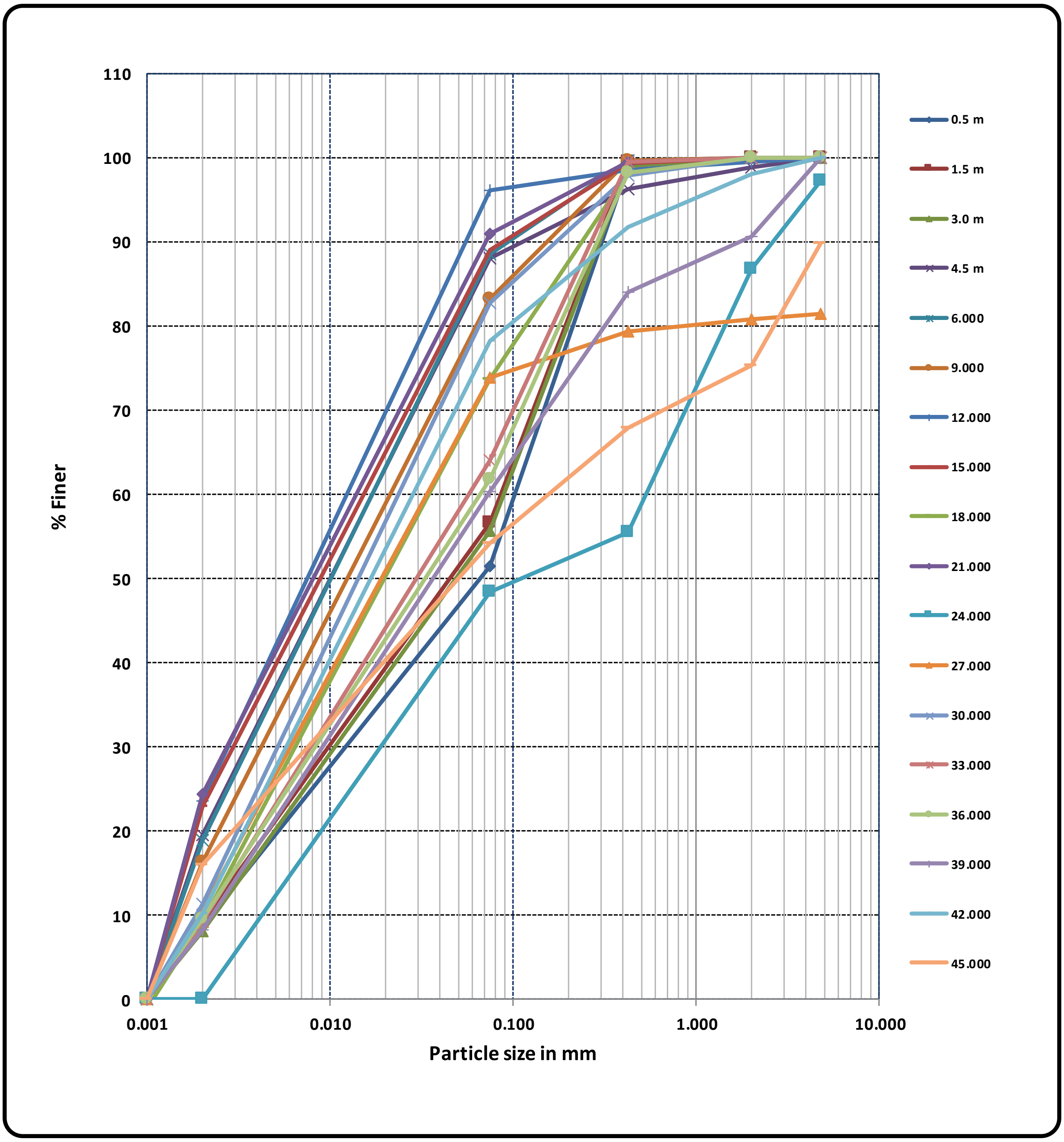
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-28



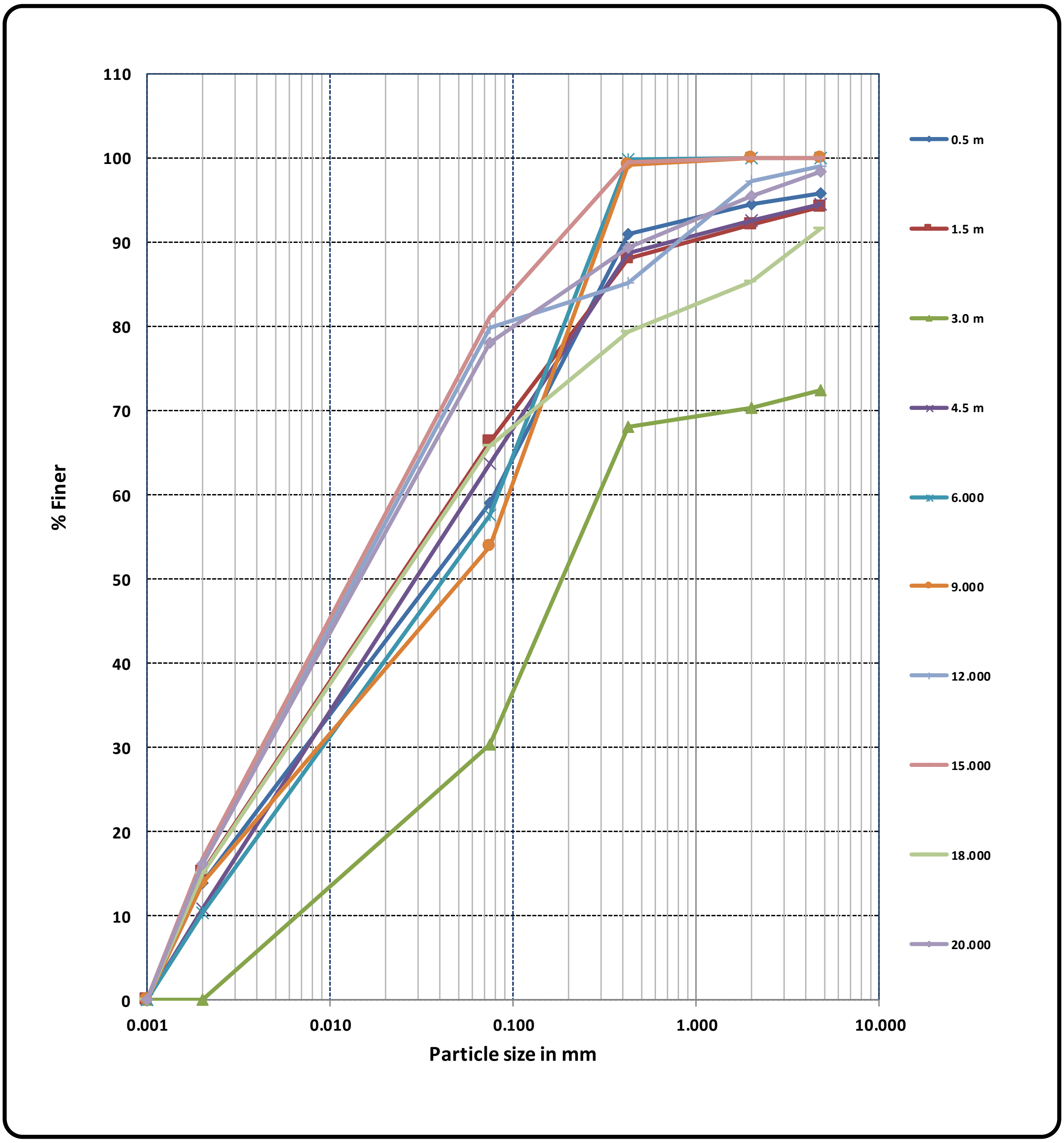
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-29



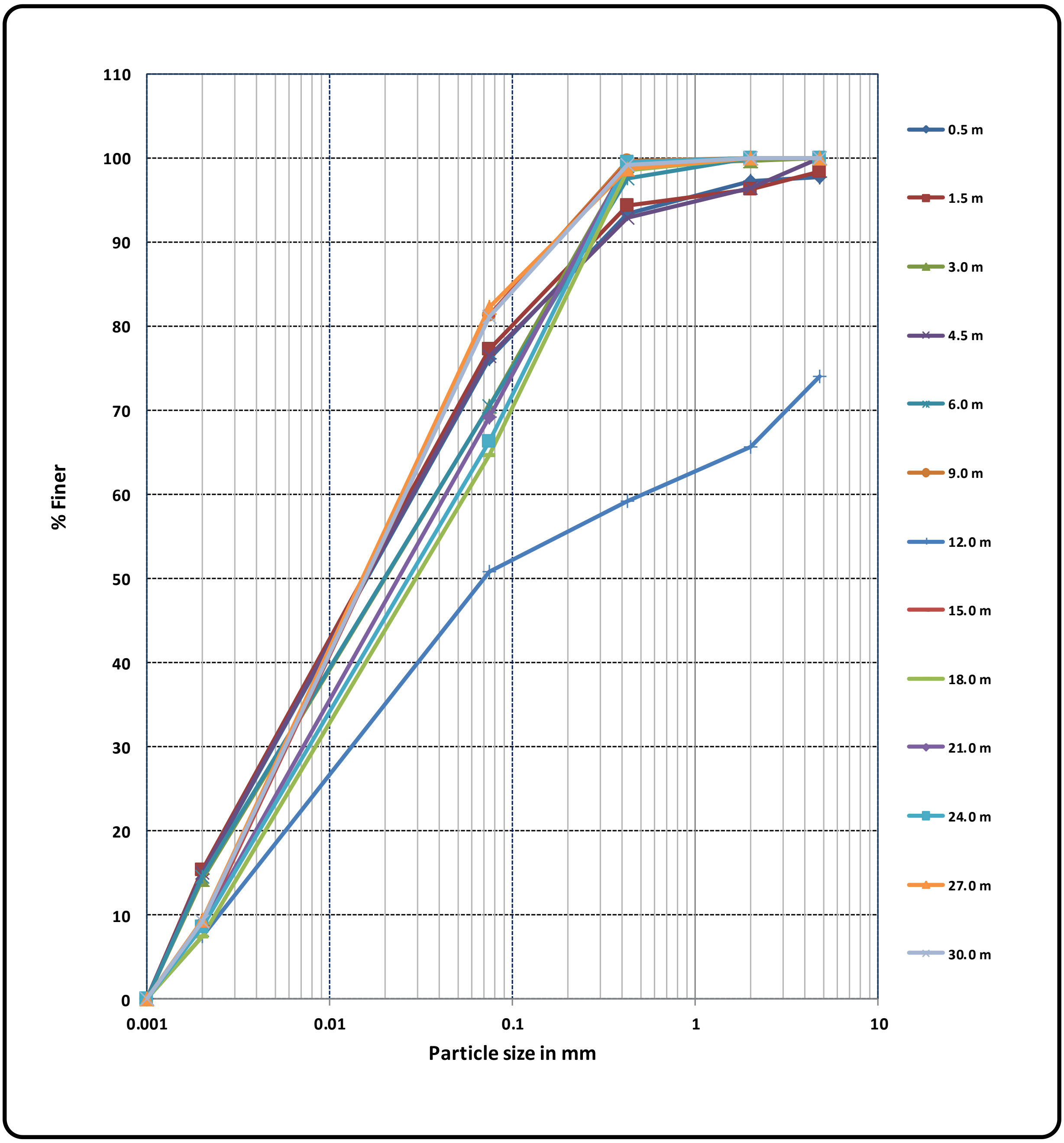
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-30



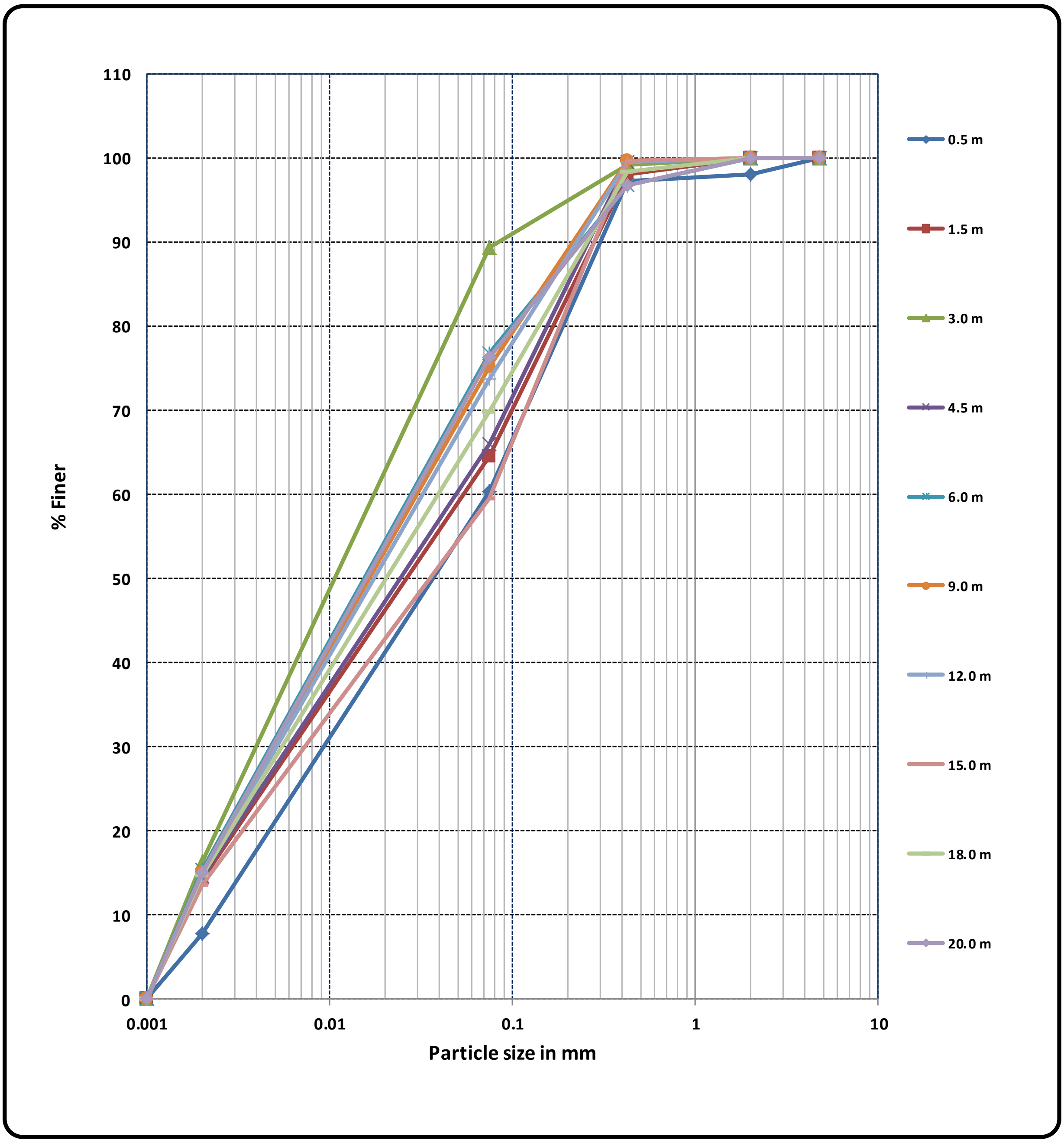
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-31



GRAIN SIZE DISTRIBUTION CURVE OF BH NO-32



GRAIN SIZE DISTRIBUTION CURVE OF BH NO-33



ANNEXURE –I
DESIGN PARAMETER & SPT N VALUE GRAPH

COMPUTATION OF CORRECTED N VALUE

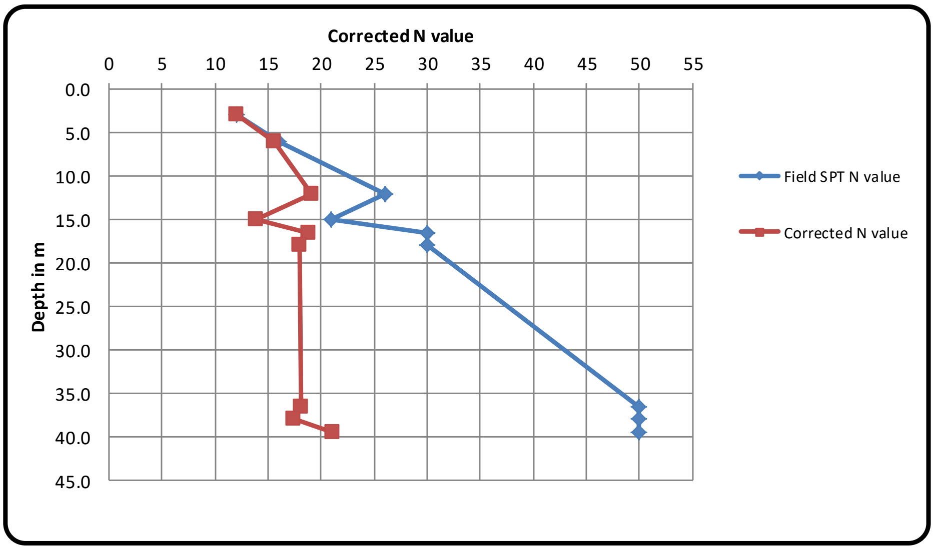
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-17(CH-25785 M)	3.0	38.6 M	ML-CL	12		1.785	0.536	1.00	12.0	12.0
2		6.0		ML-CL	16		1.834	1.100	0.97	15.5	15.5
3		12.0		ML-CL	26		1.853	2.224	0.73	19.1	19.1
4		15.0		ML-CL	21		1.853	2.780	0.66	13.9	13.9
5		16.5		ML-CL	37		1.853	3.057	0.63	18.8	18.8
6		18.0		ML-CL	>50	30	1.853	3.335	0.60	18.0	18.0
7		36.5		SM	>50	50	1.853	6.763	0.36	18.1	18.1
8		38.0		SM	>50	50	1.853	7.041	0.35	17.5	17.5
9		39.5		ML	>50	50	1.000	3.950	0.54	27.1	21.1

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-17



COMPUTATION OF CORRECTED N VALUE

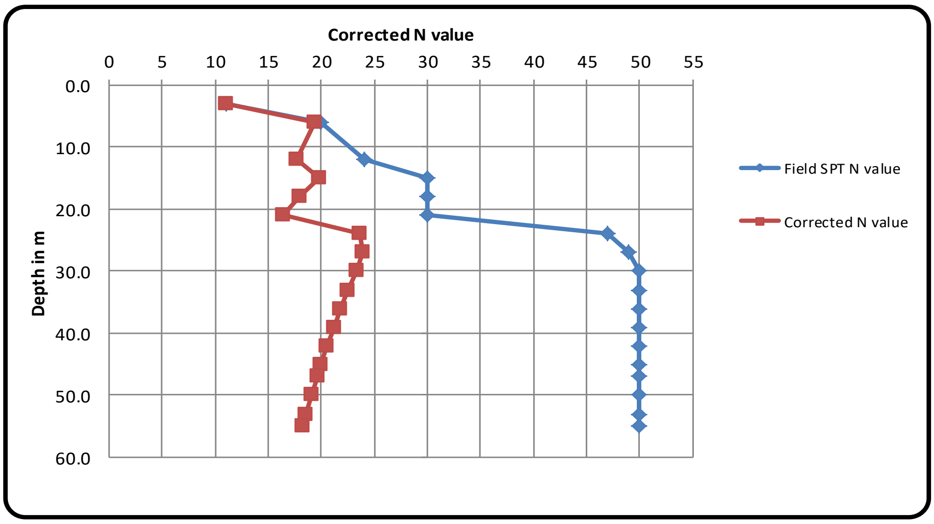
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-18(CH-25990 M)	3.0	26.2 M	ML	11		1.784	0.535	1.00	11.0	11.0
2		6.0		ML	20		1.828	1.097	0.97	19.4	19.4
3		12.0		ML	24		1.853	2.224	0.73	17.6	17.6
4		15.0		ML-CL	31	30	1.853	2.780	0.66	19.8	19.8
5		18.0		ML-CL	35	30	1.853	3.335	0.60	18.0	18.0
6		21.0		ML-CL	40	30	1.853	3.891	0.55	16.4	16.4
7		24.0		ML	47		1.853	4.447	0.50	23.6	23.6
8		27.0		ML	49		1.000	2.700	0.67	32.8	23.9
9		30.0		ML	57	50	1.000	3.000	0.63	31.7	23.4
10		33.0		ML	64	50	1.000	3.300	0.60	30.1	22.6
11		36.0		ML	69	50	1.000	3.600	0.57	28.7	21.8
12		39.0		ML	77	50	1.000	3.900	0.55	27.3	21.2
13		42.0		ML	84	50	1.000	4.200	0.52	26.1	20.5
14		45.0		ML	>50	50	1.000	4.500	0.50	24.9	20.0
15		47.0		ML	>50	50	1.000	4.700	0.48	24.2	19.6
16		50.0		ML	>50	50	1.000	5.000	0.46	23.2	19.1
17		53.0		ML	>50	50	1.000	5.300	0.44	22.2	18.6
18		55.0		ML	>50	50	1.000	5.500	0.43	21.6	18.3

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-18



COMPUTATION OF CORRECTED N VALUE

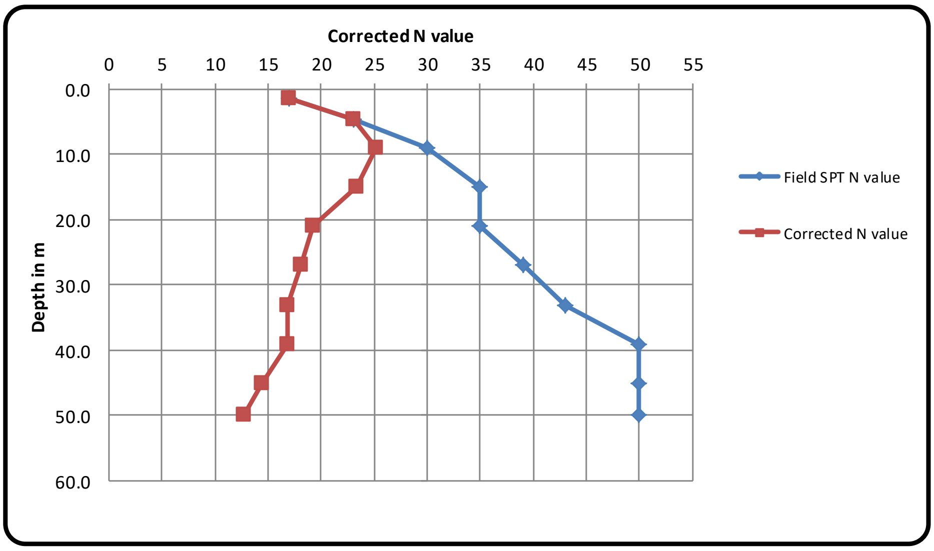
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-19(CH-26210 M)	1.5	NOT FOUND	ML	17		1.761	0.264	1.00	17.0	17.0
2		4.5		ML	23		1.776	0.799	1.00	23.0	23.0
3		9.0		ML	30		1.802	1.622	0.84	25.2	25.2
4		15.0		ML	35		1.819	2.729	0.67	23.3	23.3
5		21.0		ML	35		1.837	3.858	0.55	19.3	19.3
6		27.0		ML	39		1.856	5.011	0.46	18.1	18.1
7		33.0		SM	43		1.871	6.174	0.39	16.9	16.9
8		39.0		SM	52	50	1.871	7.297	0.34	16.9	16.9
9		45.0		SM	65	50	1.871	8.420	0.29	14.5	14.5
10		50.0		SM	80	50	1.871	9.355	0.25	12.7	12.7

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-19



COMPUTATION OF CORRECTED N VALUE

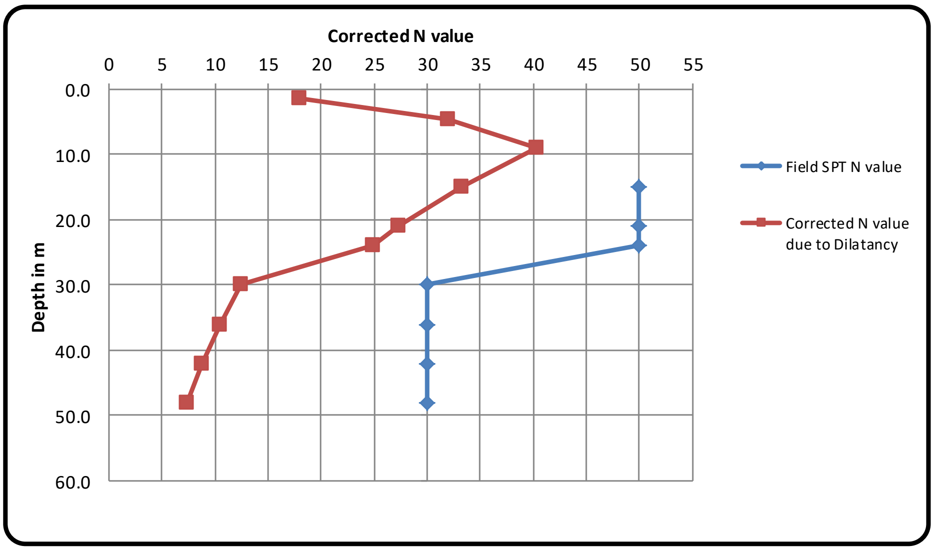
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-20(CH-26387 M)	1.5	NOT FOUND	ML	18		1.761	0.264	1.00	18.0	18.0
2		4.5		ML	32		1.778	0.800	1.00	32.0	32.0
3		9.0		ML	48		1.795	1.616	0.84	40.4	40.4
4		15.0		ML	60	50	1.830	2.745	0.66	33.2	33.2
5		21.0		ML	67	50	1.858	3.902	0.55	27.3	27.3
6		24.0		ML	76	50	1.879	4.510	0.50	24.9	24.9
7		30.0		CL	58	30	1.918	5.754	0.42	12.5	12.5
8		36.0		CL	67	30	1.946	7.006	0.35	10.5	10.5
9		42.0		CL	75	30	1.973	8.287	0.29	8.8	8.8
10		48.0		CL	79	30	1.988	9.542	0.25	7.4	7.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-20



COMPUTATION OF CORRECTED N VALUE

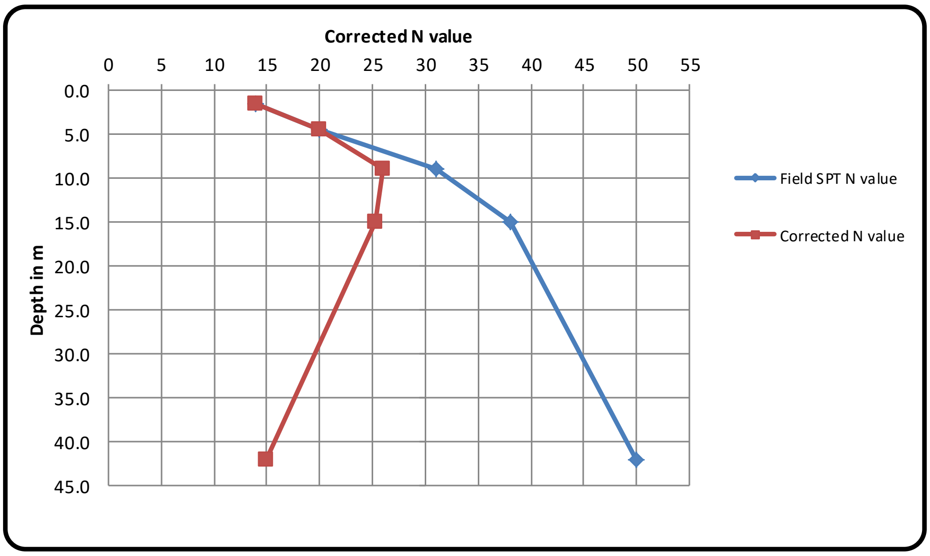
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-21(CH-26587 M)	1.5	NOT FOUND	ML	14		1.768	0.265	1.00	14.0	14.0
2		4.5		ML	20		1.793	0.807	1.00	20.0	20.0
3		9.0		ML	31		1.821	1.639	0.84	25.9	25.9
4		15.0		ML	38		1.824	2.736	0.67	25.3	25.3
5		42.0		ML	77	50	1.942	8.156	0.30	15.0	15.0

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-21



COMPUTATION OF CORRECTED N VALUE

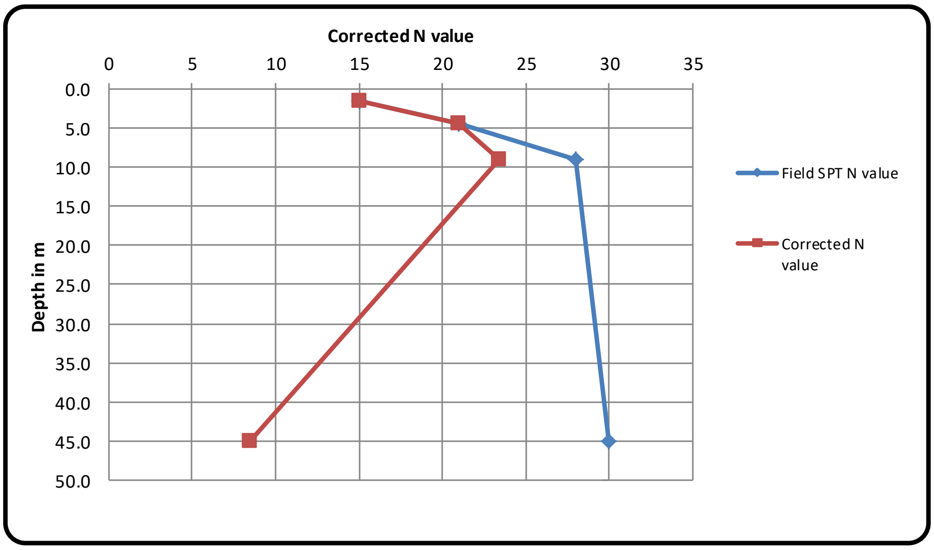
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-22(CH-26787 M)	1.5	NOT FOUND	ML	15		1.752	0.263	1.00	15.0	15.0
2		4.5		ML	21		1.789	0.805	1.00	21.0	21.0
3		9.0		ML	28		1.826	1.643	0.84	23.4	23.4
4		45.0		CL	60	30	1.916	8.622	0.28	8.4	8.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-22



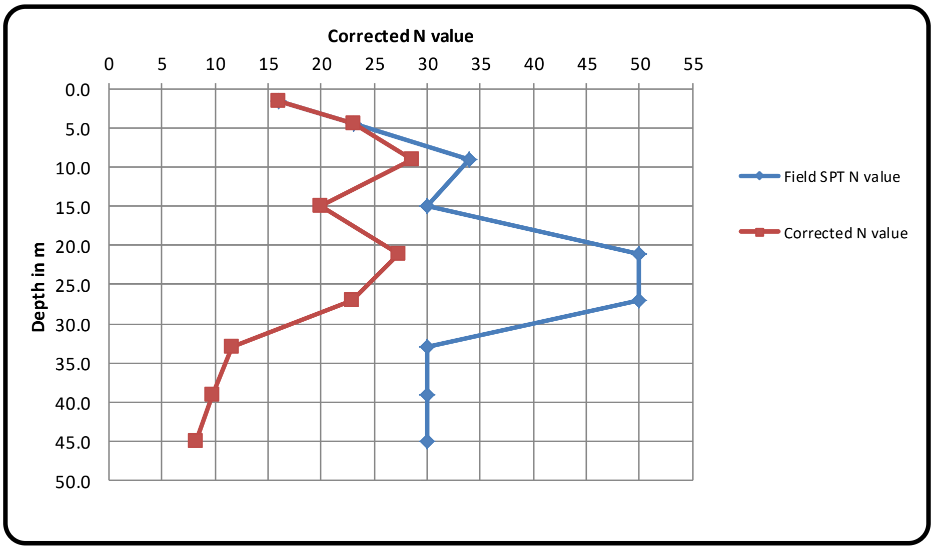
COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-23(CH-26980 M)	1.5	NOT FOUND	CL	16		1.761	0.264	1.00	16.0	16.0
2		4.5		CL	23		1.778	0.800	1.00	23.0	23.0
3		9.0		ML	34		1.795	1.616	0.84	28.6	28.6
4		15.0		CL	38	30	1.830	2.745	0.66	19.9	19.9
5		21.0		SM	50		1.858	3.902	0.55	27.3	27.3
6		27.0		SM	63	50	1.879	5.073	0.46	22.9	22.9
7		33.0		CL	73	30	1.918	6.329	0.38	11.5	11.5
8		39.0		CL	77	30	1.946	7.589	0.32	9.7	9.7
9		45.0		CL	85	30	1.973	8.879	0.27	8.1	8.1

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-23



COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-24(CH-27187 M)	1.5	NOT FOUND	CL	14		1.761	0.264	1.00	14.00	14.0
2		4.5		CL	21		1.773	0.798	1.00	21.00	21.0
3		9.0		CL	27		1.804	1.624	0.84	22.67	22.7
4		15.0		CL	33	30	1.831	2.747	0.66	19.92	19.9
5		21.0		CL	43	30	1.887	3.963	0.54	16.24	16.2
6		27.0		CL	58	30	1.946	5.254	0.45	13.41	13.4
7		33.0		CL	72	30	1.975	6.518	0.37	11.25	11.2
8		39.0		CL	89	30	2.005	7.820	0.31	9.42	9.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

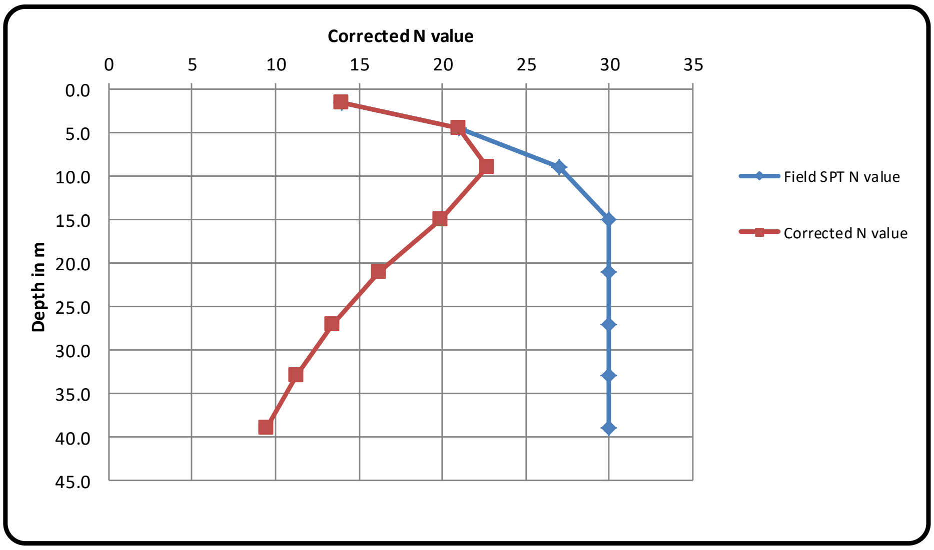
   Where N is the corrected N value.

2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.

3 In case of clay soil, if N>30 then it may be considered limited to 30.

4 Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-24



COMPUTATION OF CORRECTED N VALUE

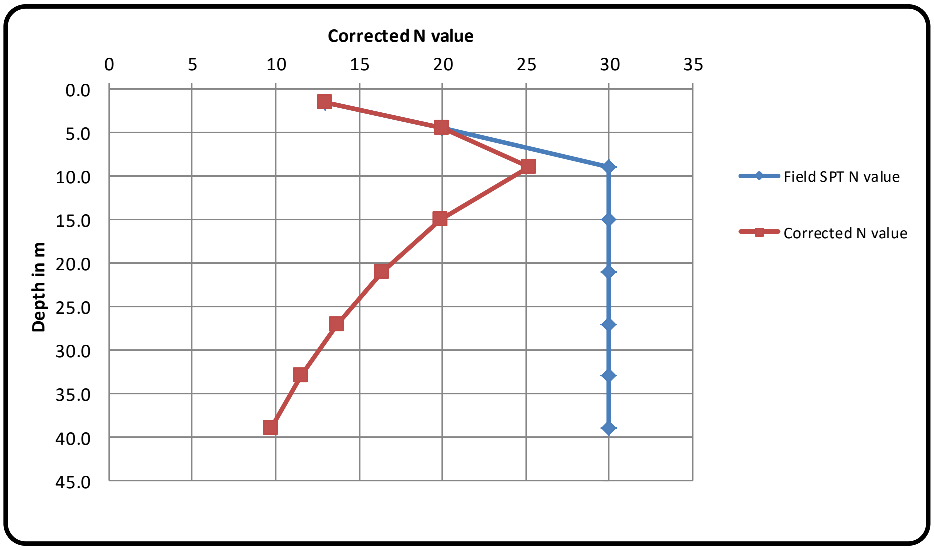
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-25(CH-27410 M)	1.5	NOT FOUND	CL	13		1.758	0.264	1.00	13.00	13.0
2		4.5		CL	20		1.768	0.796	1.00	20.00	20.0
3		9.0		CL	30		1.797	1.617	0.84	25.23	25.2
4		15.0		CL	31	30	1.831	2.747	0.66	19.92	19.9
5		21.0		CL	33	30	1.862	3.910	0.55	16.37	16.4
6		27.0		CL	48	30	1.892	5.108	0.46	13.69	13.7
7		33.0		CL	68	30	1.921	6.339	0.38	11.53	11.5
8		39.0		CL	81	30	1.944	7.582	0.32	9.73	9.7

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-25



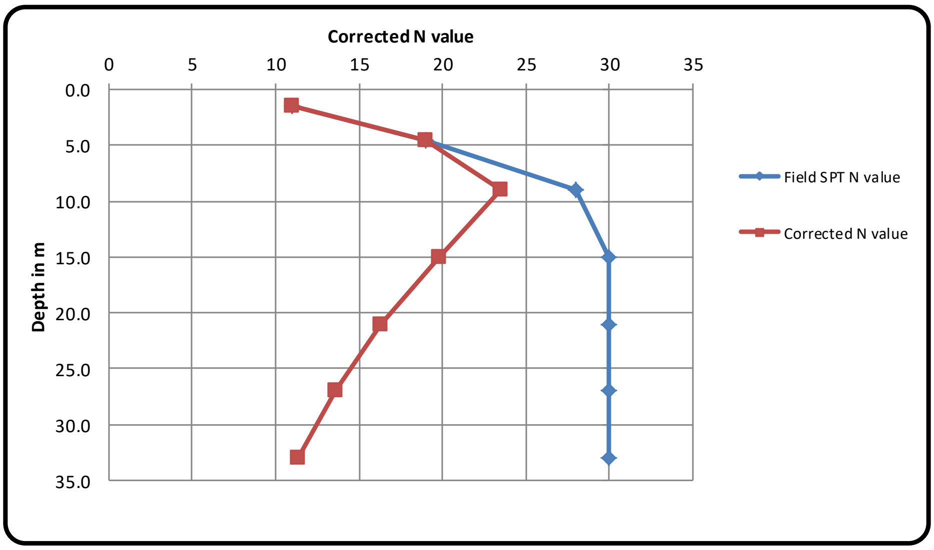
COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-26(CH-27550 M)	1.5	NOT FOUND	CL	11		1.763	0.264	1.00	11.00	11.0
2		4.5		CL	19		1.782	0.802	1.00	19.00	19.0
3		9.0		CL	28		1.815	1.634	0.84	23.46	23.5
4		15.0		CL	34	30	1.844	2.766	0.66	19.85	19.8
5		21.0		CL	41	30	1.875	3.938	0.54	16.30	16.3
6		27.0		CL	53	30	1.913	5.165	0.45	13.58	13.6
7		33.0		CL	65	30	1.947	6.425	0.38	11.39	11.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3 In case of clay soil, if N>30 then it may be considered limited to 30.
4 Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-26



COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-27(CH-28050 M)	1.5	NOT FOUND	CL	14		1.758	0.264	1.00	14.00	14.0
2		4.5		CL	24		1.768	0.796	1.00	24.00	24.0
3		9.0		CL	27		1.802	1.622	0.84	22.68	22.7
4		15.0		CL	36	30	1.839	2.759	0.66	19.87	19.9
5		21.0		CL	45	30	1.885	3.959	0.54	16.25	16.3
6		27.0		CL	54	30	1.929	5.208	0.45	13.50	13.5

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

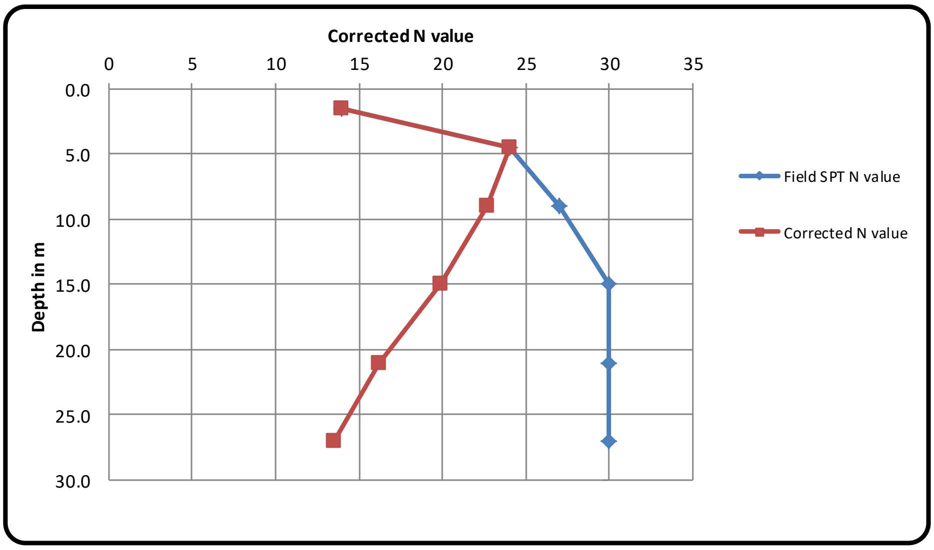
1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.

3 In case of clay soil, if N>30 then it may be considered limited to 30.

4 Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-27



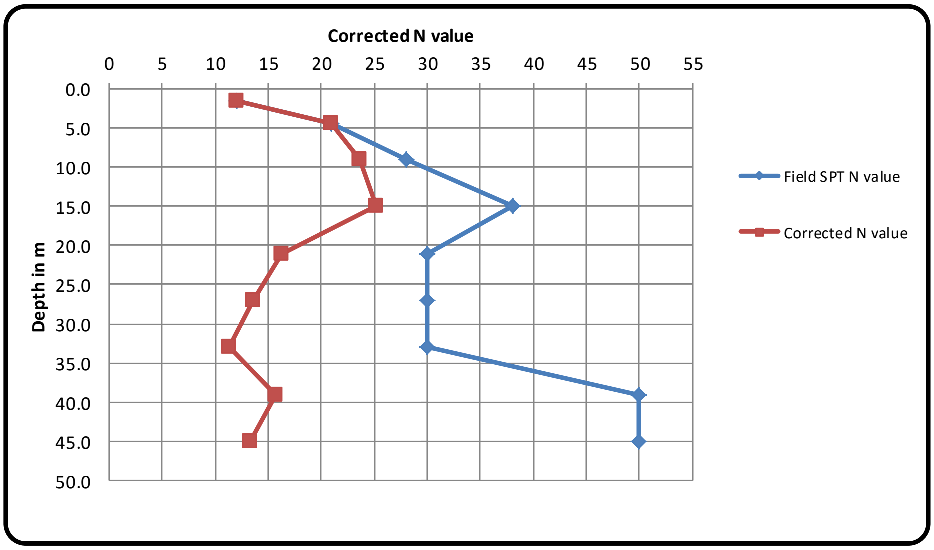
COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-28(CH-28350M)	1.5	NOT FOUND	CL	12		1.763	0.264	1.00	12.0	12.0
2		4.5		ML	21		0.772	0.347	1.00	21.0	21.0
3		9.0		ML	28		1.794	1.615	0.84	23.6	23.6
4		15.0		ML	38		1.836	2.754	0.66	25.2	25.2
5		21.0		CL	47	30	1.883	3.954	0.54	16.3	16.3
6		27.0		CL	53	30	1.912	5.162	0.45	13.6	13.6
7		33.0		CL	70	30	1.955	6.452	0.38	11.4	11.4
8		39.0		ML	81	50	1.998	7.792	0.32	15.8	15.8
9		45.0		ML	92	50	2.009	9.041	0.27	13.3	13.3

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-28



COMPUTATION OF CORRECTED N VALUE

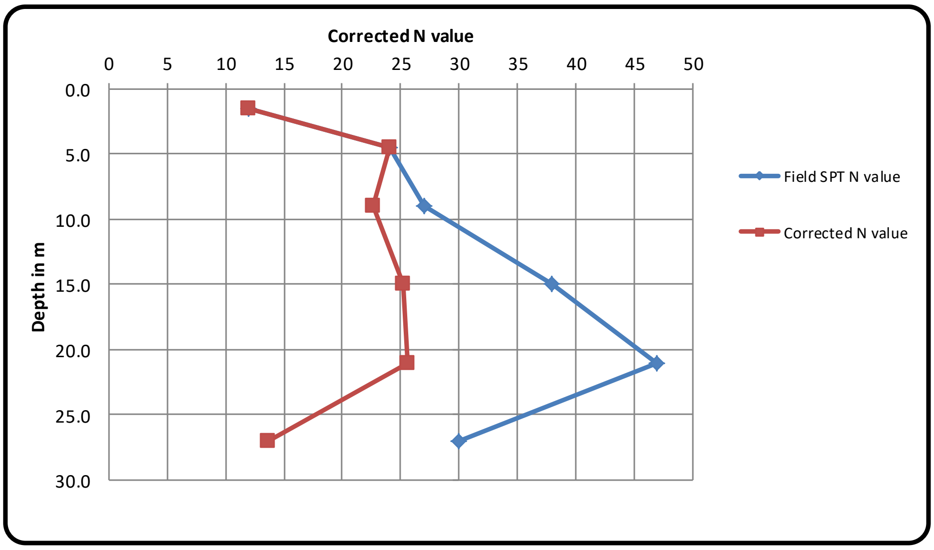
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-29(CH-28550 M)	1.5	NOT FOUND	ML	12		1.761	0.264	1.00	12.0	12.0
2		4.5		ML-CL	24		1.778	0.800	1.00	24.0	24.0
3		9.0		ML-CL	27		1.798	1.618	0.84	22.7	22.7
4		15.0		ML	38		1.829	2.744	0.66	25.2	25.2
5		21.0		ML	47		1.865	3.917	0.55	25.6	25.63
6		27.0		ML-CL	61	30	1.898	5.125	0.46	13.7	13.66

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-29



COMPUTATION OF CORRECTED N VALUE

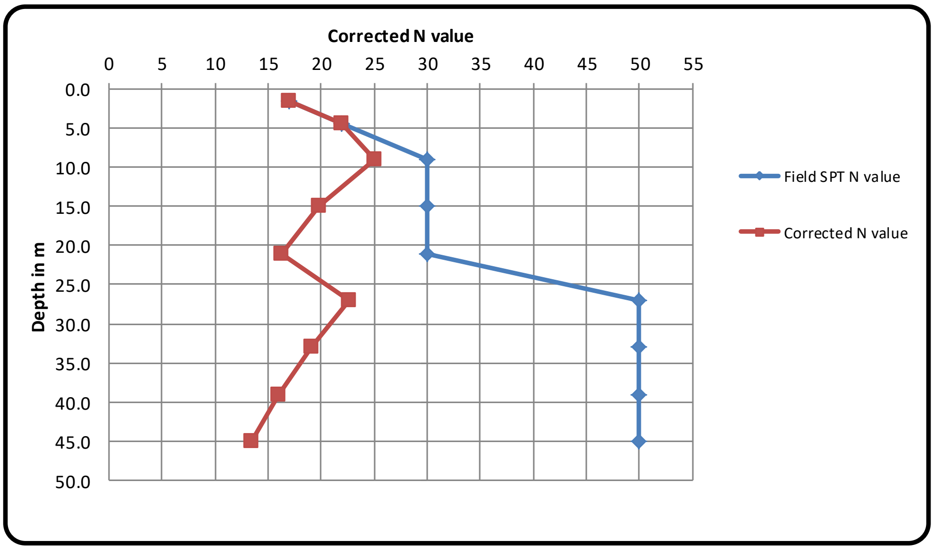
SI No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-30(CH-28750 M)	1.5	NOT FOUND	ML	17		1.768	0.265	1.00	17.0	17.0
2		4.5		ML-CL	22		1.792	0.806	1.00	22.0	22.0
3		9.0		ML-CL	30		1.831	1.648	0.83	25.0	25.0
4		15.0		CL	38	30	1.855	2.783	0.66	19.8	19.8
5		21.0		CL	44	30	1.871	3.929	0.54	16.3	16.3
6		27.0		ML	56	50	1.907	5.149	0.45	22.7	22.7
7		33.0		ML	64	50	1.941	6.405	0.38	19.0	19.0
8		39.0		ML	73	50	1.971	7.687	0.32	16.0	16.0
9		45.0		ML	84	50	1.995	8.978	0.27	13.4	13.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereeever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-30



COMPUTATION OF CORRECTED N VALUE

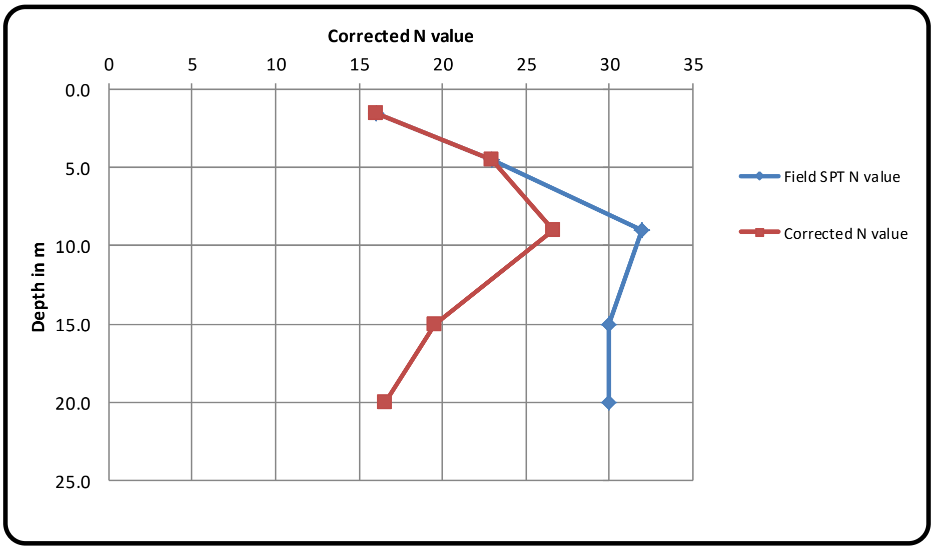
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-31(CH-29050 M)	1.5	NOT FOUND	CL	16		1.765	0.265	1.00	16.0	16.0
2		4.5		ML	23		1.786	0.804	1.00	23.0	23.0
3		9.0		ML	32		1.845	1.661	0.83	26.6	26.6
4		15.0		ML-CL	40	30	1.904	2.856	0.65	19.5	19.5
5		20.0		ML-CL	51	30	1.926	3.852	0.55	16.5	16.52

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-31



COMPUTATION OF CORRECTED N VALUE

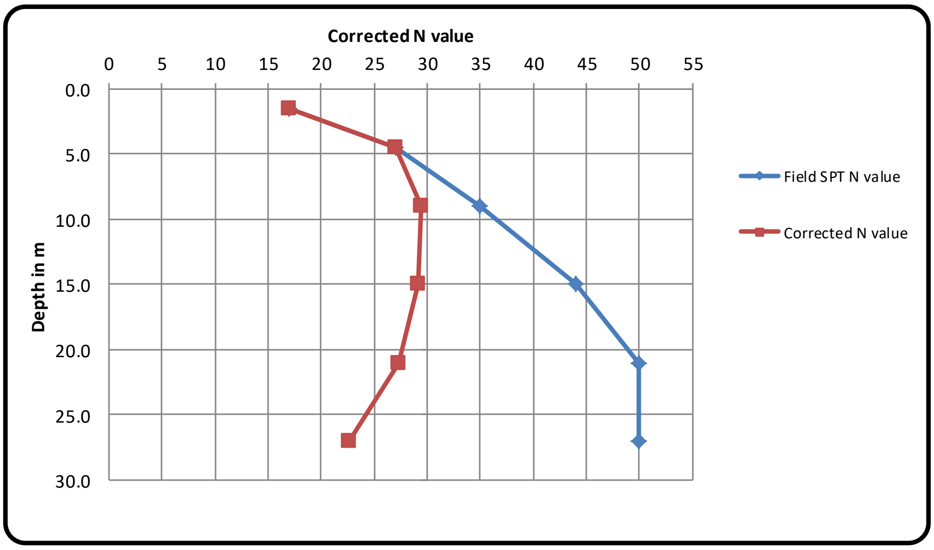
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-32(CH-29550 M)	1.5	NOT FOUND	ML-CL	17		1.754	0.263	1.00	17.0	17.0
2		4.5		ML-CL	27		1.769	0.796	1.00	27.0	27.0
3		9.0		ML	35		1.804	1.624	0.84	29.4	29.4
4		15.0		ML	44		1.835	2.753	0.66	29.2	29.2
5		21.0		ML	54	50	1.864	3.914	0.55	27.3	27.3
6		27.0		ML	63	50	1.909	5.154	0.45	22.7	22.7

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-32



COMPUTATION OF CORRECTED N VALUE

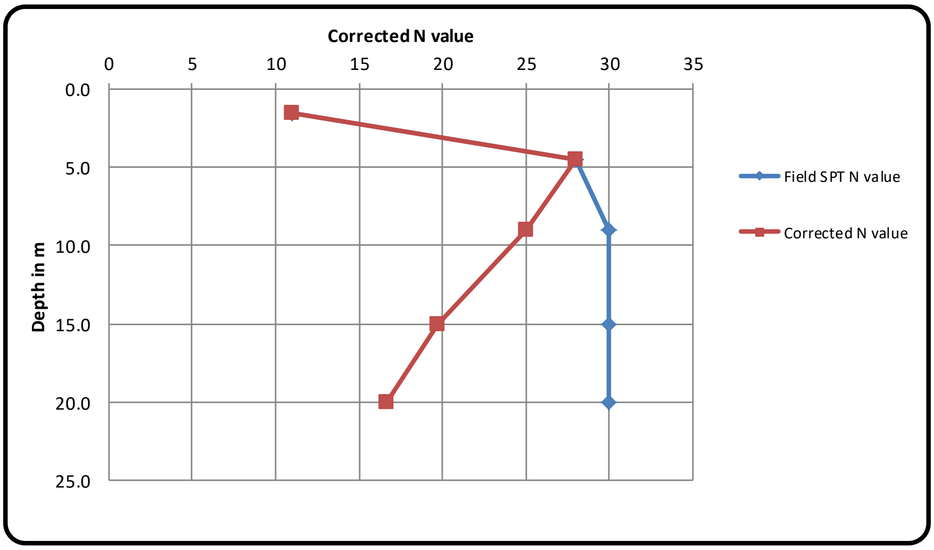
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-33(CH-30125 M)	1.5	NOT FOUND	ML-CL	11		1.772	0.266	1.00	11.0	11.0
2		4.5		ML-CL	28		1.793	0.807	1.00	28.0	28.0
3		9.0		ML-CL	39	30	1.828	1.645	0.84	25.1	25.1
4		15.0		ML-CL	50	30	1.874	2.811	0.66	19.7	19.7
5		20.0		ML-CL	63	30	1.901	3.802	0.56	16.7	16.7

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

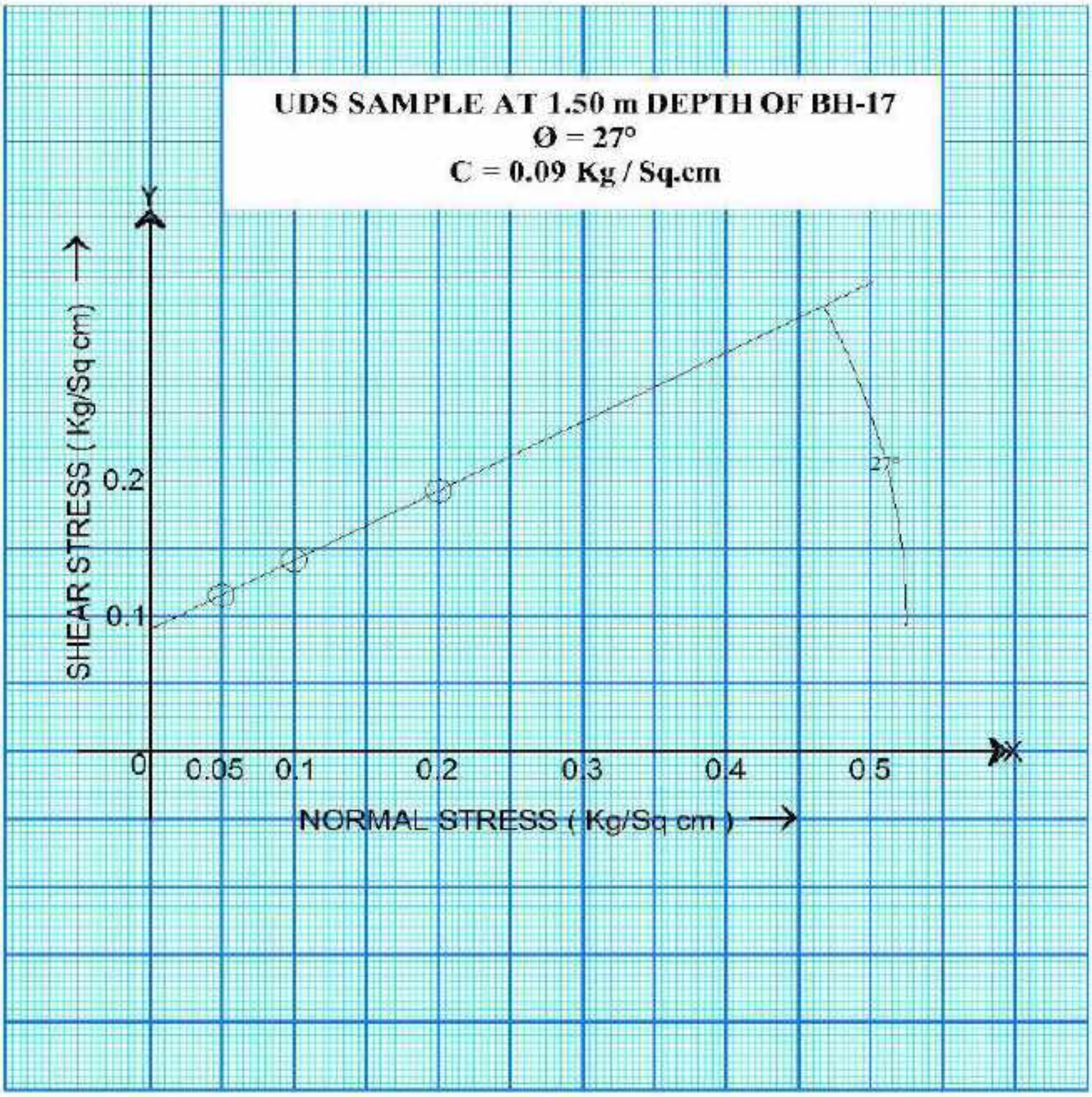
1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

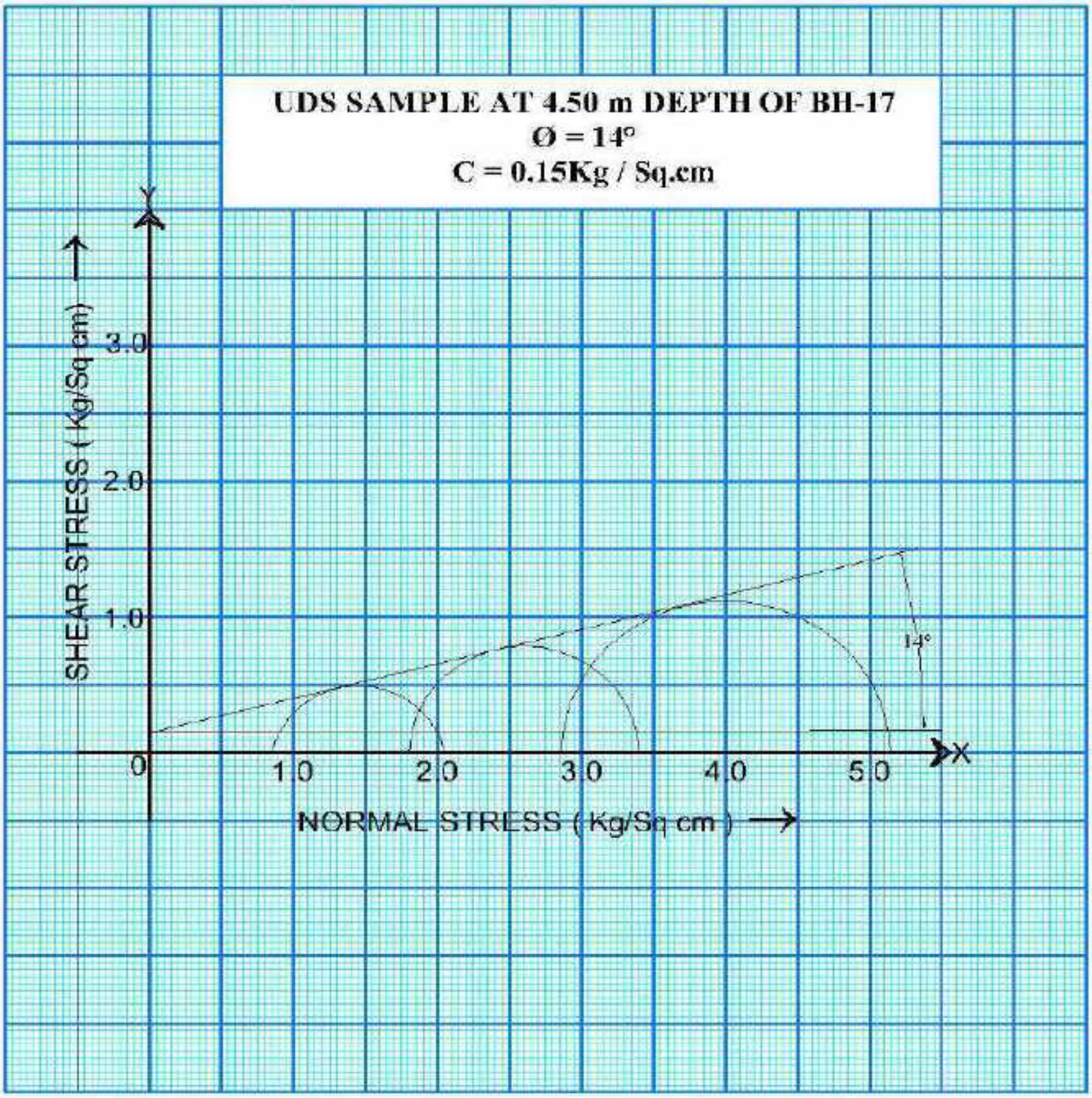
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-33

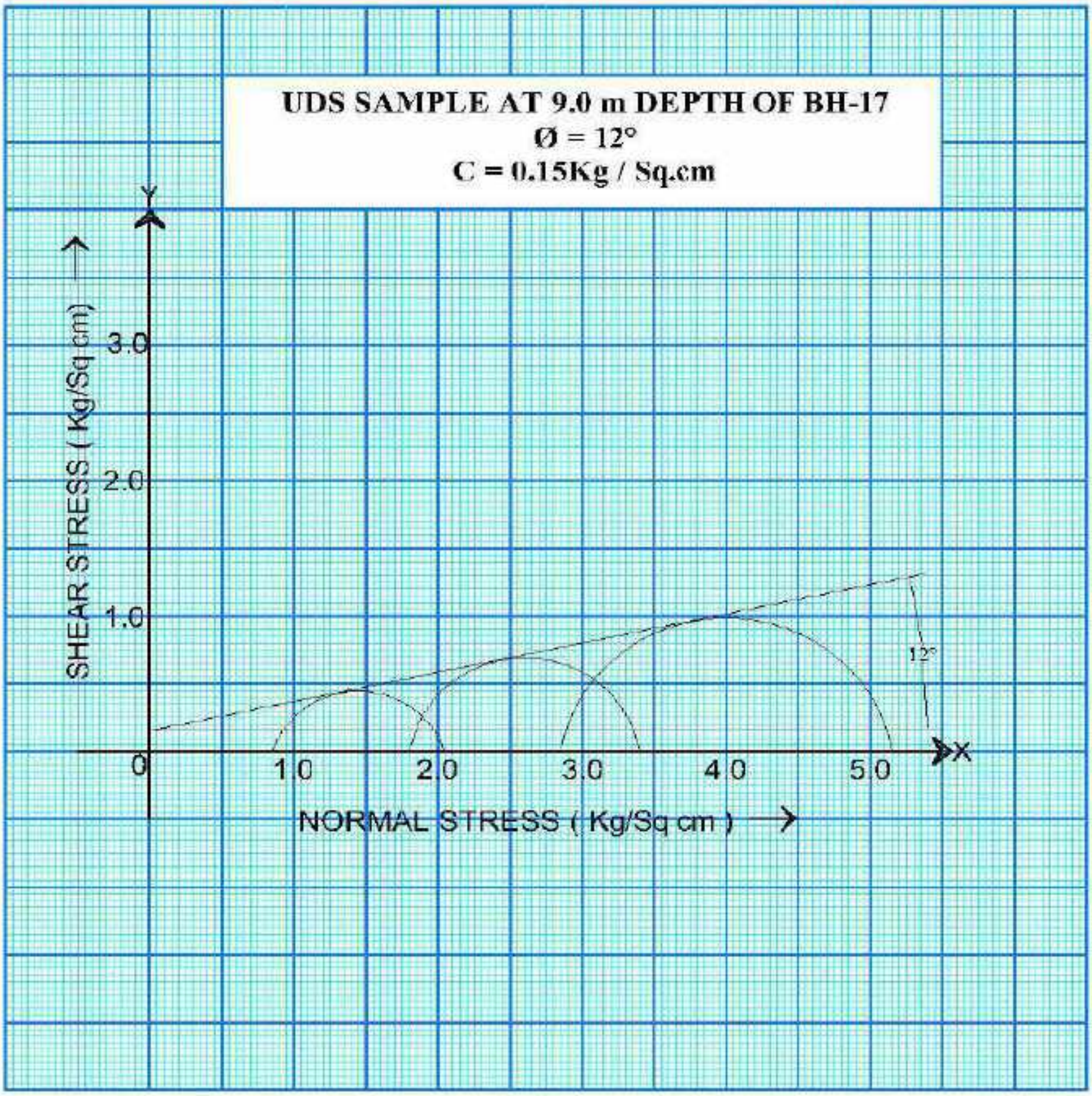


ANNEXURE –J
GRAPHICAL REPRESENTATION OF SHEAR STRENGTH PARAMETER

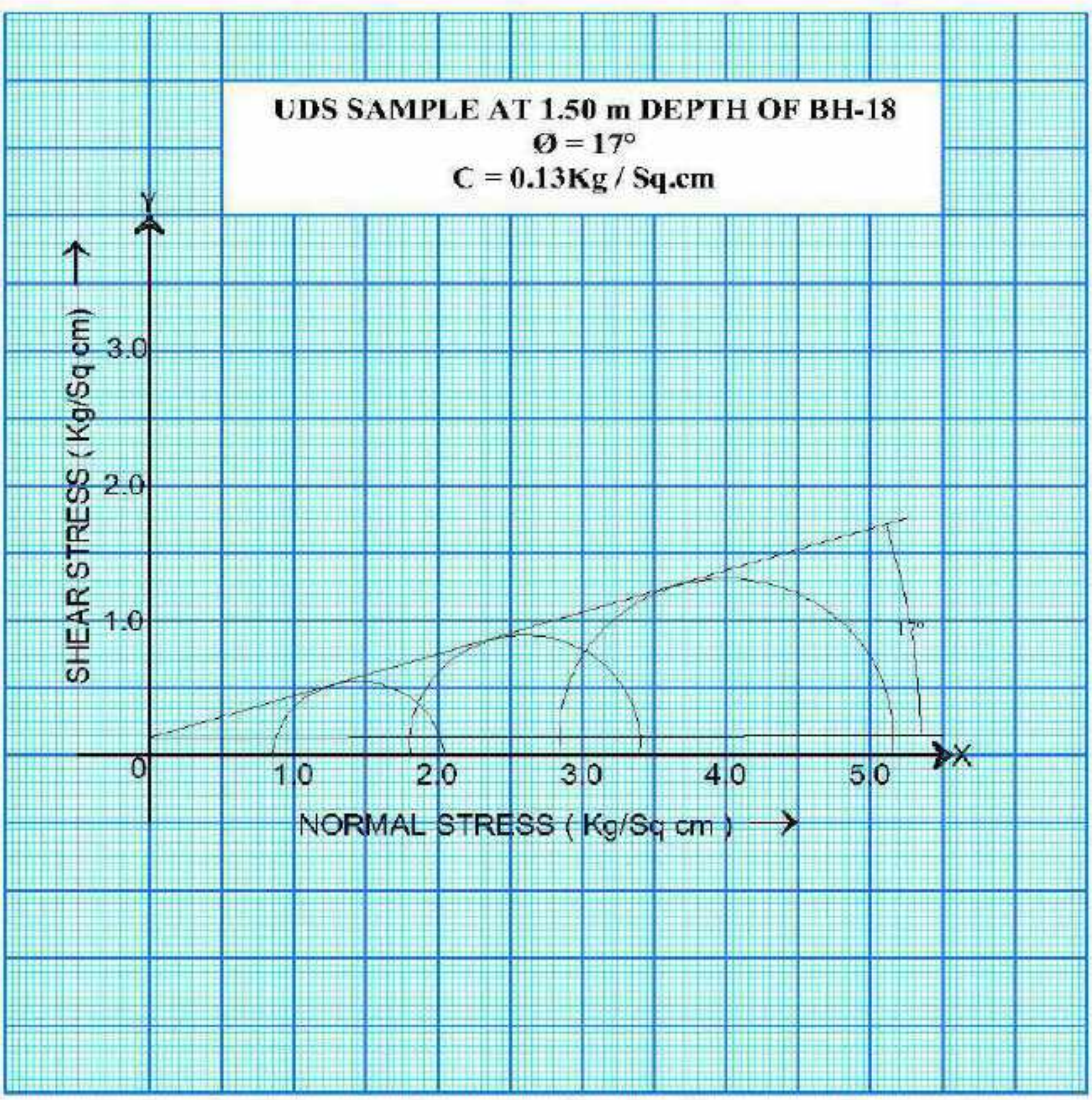

UDS SAMPLE AT 1.50 m DEPTH OF BH-17
Ø = 27°
C = 0.09 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
27°
NORMAL STRESS (Kg/Sq cm) →



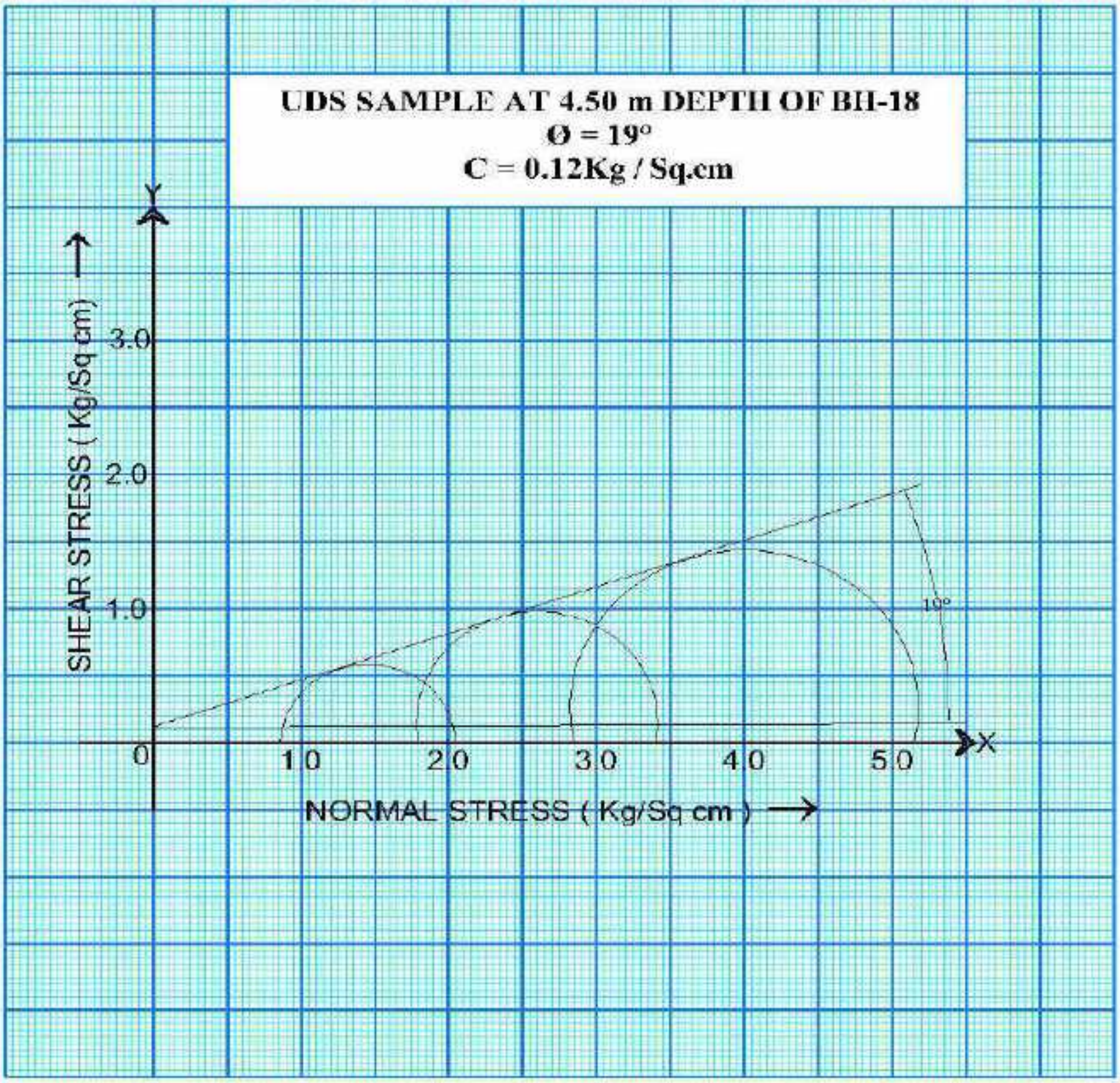
UDS SAMPLE AT 4.50 m DEPTH OF BH-17
Ø = 14°
C = 0.15Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
3.0
2.0
1.0
0
14°
X
1.0
2.0
3.0
4.0
5.0
NORMAL STRESS (Kg/Sq cm) →

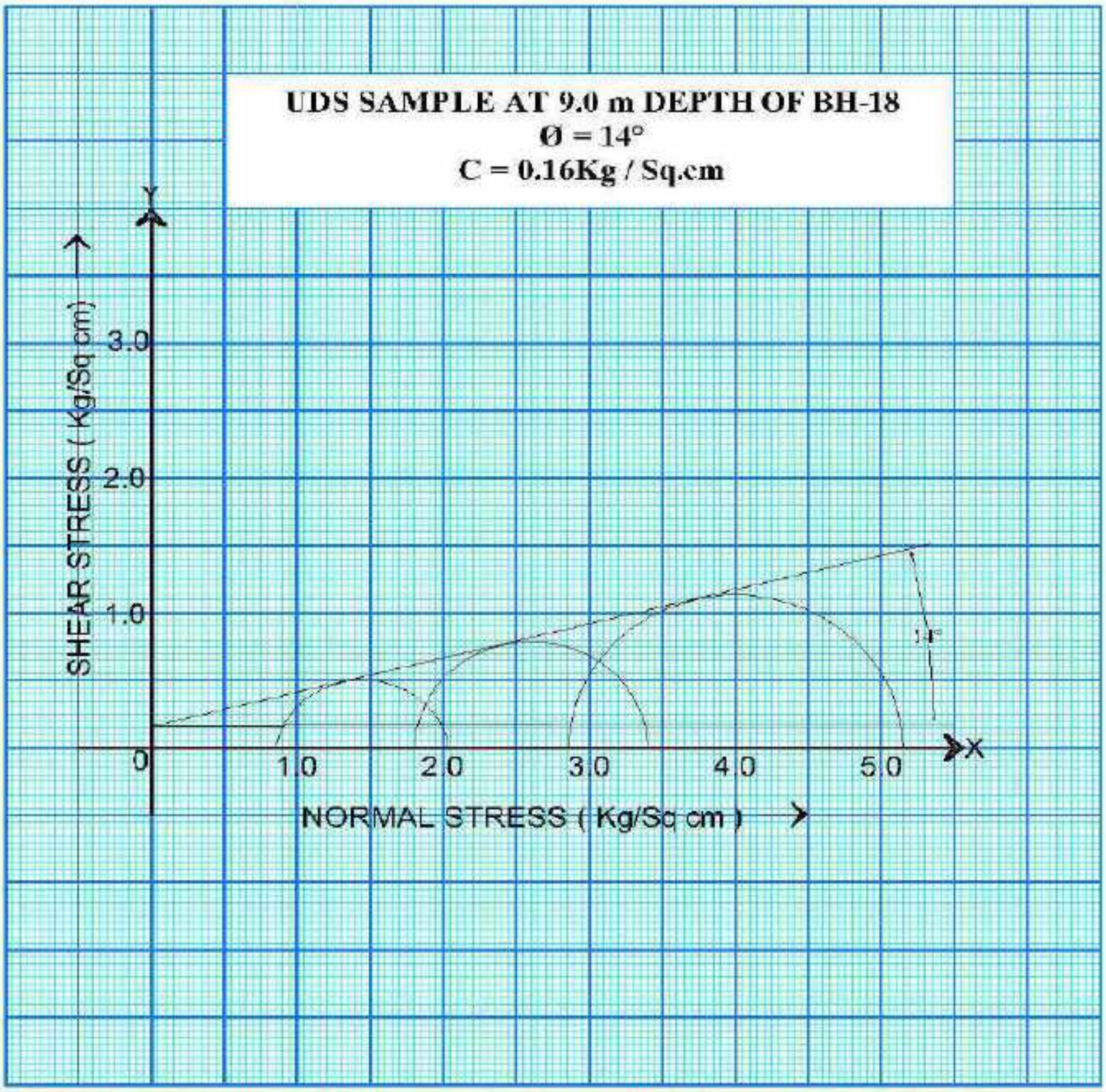


UDS SAMPLE AT 9.0 m DEPTH OF BH-17
Ø = 12°
C = 0.15Kg / Sq.cm



UDS SAMPLE AT 1.50 m DEPTH OF BH-18
Ø = 17°
C = 0.13Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
17°
NORMAL STRESS (Kg/Sq cm)

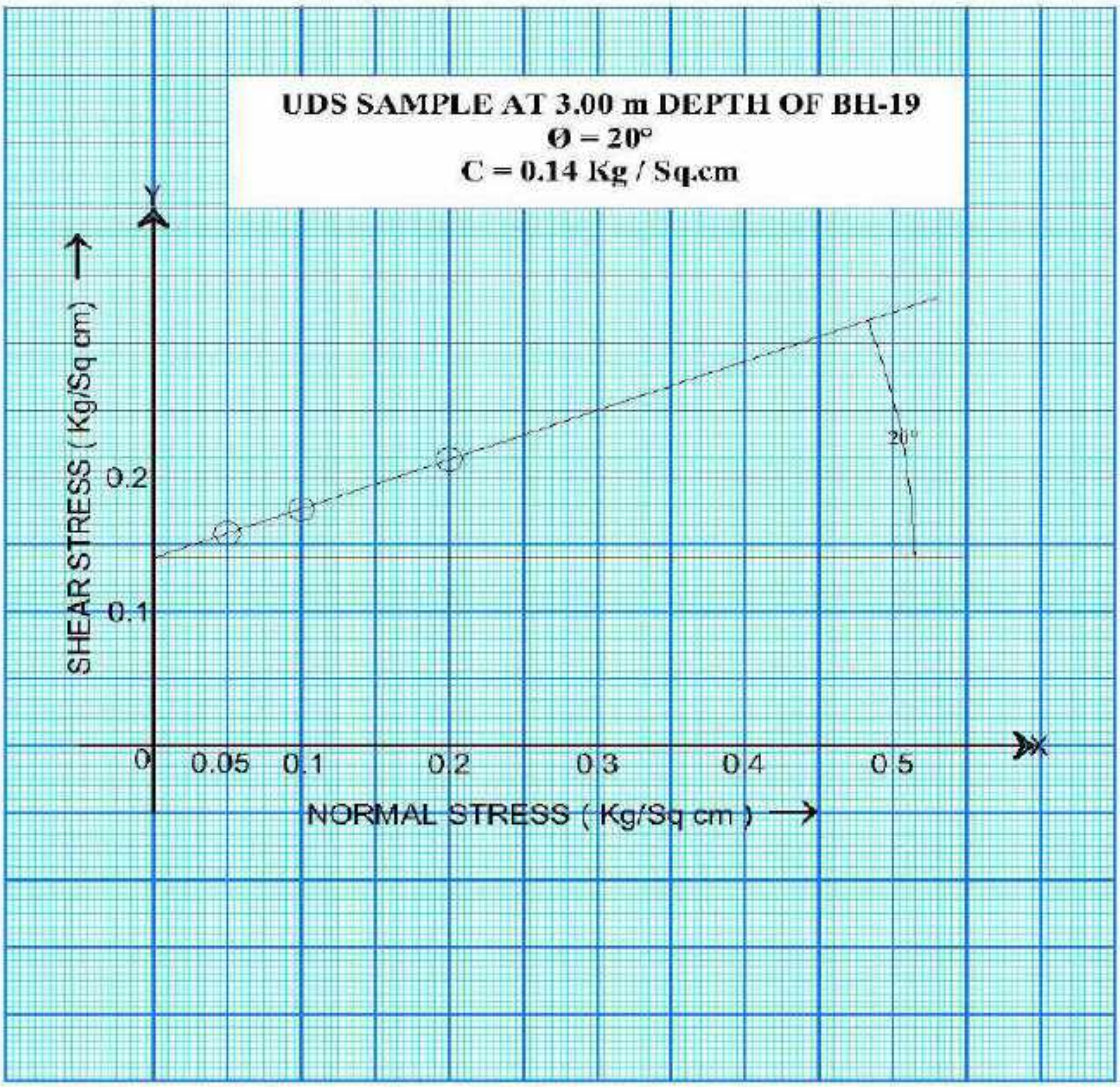

UDS SAMPLE AT 4.50 m DEPTH OF BH-18
Ø = 19°
C = 0.12Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
19°
NORMAL STRESS (Kg/Sq cm)

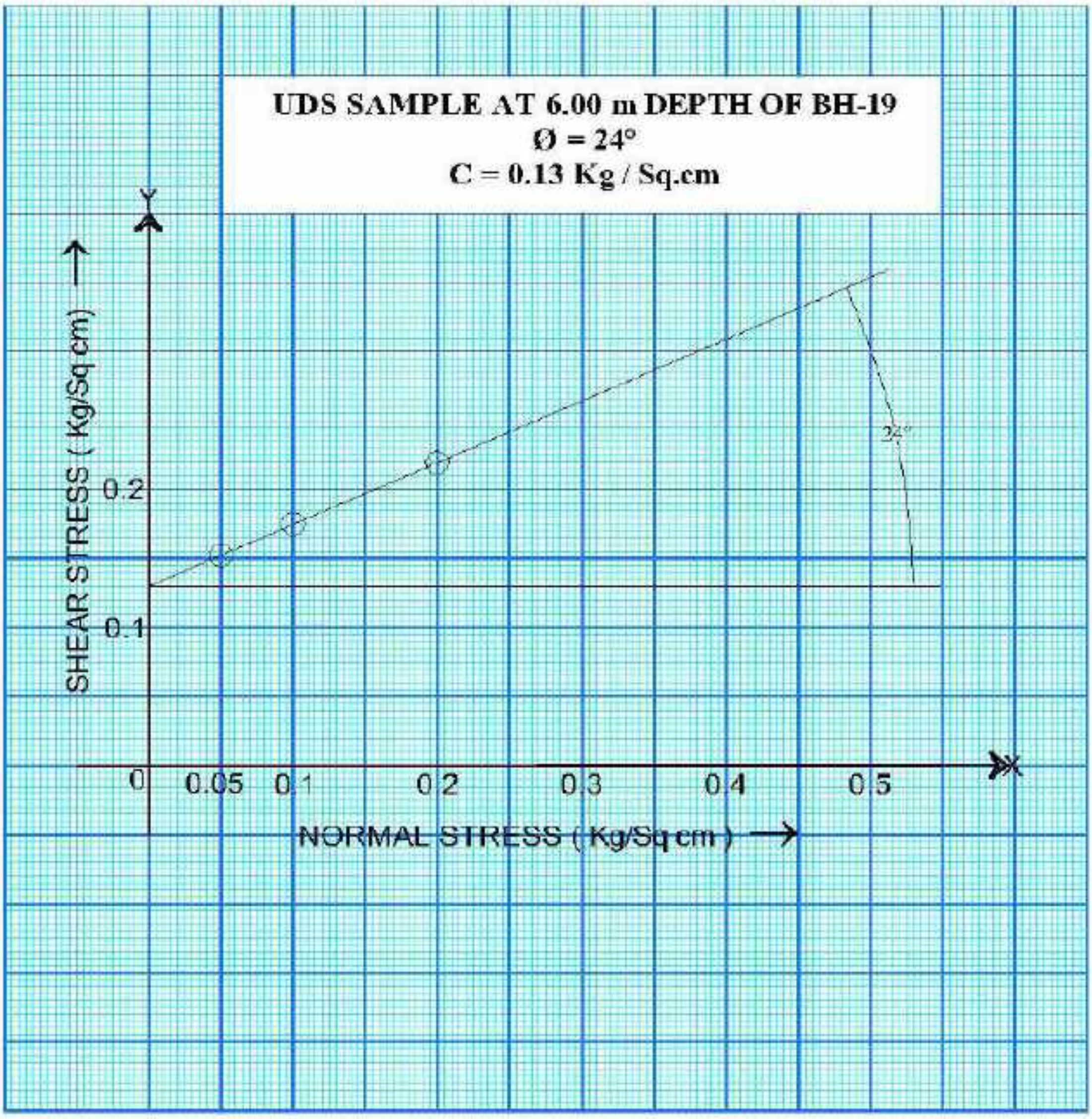


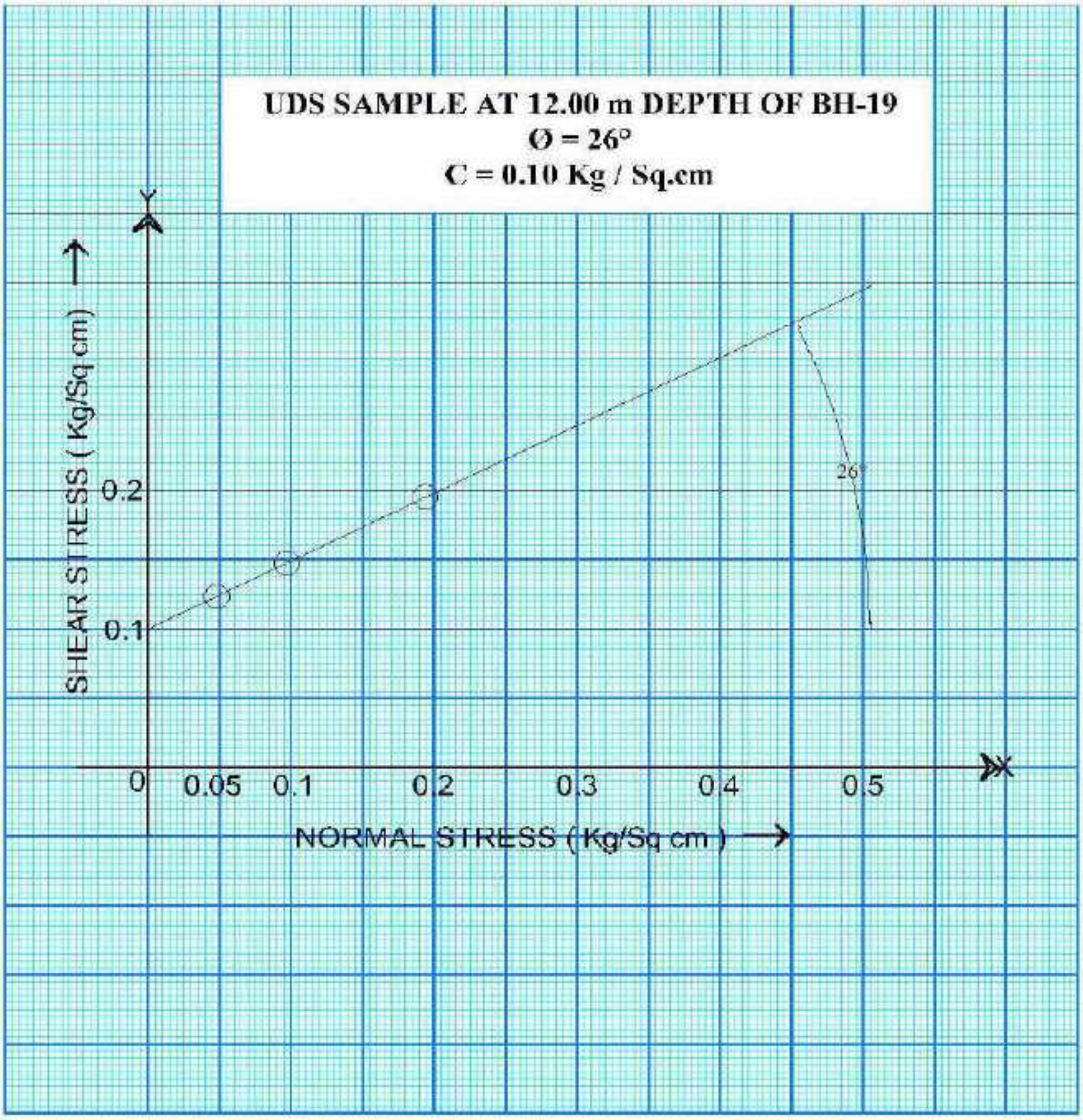
UDS SAMPLE AT 9.0 m DEPTH OF BH-18

Ø = 14°

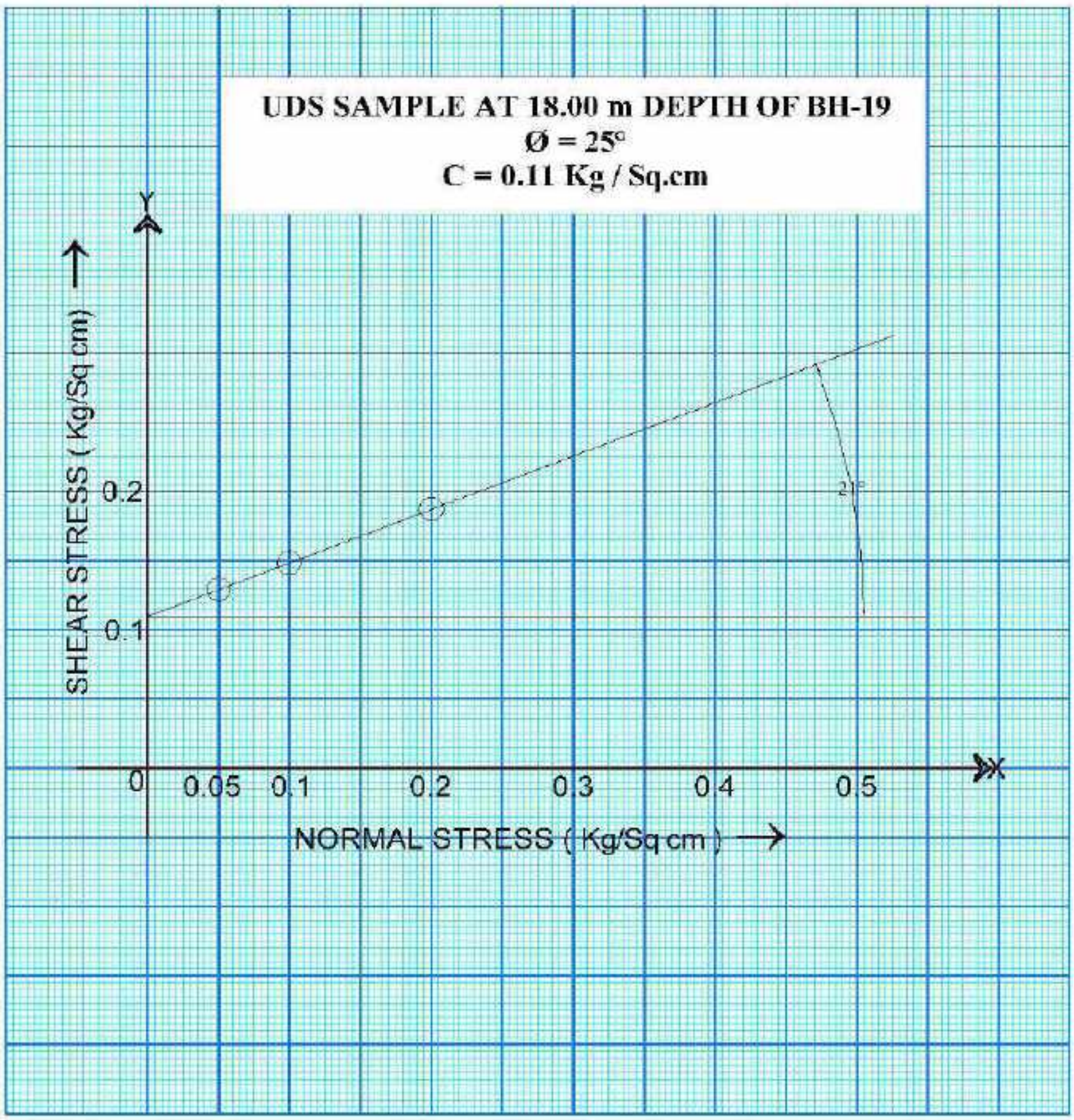
C = 0.16Kg / Sq.cm


UDS SAMPLE AT 3.00 m DEPTH OF BH-19
Ø = 20°
C = 0.14 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
20°

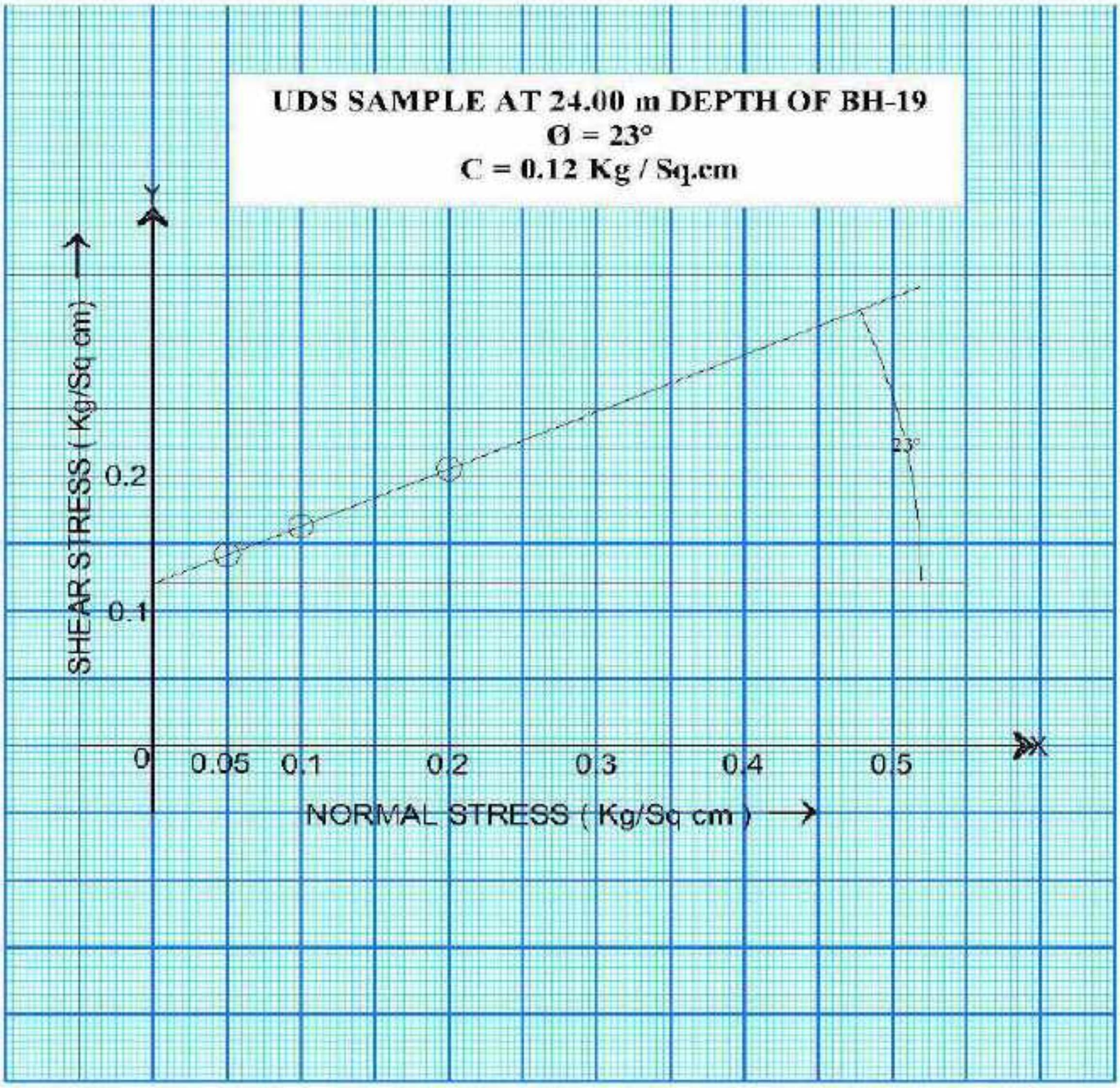

UDS SAMPLE AT 6.00 m DEPTH OF BH-19
Ø = 24°
C = 0.13 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
24°

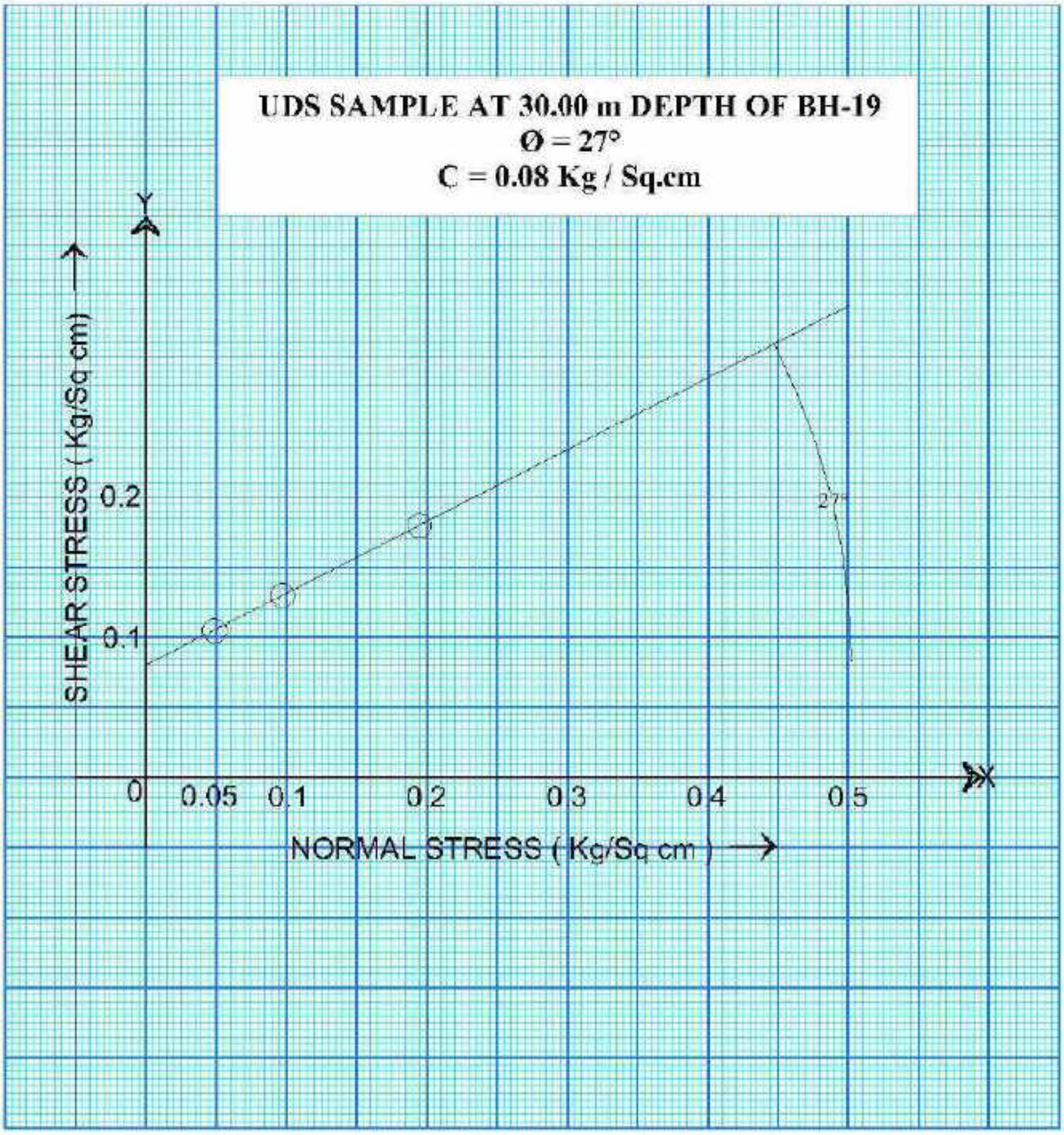


UDS SAMPLE AT 12.00 m DEPTH OF BH-19
Ø = 26°
C = 0.10 Kg / Sq.cm

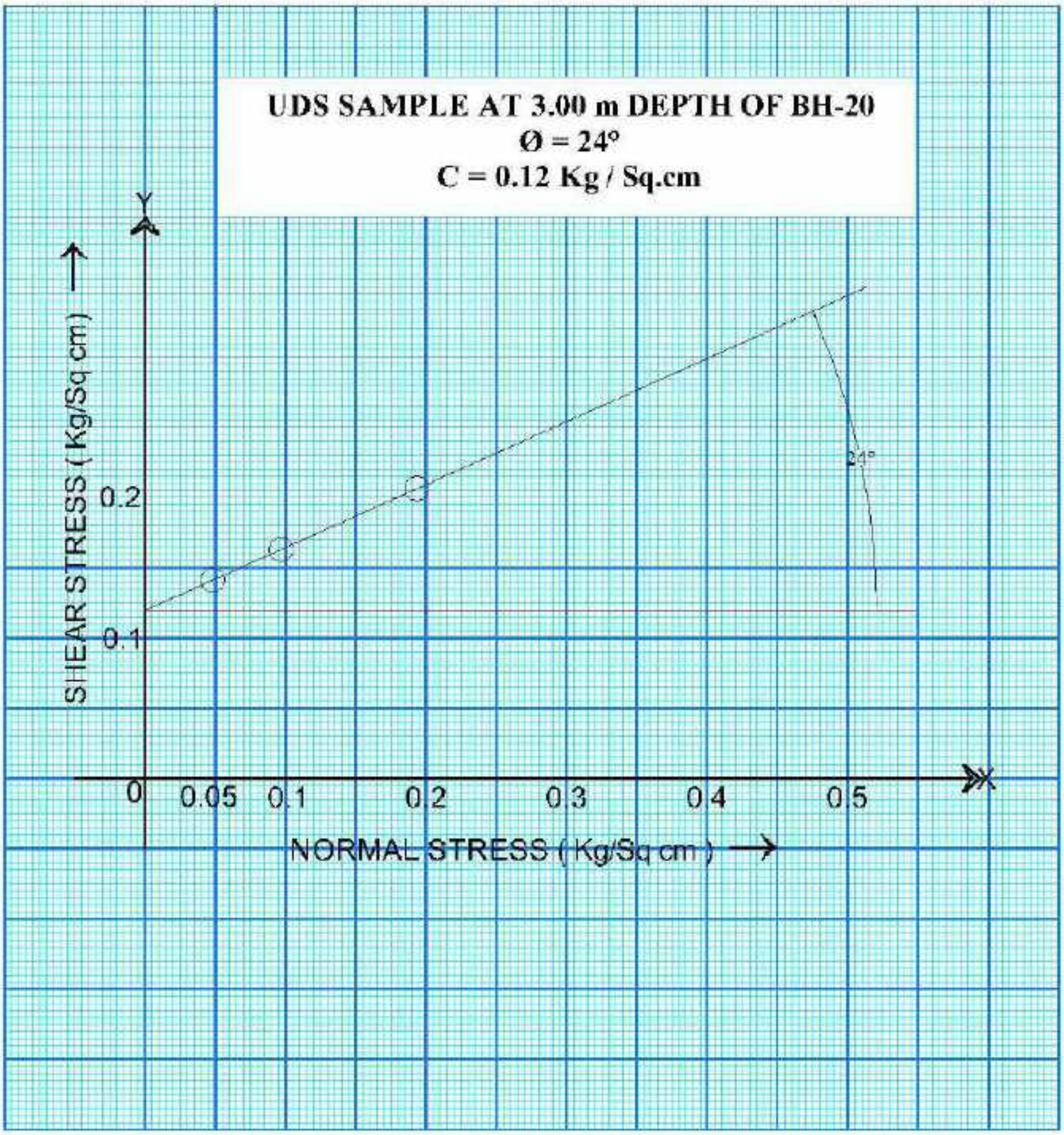


UDS SAMPLE AT 18.00 m DEPTH OF BH-19
Ø = 25°
C = 0.11 Kg / Sq.cm


UDS SAMPLE AT 24.00 m DEPTH OF BH-19
Ø = 23°
C = 0.12 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
23°
Y
X



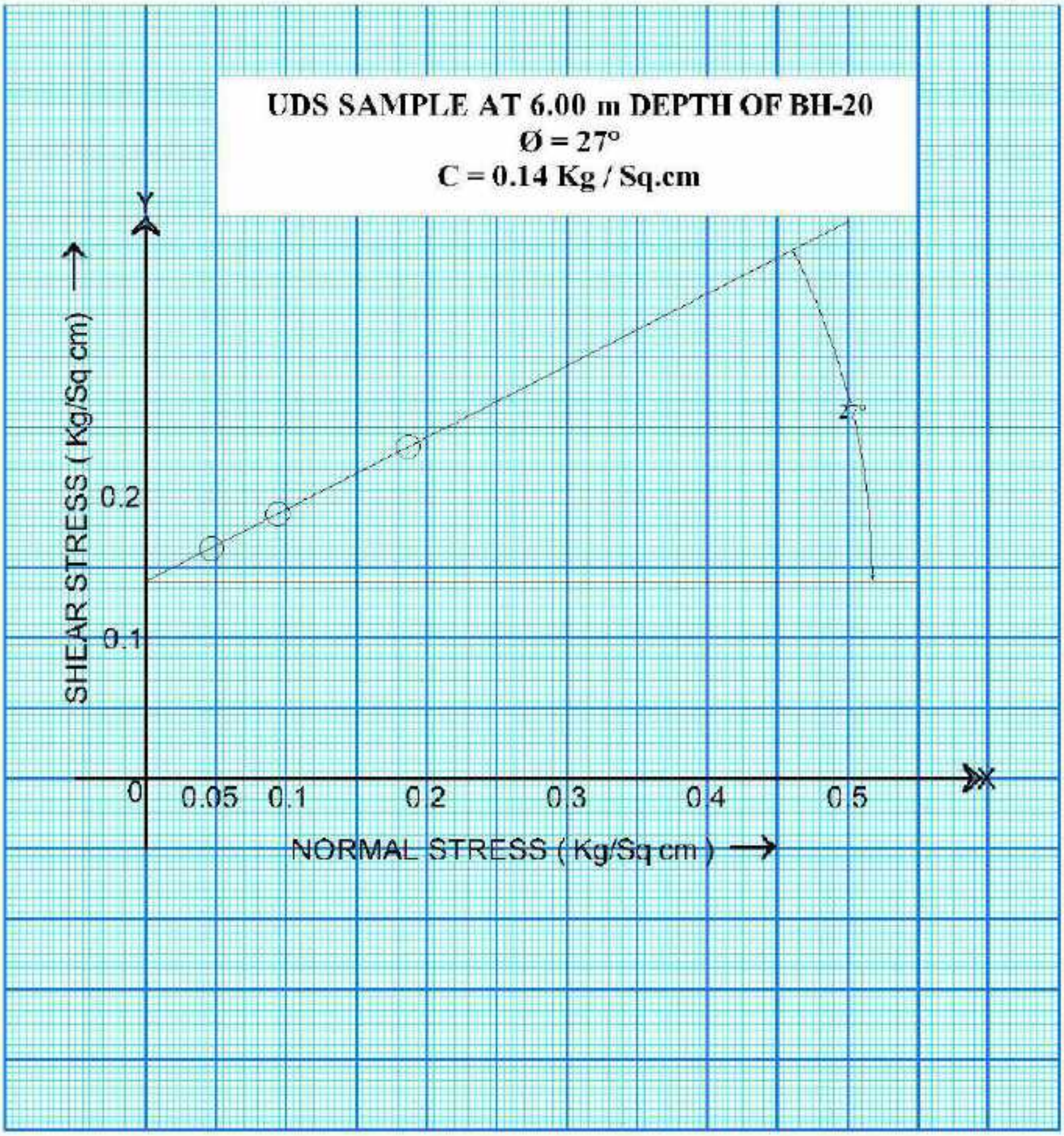
UDS SAMPLE AT 30.00 m DEPTH OF BH-19
Ø = 27°
C = 0.08 Kg / Sq.cm



UDS SAMPLE AT 3.00 m DEPTH OF BH-20

Ø = 24°

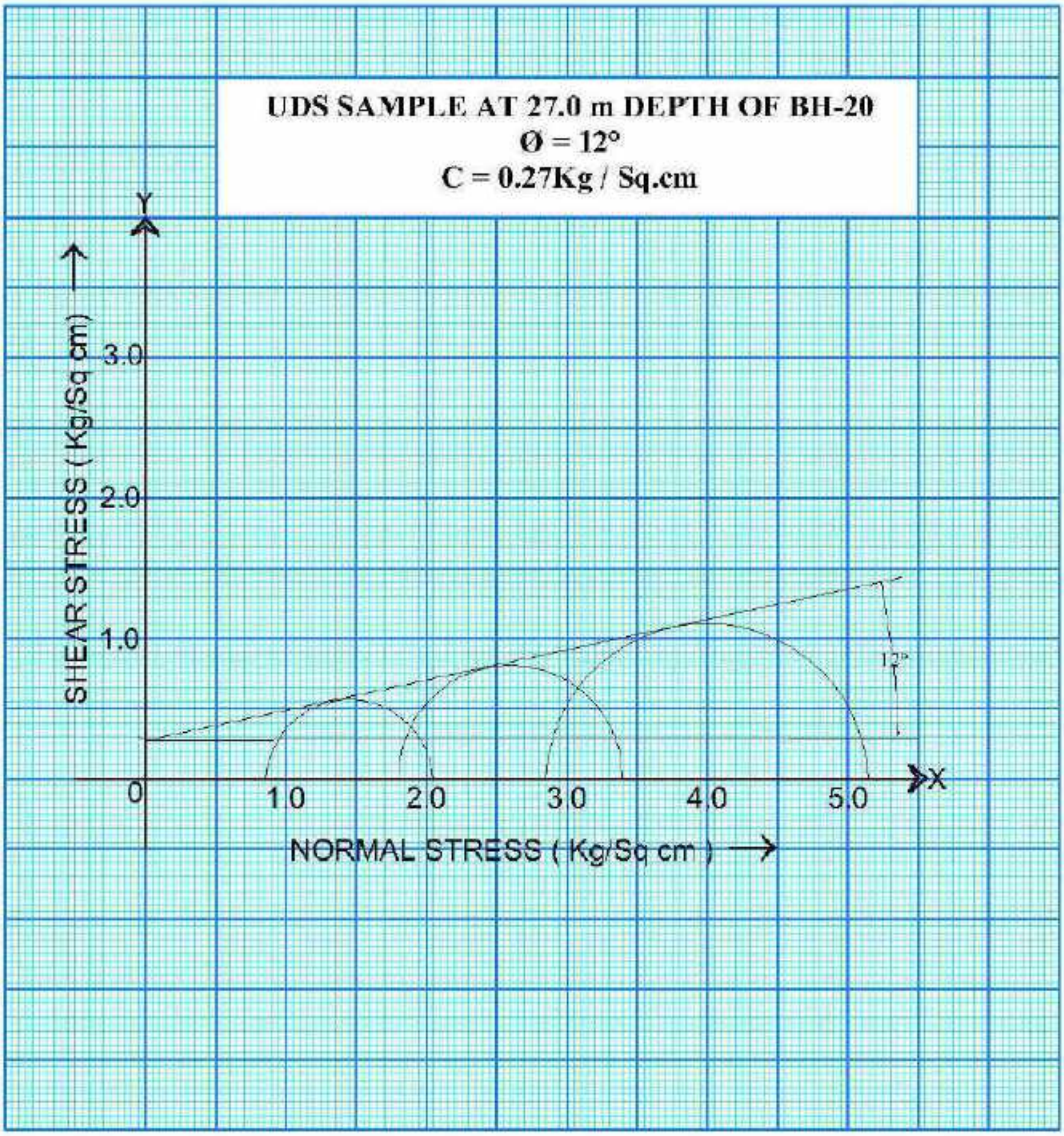
C = 0.12 Kg / Sq.cm

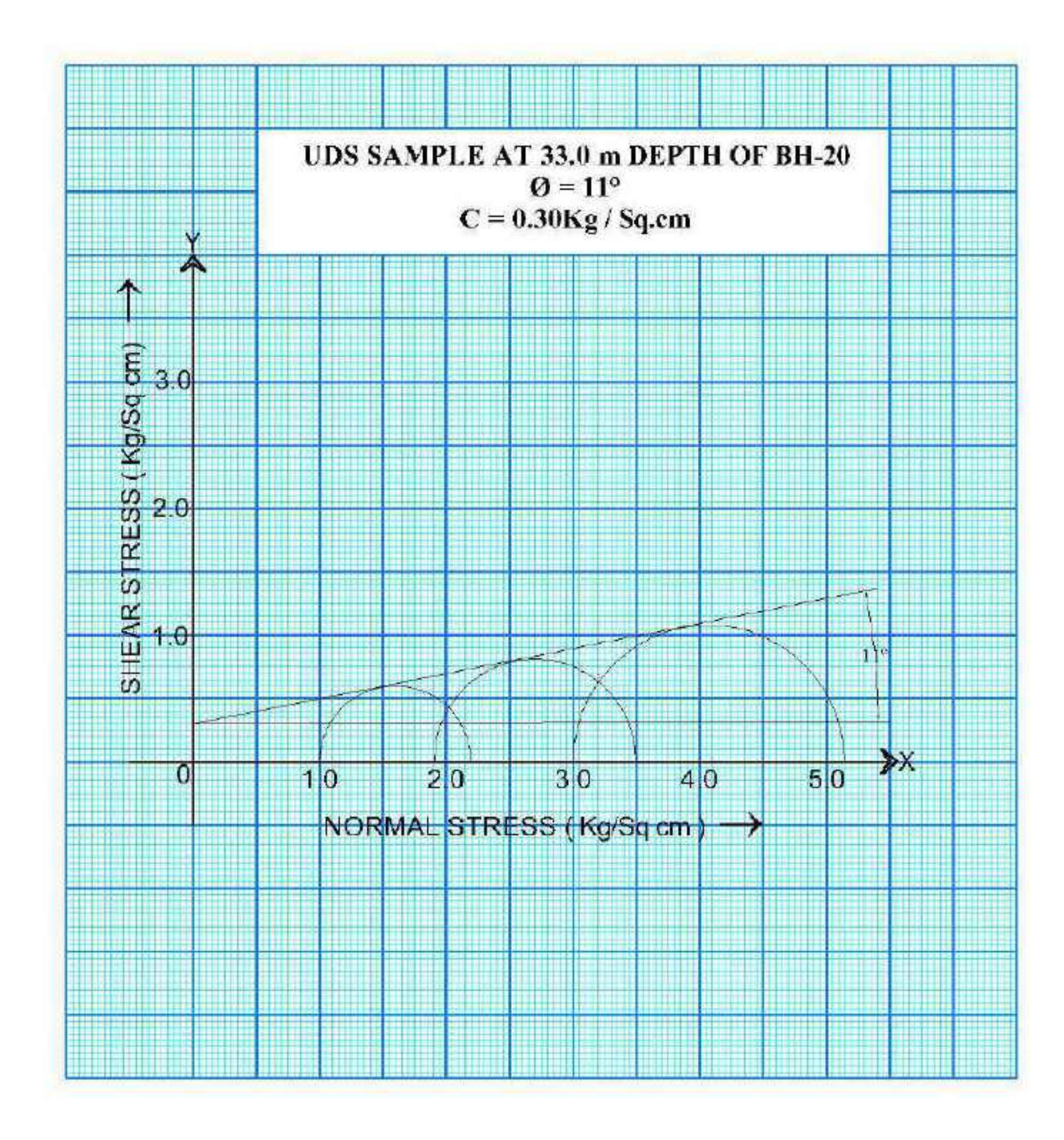

UDS SAMPLE AT 6.00 m DEPTH OF BH-20
Ø = 27°
C = 0.14 Kg / Sq.cm
Y
X
27°
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm) →

UDS SAMPLE AT 27.0 m DEPTH OF BH-20

Ø = 12°

C = 0.27Kg / Sq.cm

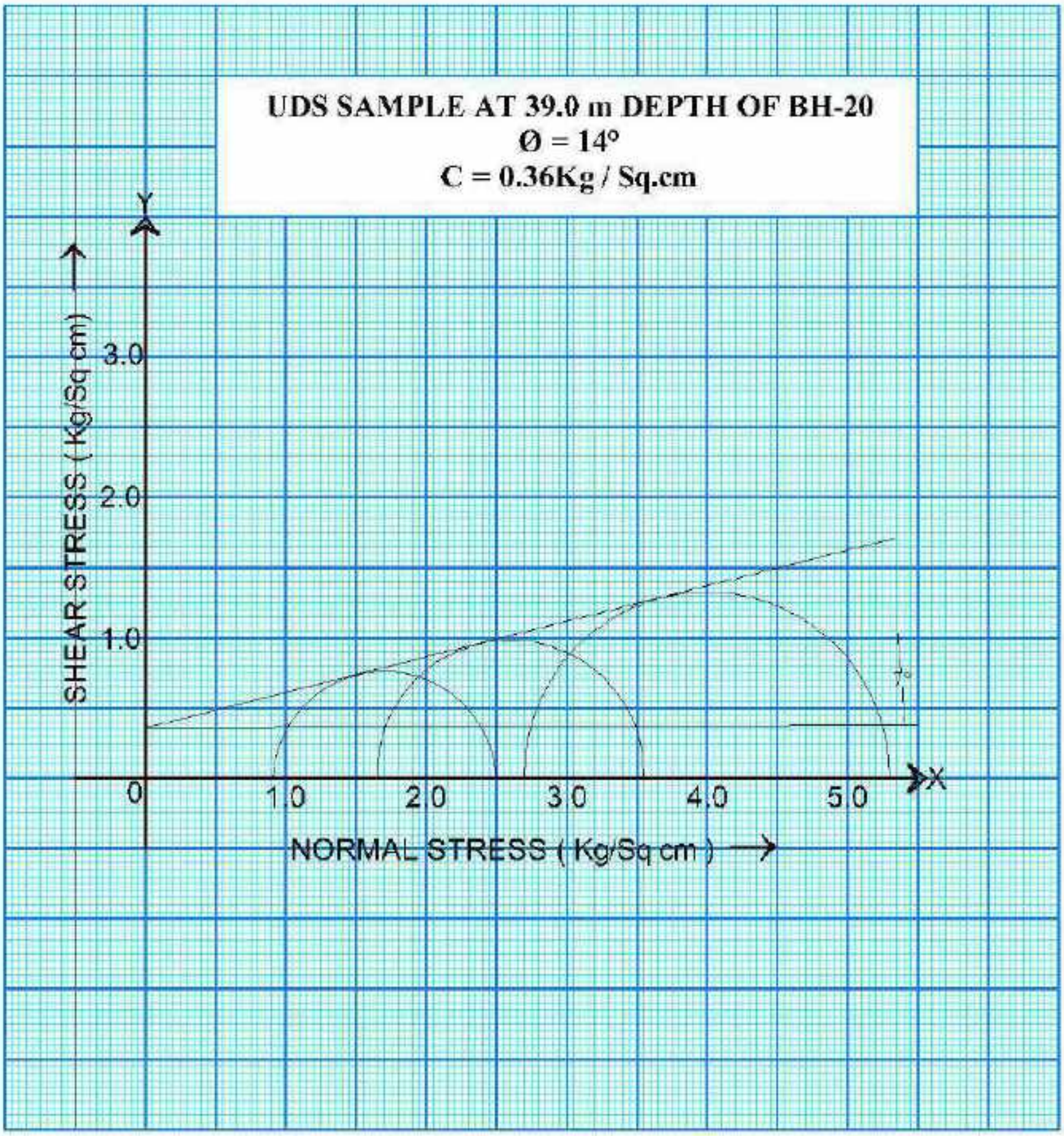




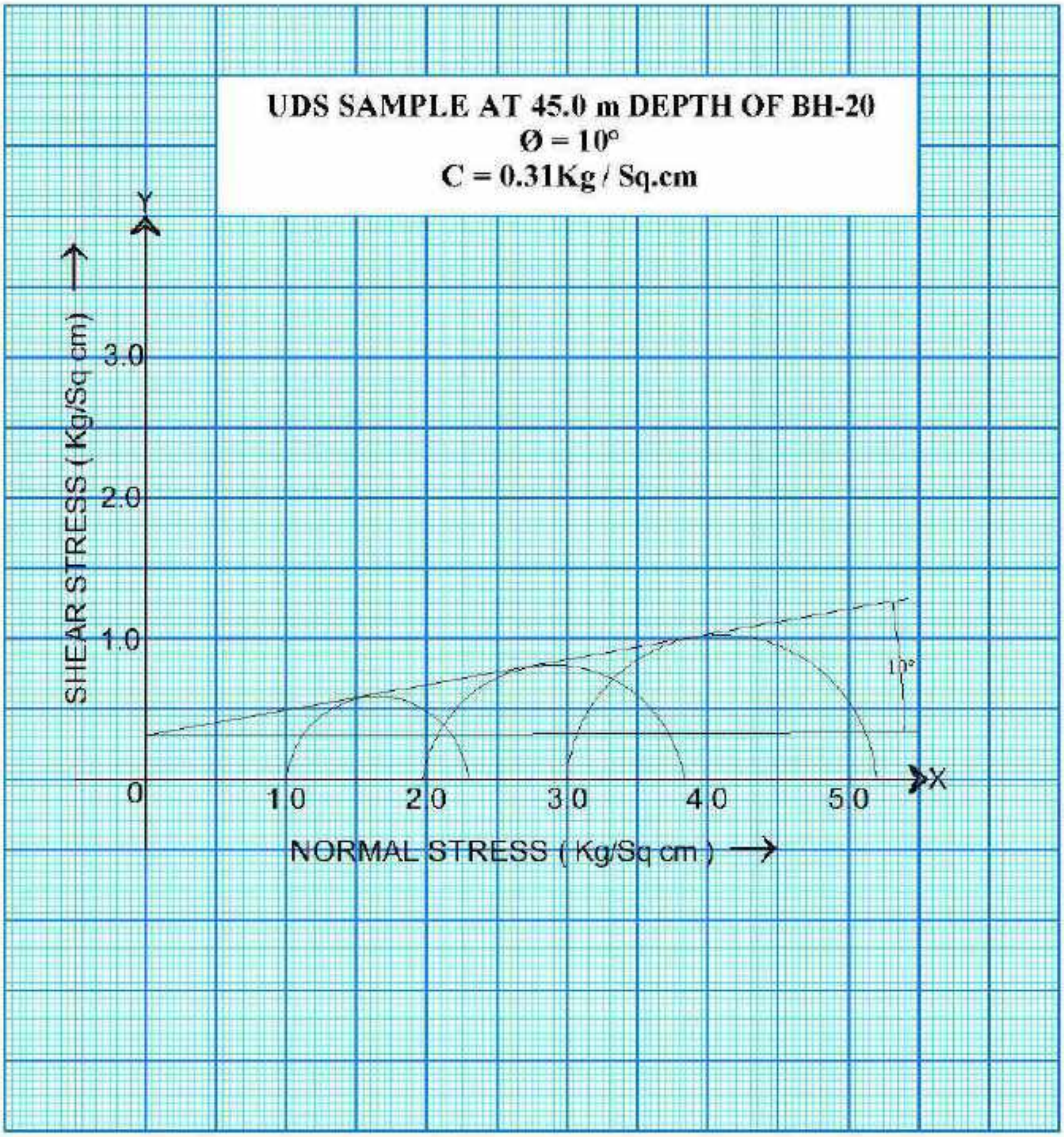
UDS SAMPLE AT 33.0 m DEPTH OF BH-20

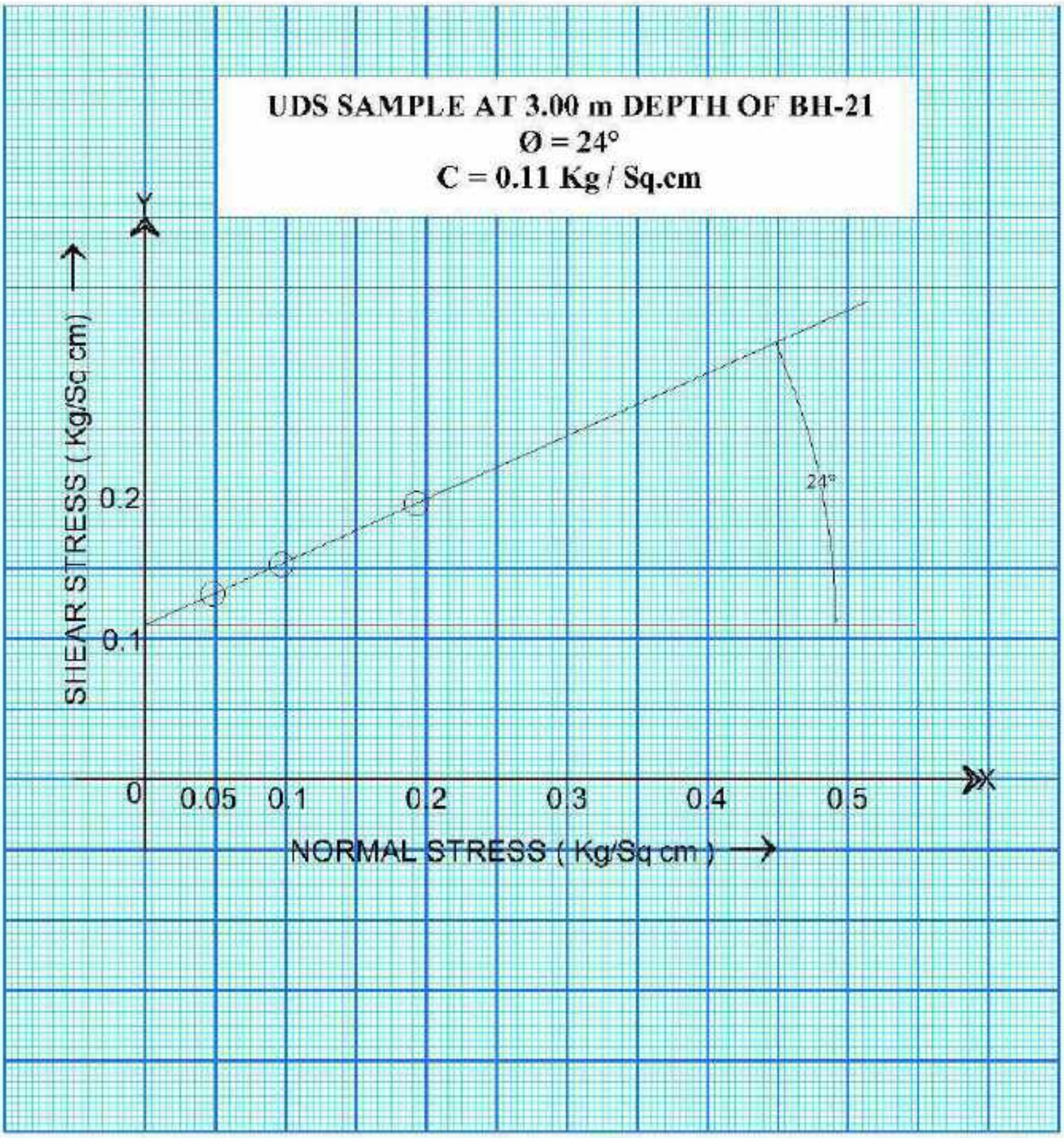
Ø = 11°

C = 0.30Kg / Sq.cm

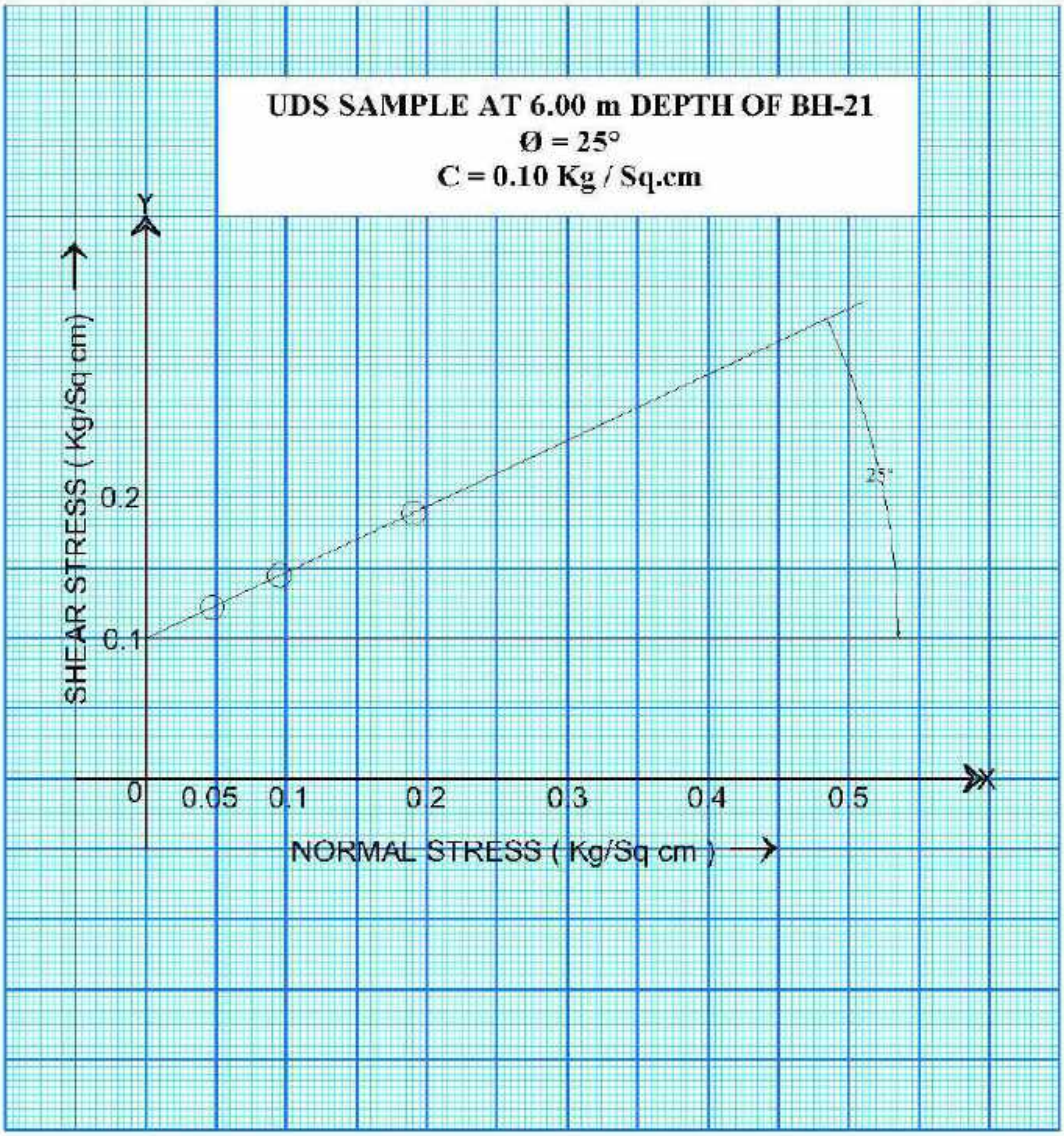


UDS SAMPLE AT 39.0 m DEPTH OF BH-20
Ø = 14°
C = 0.36Kg / Sq.cm


UDS SAMPLE AT 45.0 m DEPTH OF BH-20
Ø = 10°
C = 0.31Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
10°
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)



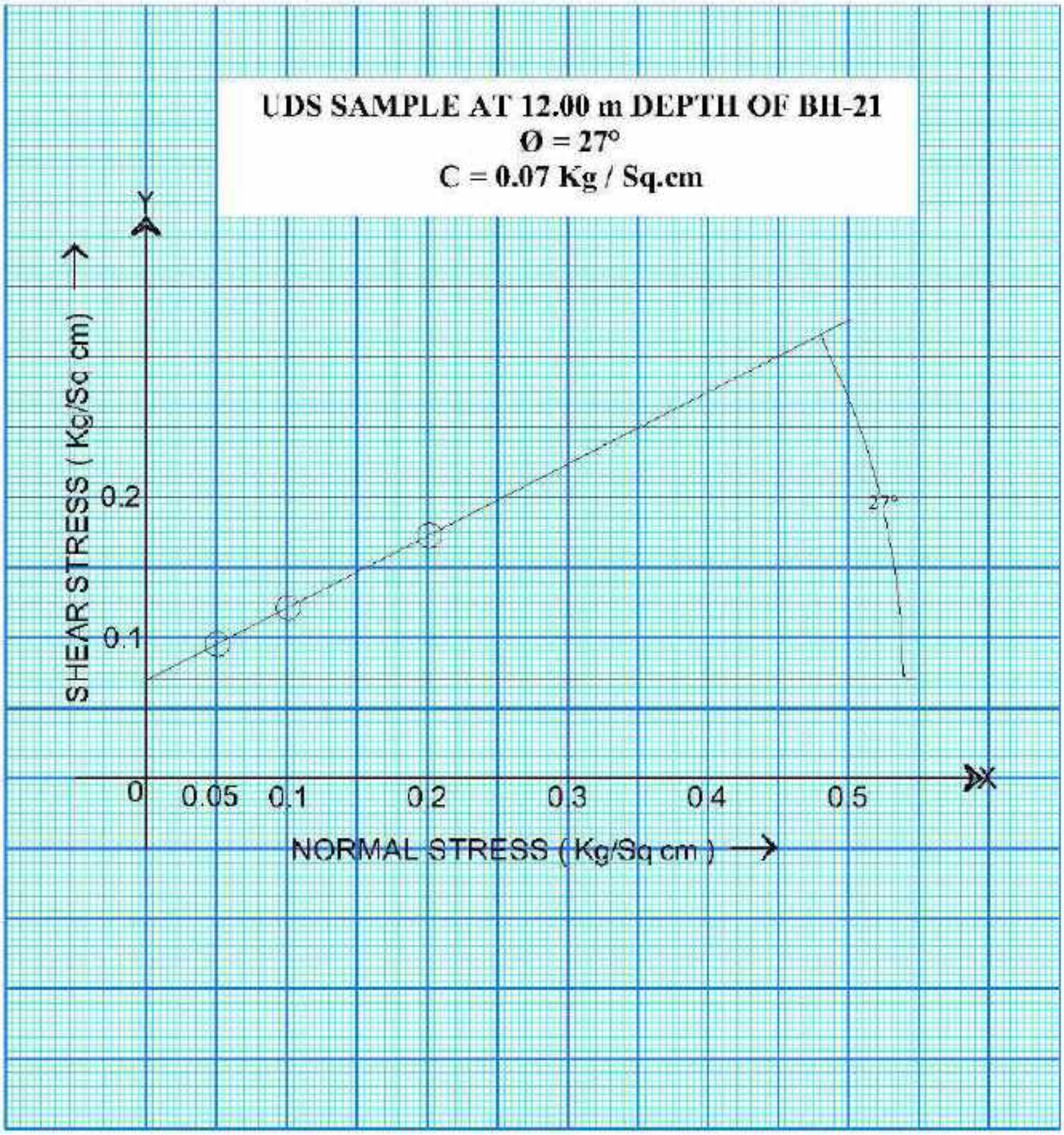
UDS SAMPLE AT 3.00 m DEPTH OF BH-21
Ø = 24°
C = 0.11 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
24°
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm) →

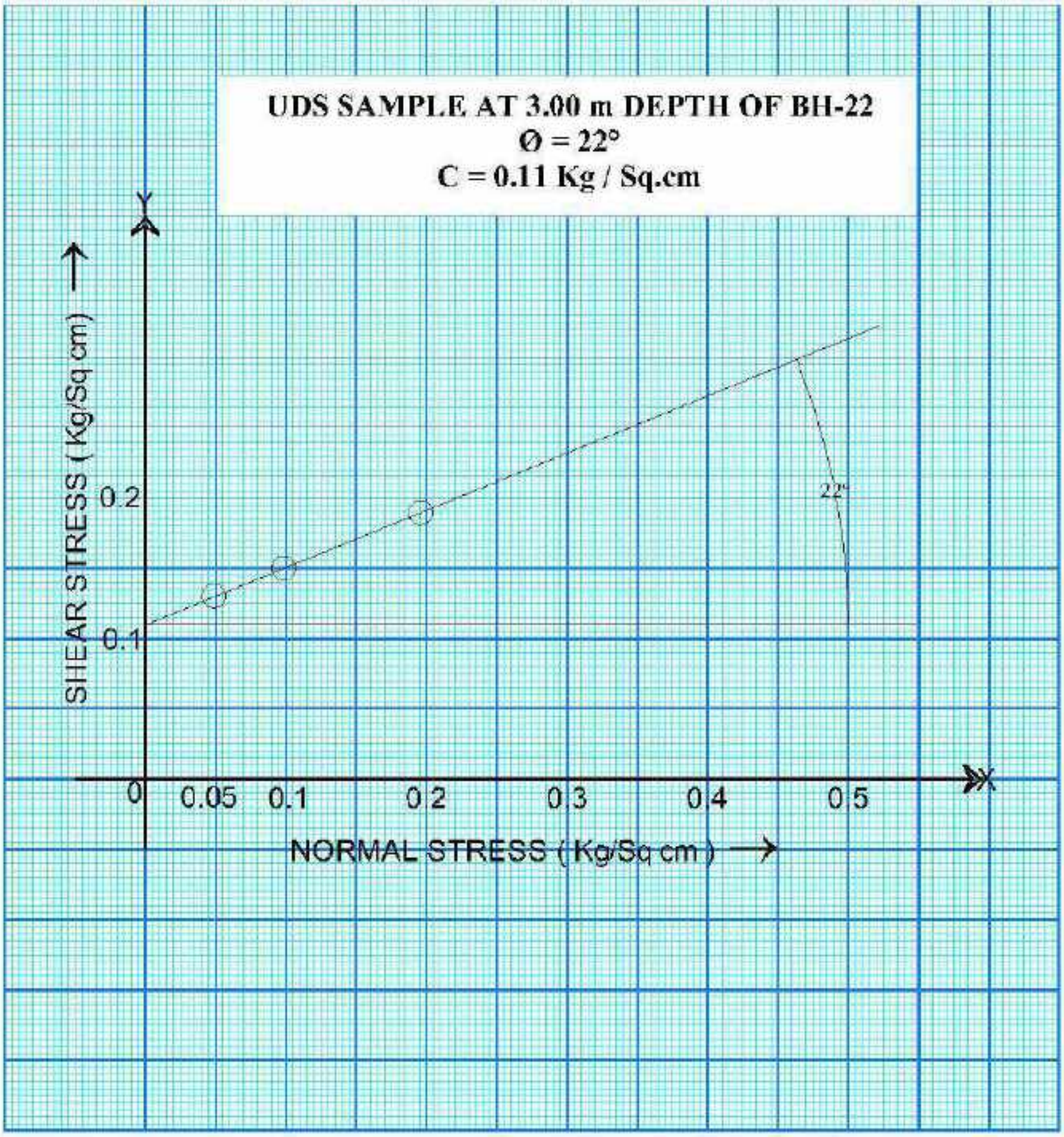

UDS SAMPLE AT 6.00 m DEPTH OF BH-21
Ø = 25°
C = 0.10 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm) →
25°

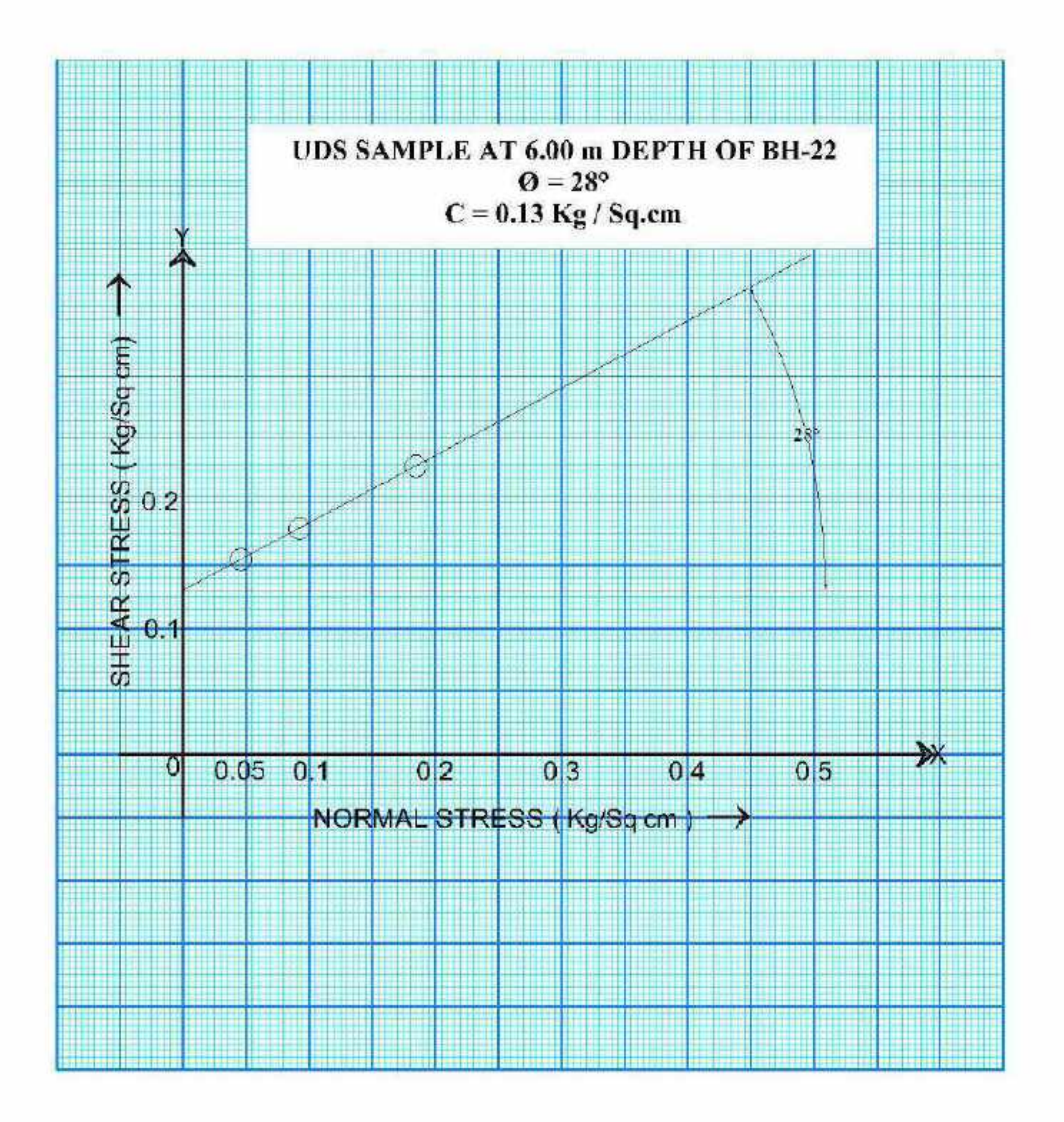
UDS SAMPLE AT 12.00 m DEPTH OF BH-21

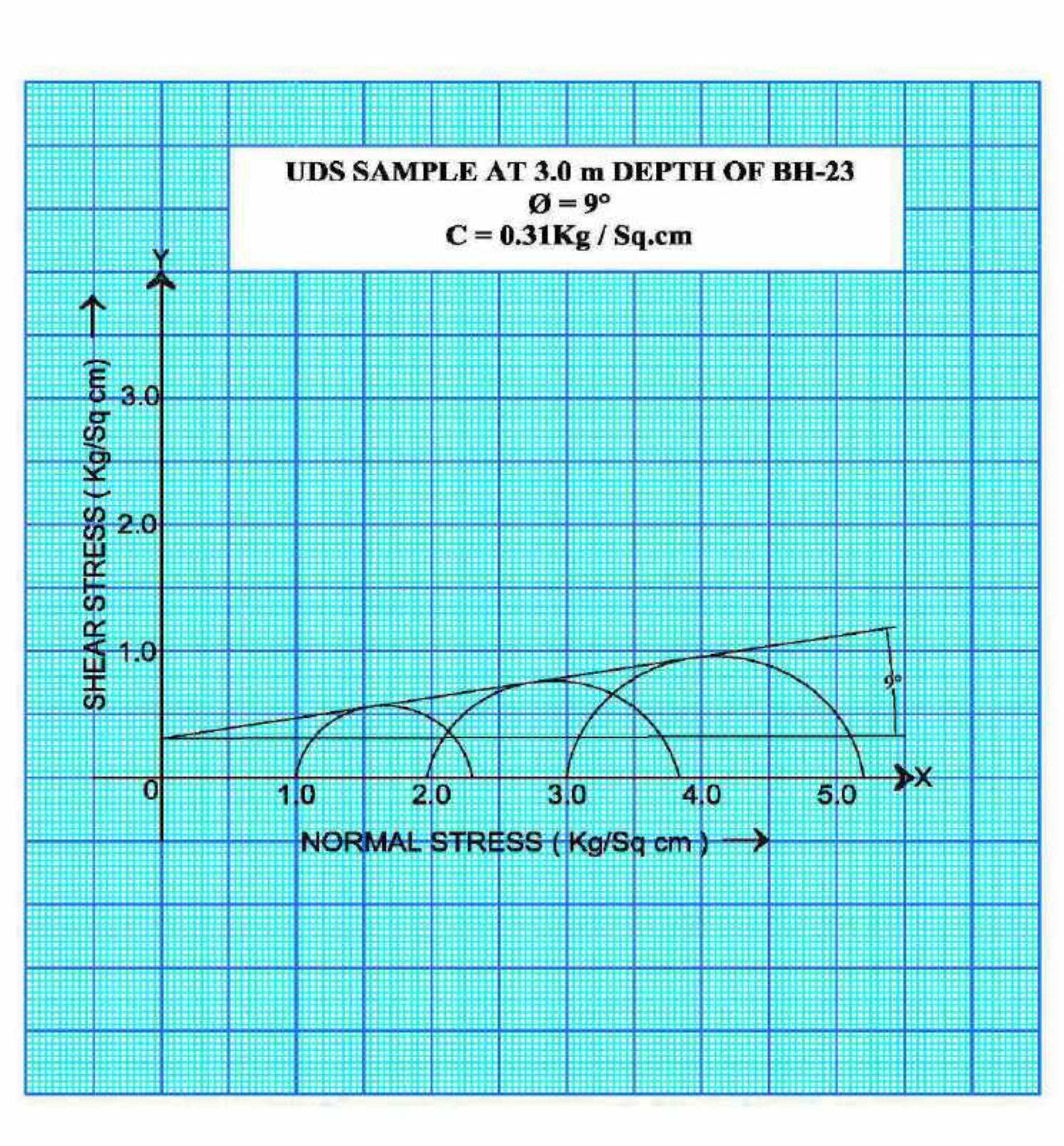
Ø = 27°

C = 0.07 Kg / Sq.cm

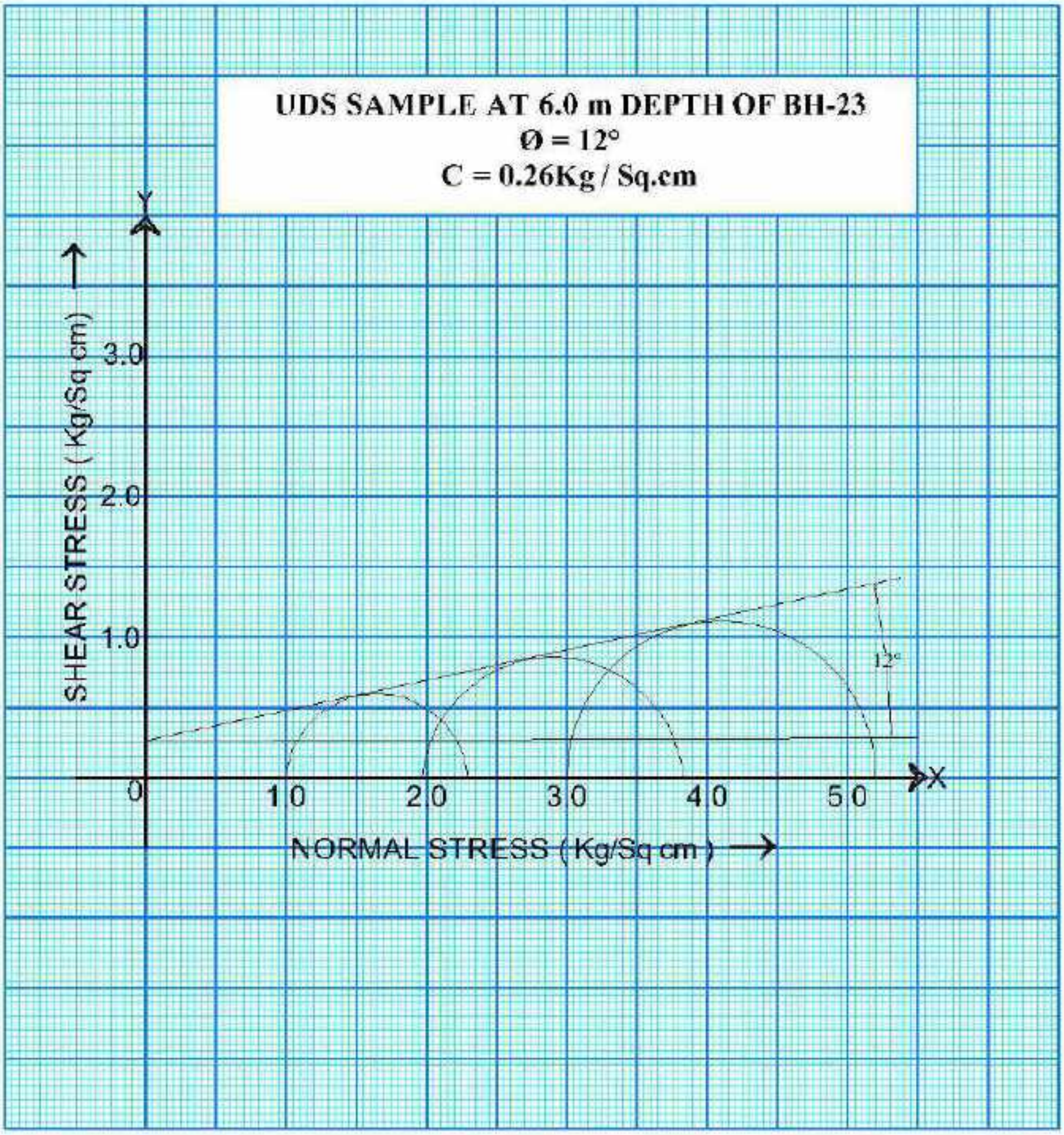


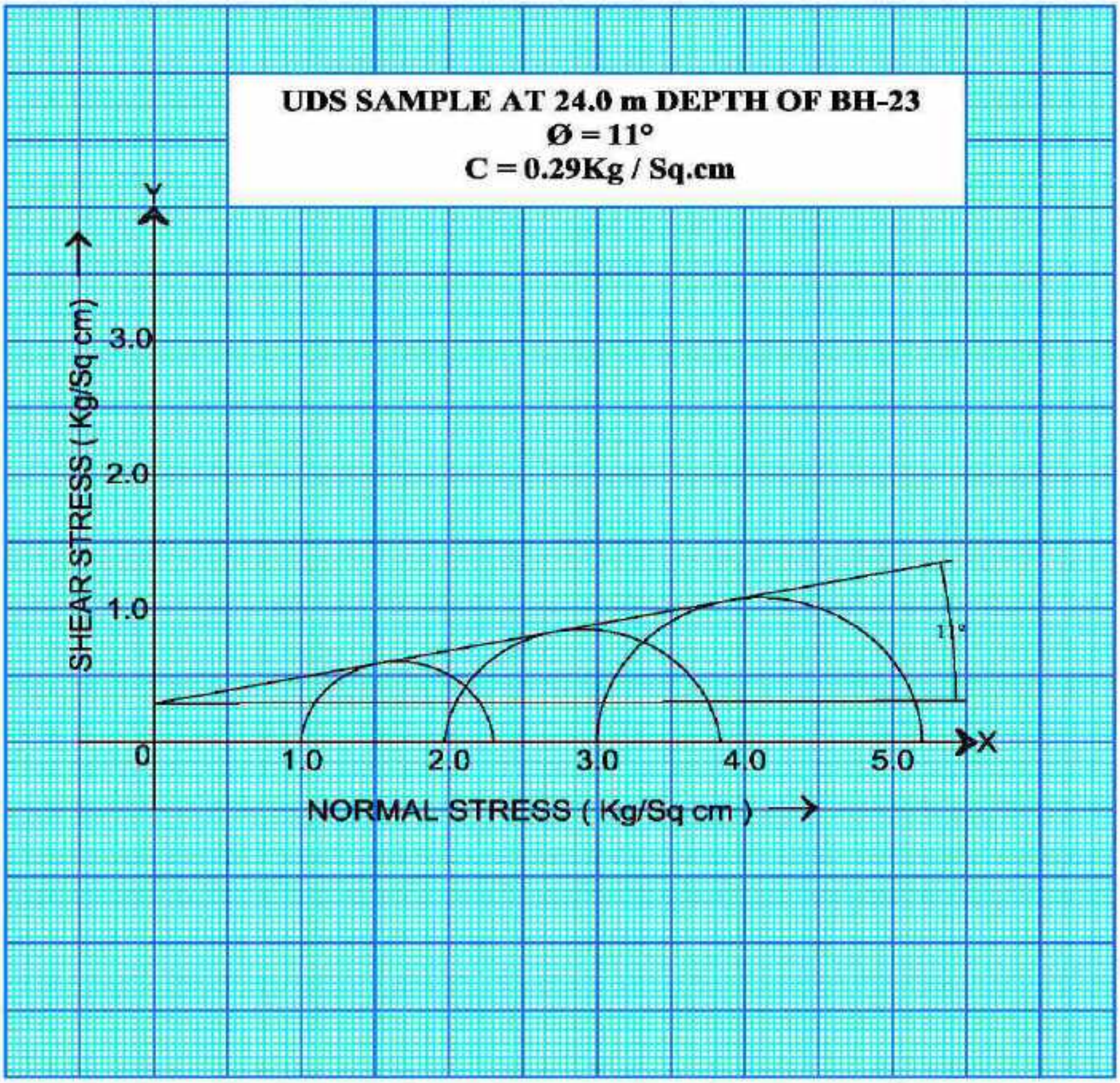

UDS SAMPLE AT 3.00 m DEPTH OF BH-22
Ø = 22°
C = 0.11 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
22°
NORMAL STRESS (Kg/Sq cm) →


UDS SAMPLE AT 6.00 m DEPTH OF BH-22
Ø = 28°
C = 0.13 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm) →
28°

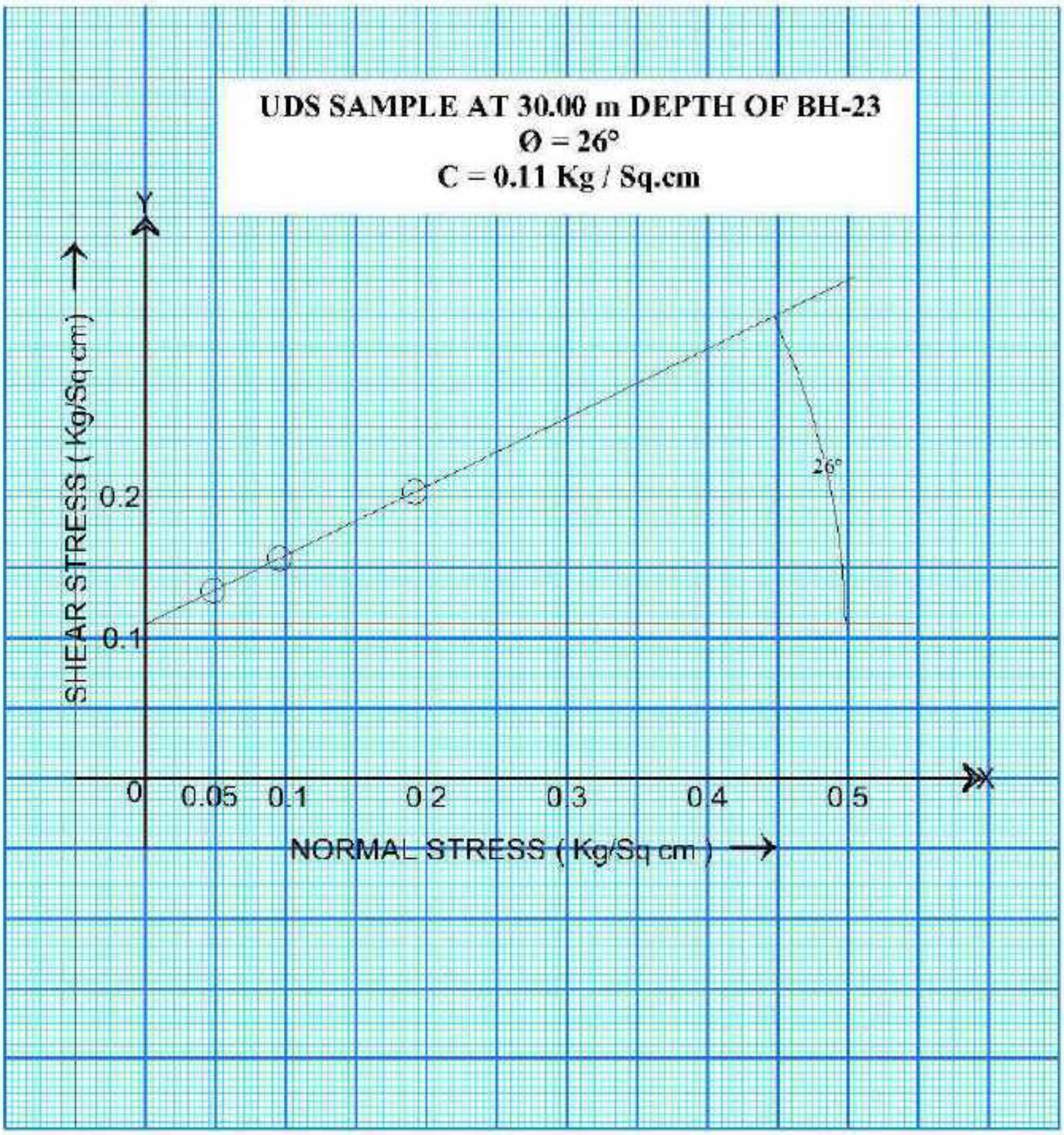


UDS SAMPLE AT 3.0 m DEPTH OF BH-23
Ø = 9°
C = 0.31Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
9°
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)

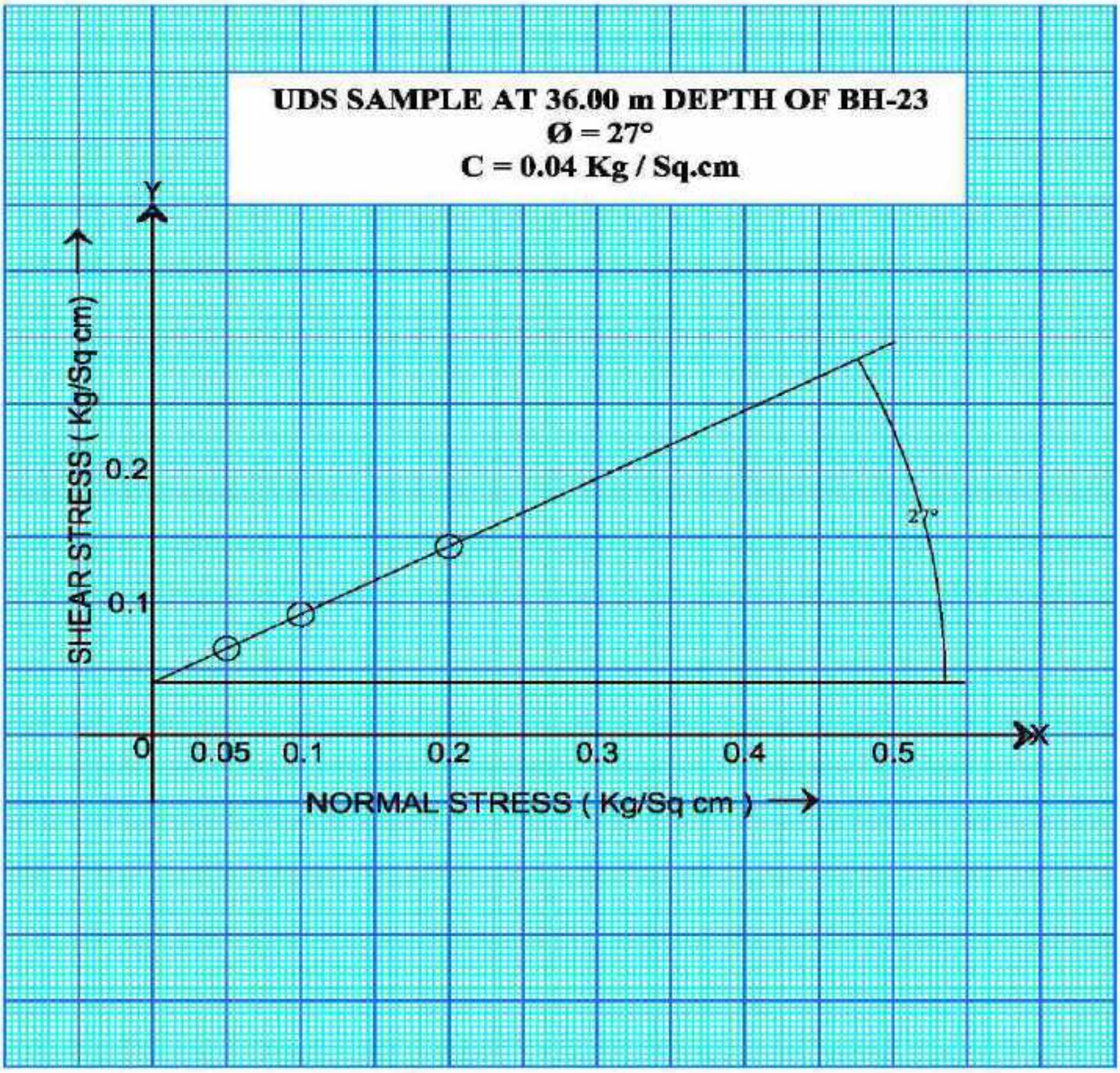

UDS SAMPLE AT 6.0 m DEPTH OF BH-23
Ø = 12°
C = 0.26Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
12°
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)

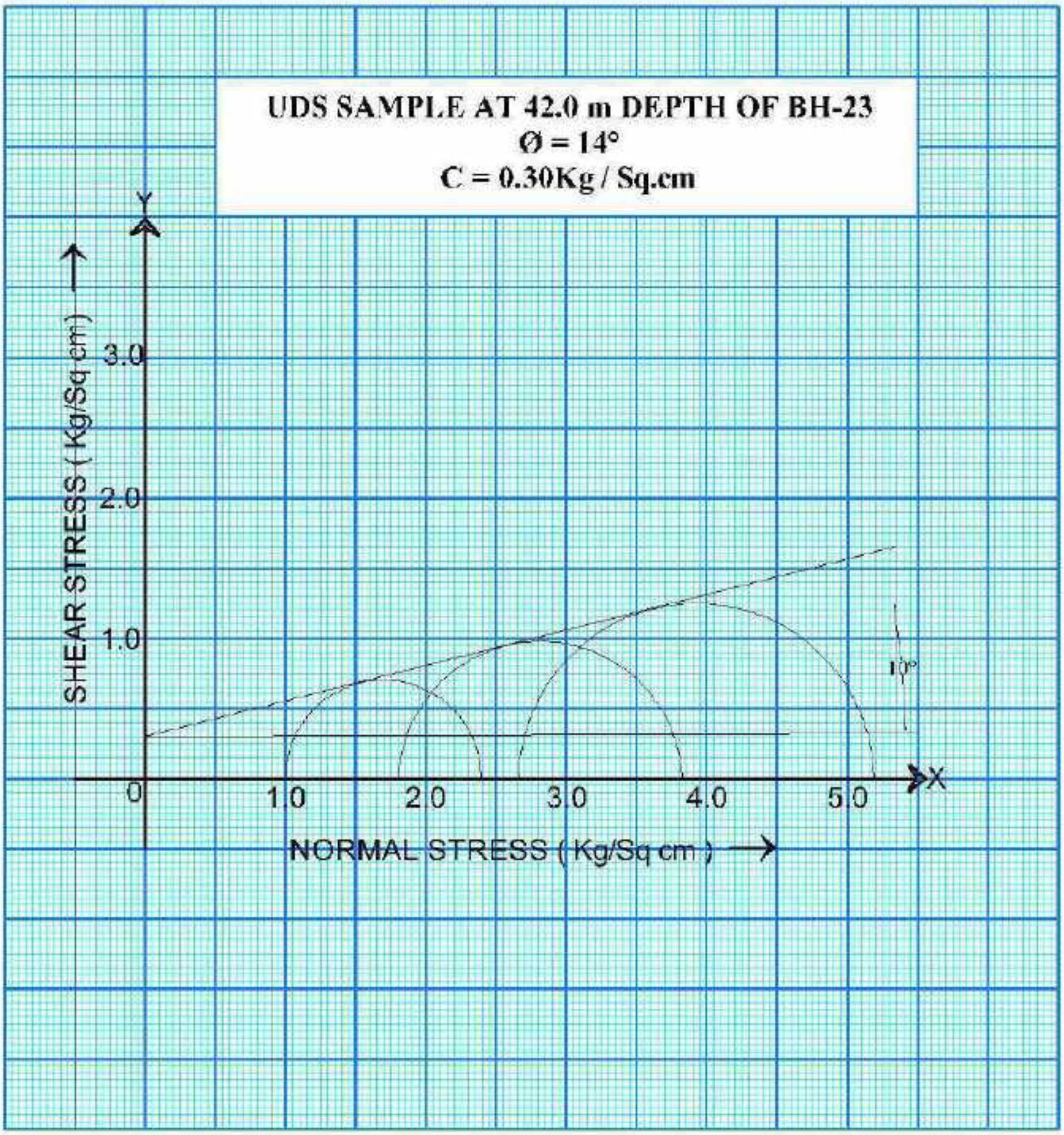


UDS SAMPLE AT 24.0 m DEPTH OF BH-23
Ø = 11°
C = 0.29Kg / Sq.cm

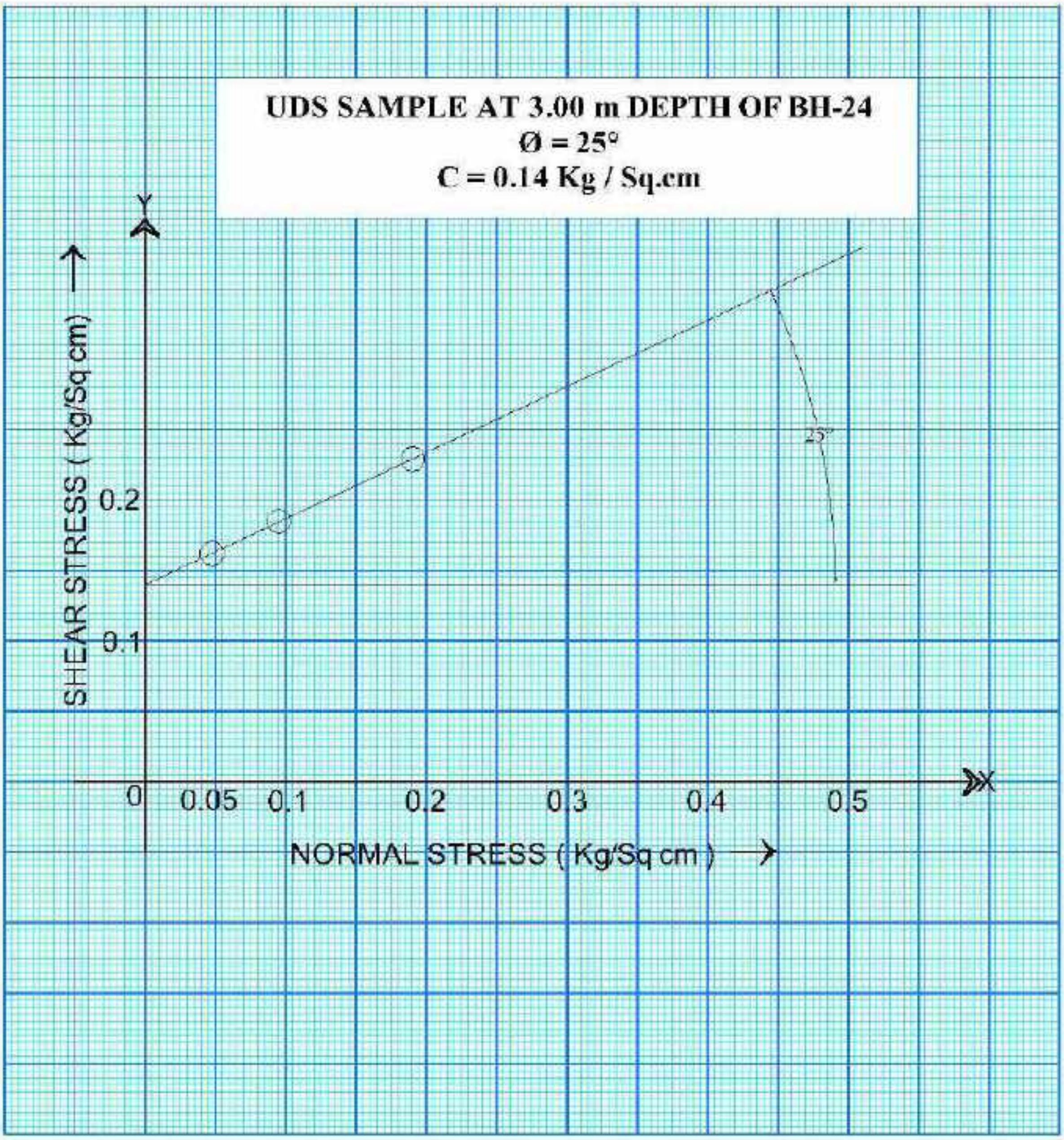


UDS SAMPLE AT 30.00 m DEPTH OF BH-23
Ø = 26°
C = 0.11 Kg / Sq.cm

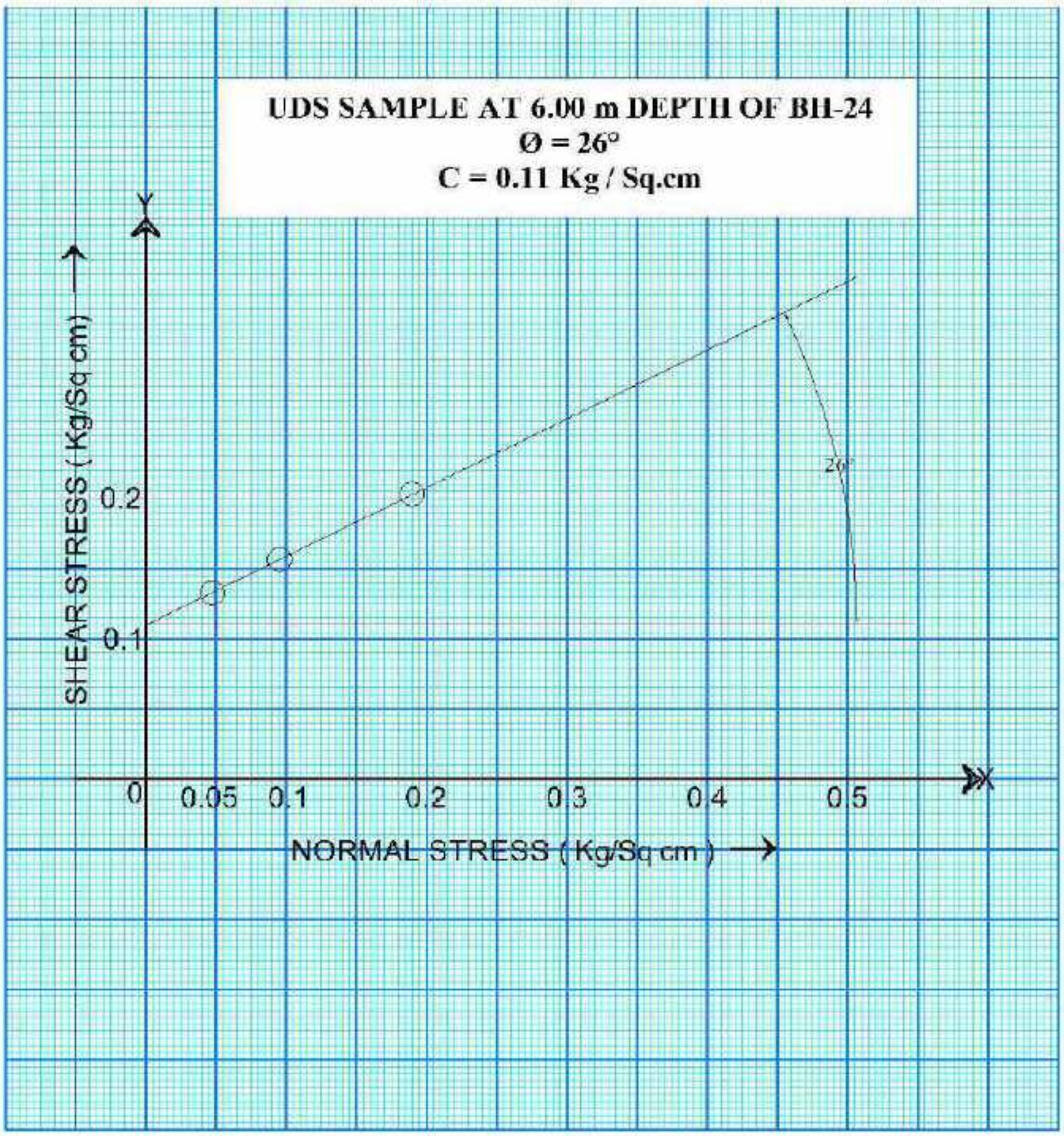

UDS SAMPLE AT 36.00 m DEPTH OF BH-23
Ø = 27°
C = 0.04 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
27°
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)

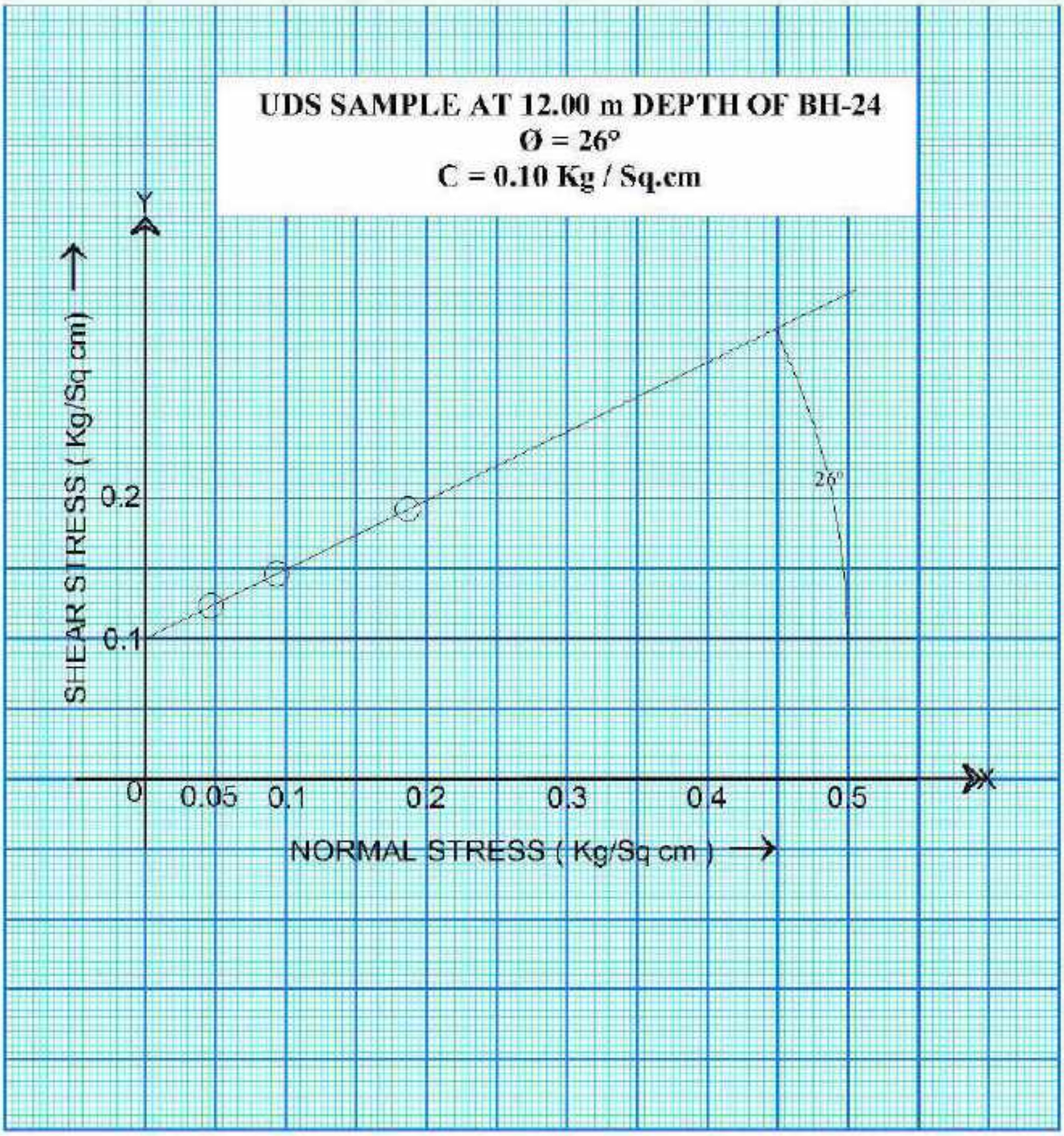


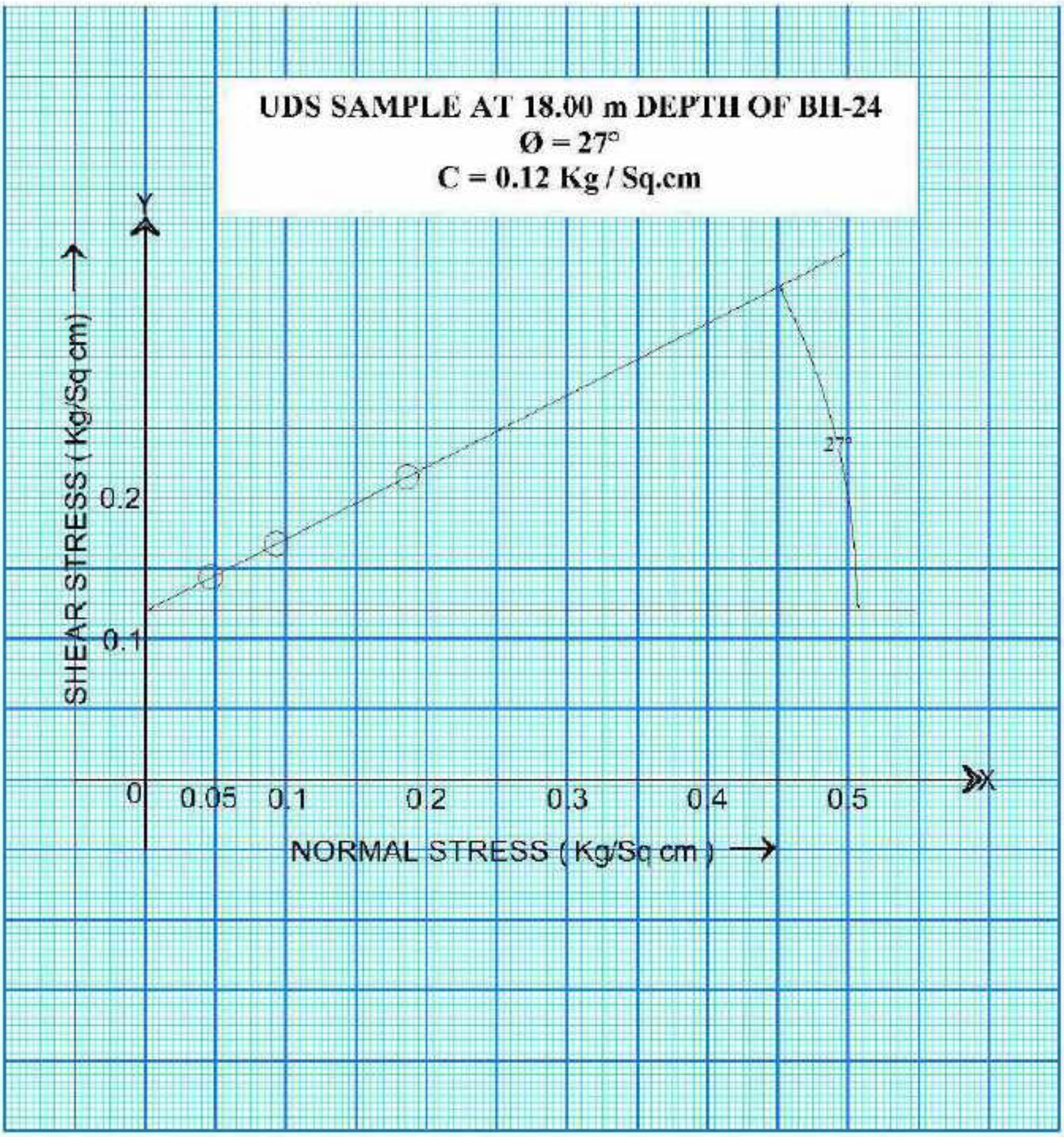
UDS SAMPLE AT 42.0 m DEPTH OF BH-23
Ø = 14°
C = 0.30Kg / Sq.cm

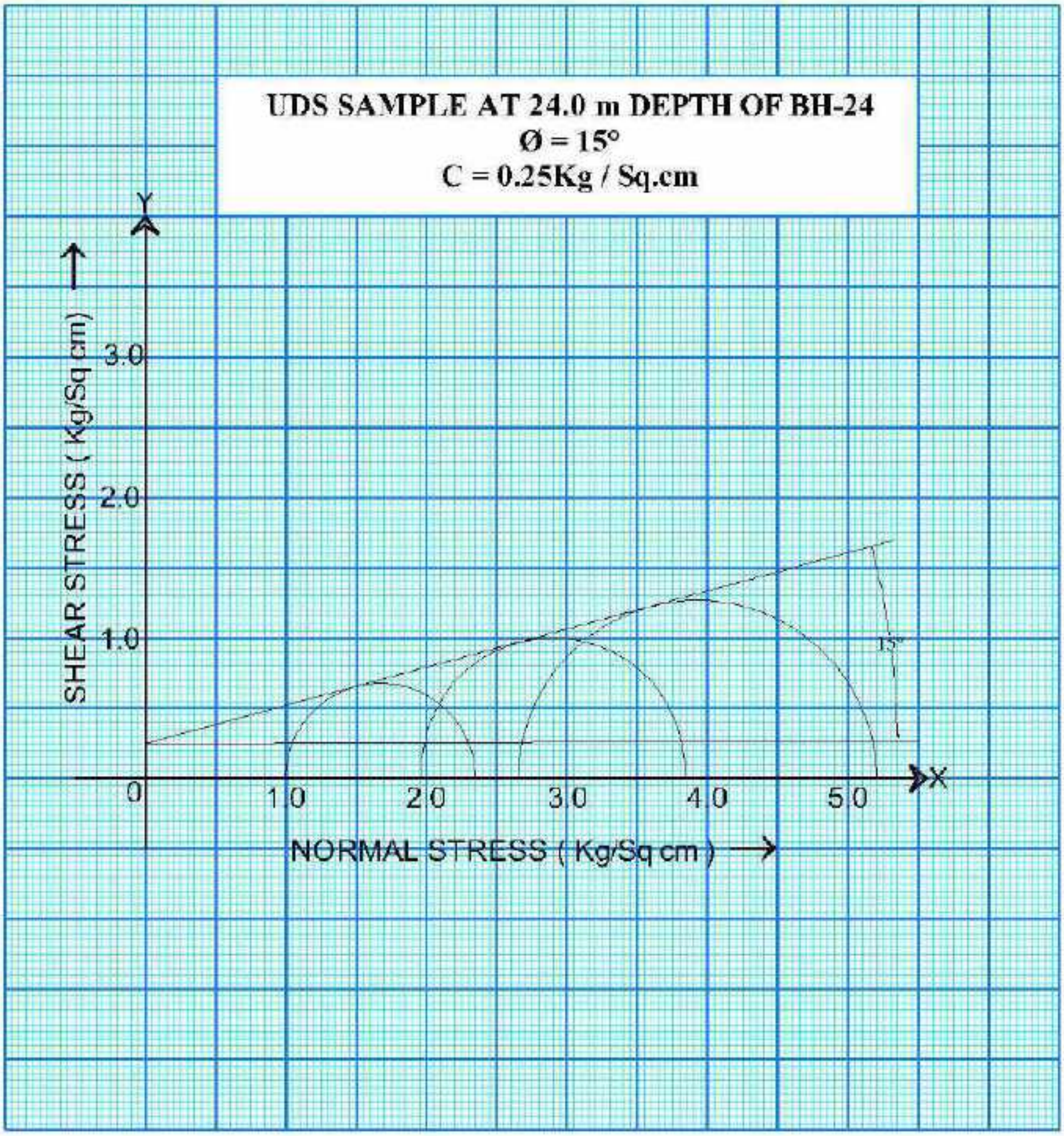


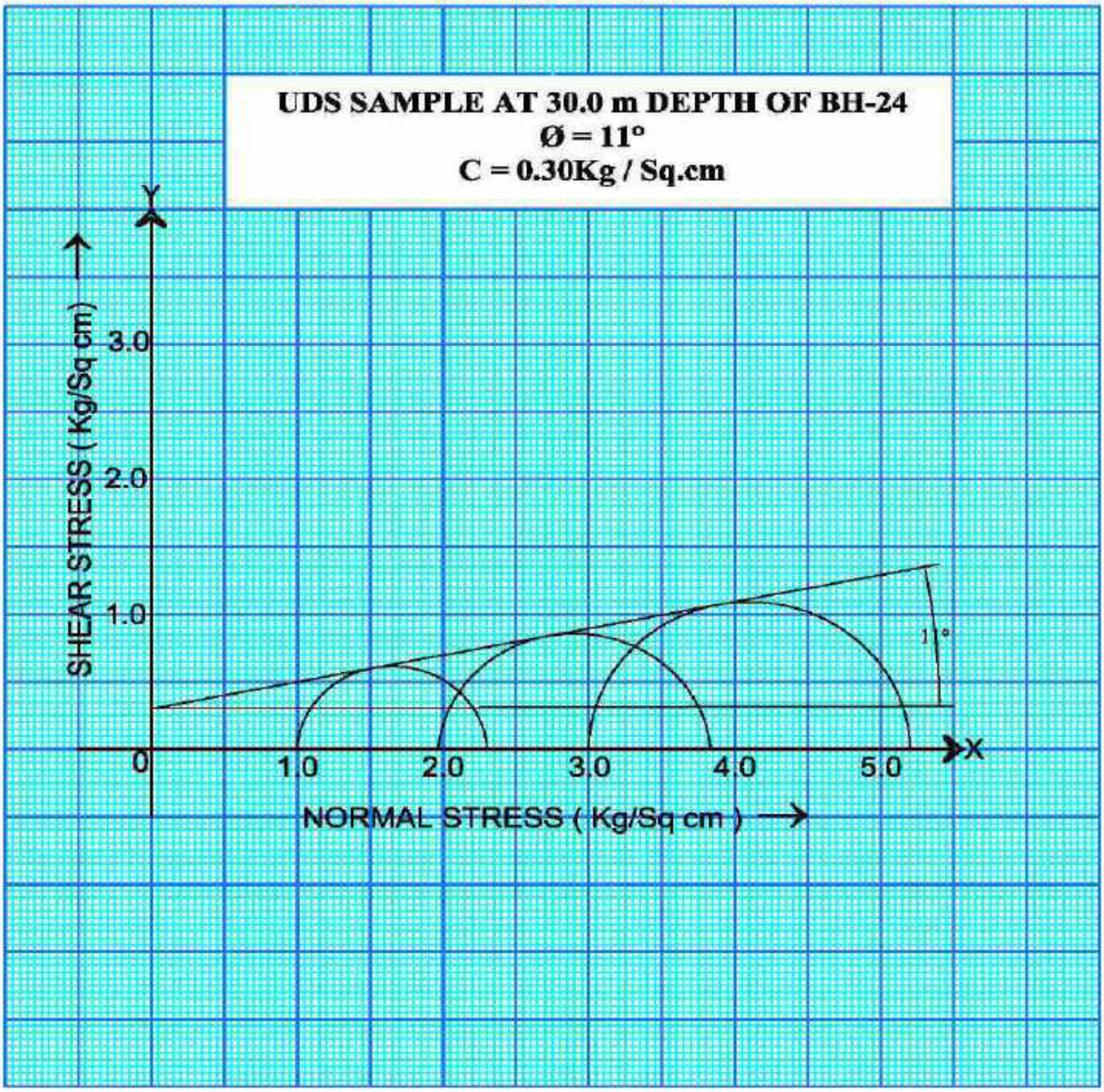
UDS SAMPLE AT 3.00 m DEPTH OF BH-24
Ø = 25°
C = 0.14 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
25°


UDS SAMPLE AT 6.00 m DEPTH OF BH-24
Ø = 26°
C = 0.11 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
26°
NORMAL STRESS (Kg/Sq cm)

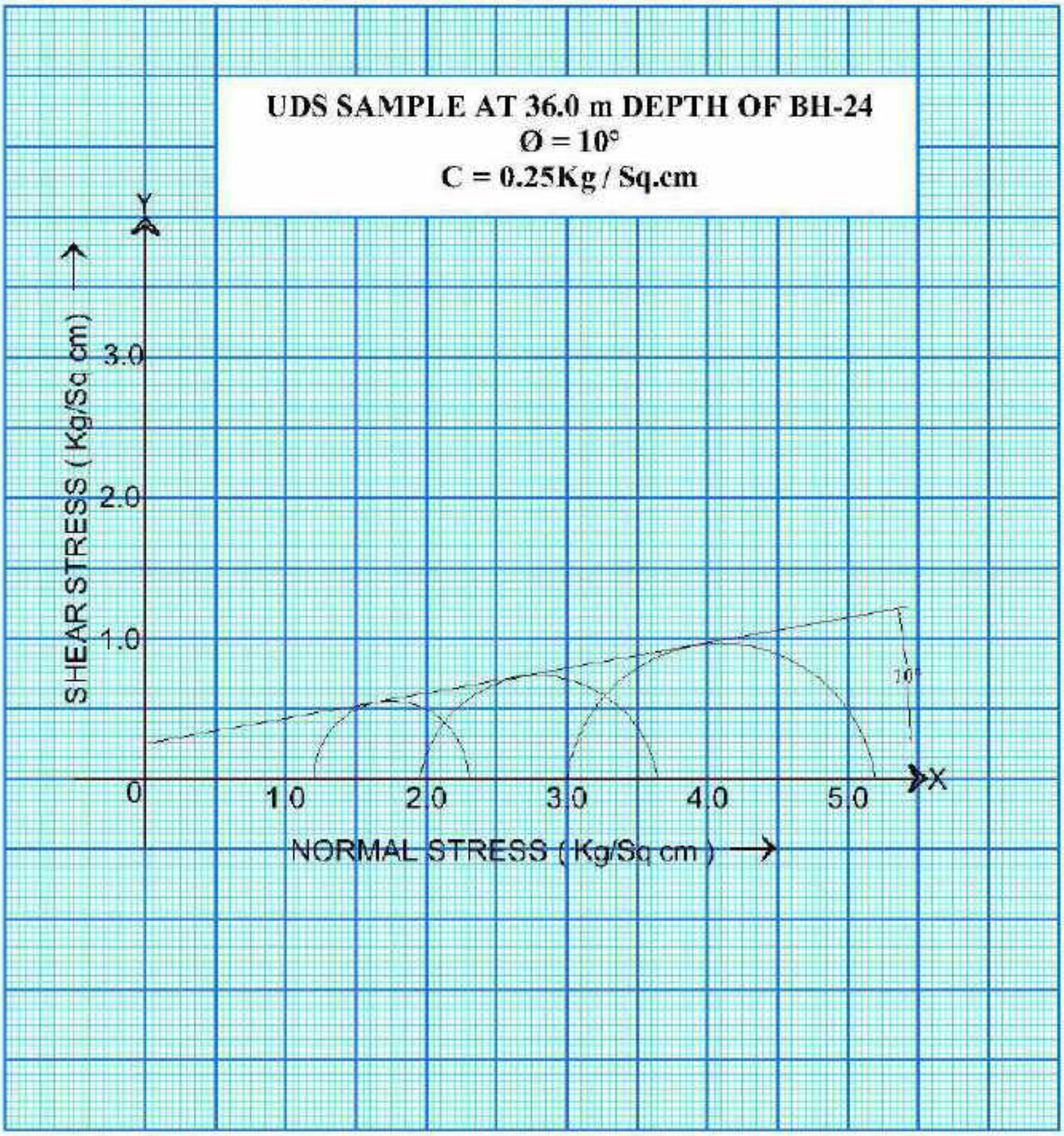

UDS SAMPLE AT 12.00 m DEPTH OF BH-24
Ø = 26°
C = 0.10 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
26°


UDS SAMPLE AT 18.00 m DEPTH OF BH-24
Ø = 27°
C = 0.12 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm) →
27°

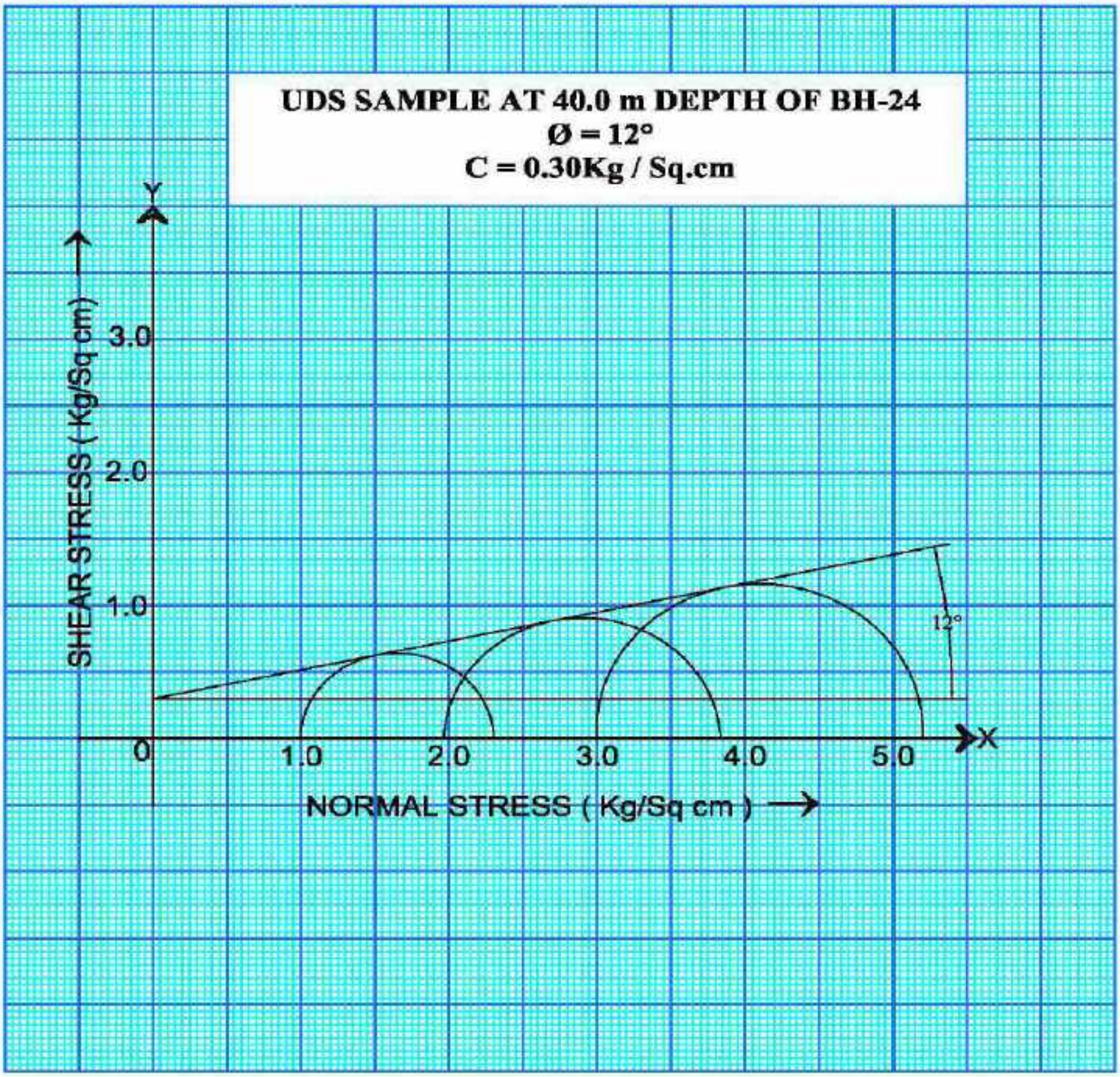

UDS SAMPLE AT 24.0 m DEPTH OF BH-24
Ø = 15°
C = 0.25Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
15°



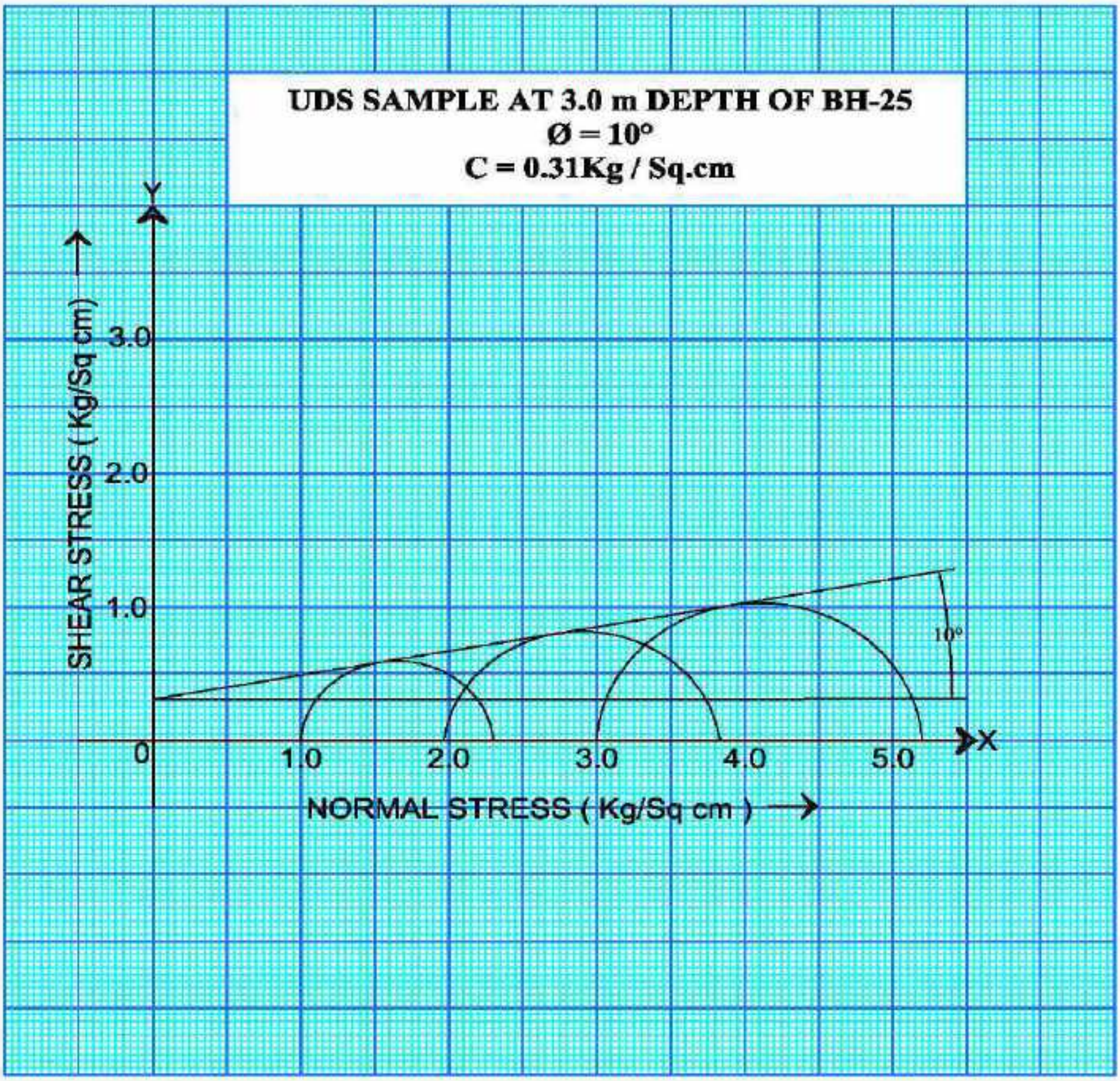
UDS SAMPLE AT 30.0 m DEPTH OF BH-24
Ø = 11°
C = 0.30Kg / Sq.cm

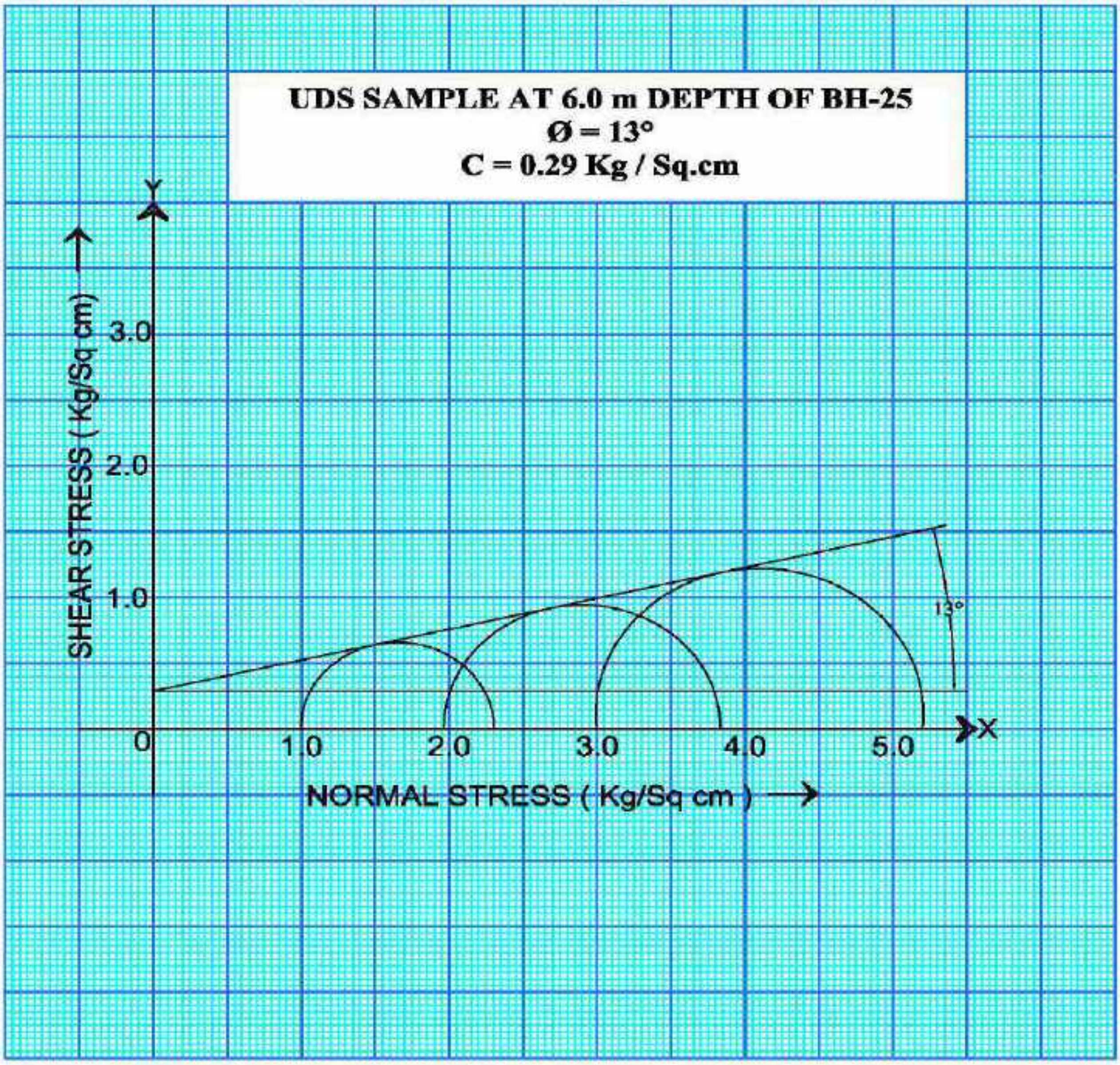


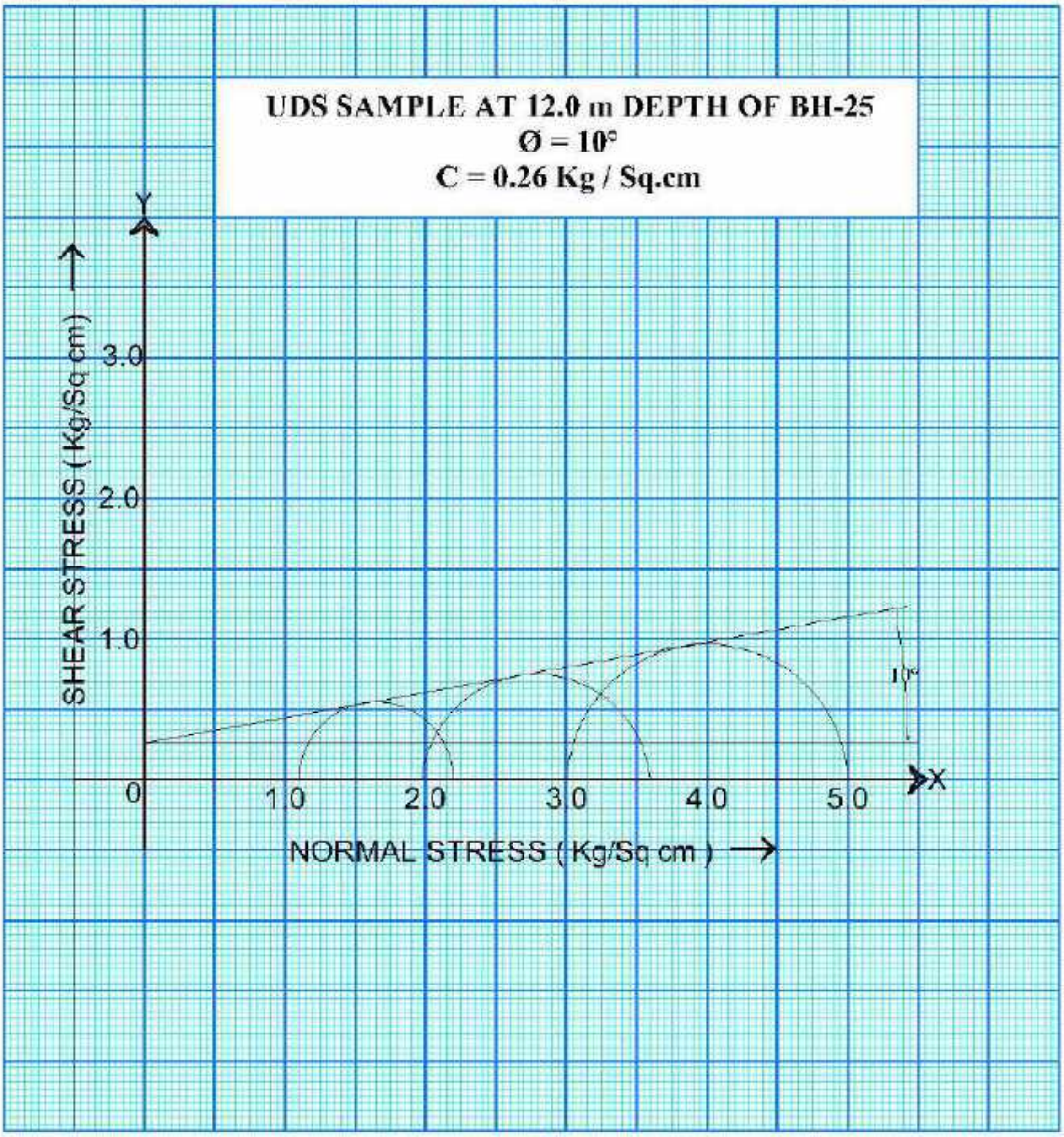
UDS SAMPLE AT 36.0 m DEPTH OF BH-24
Ø = 10°
C = 0.25Kg / Sq.cm

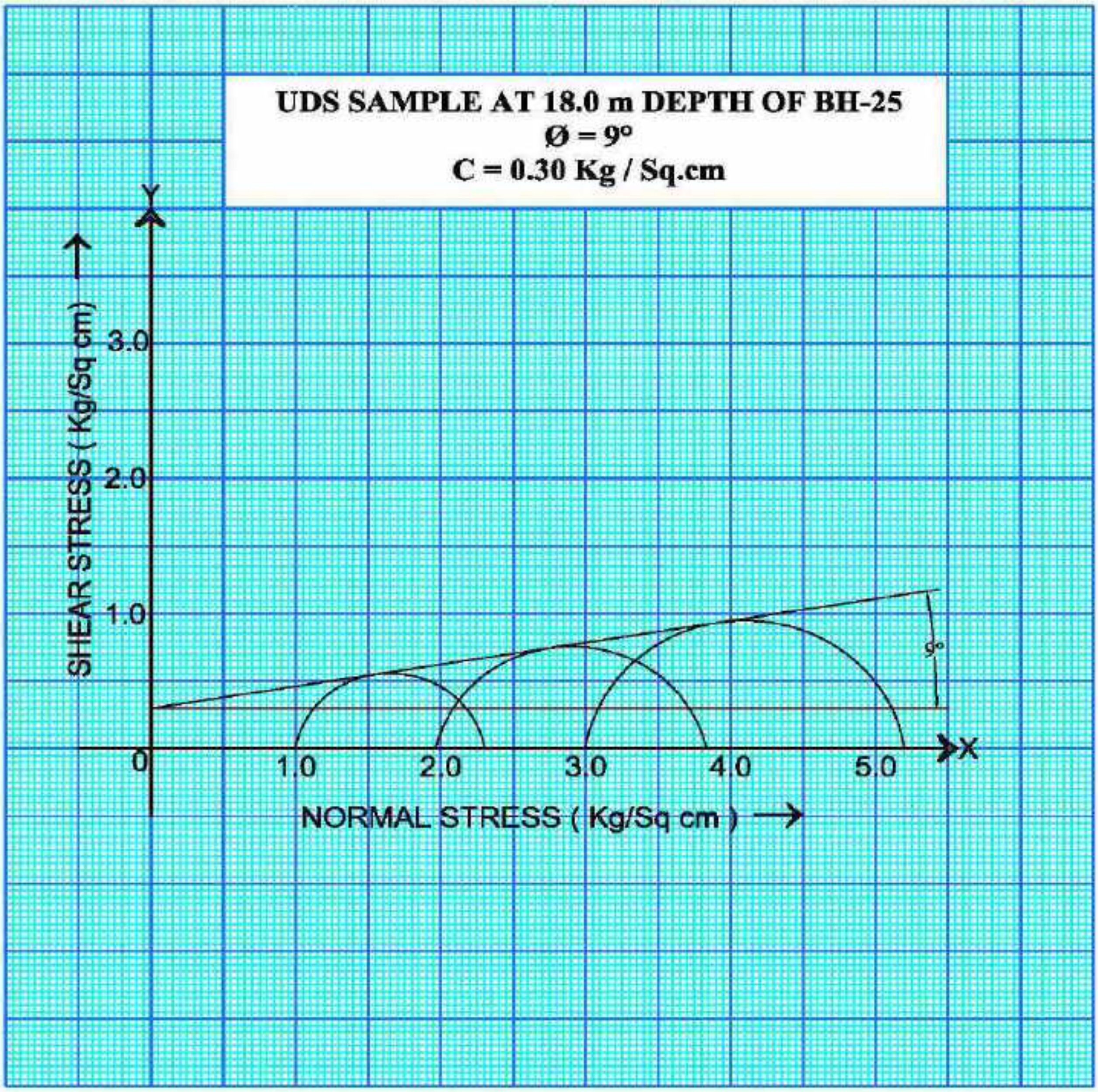


UDS SAMPLE AT 40.0 m DEPTH OF BH-24
Ø = 12°
C = 0.30Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
12°
NORMAL STRESS (Kg/Sq cm)

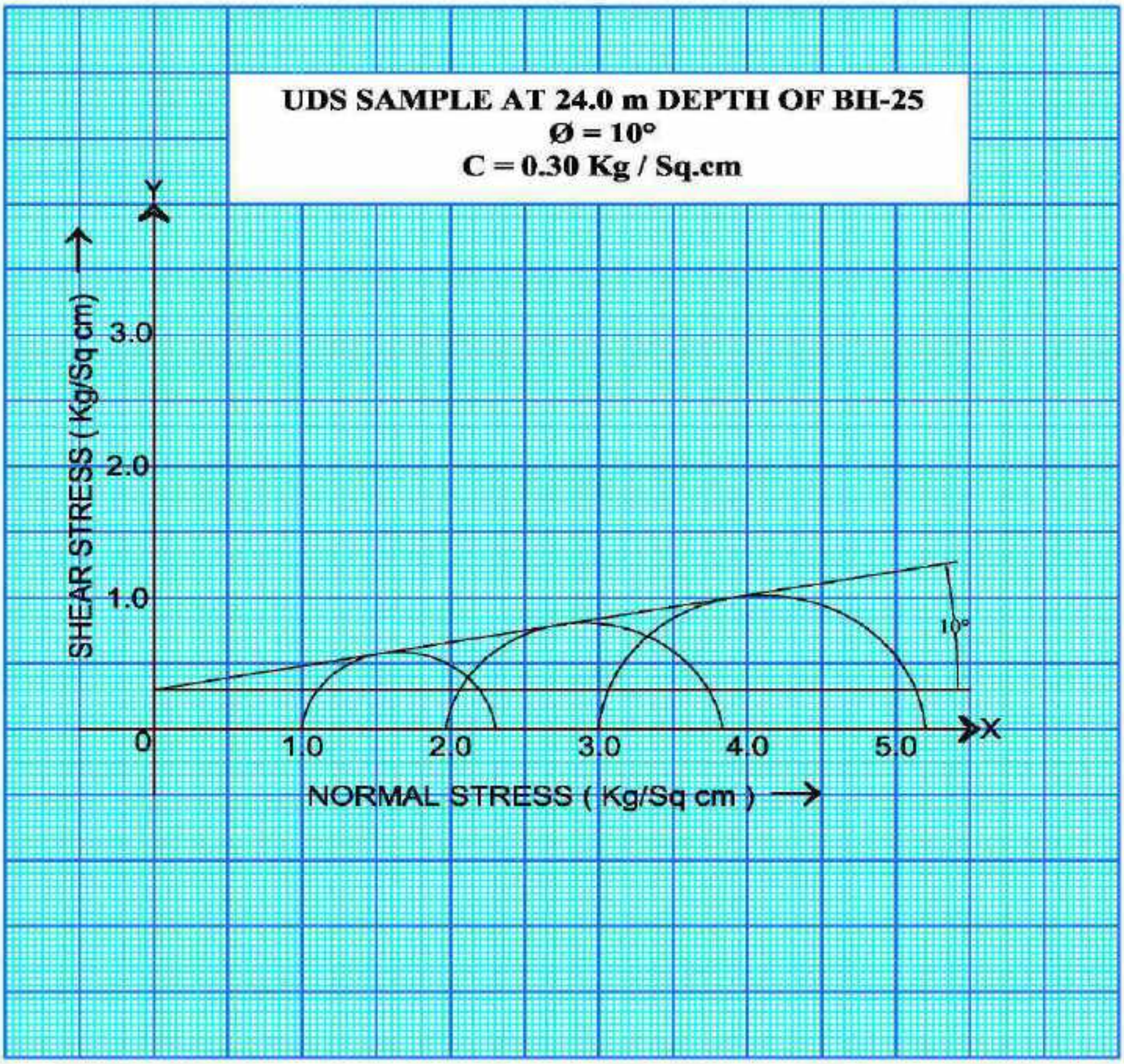

UDS SAMPLE AT 3.0 m DEPTH OF BH-25
Ø = 10°
C = 0.31Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
3.0
2.0
1.0
0
10°
X
1.0
2.0
3.0
4.0
5.0
NORMAL STRESS (Kg/Sq cm) →

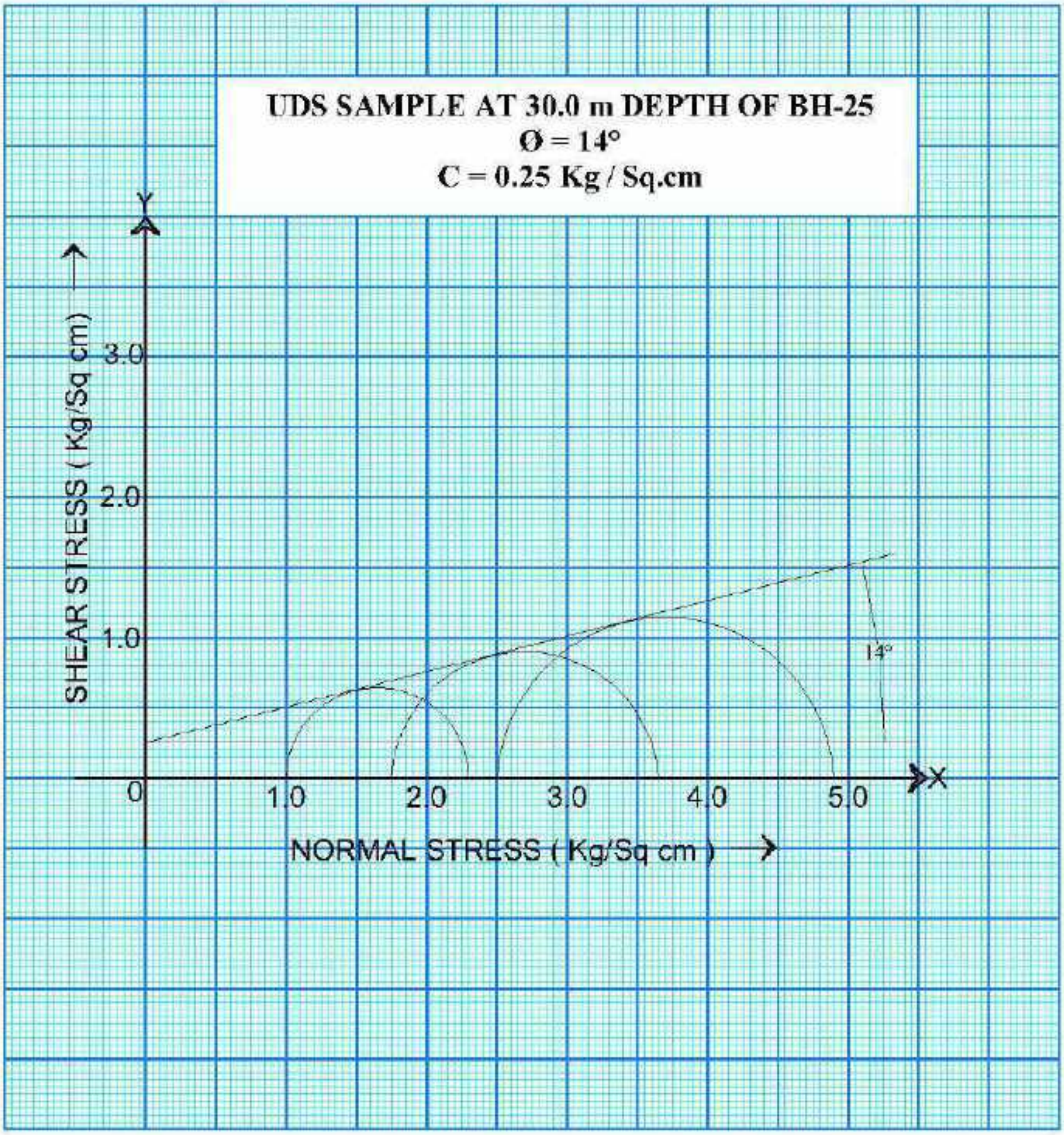

UDS SAMPLE AT 6.0 m DEPTH OF BH-25
Ø = 13°
C = 0.29 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
13°
NORMAL STRESS (Kg/Sq cm)

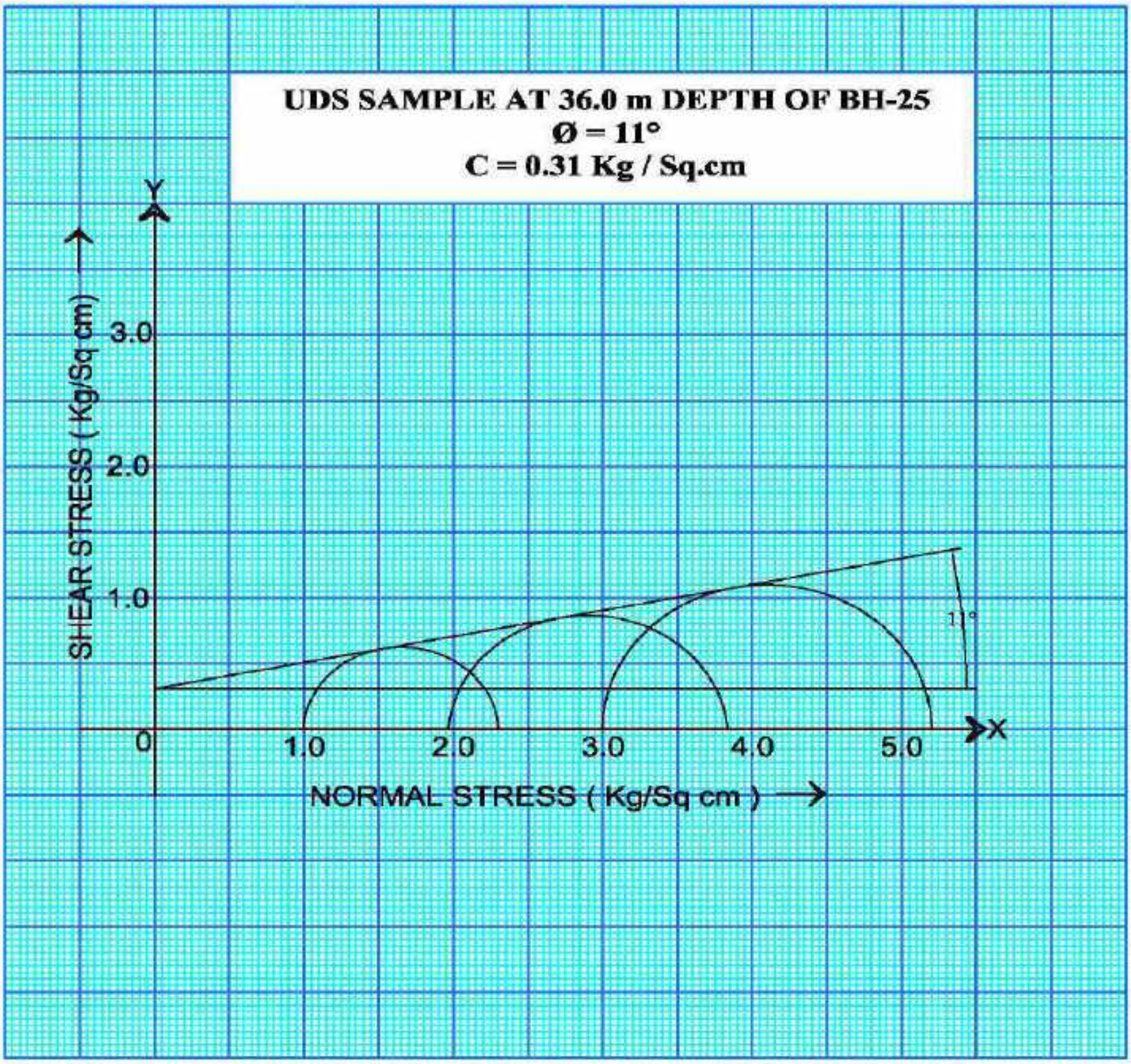

UDS SAMPLE AT 12.0 m DEPTH OF BH-25
Ø = 10°
C = 0.26 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm) →
NORMAL STRESS (Kg/Sq cm) →
0
1.0
2.0
3.0
4.0
5.0
10°

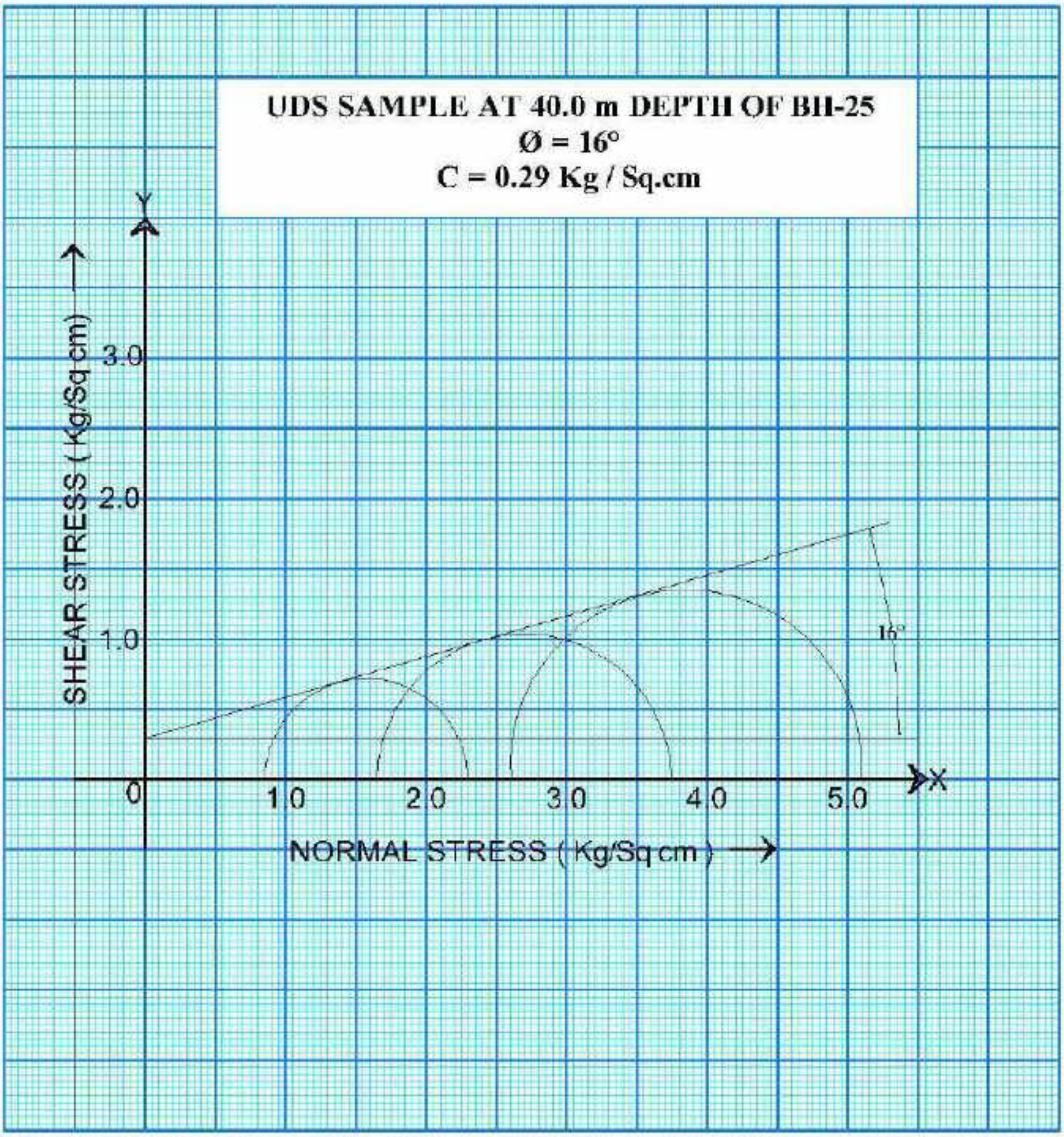


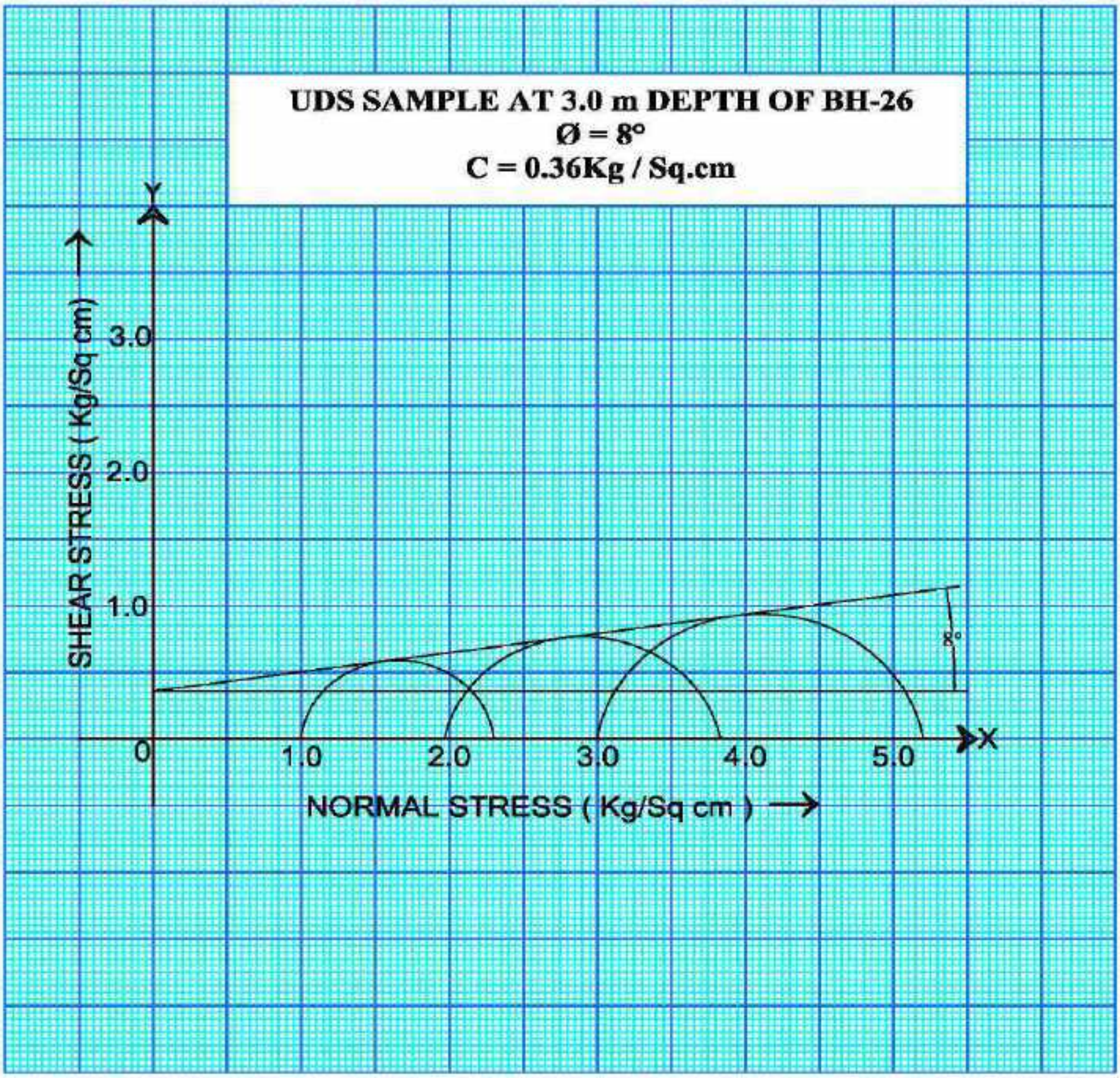
UDS SAMPLE AT 18.0 m DEPTH OF BH-25
Ø = 9°
C = 0.30 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
9°
NORMAL STRESS (Kg/Sq cm)


UDS SAMPLE AT 24.0 m DEPTH OF BH-25
Ø = 10°
C = 0.30 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
NORMAL STRESS (Kg/Sq cm) →
10°


UDS SAMPLE AT 30.0 m DEPTH OF BH-25
Ø = 14°
C = 0.25 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS (Kg/Sq cm)


UDS SAMPLE AT 36.0 m DEPTH OF BH-25
Ø = 11°
C = 0.31 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
11°

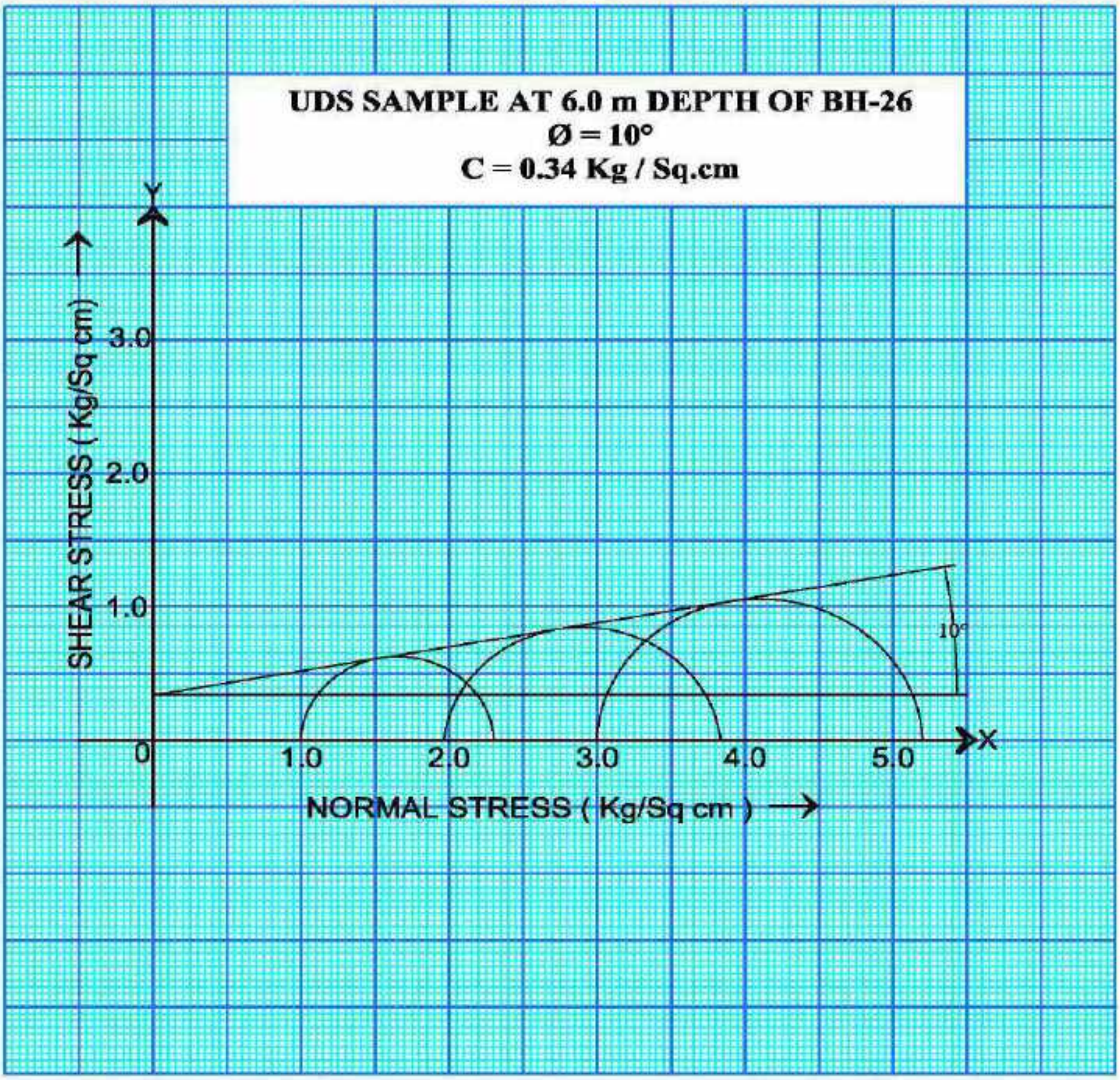

UDS SAMPLE AT 40.0 m DEPTH OF BH-25
Ø = 16°
C = 0.29 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
16°



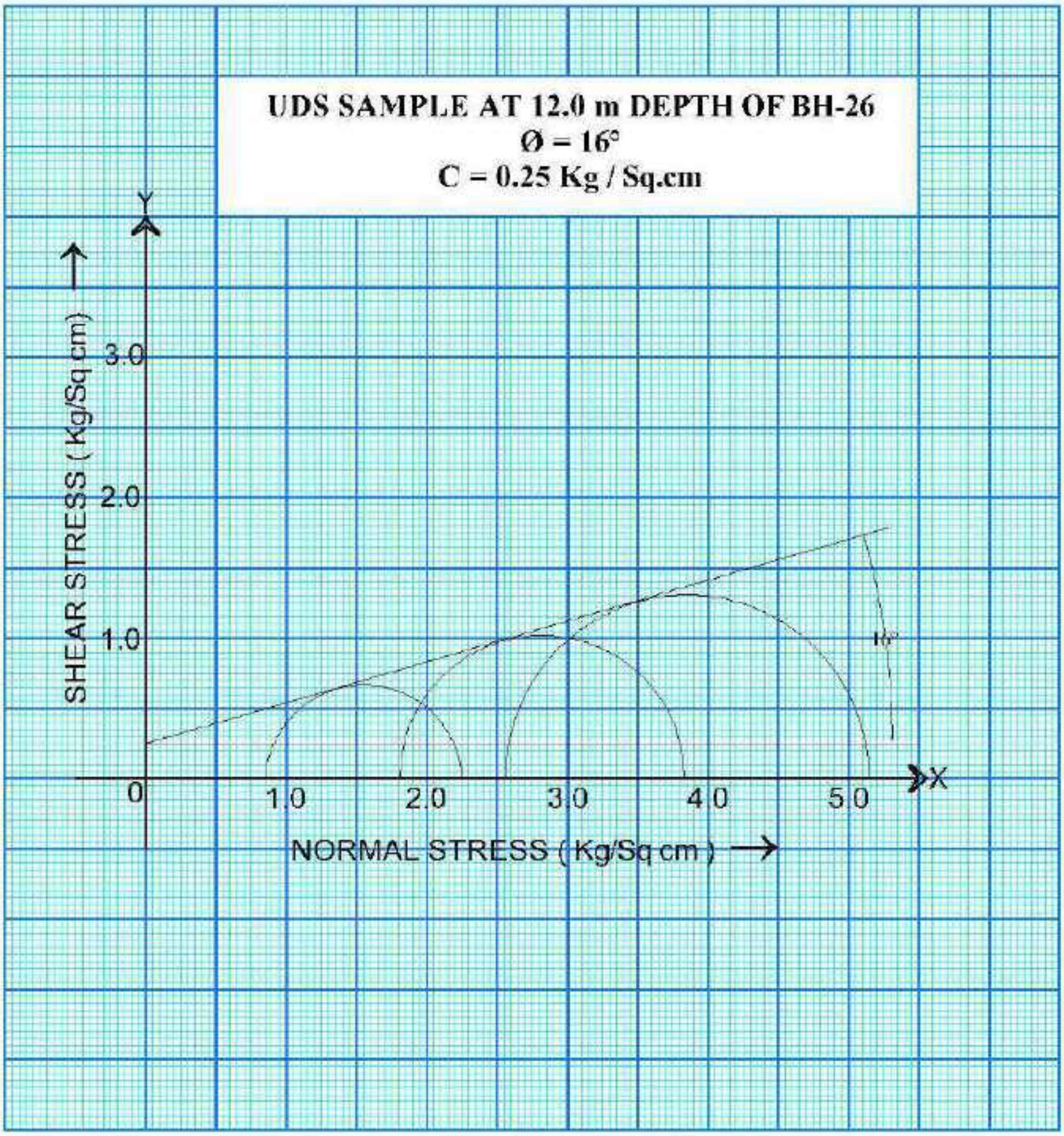
UDS SAMPLE AT 3.0 m DEPTH OF BH-26

Ø = 8°

C = 0.36Kg / Sq.cm



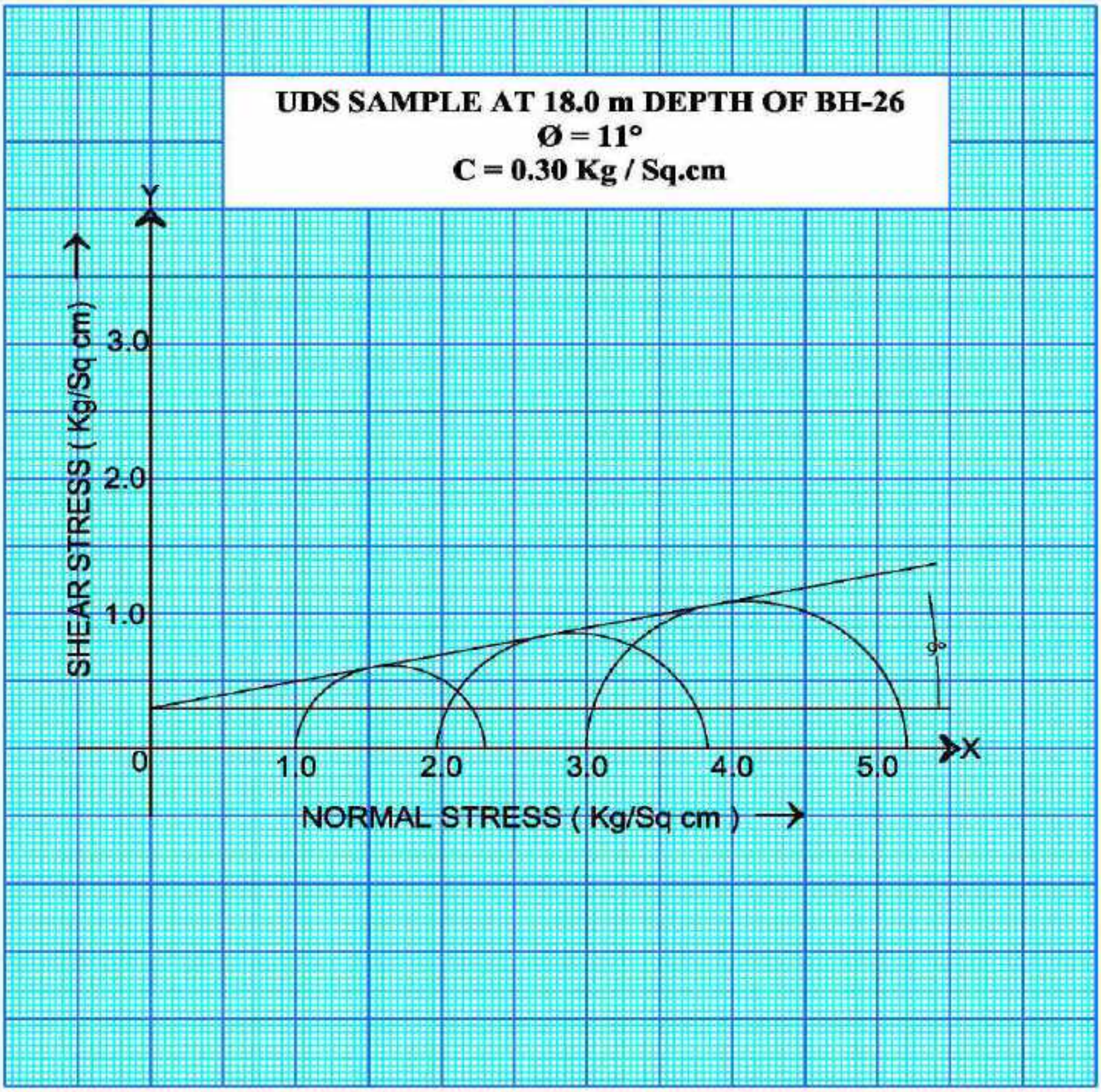
UDS SAMPLE AT 6.0 m DEPTH OF BH-26
Ø = 10°
C = 0.34 Kg / Sq.cm



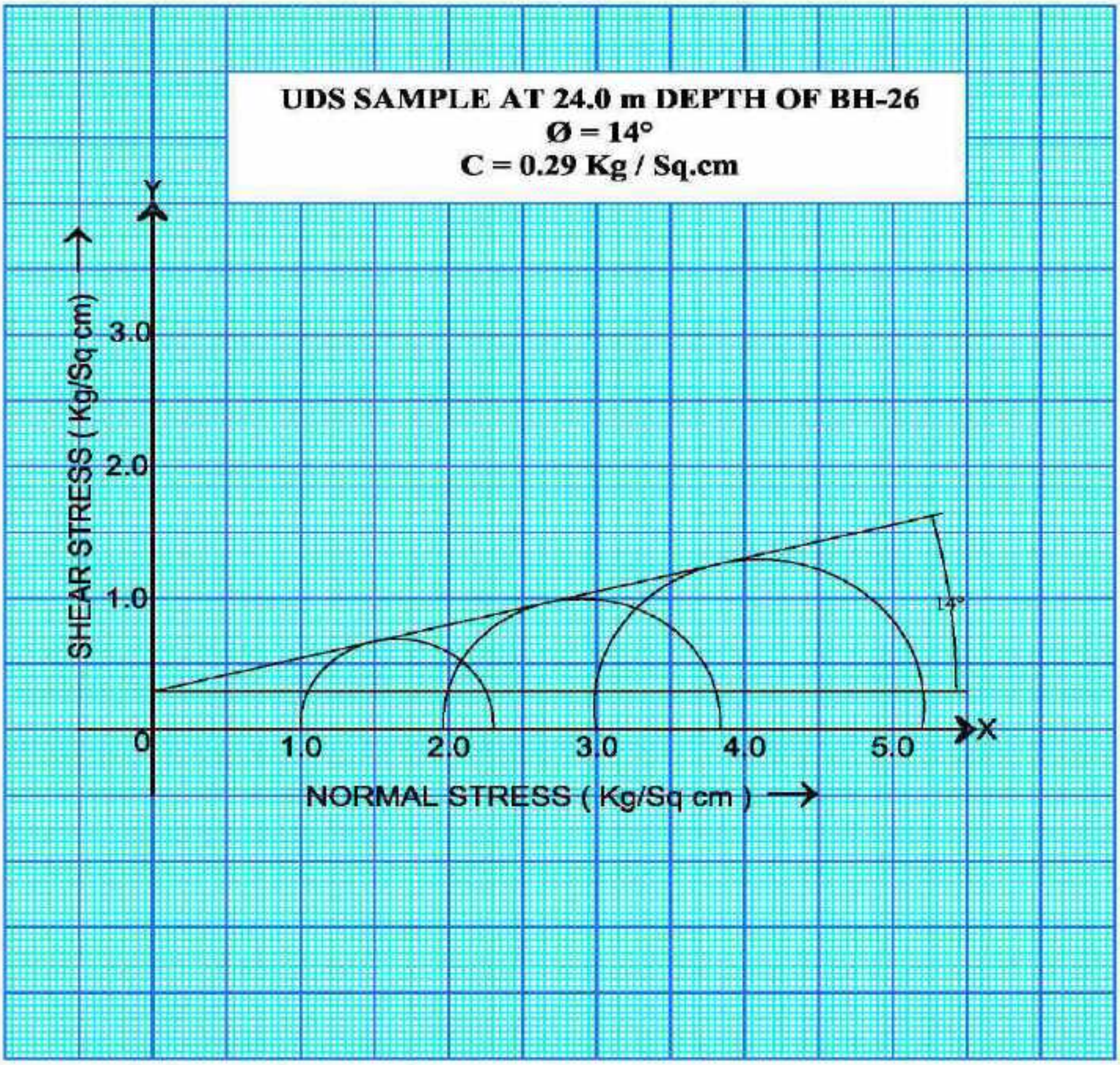
UDS SAMPLE AT 12.0 m DEPTH OF BH-26

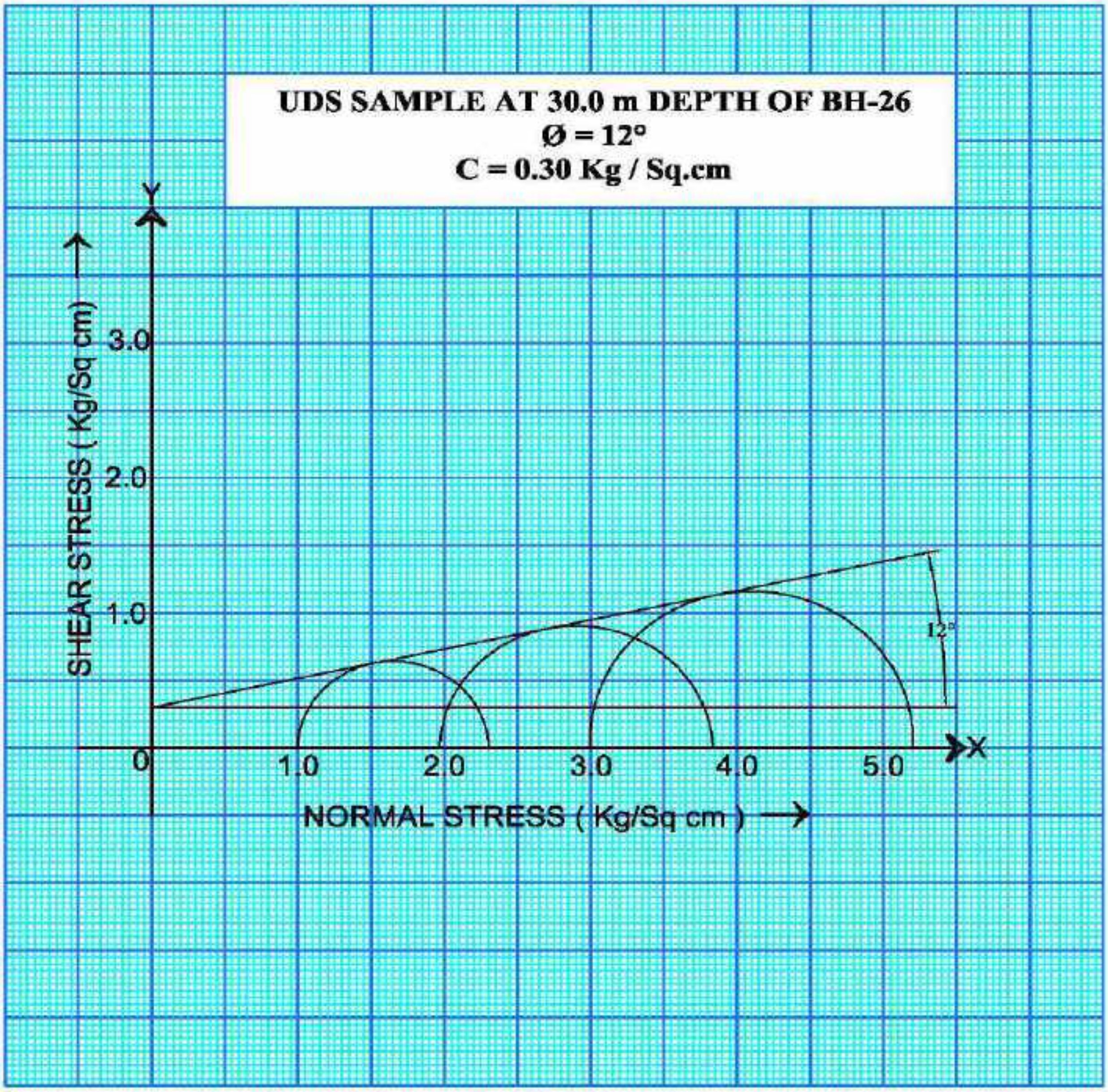
Ø = 16°

C = 0.25 Kg / Sq.cm

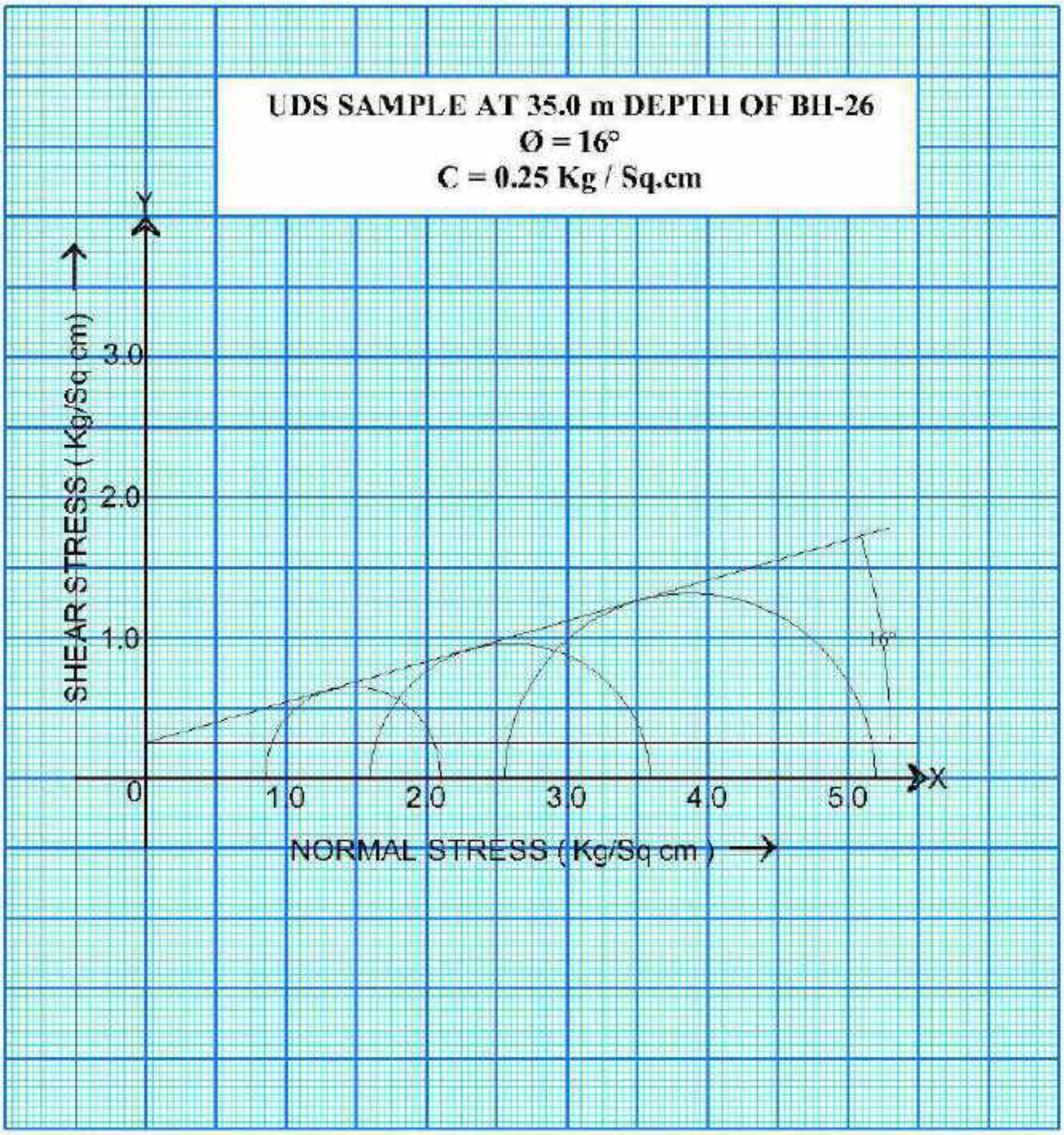


UDS SAMPLE AT 18.0 m DEPTH OF BH-26
Ø = 11°
C = 0.30 Kg / Sq.cm

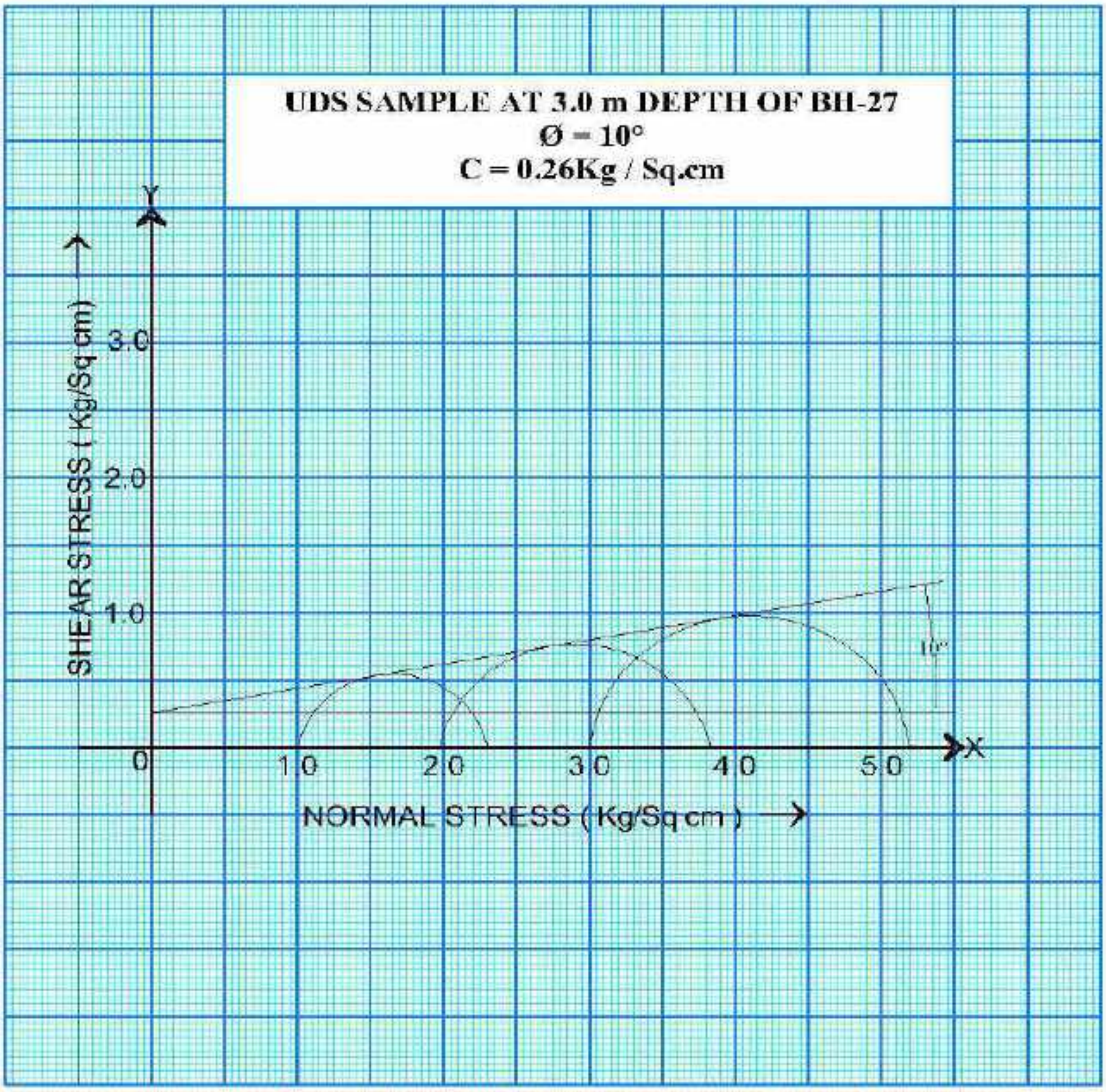

UDS SAMPLE AT 24.0 m DEPTH OF BH-26
Ø = 14°
C = 0.29 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS (Kg/Sq cm)

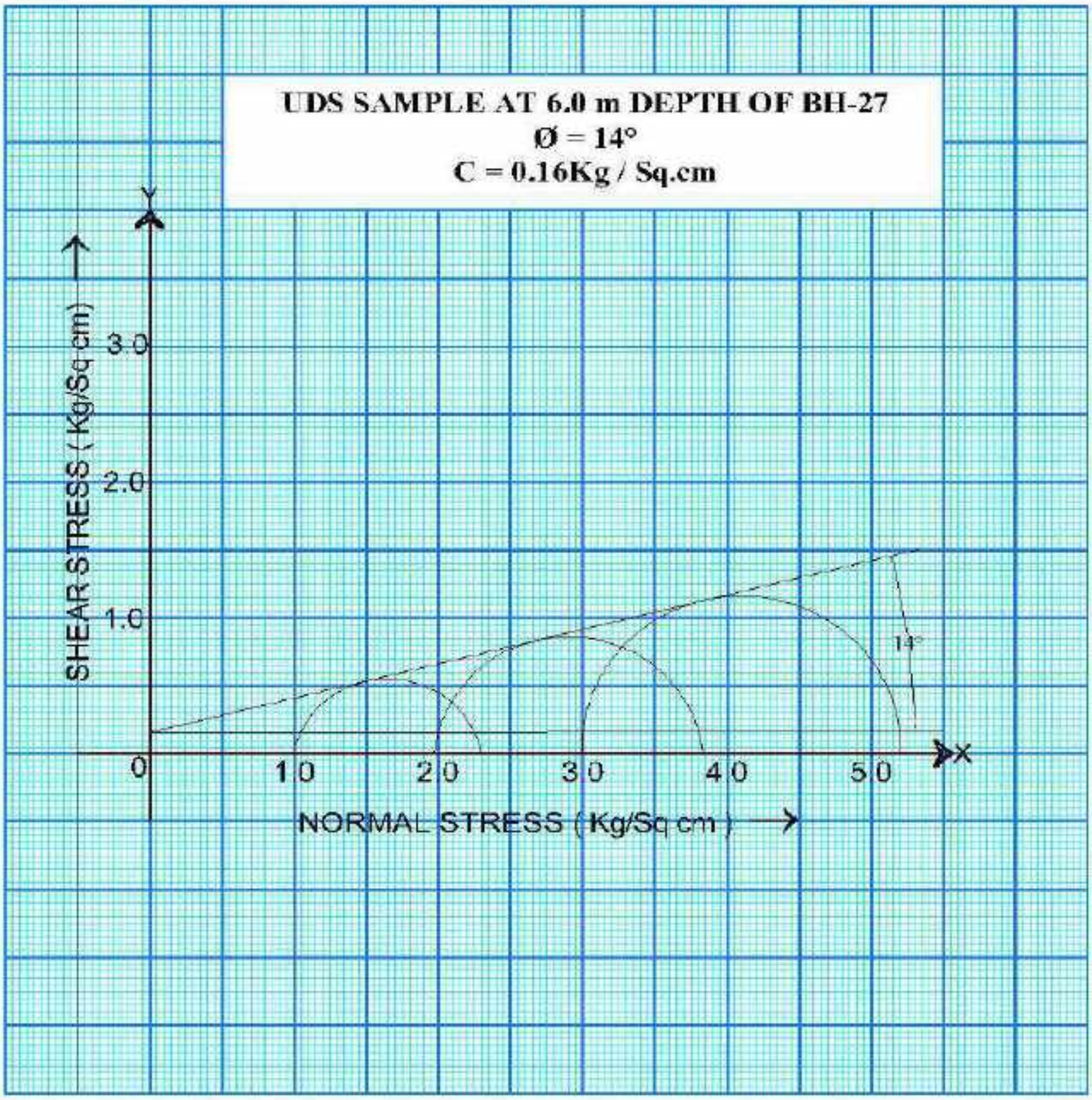


UDS SAMPLE AT 30.0 m DEPTH OF BH-26
Ø = 12°
C = 0.30 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
12°

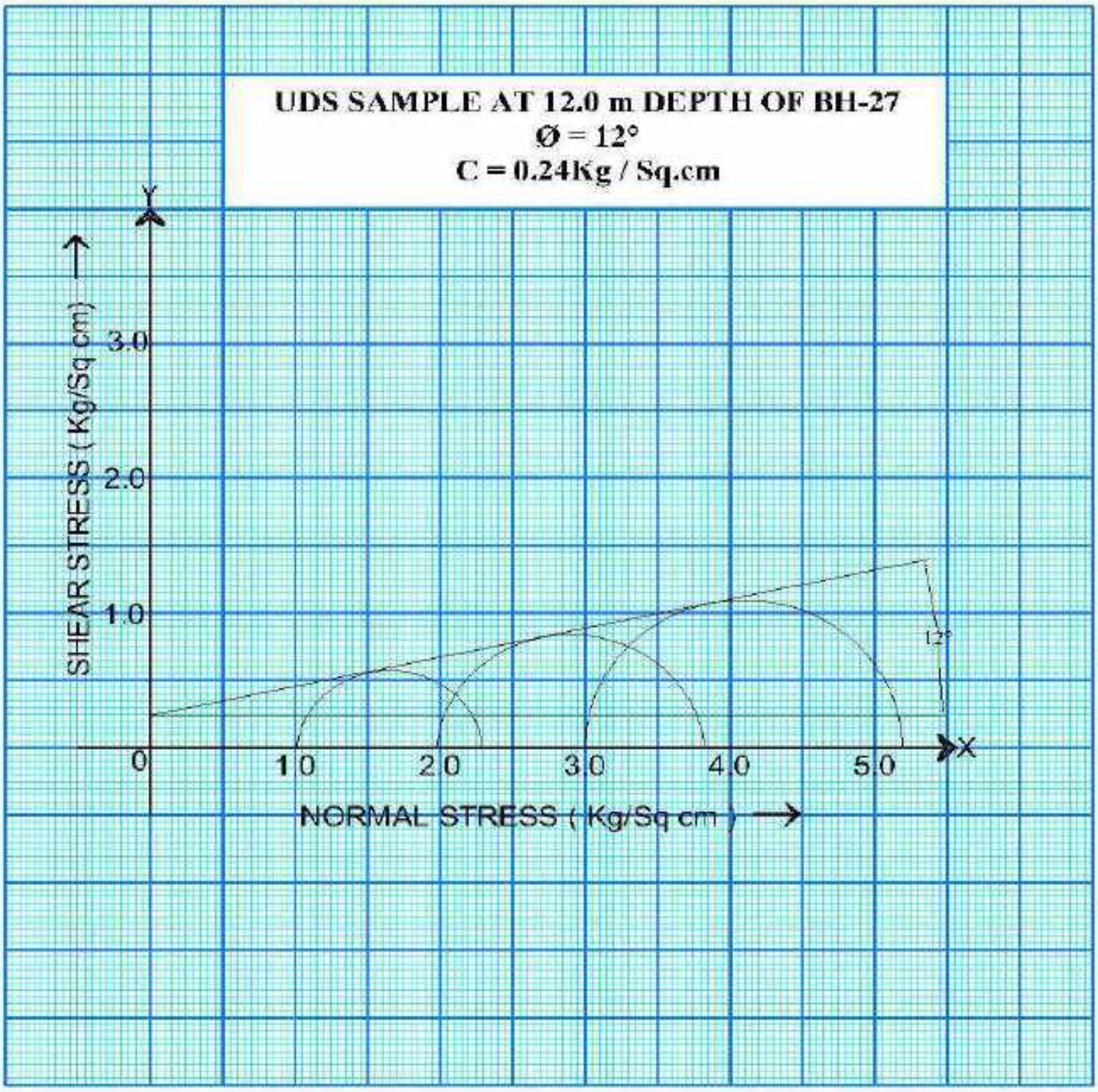


UDS SAMPLE AT 35.0 m DEPTH OF BH-26
Ø = 16°
C = 0.25 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
16°
NORMAL STRESS (Kg/Sq cm)

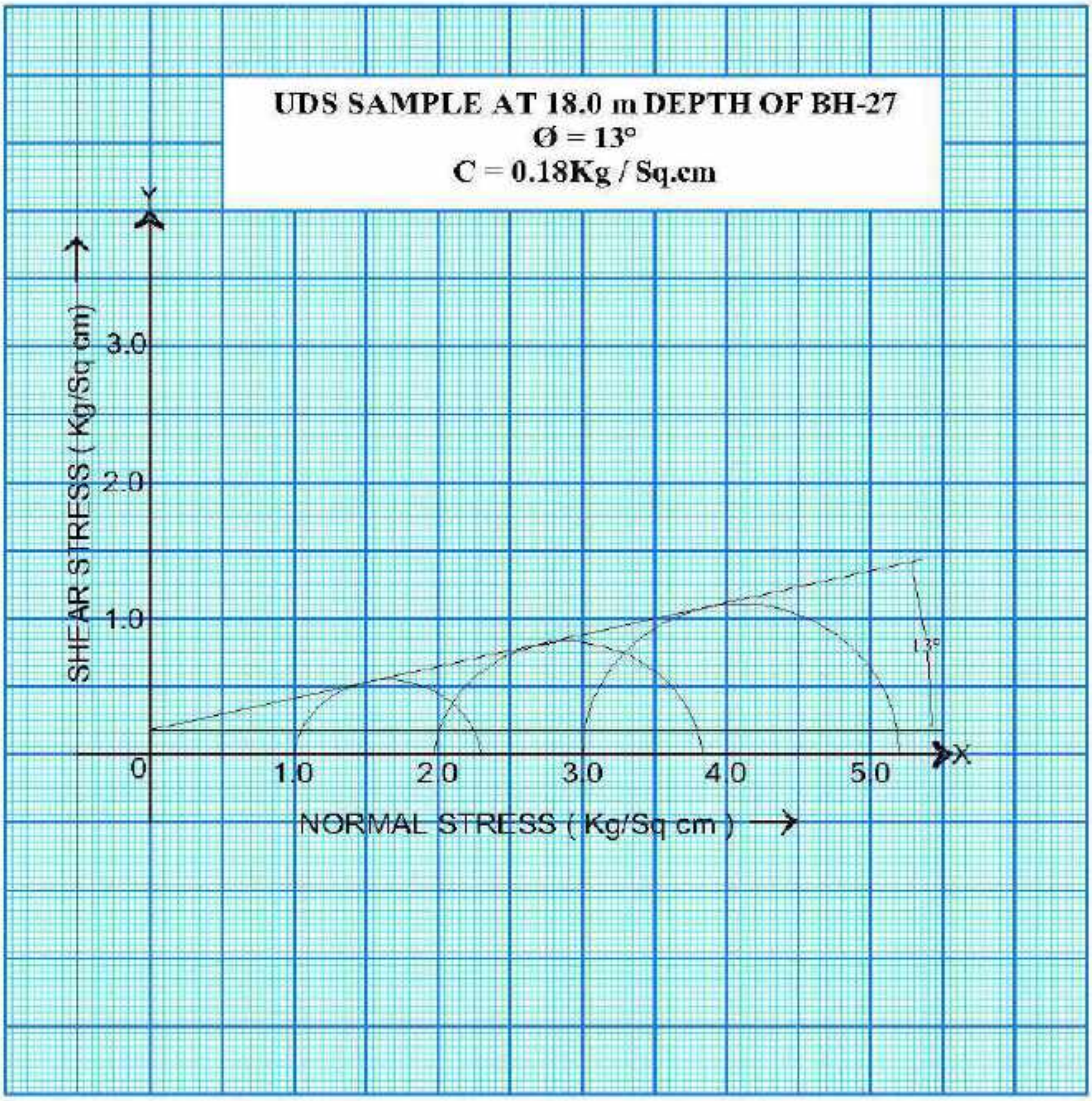

UDS SAMPLE AT 3.0 m DEPTH OF BH-27
Ø = 10°
C = 0.26Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
10°
NORMAL STRESS (Kg/Sq cm)



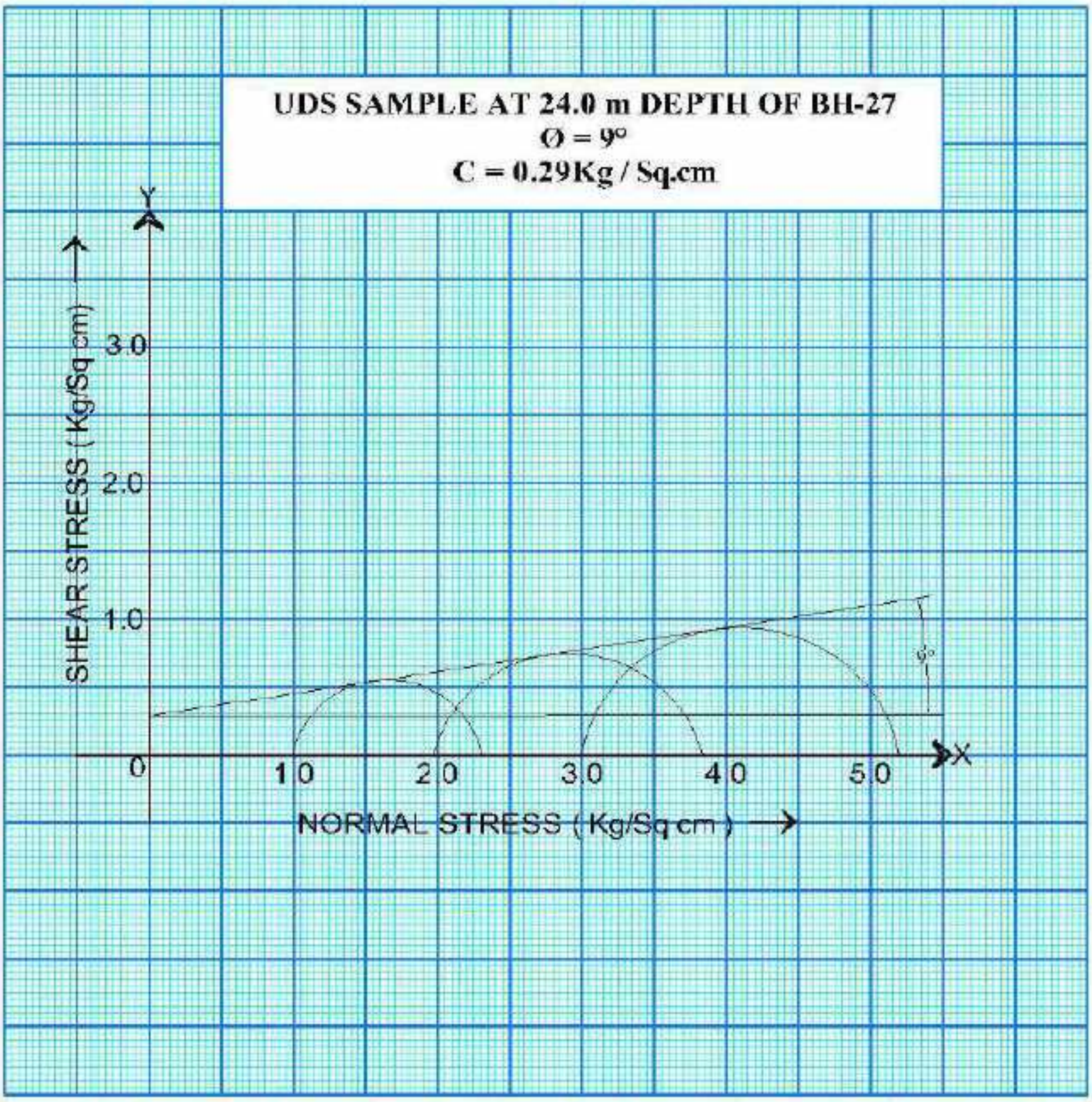
UDS SAMPLE AT 6.0 m DEPTH OF BH-27
Ø = 14°
C = 0.16Kg / Sq.cm

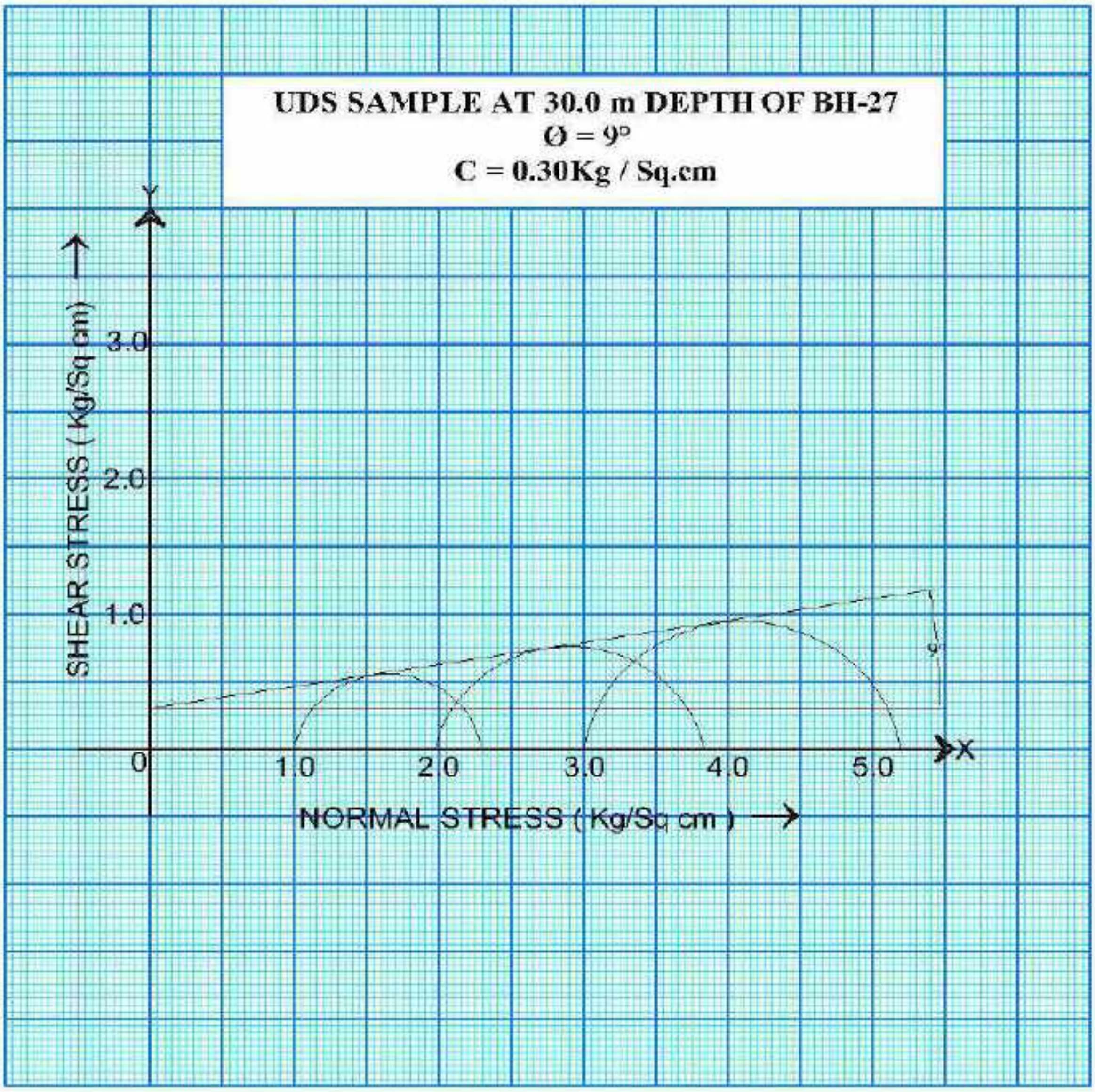


UDS SAMPLE AT 12.0 m DEPTH OF BH-27
Ø = 12°
C = 0.24Kg / Sq.cm

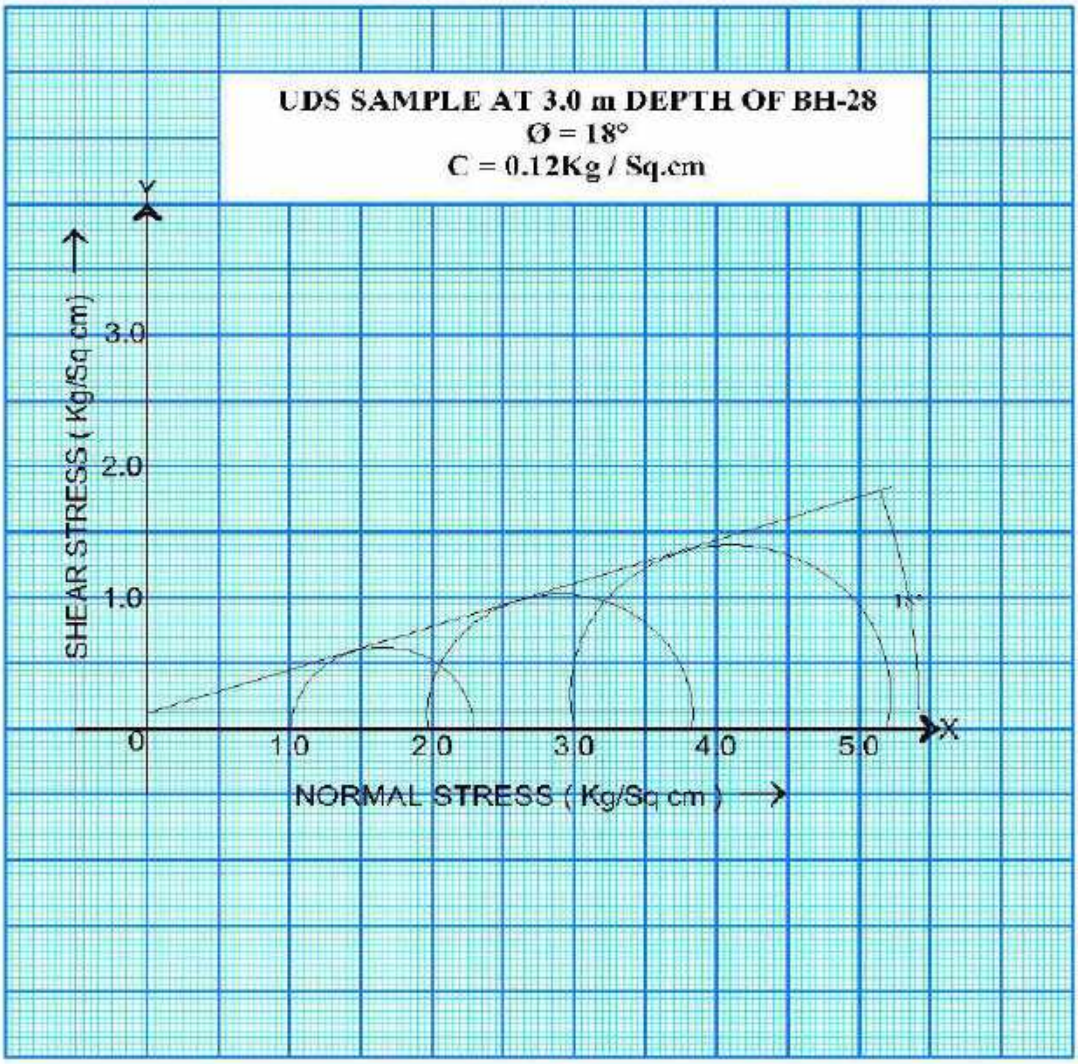


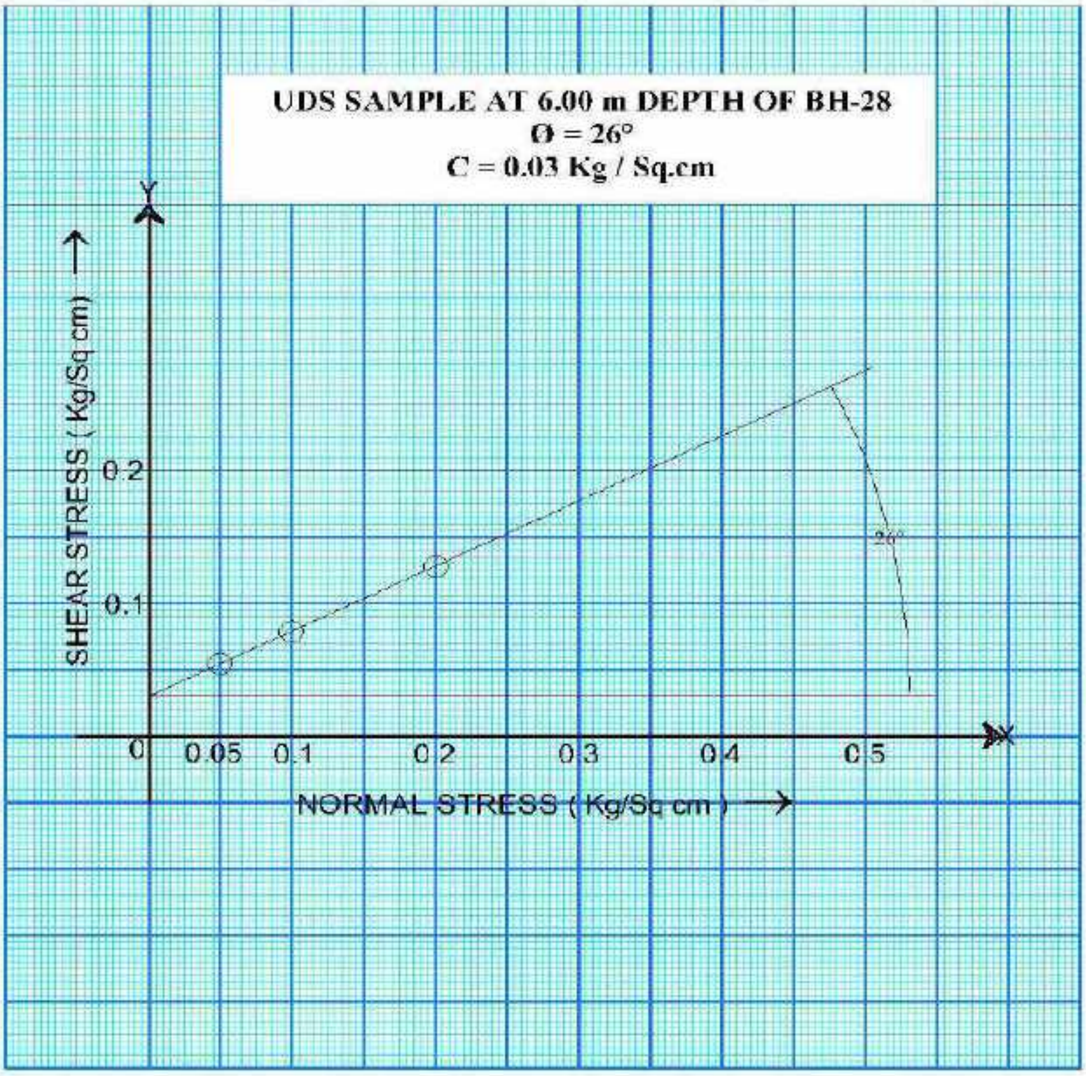
UDS SAMPLE AT 18.0 m DEPTH OF BH-27
Ø = 13°
C = 0.18Kg / Sq.cm

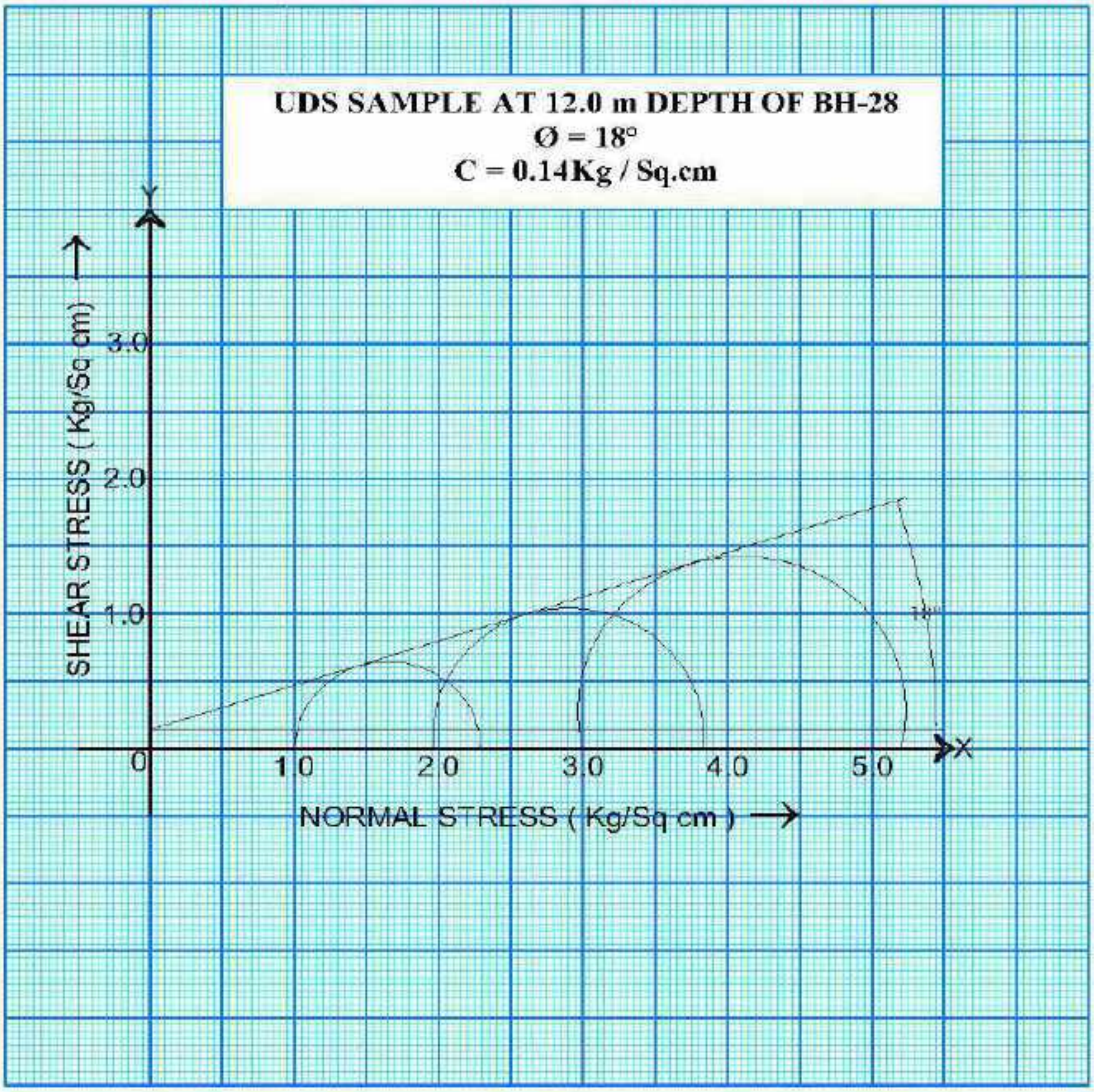

UDS SAMPLE AT 24.0 m DEPTH OF BH-27
Ø = 9°
C = 0.29Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
9°
NORMAL STRESS (Kg/Sq cm)



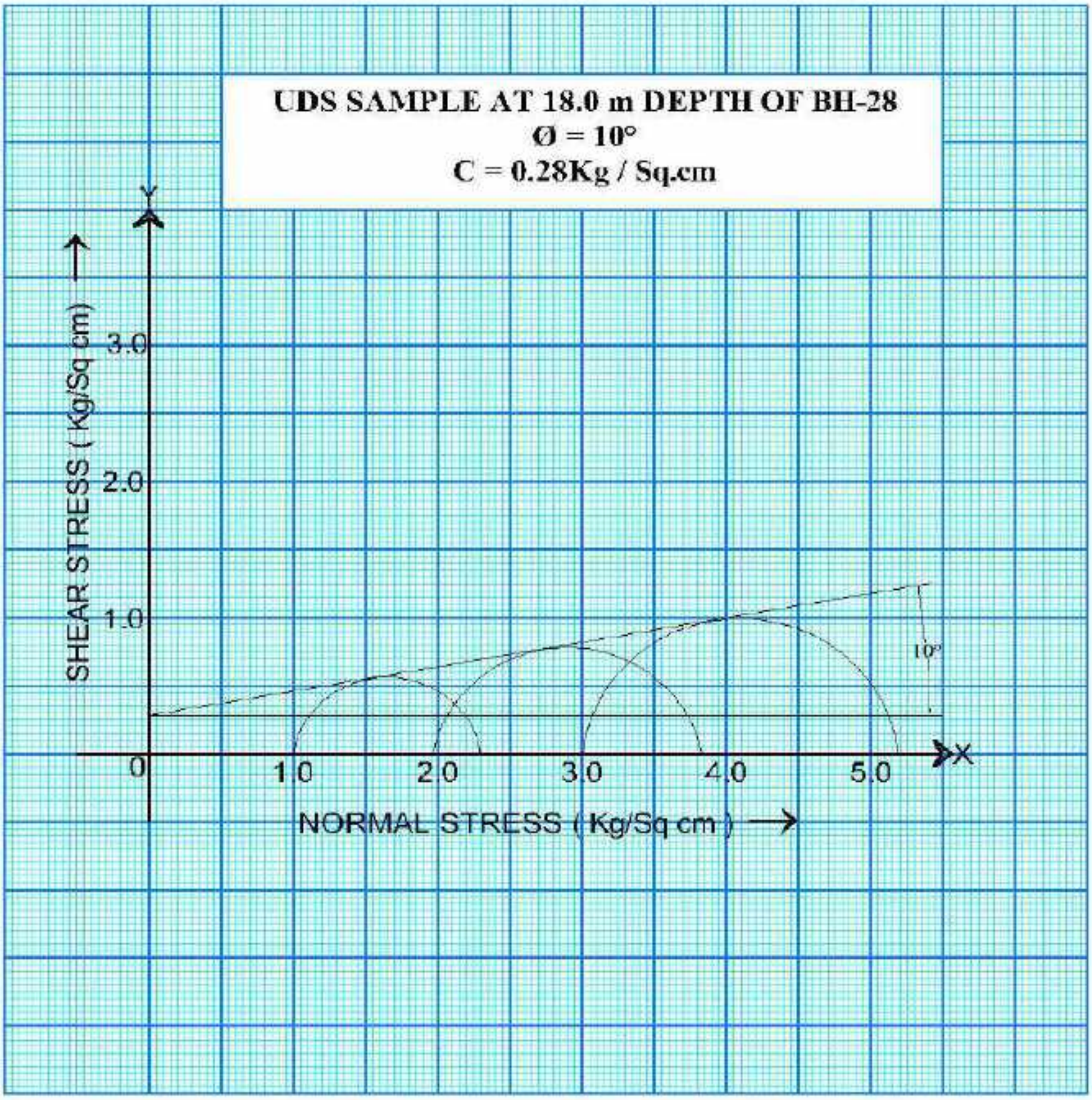
UDS SAMPLE AT 30.0 m DEPTH OF BH-27
Ø = 9°
C = 0.30Kg / Sq.cm


UDS SAMPLE AT 3.0 m DEPTH OF BH-28
Ø = 18°
C = 0.12Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
18°
NORMAL STRESS (Kg/Sq cm)


UDS SAMPLE AT 6.00 m DEPTH OF BH-28
Ø = 26°
C = 0.03 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm) →
26°



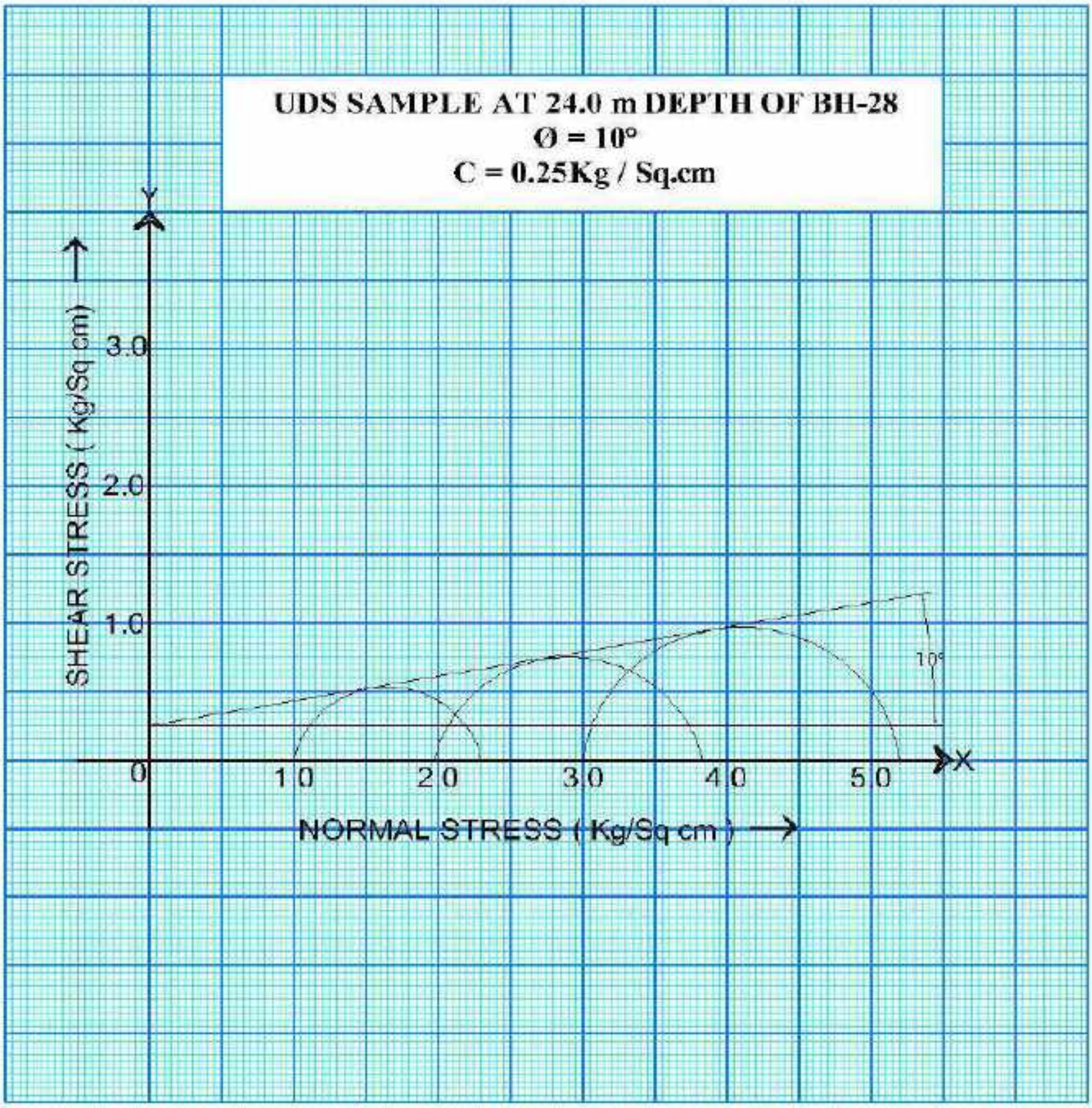
UDS SAMPLE AT 12.0 m DEPTH OF BH-28
Ø = 18°
C = 0.14Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
18°
NORMAL STRESS (Kg/Sq cm)

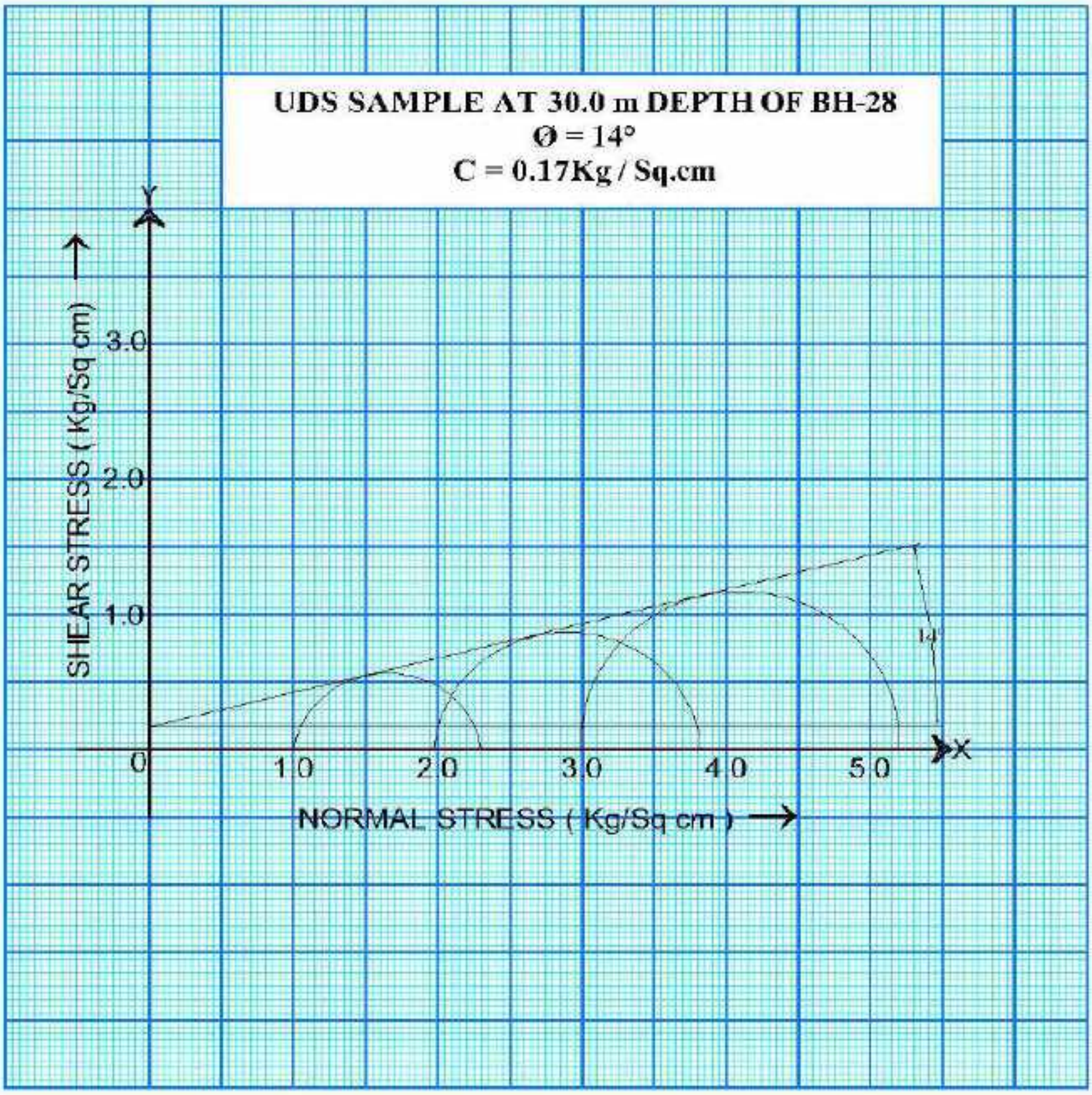


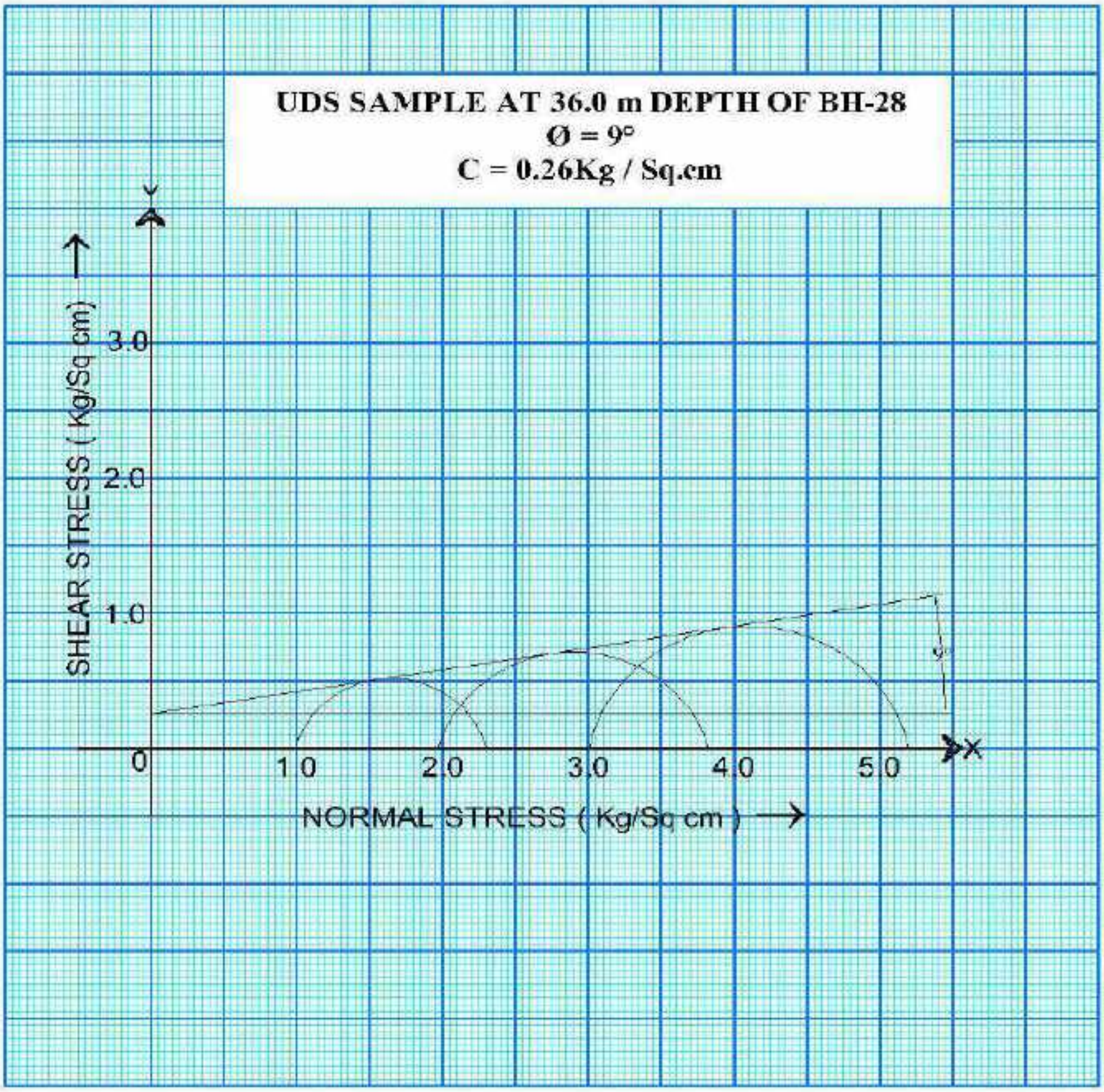
UDS SAMPLE AT 18.0 m DEPTH OF BH-28

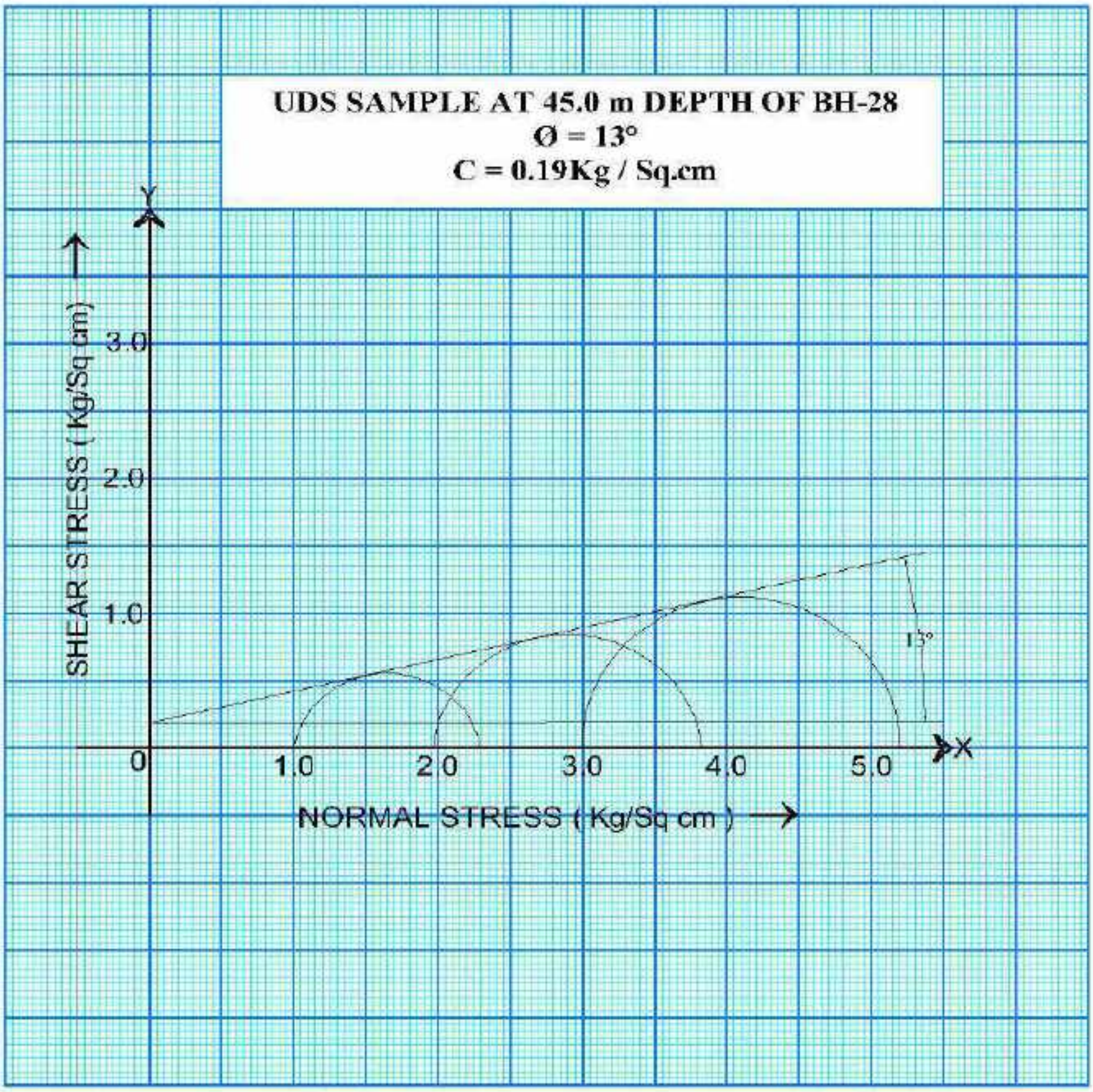
Ø = 10°

C = 0.28Kg / Sq.cm

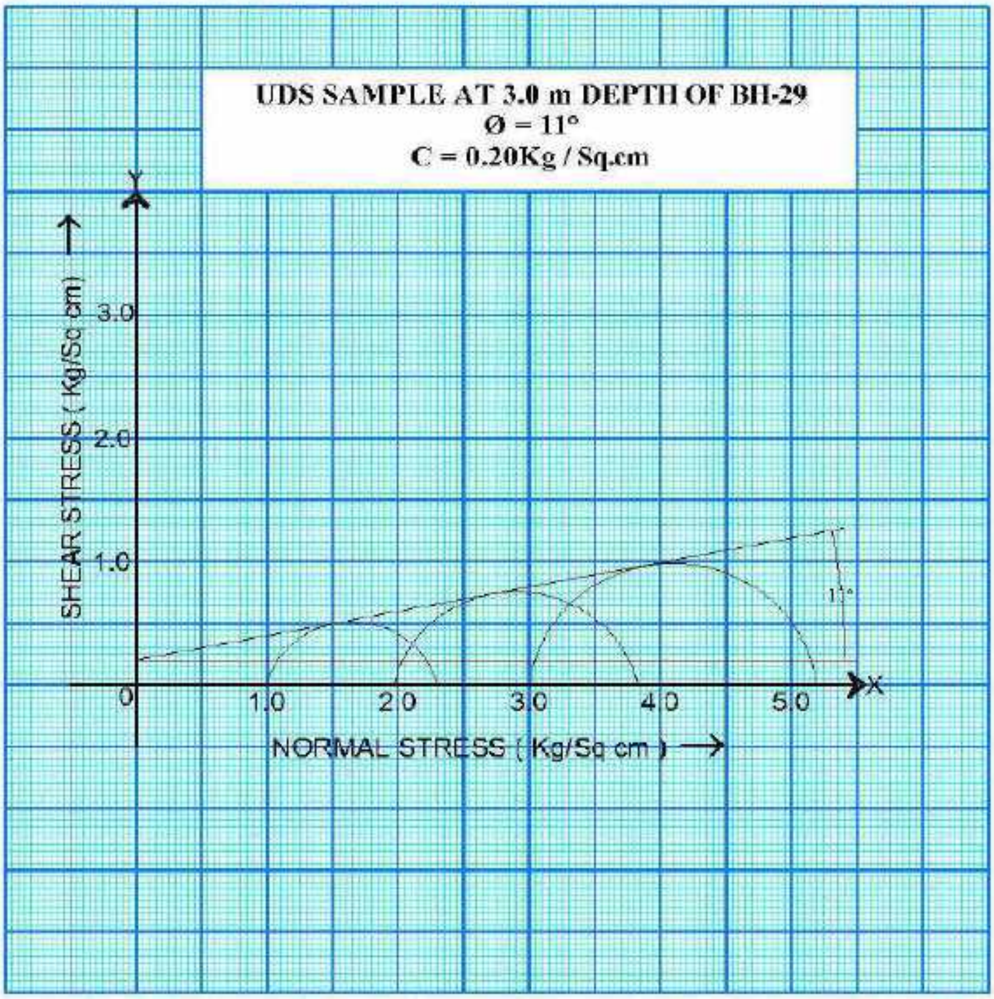

UDS SAMPLE AT 24.0 m DEPTH OF BH-28
Ø = 10°
C = 0.25Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
10°
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)


UDS SAMPLE AT 30.0 m DEPTH OF BH-28
Ø = 14°
C = 0.17Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS (Kg/Sq cm) →

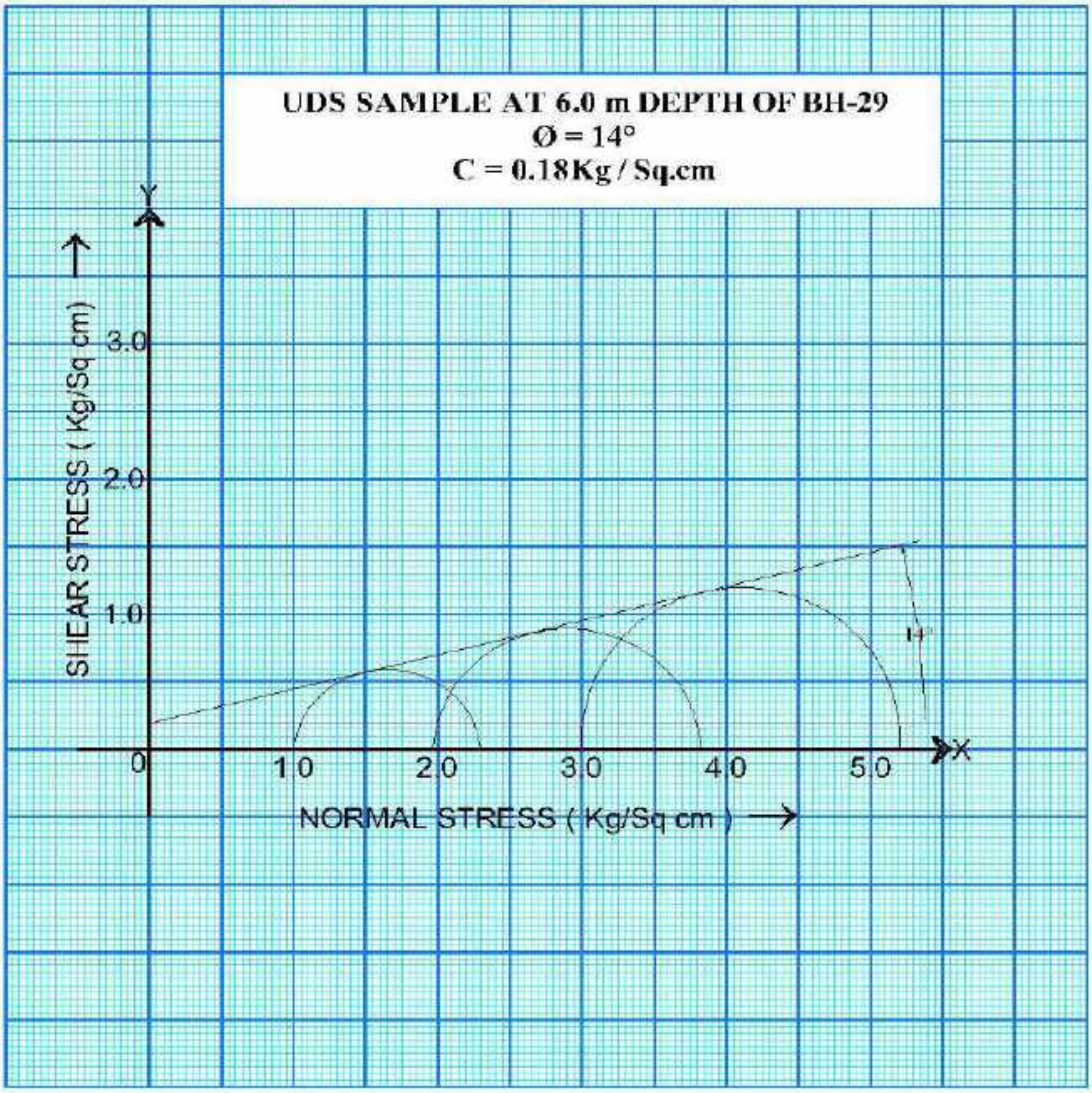

UDS SAMPLE AT 36.0 m DEPTH OF BH-28
Ø = 9°
C = 0.26Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
9°
NORMAL STRESS (Kg/Sq cm)



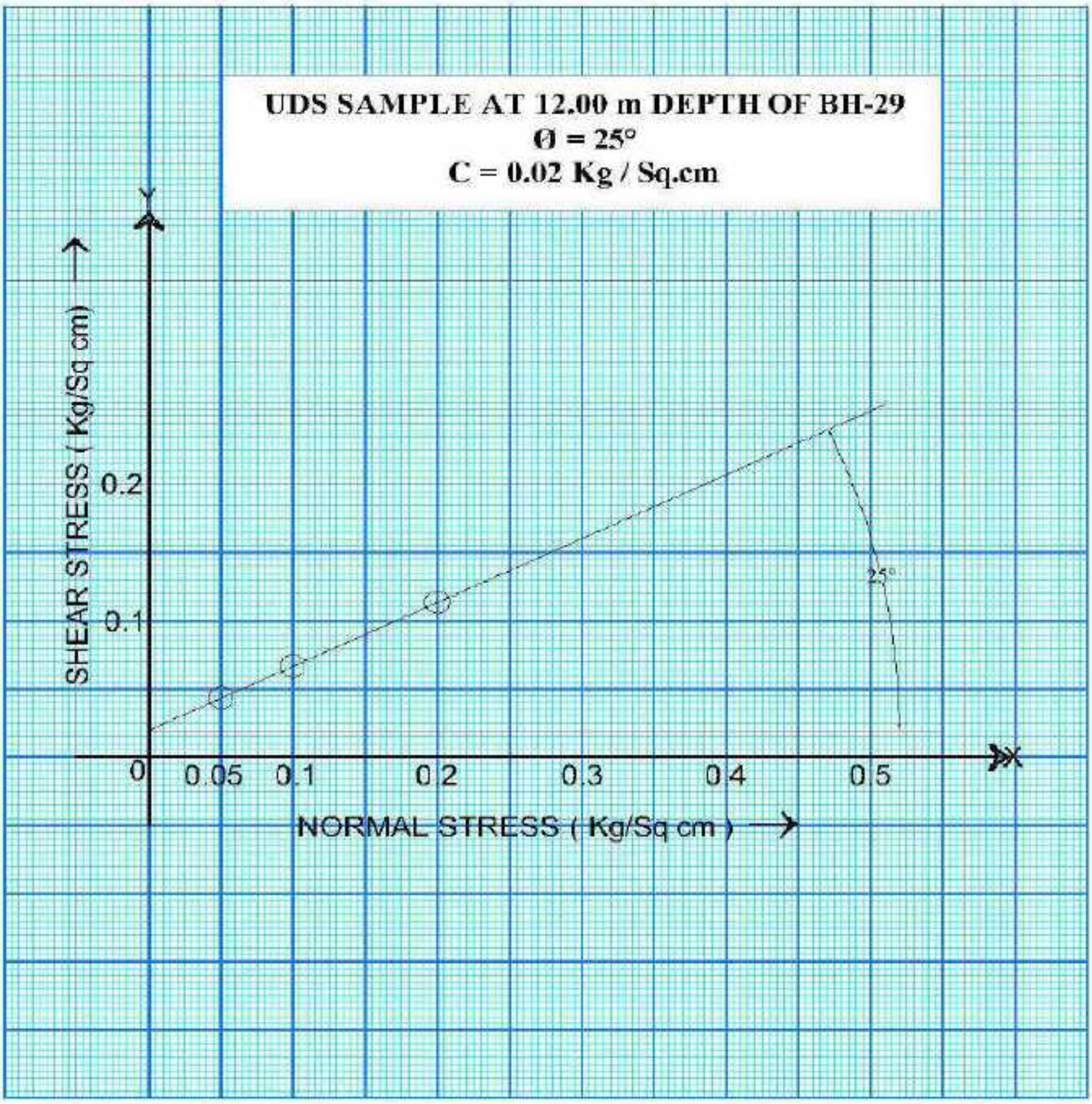
UDS SAMPLE AT 45.0 m DEPTH OF BH-28
Ø = 13°
C = 0.19Kg / Sq.cm



UDS SAMPLE AT 3.0 m DEPTH OF BH-29
Ø = 11°
C = 0.20Kg / Sq.cm



UDS SAMPLE AT 6.0 m DEPTH OF BH-29
Ø = 14°
C = 0.18Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
4.0
5.0
14°

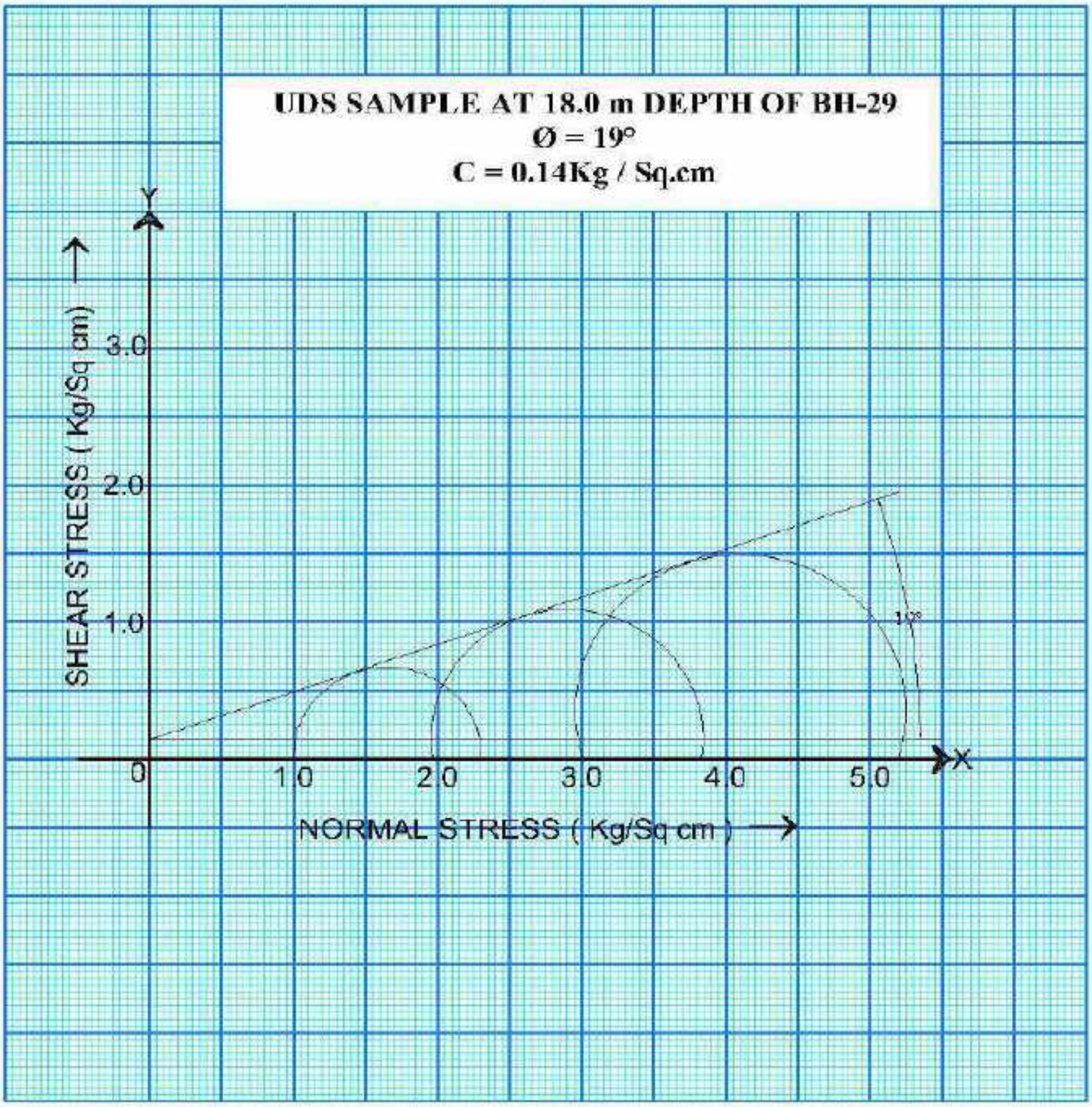


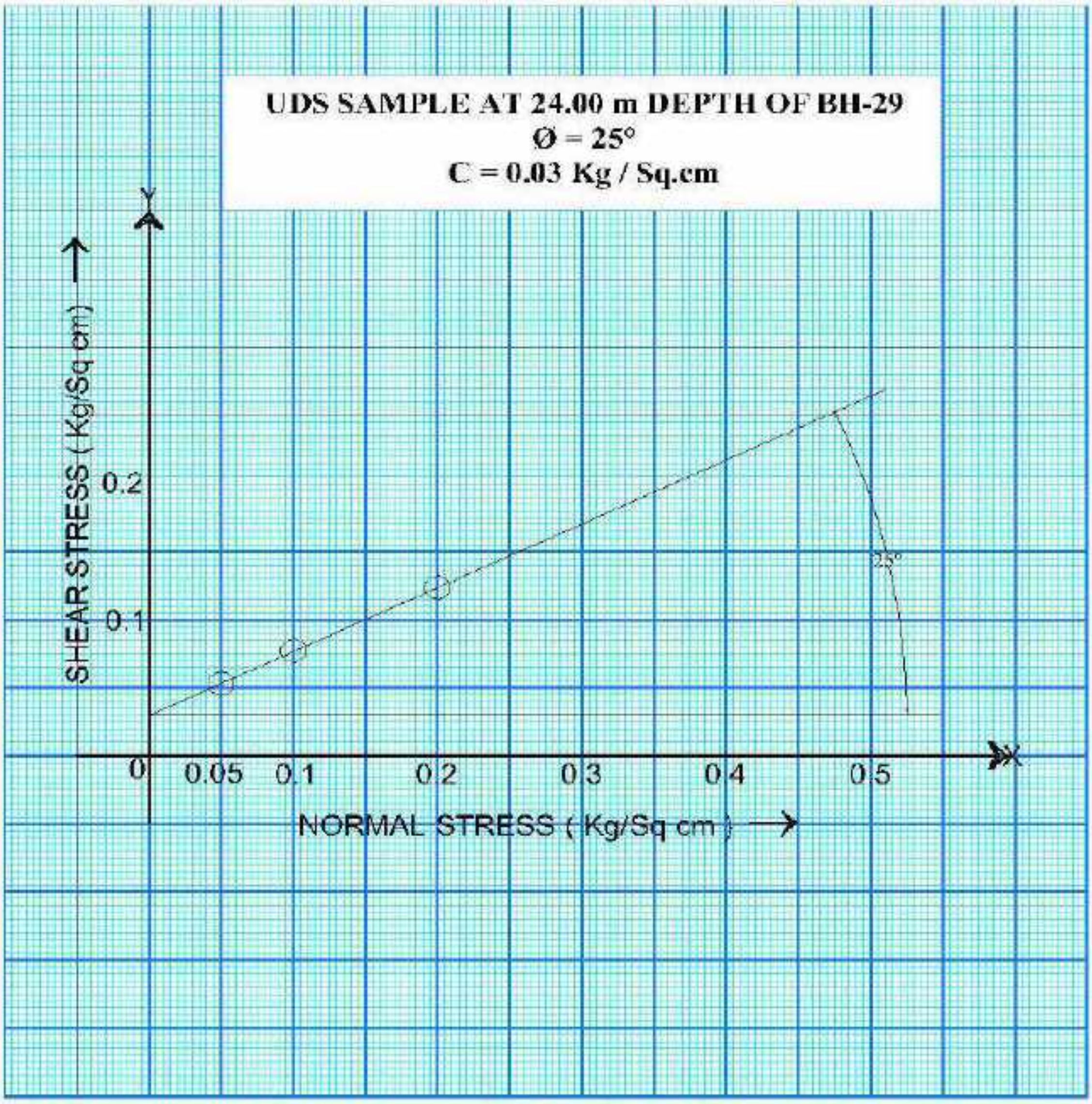
UDS SAMPLE AT 12.00 m DEPTH OF BH-29
Ø = 25°
C = 0.02 Kg / Sq.cm

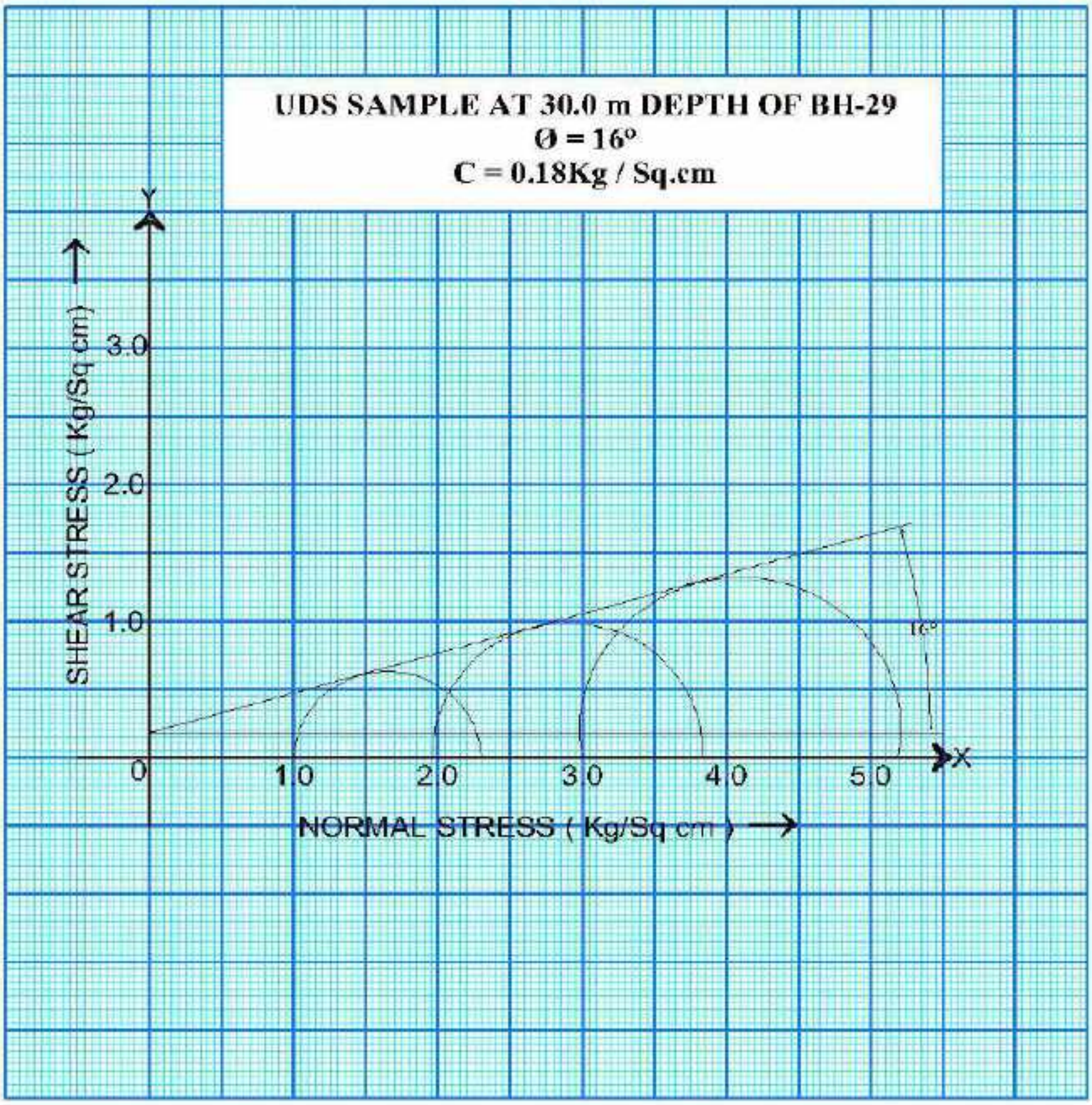
UDS SAMPLE AT 18.0 m DEPTH OF BH-29

Ø = 19°

C = 0.14Kg / Sq.cm



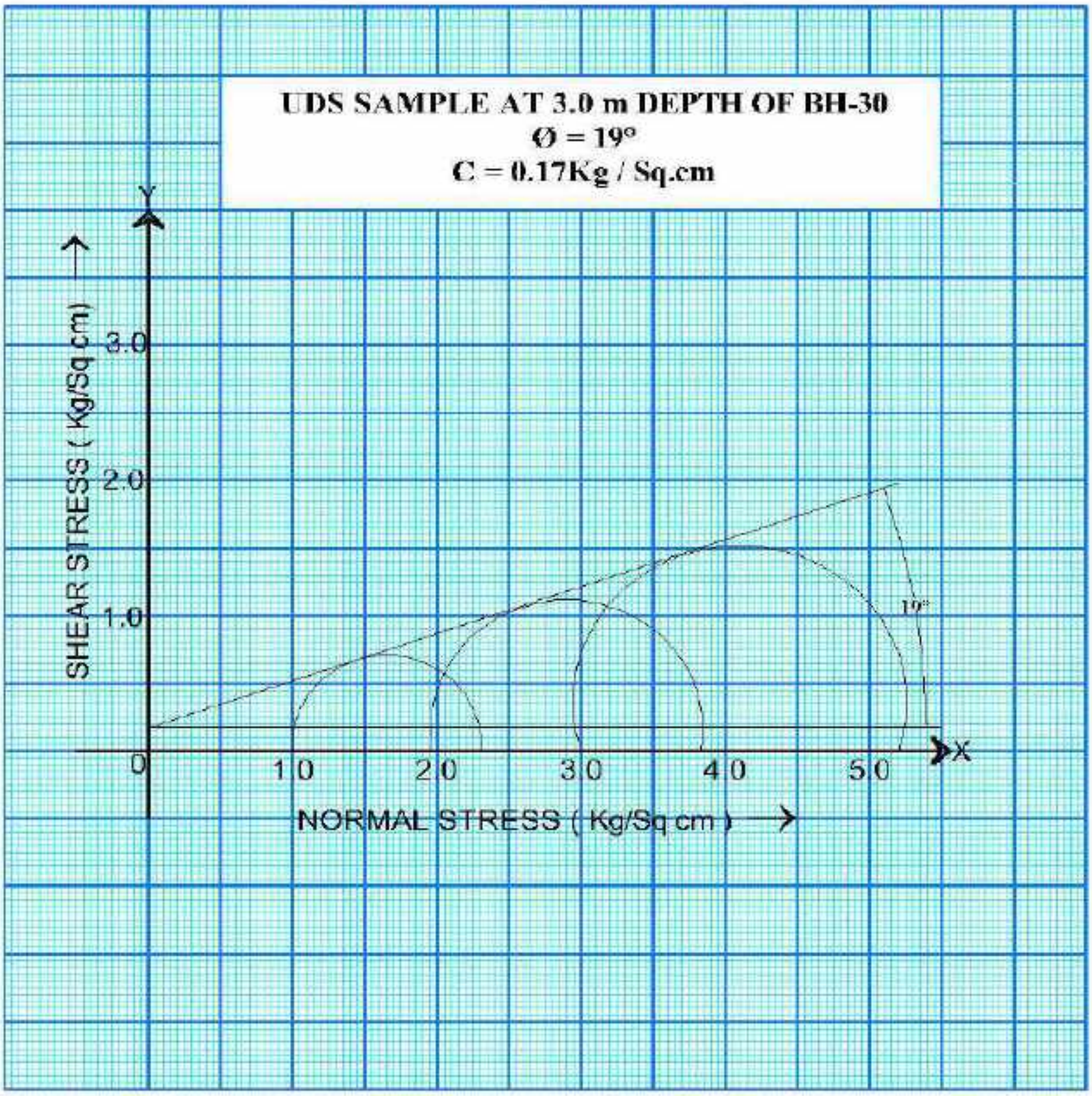

UDS SAMPLE AT 24.00 m DEPTH OF BH-29
Ø = 25°
C = 0.03 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
25°
NORMAL STRESS (Kg/Sq cm) →

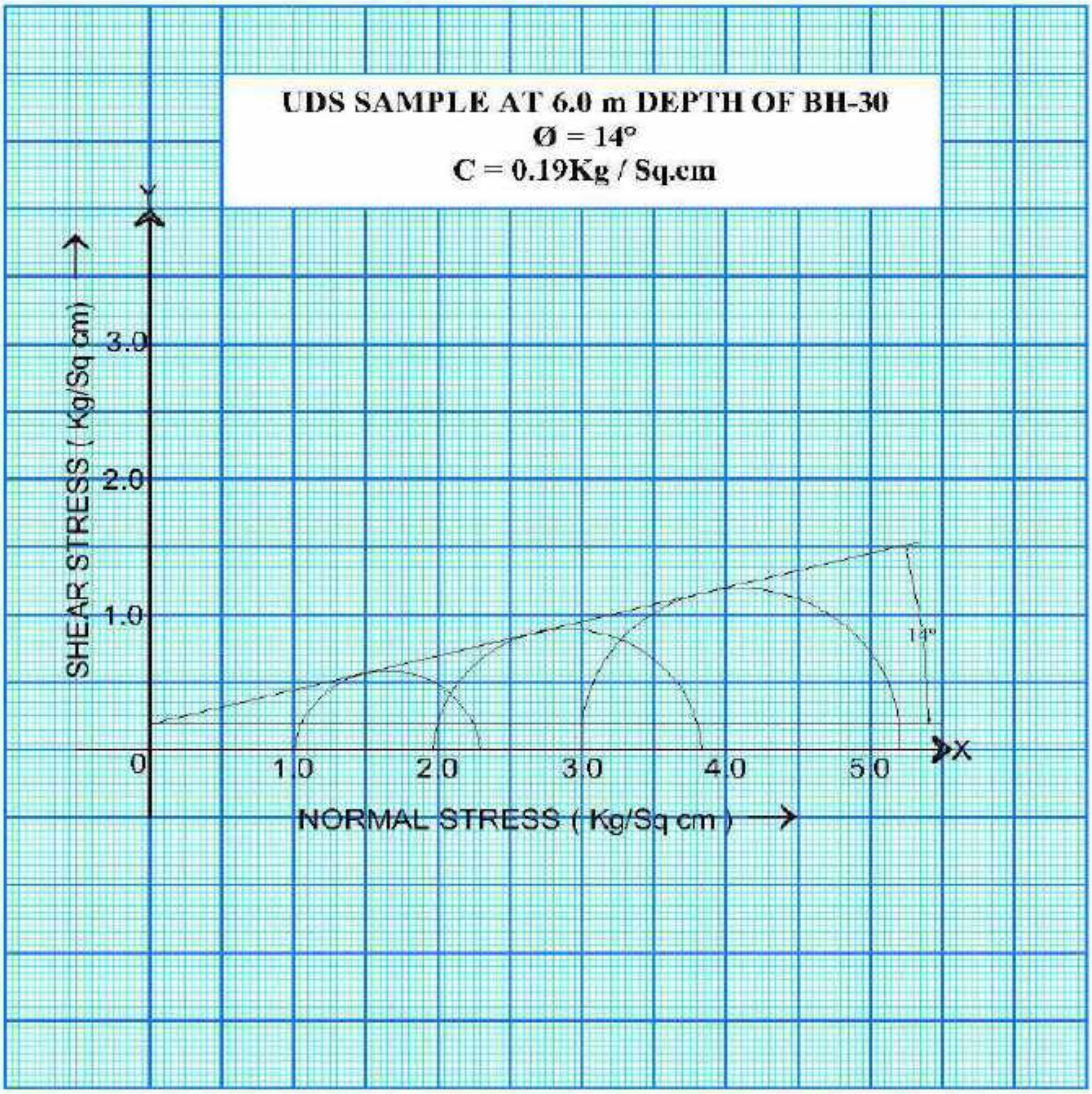


UDS SAMPLE AT 30.0 m DEPTH OF BH-29

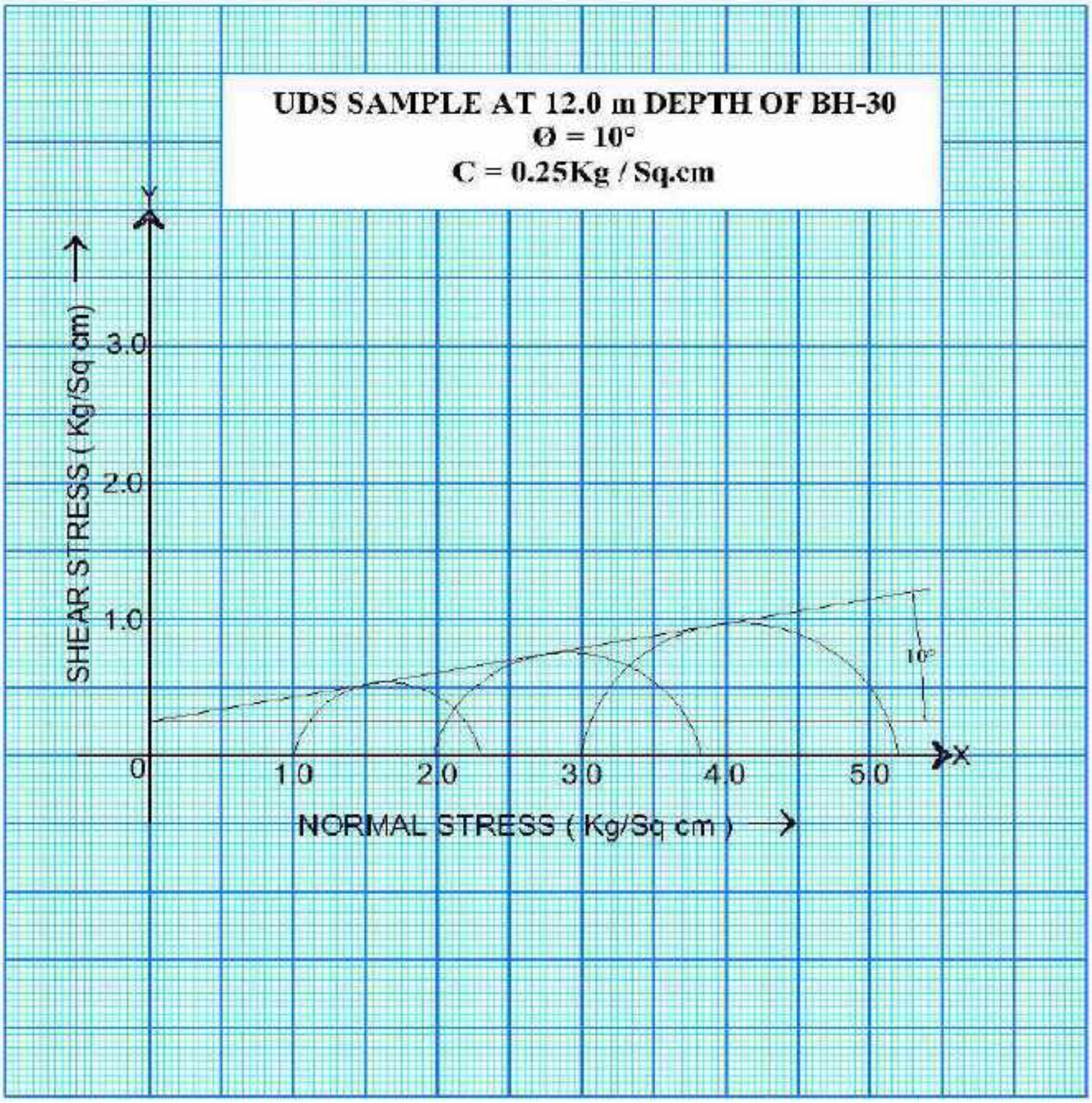
Ø = 16°

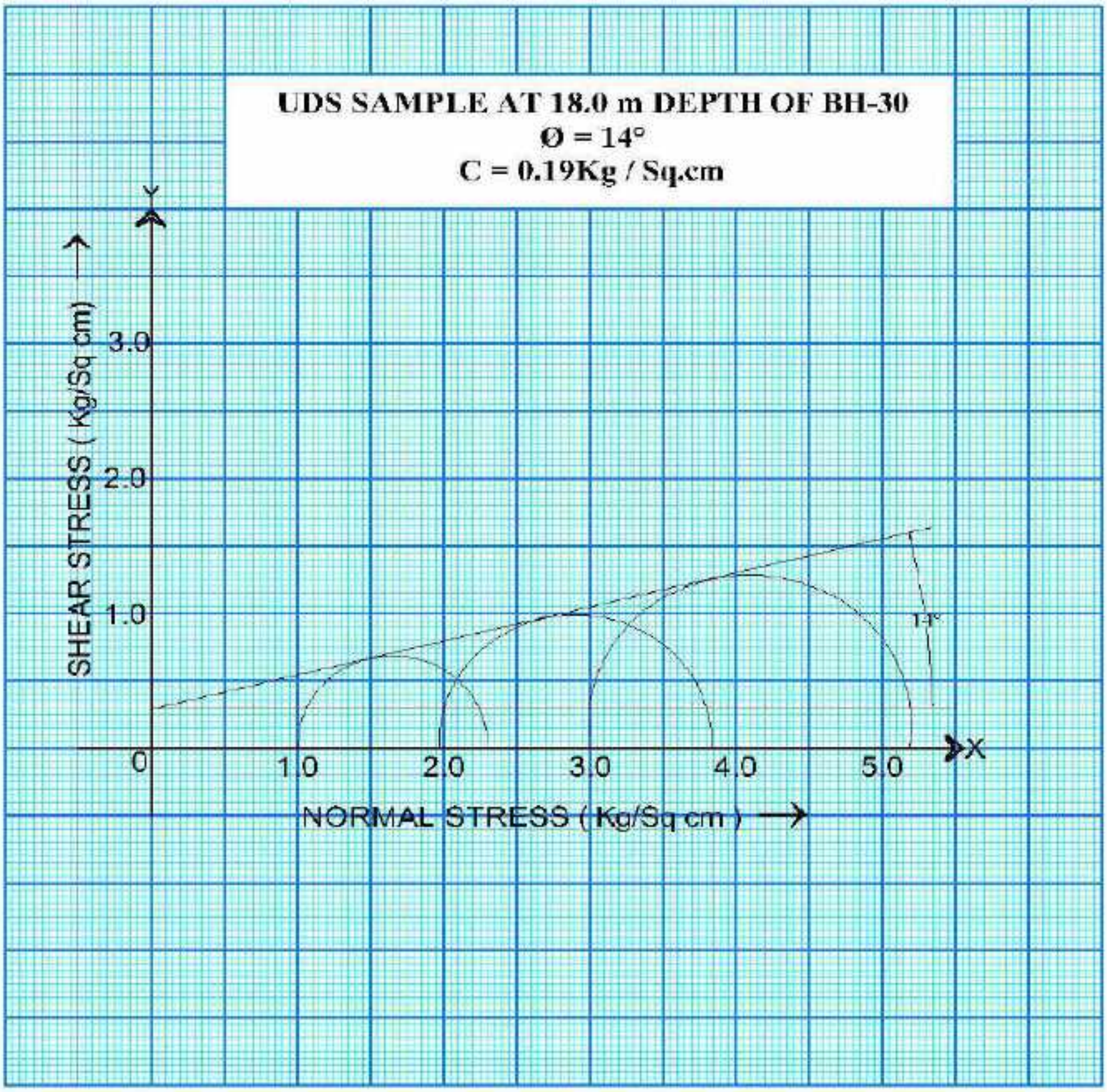
C = 0.18Kg / Sq.cm

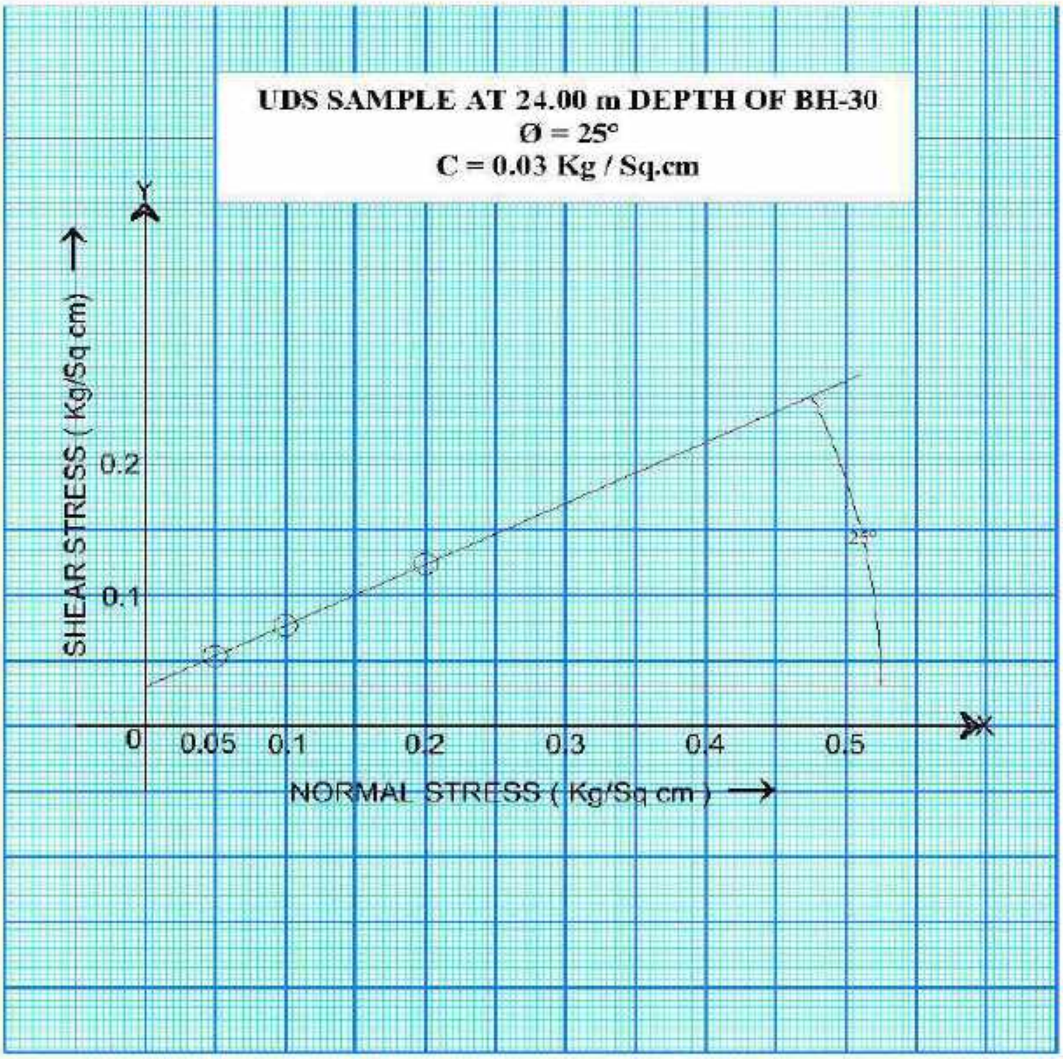

UDS SAMPLE AT 3.0 m DEPTH OF BH-30
Ø = 19°
C = 0.17Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm) →
19°

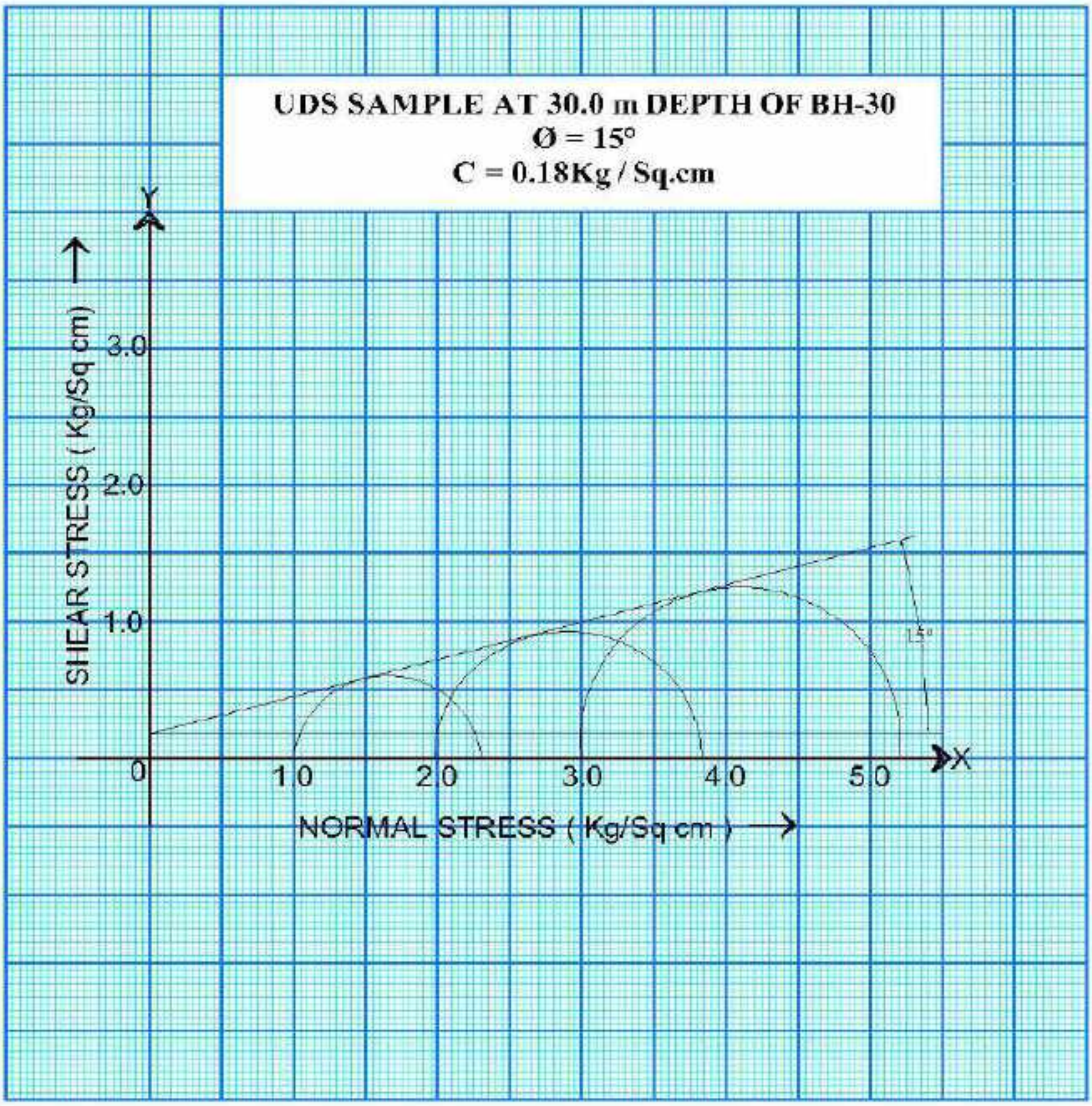


UDS SAMPLE AT 6.0 m DEPTH OF BH-30
Ø = 14°
C = 0.19Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS (Kg/Sq cm)

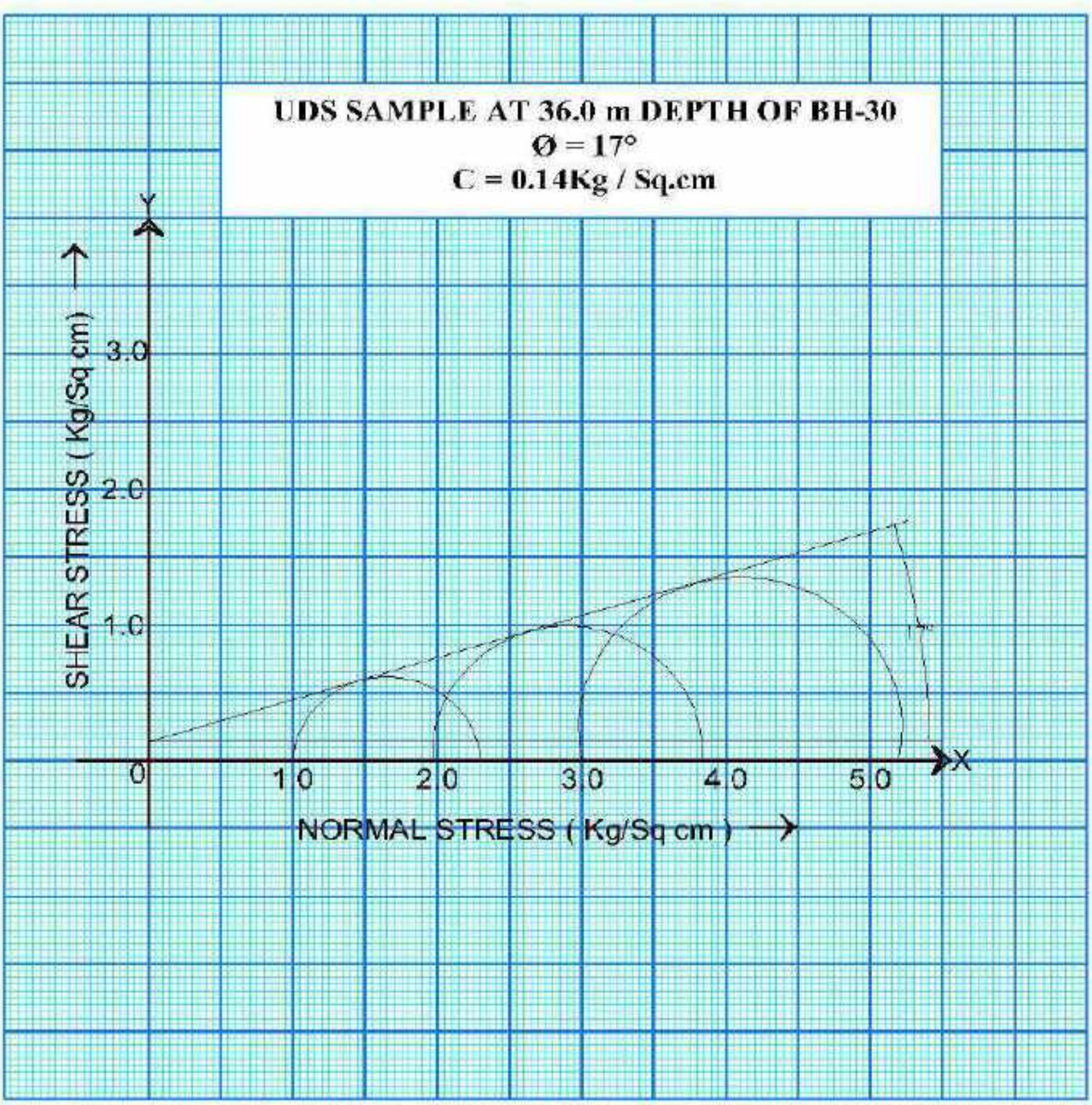

UDS SAMPLE AT 12.0 m DEPTH OF BH-30
Ø = 10°
C = 0.25Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
Y
10°
NORMAL STRESS (Kg/Sq cm)

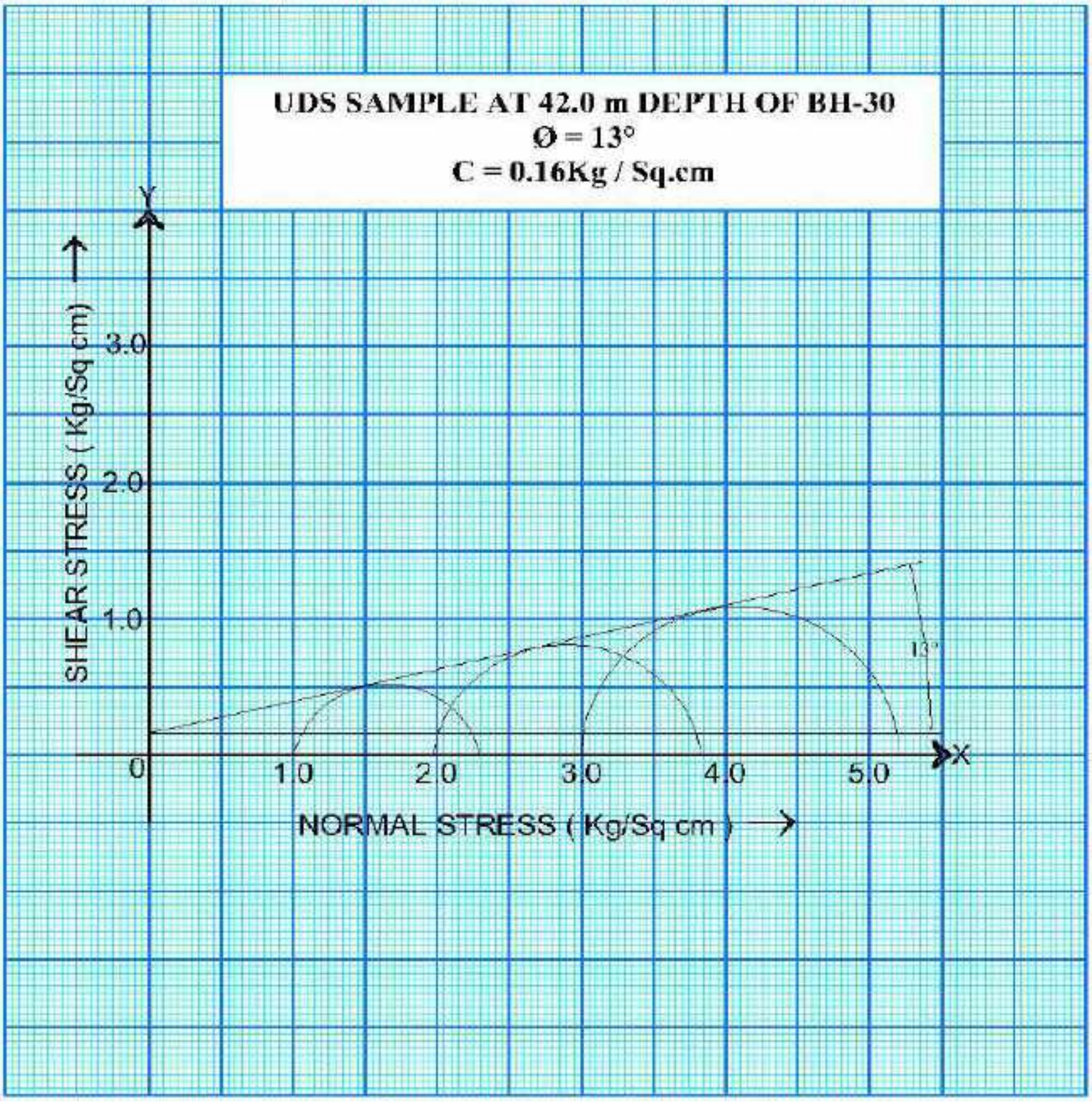

UDS SAMPLE AT 18.0 m DEPTH OF BH-30
Ø = 14°
C = 0.19Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
14°

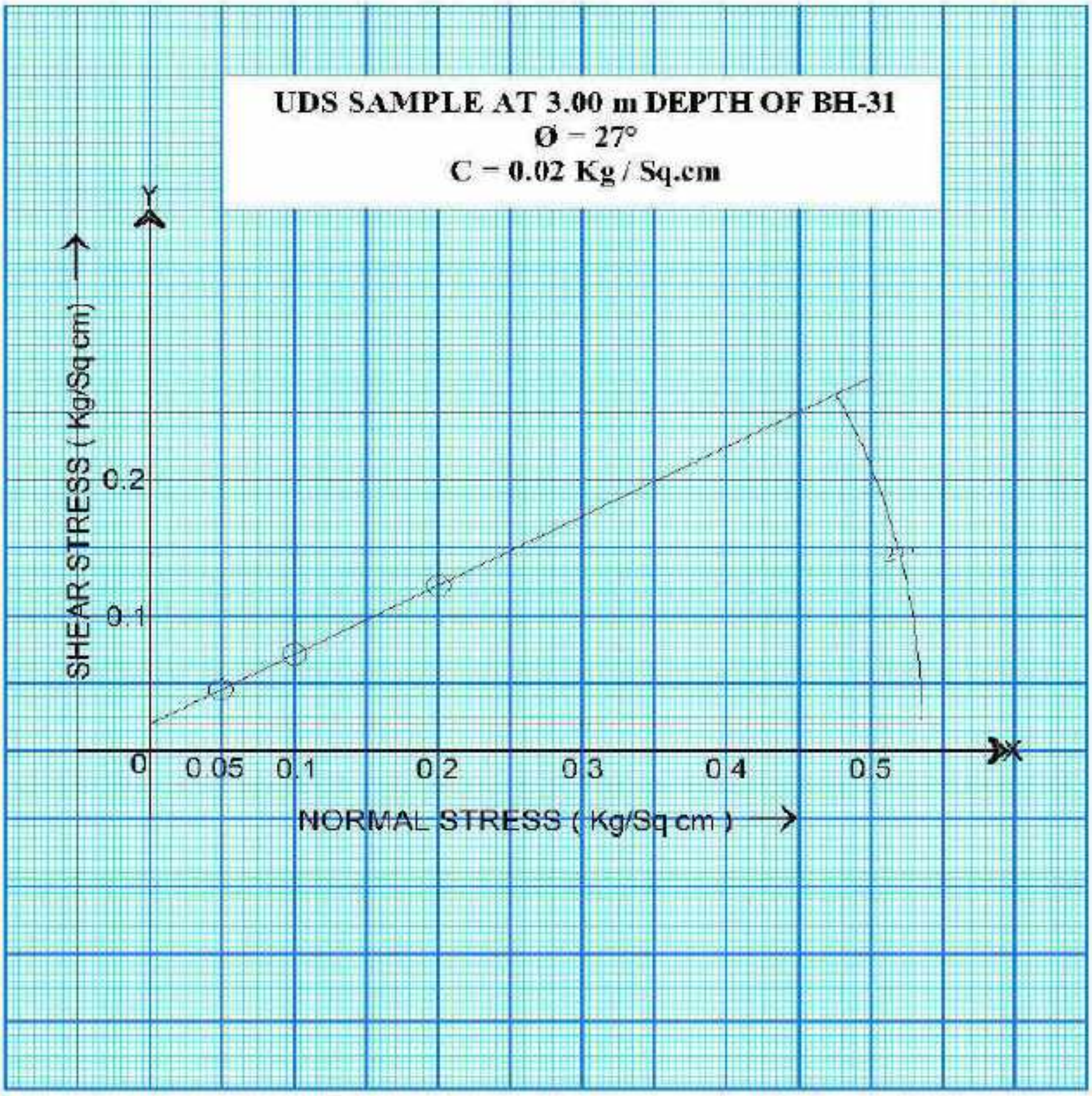

UDS SAMPLE AT 24.00 m DEPTH OF BH-30
Ø = 25°
C = 0.03 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm) →
25°

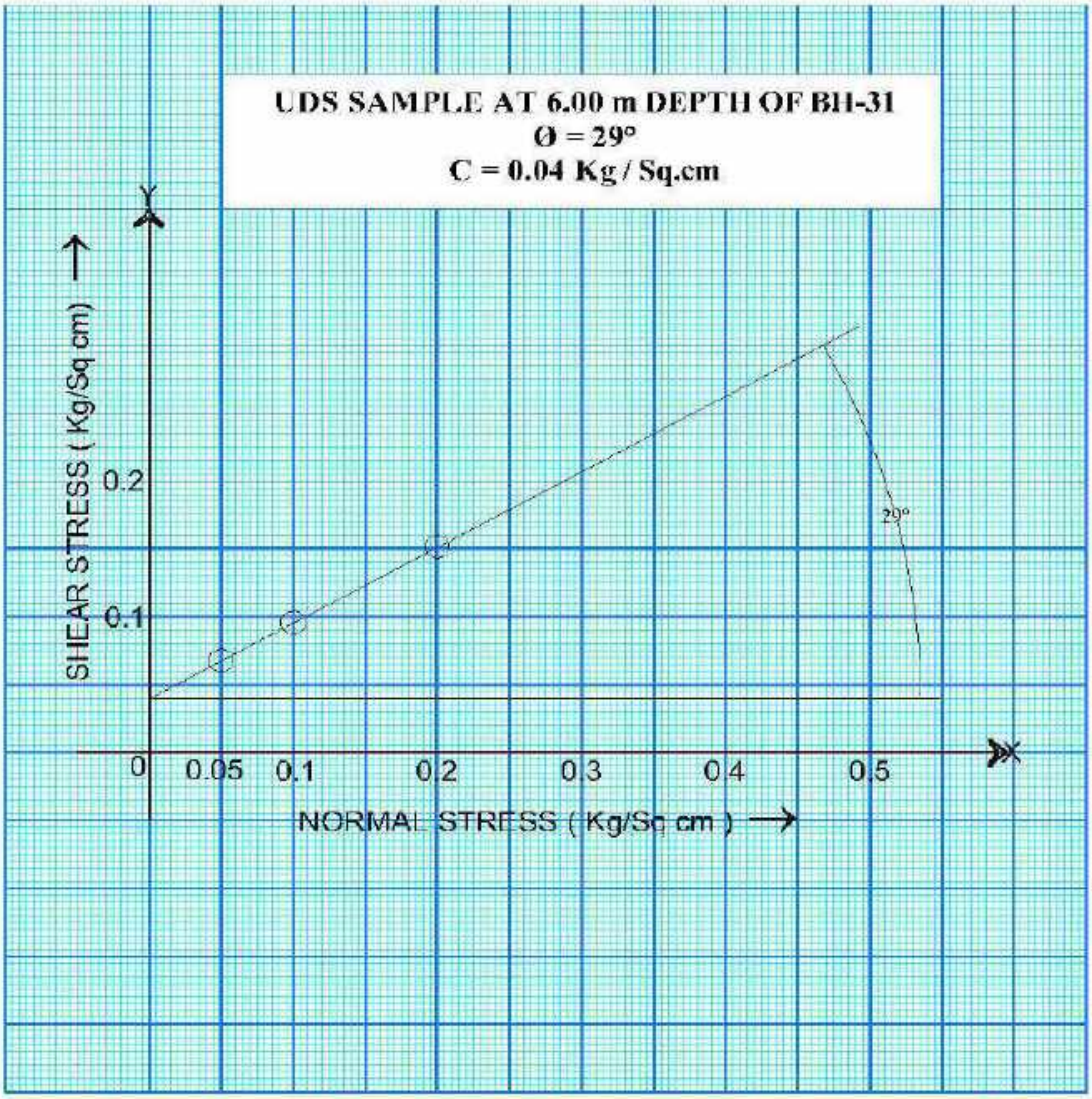


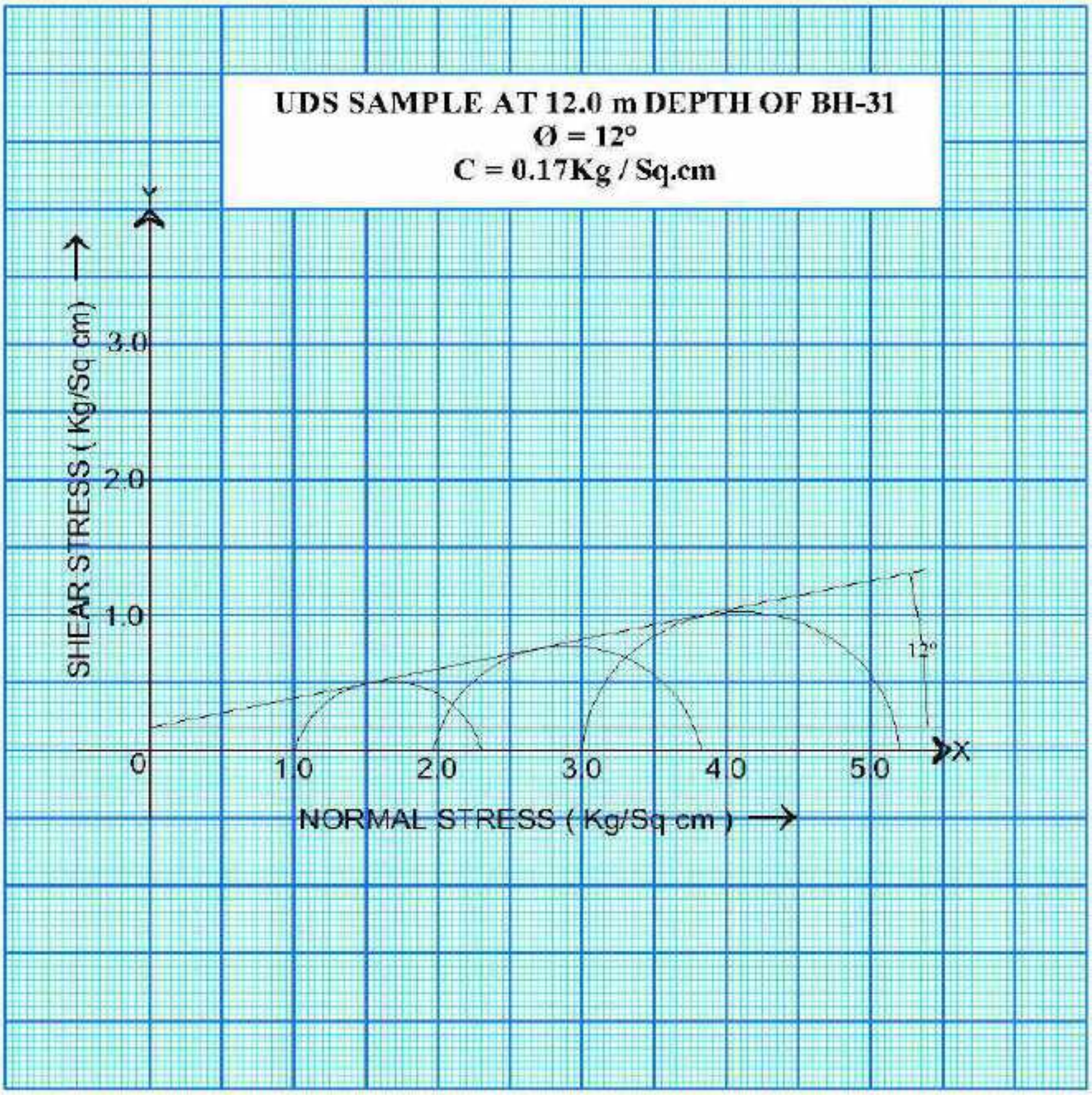
UDS SAMPLE AT 30.0 m DEPTH OF BH-30
Ø = 15°
C = 0.18Kg / Sq.cm


UDS SAMPLE AT 36.0 m DEPTH OF BH-30
Ø = 17°
C = 0.14Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
17°


UDS SAMPLE AT 42.0 m DEPTH OF BH-30
Ø = 13°
C = 0.16Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
13°
NORMAL STRESS (Kg/Sq cm)


UDS SAMPLE AT 3.00 m DEPTH OF BH-31
Ø = 27°
C = 0.02 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm) →
27°

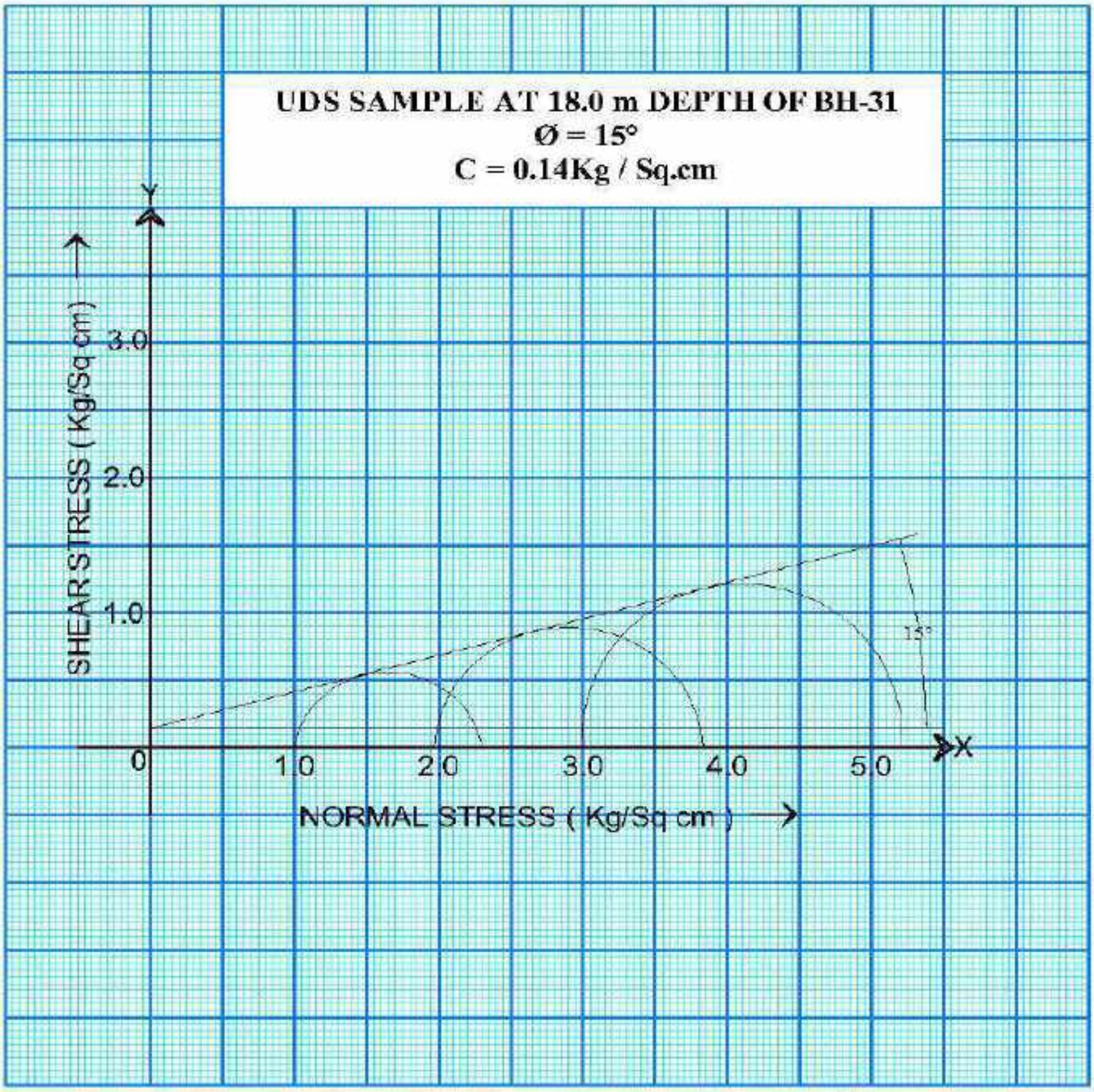

UDS SAMPLE AT 6.00 m DEPTH OF BH-31
Ø = 29°
C = 0.04 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm) →
29°

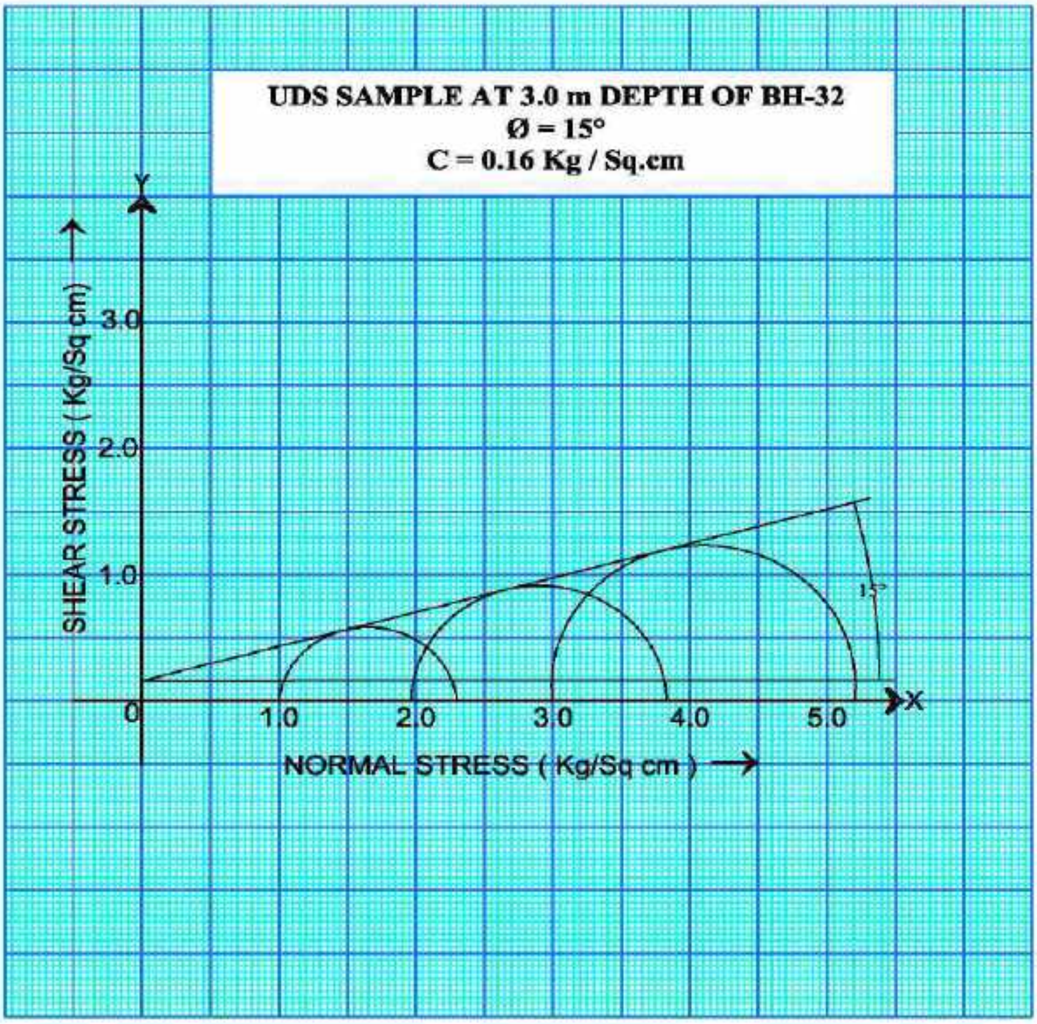

UDS SAMPLE AT 12.0 m DEPTH OF BH-31
Ø = 12°
C = 0.17Kg / Sq.cm

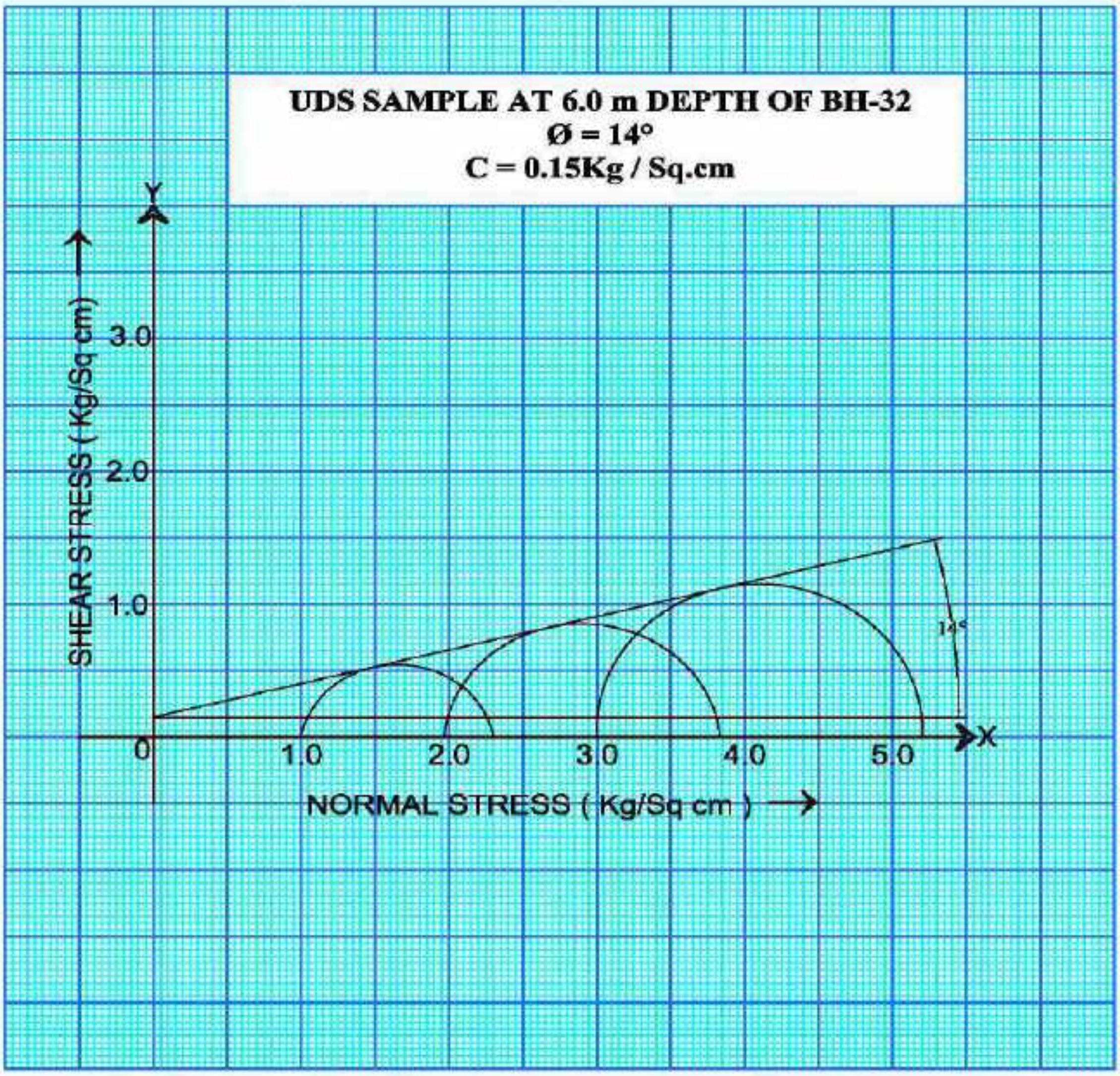
UDS SAMPLE AT 18.0 m DEPTH OF BH-31

Ø = 15°

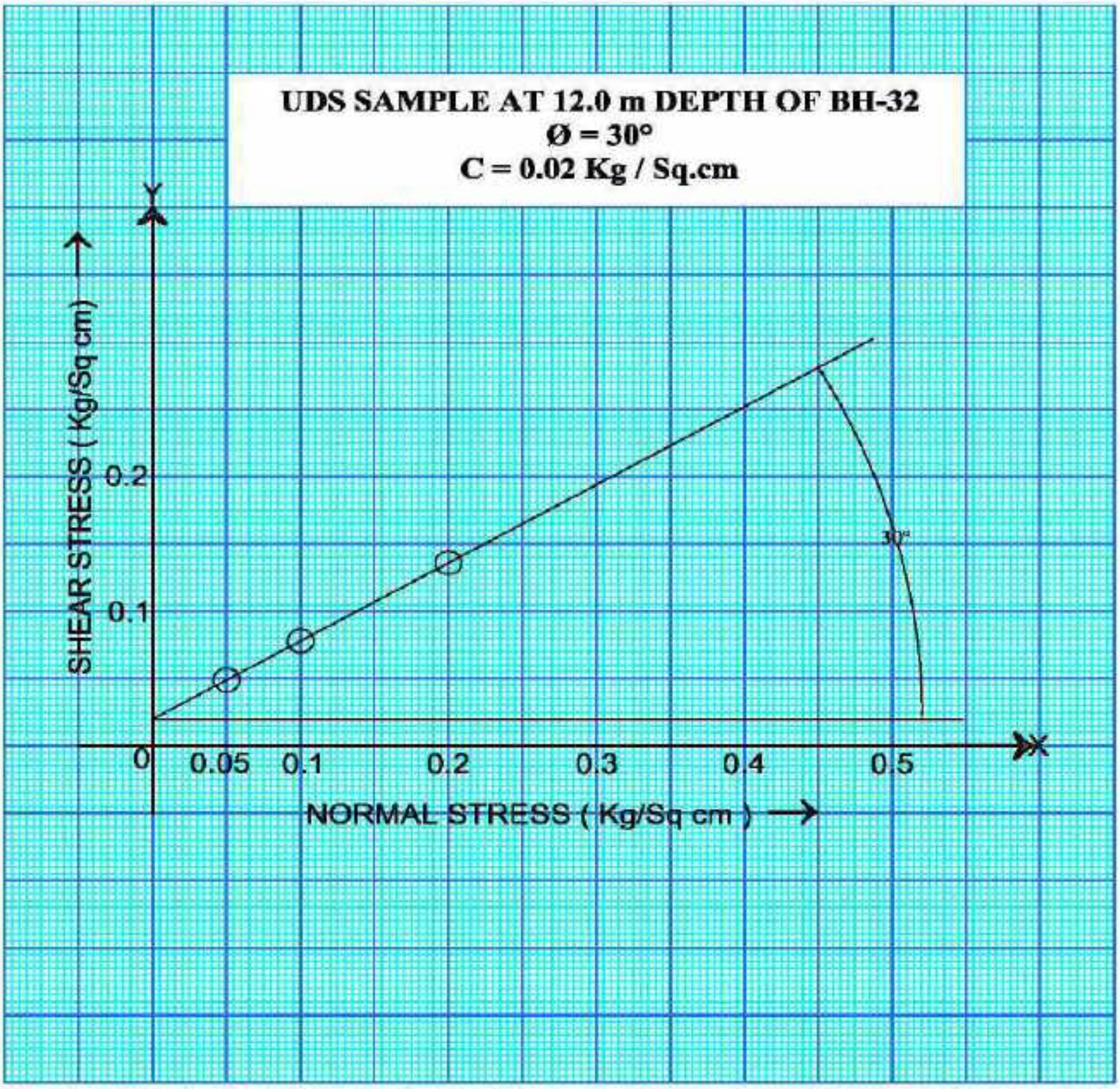
C = 0.14Kg / Sq.cm

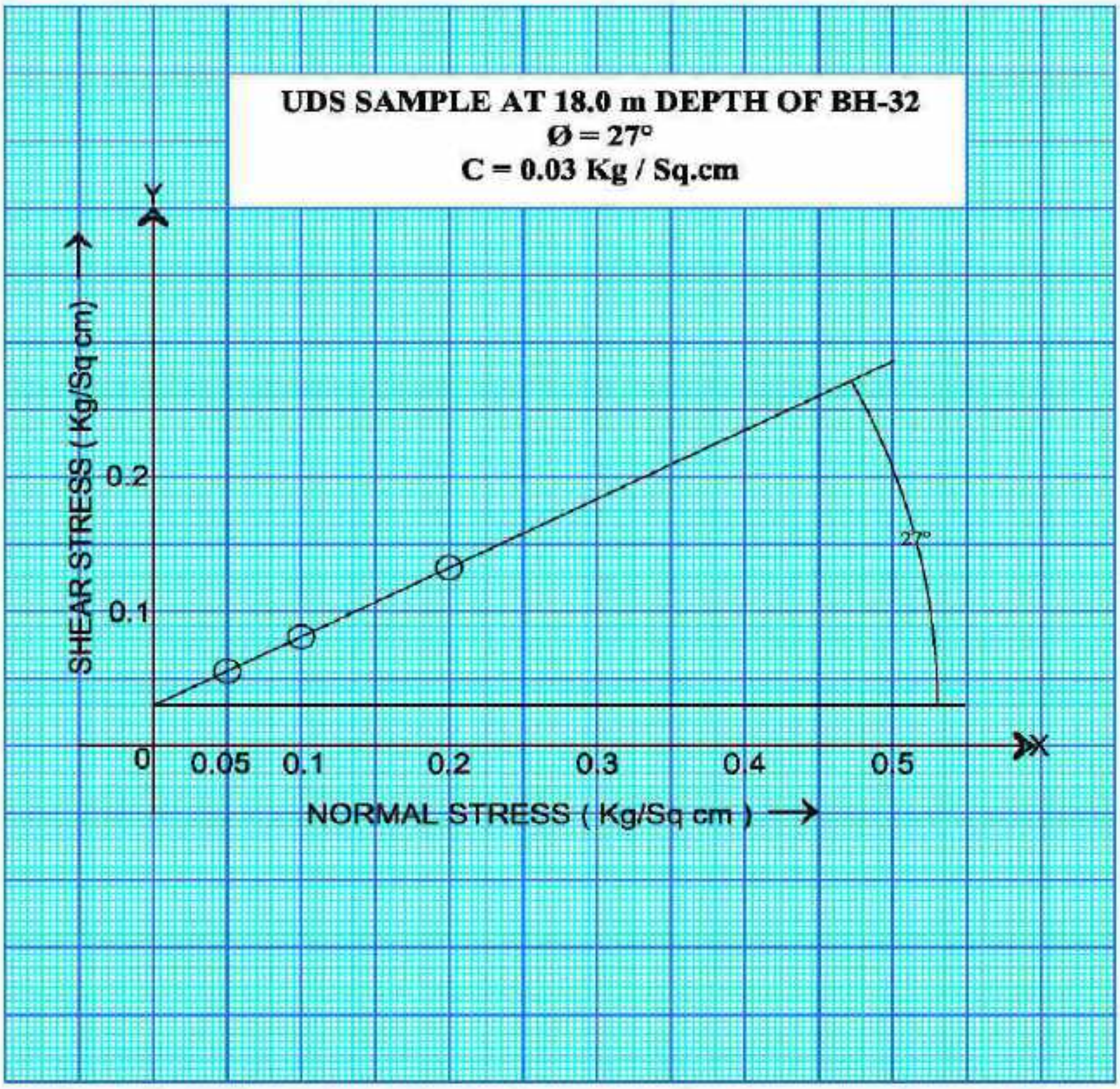



UDS SAMPLE AT 3.0 m DEPTH OF BH-32
Ø = 15°
C = 0.16 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
15°
NORMAL STRESS (Kg/Sq cm) →

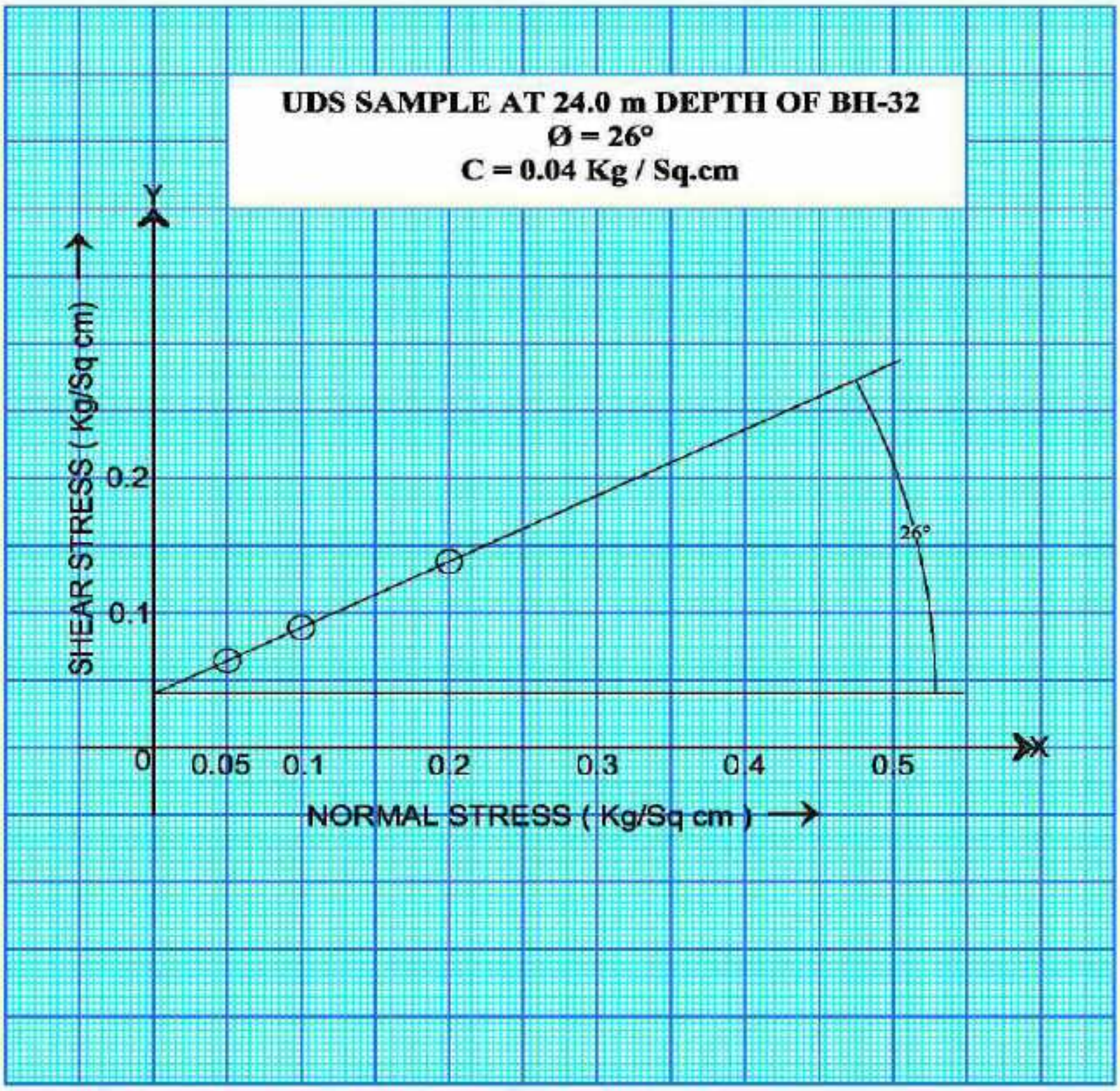


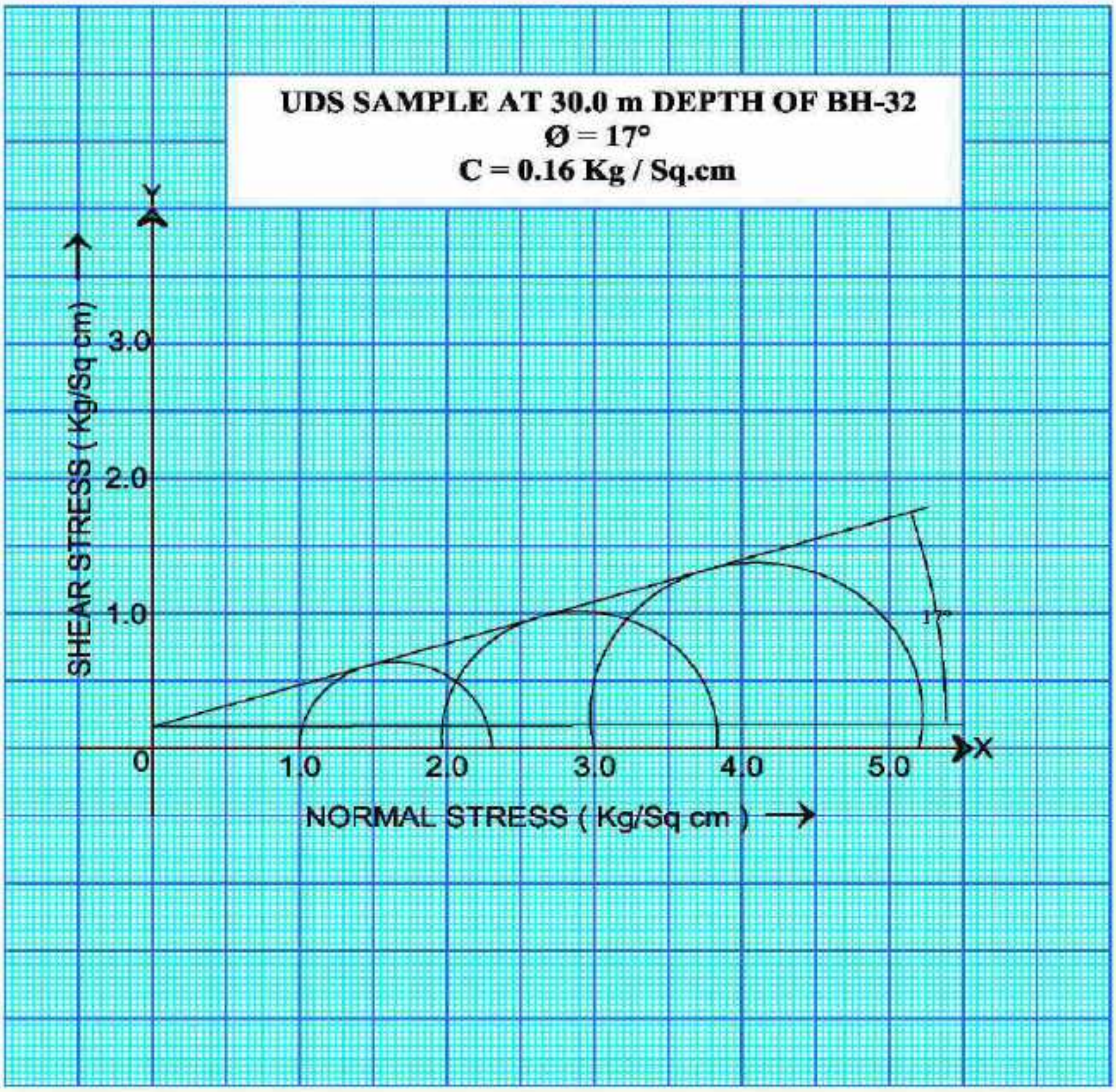
UDS SAMPLE AT 6.0 m DEPTH OF BH-32
Ø = 14°
C = 0.15Kg / Sq.cm

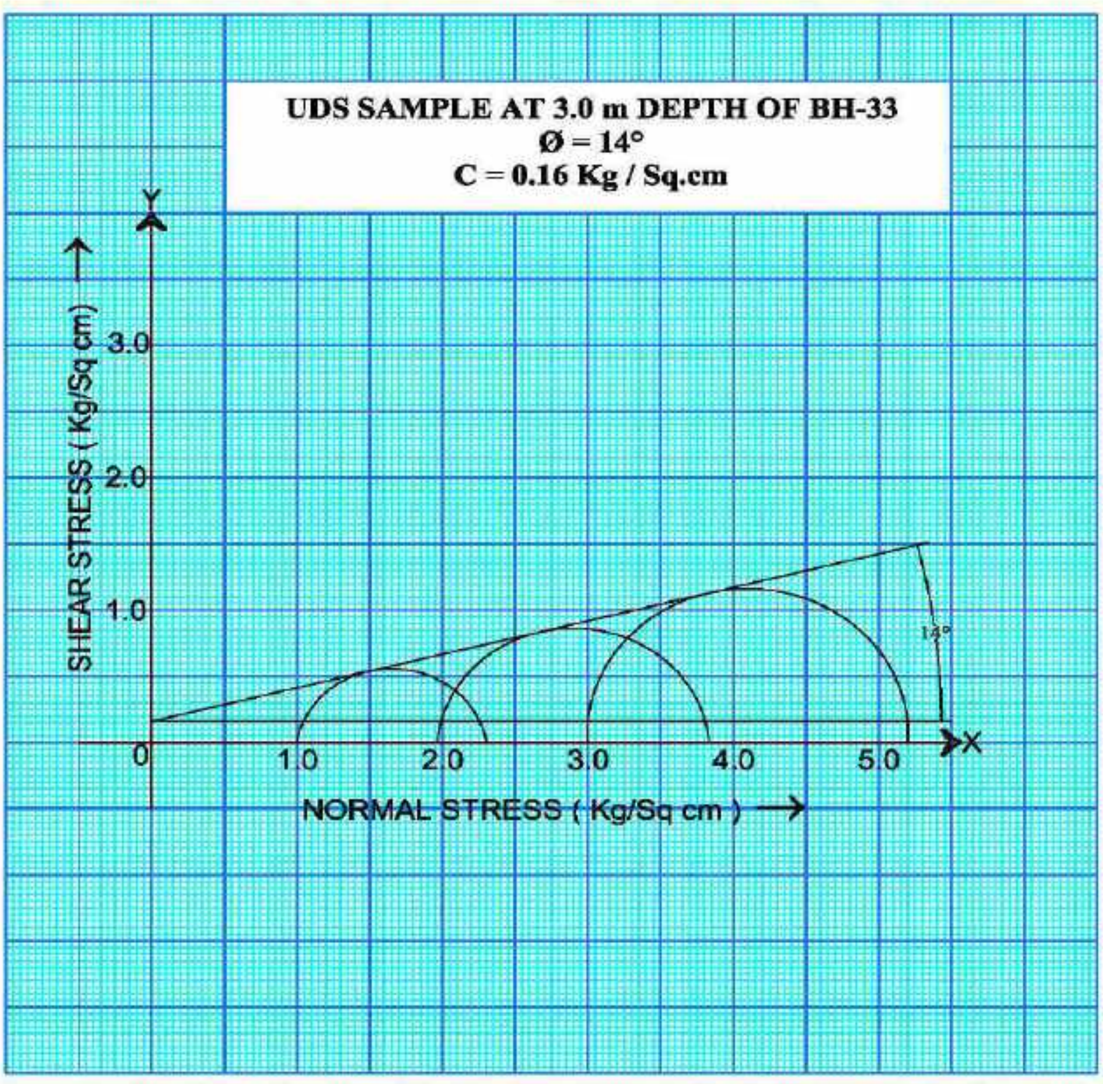

UDS SAMPLE AT 12.0 m DEPTH OF BH-32
Ø = 30°
C = 0.02 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm) →
30°

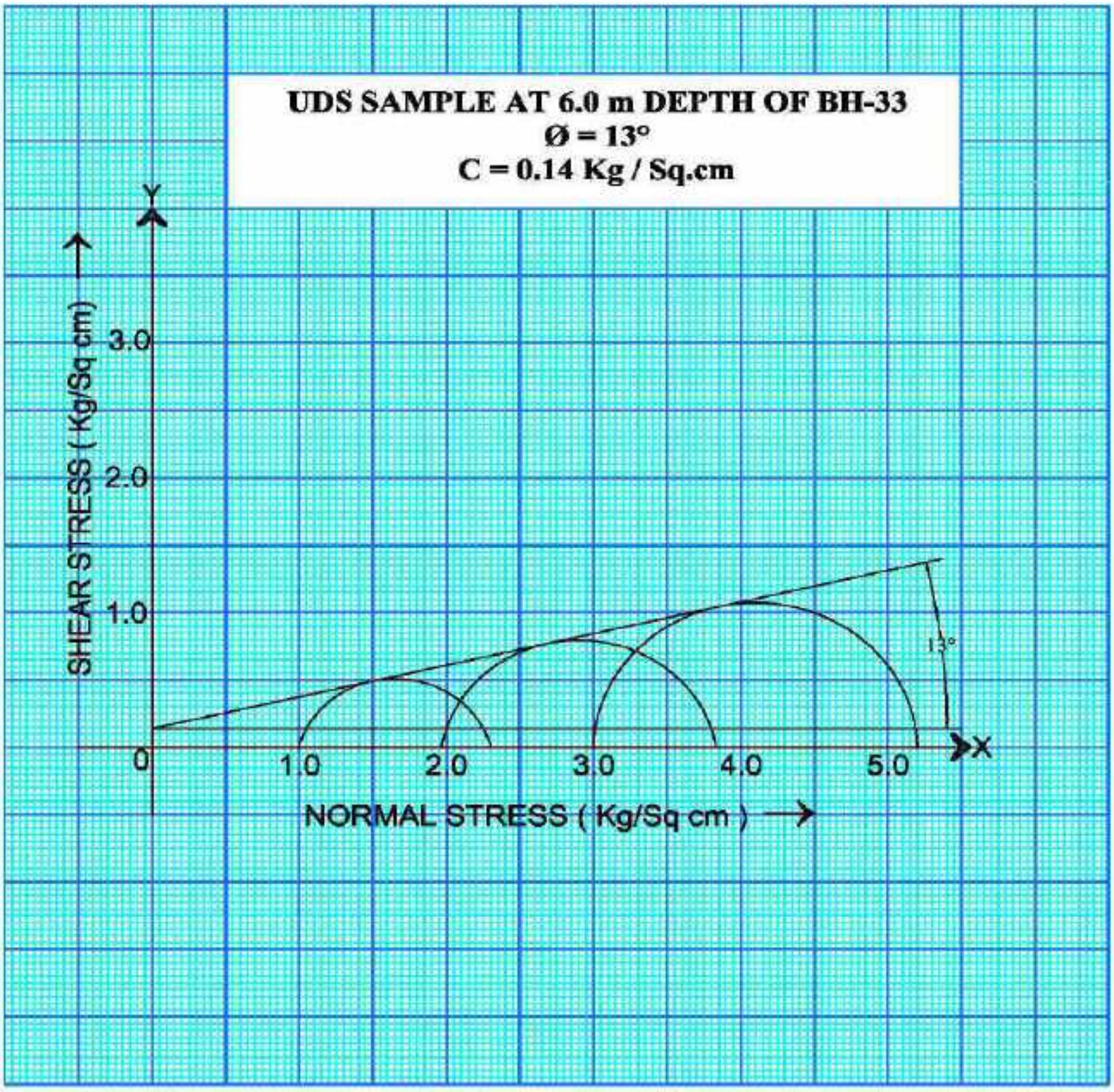


UDS SAMPLE AT 18.0 m DEPTH OF BH-32
Ø = 27°
C = 0.03 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm) →
27°

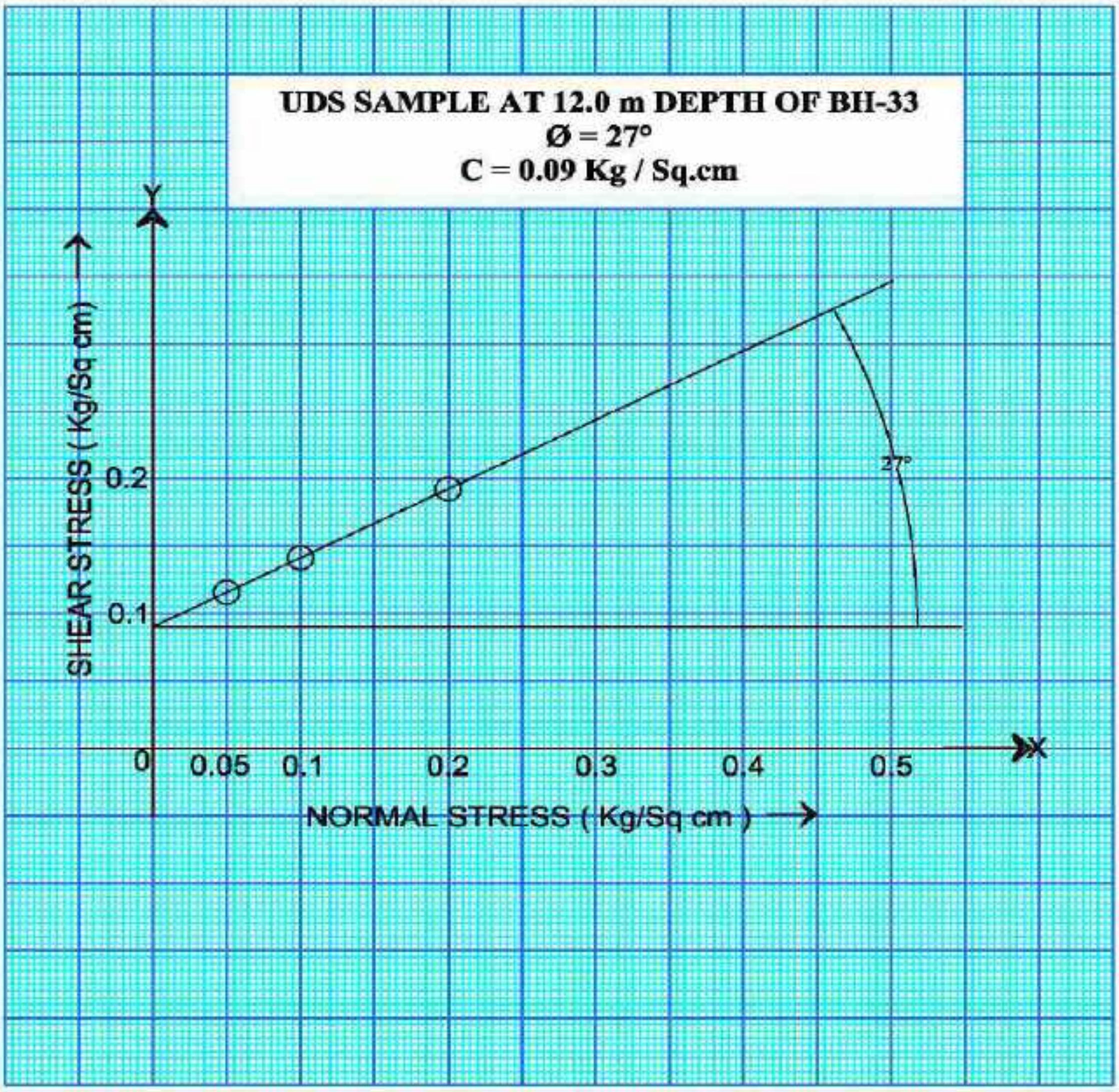

UDS SAMPLE AT 24.0 m DEPTH OF BH-32
Ø = 26°
C = 0.04 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
26°


UDS SAMPLE AT 30.0 m DEPTH OF BH-32
Ø = 17°
C = 0.16 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
17°
NORMAL STRESS (Kg/Sq cm)

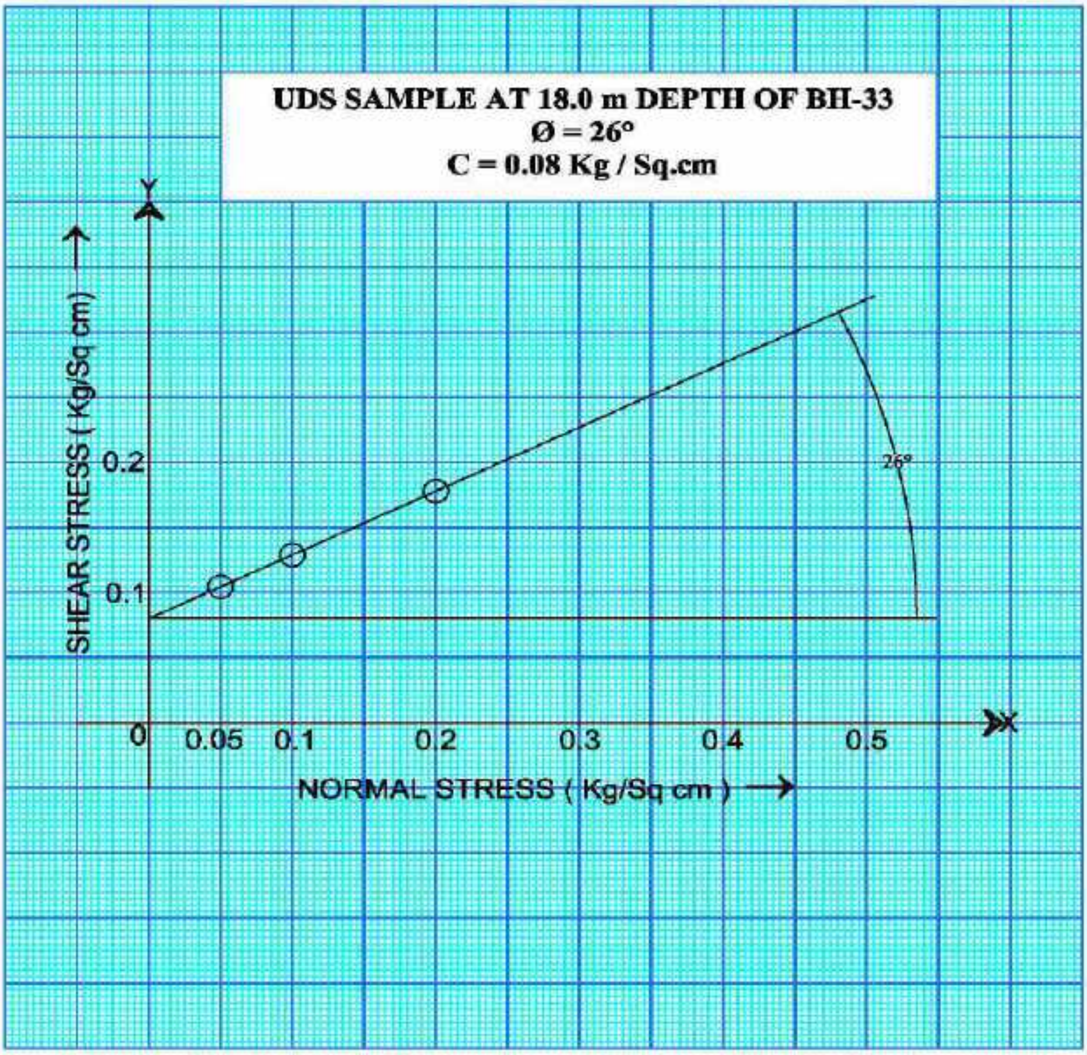

UDS SAMPLE AT 3.0 m DEPTH OF BH-33
Ø = 14°
C = 0.16 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS (Kg/Sq cm)



UDS SAMPLE AT 6.0 m DEPTH OF BH-33
Ø = 13°
C = 0.14 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
13°
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)



UDS SAMPLE AT 12.0 m DEPTH OF BH-33
Ø = 27°
C = 0.09 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
27°



UDS SAMPLE AT 18.0 m DEPTH OF BH-33
Ø = 26°
C = 0.08 Kg / Sq.cm

ANNEXURE K

ON-SITE LOG OF BOREHOLES

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S M CONSULTANTS

Geological Log of Borehole 13

BORE HOLE NO : 13
CHAINAGE m. : 25000
COLLAR ELEVATION : ---
RAIL LEVEL : ---
START DATE : 25-08-2021

CO-ORDINATES X: 700692.317
Y: 3121852.437
GROUND ELEVATION : 276.867 m
AZIMUTH : ---
ANGLE WITH HORIZONTAL: 0°
DATE COMPLETED : 06-09-2021

LOCATION Sohna
TOTAL DEPTH 60.0 m
TYPE OF CORE BARREL Double Tube
DEPTH OF WATER TABLE (m) Not Found
DRILLING AGENCY S.M ConsultantS
NAME OF GEOLOGIST Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					Structural condition	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss			Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS	
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description		20 40 60 80 100						Nil	Partial	Complete				
276.867	0.00		Clayey Silt(DS), Silty Sand(DS Wash)												NX			■					
275.367	1.50		Slightly Weathered, Highly Fractured, Highly Jointed, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	86		8	6		Joints of 0°,5°	▨	18	Diamond Bit	Nil	>15				■		Light Brown	12.5	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*	18
273.867	3.00		Slightly Weathered, Moderately Fractured, Highly Jointed, White to Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	82		7	11		Joints of 0°,10°, One Andulating Joint	▨	28.6		Nil	>15				■			13.63		28.6
272.367	4.50		Slightly Weathered, Highly Fractured, Highly Jointed, Light Grey to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	95		5			Joints of 0°,5°,10°	▨	44.6		Nil	>15				■			15		44.6
270.867	6.00		Highly Weathered, Highly Fractured, Highly Jointed, Light Grey to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	93	1	6			Highly Fractured, Crushed Zone	▨	21.33		Nil	>15				■			12.5		21.3
269.367	7.50		Slightly Weathered, Highly Fractured, Highly Jointed, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	85			15		Highly Fractured, Joints of 0°,10°,15°	▨	70		10	>15				■			12		25.3
267.867	9.00		Highly Weathered, Highly Fractured, Highly Jointed, White to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	91	1	8			Highly Fractured, Crushed Zone	▨	37.33		Nil	>15				■			12.5		37.3
266.367	10.50			97		3				▨	34		Nil	>15				■			12.5		34
264.867	12.00		Moderately Weathered, Highly Fractured, Highly Jointed, Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	80		2	7	11	Joints of 0°,10°, 65°, 80°	▨	28		17.3	>15				■			13.04		28
263.367	13.50		Highly Weathered, Highly Fractured, Highly Jointed, Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	98	2				Highly Fractured, Joint of 80°	▨	21.33		Nil	>15				■			11.53		21.3
261.867	15.00			100					Highly Fractured, Joints of 0°,10°,80°	▨	34		Nil	>15				■			12.5		34
260.367	16.50		Slightly Weathered, Highly Fractured, Highly Jointed, Reddish Brown to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	87		8	5		Joints of 0°,5°,10°	▨	32		Nil	>15					■		14.28		32
258.867	18.00		Slightly Weathered, Highly Fractured, Highly Jointed, Milky White to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	84	1	4	11			▨	32.85		Nil	>15					■		12.5		32.9
257.367	19.50		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Reddish Brown to Light Brown Staining)	87		3	10		Highly Fractured, Joint of 0°	▨	30		9	>15					■		12.5		30
255.867	21.00			87		5	8		Joints of 0°,5°,10°	▨	39.33		Nil	>15					■		14.28		39.3
254.367	22.50			75		9	16		Joints of 0°,10°,65°, Closed Joint of 80°	▨	33.33		Nil	>15					■		15		33.3
252.867	24.00		Slightly Weathered, Highly Fractured, Highly Jointed, Reddish Brown to Light Brown and Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	82		7	11		Joints of 0°,10°,45°	▨	39.33 28.66		Nil	>15					■		12.5		39.3
251.367	25.50		Slightly Weathered, Highly Fractured, Highly Jointed, Milky White to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	70		4	26		Joints of 0°,10°	▨			9	>15					■		14.28		28.7
249.867	27.00			74			14	12		▨	34		18	>15					■		13.63		34
248.367	28.50			64			8	28		▨	34		24	>15					■		14.28		34

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AN ISO 9001 COMPANY
BHUBANESHWAR

Geological Log of Borehole 13

BORE HOLE NO	: 13	CO-ORDINATES X:	700692.317	LOCATION	Sohna
CHAINAGE m.	: 25000	Y:	3121852.437	TOTAL DEPTH	60.0 m
COLLAR ELEVATION	: ---	GROUND ELEVATION :	276.867 m	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH :	---	DEPTH OF WATER TABLE (m)	Not Found
START DATE	: 25-08-2021	ANGLE WITH HORIZONTAL:	0°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED:	06-09-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					Structural condition	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss			Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description		20 40 60 80 100						Nil	Partial	Complete			
248.367	28.50																					
246.867	30.00		Slightly Weathered, Highly Fractured, Highly Jointed, Milky White to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Completely weathered Garnet Pores)	68			15	17	Joints of 0°,10°		40	Diamond Bit	20	>15				▨		Light Brown	12.5	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
245.367	31.50		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	79		21			Joints of 0°,10°, Closed Joint of 80°		31.33		Nil	>15				▨			14.28	
243.867	33.00			80			20		Joints of 0°,5°,10°		33.33		8.6	>15					▨		12.5	
242.367	34.50			76		5	7	12			24		10.6	>15					▨		11.53	
240.867	36.00		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Minor Phyllite Band Noticed)	87		5	8		Joints of 0°,10°, Closed Joint of 85°		35.33		7.6	>15					▨		13.63	
239.367	37.50			76		7	17		Contact Joint of 85°		32.6		7.6	>15					▨		14.28	
237.867	39.00		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Reddish Brown to Light Brown Staining)	94			6		Highly Fractured, Highly Jointed		26.66		Nil	>15					▨		11.53	
236.367	40.50			85		6	9		Joints of 0°,10°, 30°, 80°		32		8.6	>15					▨		13.63	
234.867	42.00			78			6	16	Joints of 0°,10°,Contact Joint of 80°		43.33		9.3	>15					▨		16.66	
233.367	43.50			83		3	14		Joints of 0°,10°, Very Rough Joint of 80°		26		7.6	>15					▨		12.5	
231.867	45.00			78			15	7	Joints of 0°,10°		33.33		15.6	>15					▨		14.28	
230.367	46.50			97		3			Highly Fractured, Joints of 10°,20°, 70°, 80°		30		Nil	>15					▨		12.5	
228.867	48.00			79		3	8	10	Highly Fractured, Joints of 0°,10°,15°		22.66		19	>15					▨		14.28	
227.367	49.50			69		2	7	22			34		28.6	15-8					▨		12.5	
225.867	51.00			90		4	6				27.33		Nil	>15					▨		13.63	
224.367	52.50			92		2	6				26		Nil	>15					▨		14.28	
222.867	54.00			91		4	5				34		Nil	>15					▨		12.5	
221.367	55.50			81		5	14		Joints of 0°,10°, 15°, 20°		34		Nil	>15					▨		12.5	
219.867	57.00			88		3	9		Joints of 10°, 15°, 20°, Very Rough Joint 80°		26.66		8.6	>15					▨		1..63	
218.367	58.50			88				12	Joints of 0°,10°, 15°, 20°		28		8	>15					▨		12.5	
216.867	60.00			84		3		13	Joints of 0°,10°, 15°, 30°		22		13	>15					▨		12.5	

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BHUBANESWAR

Geological Log of Borehole 14

BORE HOLE NO	: 14	CO-ORDINATES X:	700578.153	LOCATION	Sohna
CHAINAGE m.	: 25195	Y:	3122015.421	TOTAL DEPTH	75m
COLLAR ELEVATION	: ---	GROUND ELEVATION :	294.218	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH :	---	DEPTH OF WATER TABLE (m)	Not Found
START DATE	: 11-08-2021	ANGLE WITH HORIZONTAL:	0°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED :	23-08-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					Structural condition	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss			Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description		20 40 60 80 100						Nil	Partial	Complete			
294.218	0.00																					
292.718	1.50		Moderately Weathered, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	100					Highly Fractured		30	Diamond Bit	Nil	>15	NX					Light Brown	16.6	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
291.218	3.00			82		5	13		Joints of 0°,5°,10°,65°		48		Nil	>15							15	
289.718	4.50			76		11	13				38		Nil	>15							16.6	
288.218	6.00		Moderately Weathered, Moderately Fractured, Highly Jointed Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite (Small Talc Amygdals Noticed)	54		3	43				66		24	>15							20	
286.718	7.50		Slightly Weatherd, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	82		11	7		Highly Fractured		45		Nil	>15							16.6	
285.218	9.00		Slightly to Moderately Weatherd, Highly Farctured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite (Very Fine Grained Muscovite Flakes)	88		3	9		Joints of 0°,5°,10°,65°		50		18	>15							11.5	
283.718	10.50		Moderately Weathered, Moderately Fractured, Highly Jointed Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	76		11	13				51		Nil	>15							12.5	
282.218	12.00		Slightly to Moderately Weatherd, Highly Farctured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	60		4	9	27			40		21	>15							13.6	
280.718	13.50		Moderately Weathered, Highly Fractured, Highly Jointed Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	78		4		18			34		15	>15							16.6	
279.218	15.00		Highly Weathered, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	96		4			Highly Fractured		21		Nil	>15							12.5	
277.718	16.50			93		7					29		Nil	>15							12.5	
276.218	18.00			89				11	Joints of 0°,5°,10°,65°		28		9	>15							16.6	
274.718	19.50		Slightly Weathered, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	84			16				34		6	>15							16.6	
273.218	21.00			81		3	16				23		Nil	>15							11.53	
271.718	22.50			78		3	19				28		13	>15							10.71	
270.218	24.00			83			17				23		6	>15							13	
268.718	25.50			92		8					20		Nil	>15							11.5	
267.218	27.00			88		2		10	Joints of 0°,5°,10°		25		9	>15							13.6	
265.718	28.50			90		4	6				28		Nil	>15							12.5	
264.218	30.00			75			5	20			25		18	>15							16.3	
262.718	31.50			75		4	6	15			28		14	>15							16.3	
261.218	33.00		Moderately Weathered, Modertely Fractured, Highly Jointed, Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	69			11	20			28		18	>15							19.7	
259.718	34.50		Highly Weathered, Highly Fractured, Highly Jointed, Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	87			5	8			22		6	>15							16.6	
258.218	36.00			96		4			Joints of 0°,5°,10°,65°		25		Nil	>15							16.6	
256.718	37.50			79		5	16				29		10	>15							12.5	

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BHUBANESHWAR

Geological Log of Borehole 14

BORE HOLE NO	: 14	CO-ORDINATES	X:	700578.153		LOCATION	Sohna
CHAINAGE m.	: 25195		Y:	3122015.421		TOTAL DEPTH	75m
COLLAR ELEVATION	: ---	GROUND ELEVATION	:	294.218		TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH	:	---		DEPTH OF WATER TABLE (m)	Not Found
START DATE	: 11-08-2021	ANGLE WITH HORIZONTAL	:	0°		DRILLING AGENCY	S.M Consultants
		DATE COMPLETED	:	23-08-2021		NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					Structural condition	Log	% of Core-Recovery (20 40 60 80 100)	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss			Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description								Nil	Partial	Complete			
256.718	37.50																					
255.218	39.00	░	Highly Weathered, Highly Fractured, Highly Jointed, Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	84		9	7		Joints of 0°,5°,10°,65°	▨	28	Diamond Bit	7	>15					■		15	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
253.718	40.50			96		4			Highly Fractured		30		Nil	>15							15	
252.218	42.00			87		6	7		Joints of 0°,5°,10°,65°		28		7	>15							12.5	
250.718	43.50		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	81		8	11				25		Nil	>15							12.5	
249.218	45.00			85			6	9			26		6	>15							13.6	
247.718	46.50			83		6	11				24		Nil	>15							21.12	
246.218	48.00			74		20	6				26		Nil	>15							18.07	
244.718	49.50			84		4		12	Joints of 0°,5°,10°		27		18	>15							178	
243.218	51.00			90		4	6				22		Nil	>15							15.95	
241.718	52.50			90		3	7				22		Nil	>15							15.78	
240.218	54.00			70		2		28			22		Nil	>15							18.75	
238.718	55.50			84		16					26		Nil	>15							13.63	
237.218	57.00			91	1	8					26		Nil	>15							18.07	
235.718	58.50			93			7				22		10	>15							20.27	
234.218	60.00			93		2	5				21		Nil	>15							18.75	
232.718	61.50			91			9				22		Nil	>15							15.78	
231.218	63.00			100					Joints of 0°,5°,10°,80°		22		Nil	>15							16.4	
229.718	64.50			86		5	9		Highly Fractured		25		13	>15							16.3	
228.218	66.00			91		2	7				28		11	>15							19.7	
226.718	67.50			95			5				28		Nil	>15							17.6	
225.218	69.00			82		13	5				28		Nil	>15							14.8	
223.718	70.50			91			9		Joints of 0°,5°,10°,65°		26		8	>15							16.6	
222.218	72.00			82			18				27		14	>15							15.15	
220.718	73.50			80		9	11		Joints of 0°,5° ,65°		26		14	>15							19.23	
219.218	75.00			100					Highly Fractured		22		Nil	>15							12.50	

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S.M CONSULTANTS

Geological Log of Borehole 15

BORE HOLE NO	:	15	CO-ORDINATES	X:	700451.868	LOCATION	Sohna
CHAINAGE Km.	:	25380		Y:	3122157.745	TOTAL DEPTH	70.0 m
COLLAR ELEVATION	:	---	GROUND ELEVATION	:	295.532	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	:	---	AZIMUTH	:	---	DEPTH OF WATER TABLE (m)	61.0 m
START DATE	:	12-08-2021	ANGLE WITH HORIZONTAL:		0°	DRILLING AGENCY	S.M Consultants
			DATE COMPLETED	:	28-08-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					Structural condition	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss			Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS	
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description		20 40 60 80 100						Nil	Partial	Complete				
295.532	0.00																						
294.032	1.50		Moderately Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	91		4	5		Joints of 0°, 5, 10°, 15°		26	Diamond Bit	0	>15	NX			■		Light Brown	12.5	As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.	26
292.532	3.00			83		9	8				28		7	>15					■		16.6		28
291.032	4.50			75		6	19				42		7	>15					■		16.3		42
289.532	6.00			72		15	13				36		0	>15					■		15.6		36
288.032	7.50			59		22	19				46		0	>15					■		13.04		46
286.532	9.00			78		9	13				24		7	>15					■		17.64		24
285.032	10.50			78		8	14				34		14	>15					■		16.3		34
283.532	12.00			87	1	12					20		0	>15					■		16.66		20
282.032	13.50			90		10					23		0	>15					■		18.75		23
280.532	15.00			100							16		0	>15					■		15		16
279.032	16.50		Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	91		9			Joints of 0°, 5, 10°, 25°		16		0	>15					■		12.5		16
277.532	18.00			84		5	11		Joints of 0°, 5, 10°, 15°		22		0	>15					■		12.5		22
276.032	19.50			68	2	8	22				41		17	>15					■		14.28		41
274.532	21.00			82		12	6				28		0	>15					■		14.28		28
273.032	22.50			95		5					26		0	>15					■		16.66		26
271.532	24.00			80			7	13	Joints of 0°, 5, 10°, 35°		36		18	>15					■		13.63		36
270.032	25.50			97		3					27		0	>15					■		12.5		27
268.532	27.00			85		9	6				36		0	>15					■		16.66		36
267.032	28.50			82		9	9				33		8	>15					■		16.66		33
265.532	30.00			91	2	7					20		0	>15					■		15.7		20
264.032	31.50			84		16					23		0	>15					■		16.66		23
262.532	33.00			81	2	4	13				21		0	>15					■		16.66		21
261.032	34.50			78		2	20				30		7	>15					■		14.7		30
259.532	36.00			82			18		Joints of 0°, 5, 10°, 45°		32		0	>15					■		17.04		32
258.032	37.50			84		9	7				31		0	>15					■		15.6		31

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
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BHUBANESHWAR

Geological Log of Borehole 15

BORE HOLE NO	:	15	CO-ORDINATES X:	700451.868	LOCATION	Sohna
CHAINAGE Km.	:	25380	Y:	3122157.745	TOTAL DEPTH	70.0 m
COLLAR ELEVATION	:	---	GROUND ELEVATION :	295.532	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	:	---	AZIMUTH :	---	DEPTH OF WATER TABLE (m)	61.0 m
START DATE	:	12-08-2021	ANGLE WITH HORIZONTAL:	0°	DRILLING AGENCY	S.M Consultants
			DATE COMPLETED:	25-08-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					Structural condition	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss			Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description		20 40 60 80 100						Nil	Partial	Complete			
258.032																						
256.532	39.00		Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	83		10	7		Joints of 0°, 5, 10°, 45°		30	Diamond Bit	6	>15					■		18.51	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominent Rock*
255.032	40.50			94	1	5			Joints of 0°, 5, 10°, 15°		25		0	>15					■		16.12	
253.532	42.00			63		13	8	16			40		22	>15					■		15.7	
252.032	43.50			66		11	23				28		8	>15					■		15	
250.532	45.00			82	1		17				30		6	>15					■		15.7	
249.032	46.50			85		4	11				26		0	>15					■		15	
247.532	48.00			69		4	27		Joints of 0°, 5, 10°, 55°		38		27	>15					■		15.7	
246.032	49.50			85		5	10		Joints of 0°, 5, 10°, 15°		29		10	>15					■		16.6	
244.532	51.00			90			10				22		0	>15					■		17.6	
243.032	52.50			76		3	21				26		15	>15					■		14.8	
241.532	54.00			88				12			20		10	>15					■		15.9	
240.032	55.50			83			17		Joints of 0°, 5, 10°, 35°		26		0	>15					■		15.7	
238.532	57.00			100					Joints of 0°, 5, 10°, 90°		20		0	>15					■		15.7	
237.032	58.50			87		6	7		Highly Fractured		25		0	>15					■		16.6	
235.532	60.00			92		8					34		0	>15				■		Greyish Brown	16.3	
234.032	61.50			76			24		Joints of 0°, 5, 10°, 15°		28		24	>15				■			14.2	
232.532	63.00			92			8				20		8	>15				■			15.7	
231.032	64.50			84			16				32		16	>15				■			14.2	
229.532	66.00			79		7	14		Joints of 0°, 5, 10°, 30° 75°		31		14	>15				■		Light Brown	12.5	
228.032	67.50			83			7	10			27		9	>15				■			14.28	
226.532	69.00			73		4	23				28		8	>15				■			12.5	
225.532	70.00			67		6	27				57		10	>15				■			12.5	

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S.M CONSULTANTS
BHUBANESWAR

Geological Log of Borehole 15(A)

BORE HOLE NO	: 15A (Ditch)	CO-ORDINATES	X:	700374.567	LOCATION	Sohna
CHAINAGE m.	: 25488		Y:	3122232.681	TOTAL DEPTH	50m
COLLAR ELEVATION	: ---	GROUND ELEVATION	:	276.442 m	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH	:	---	DEPTH OF WATER TABLE (m)	10m
START DATE	: 15-09-2021	ANGLE WITH HORIZONTAL:		0°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED	:	01-10-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery 20 40 60 80 100	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
276.442	0.00															↓		■				
274.942	1.50	░	Moderately Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Very Fine Grained Pyrite Crystals)	90	1	4	5		Joints of 0°, 5°,10°,15°	▨		Diamond Bit	0	>15		↓		■		Light Brown	15	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
273.442	3.00	░		78	4	3		15		▨	39		10	>15		↓		■			14	
271.942	4.50	░		79			21			▨	32		21	>15		↓		■			15	
270.442	6.00	░		88		12			Joints of 0°, 5°,10°,15°, 30°	▨	35		0	>15		↓		■			13	
268.942	7.50	░	Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Very Fine Grained Pyrite Crystals)	72			28			▨			28	15-8		↓		■			18	
267.442	9.00	░		90	3	7				▨			0	>15		↓		■			14	
265.942	10.50	░		70	3	4	23			▨			30	15-8		↓		■			15	
264.442	12.00	░		78			22		Joints of 0°, 5°,15°, 45°	▨	35		22	>15				■			14	
262.942	13.50	░		82	1	3	14			▨	32		8	>15				■			15	
261.442	15.00	░		65	2			33		▨	47		32	15-8				■			15	
259.942	16.50	░		89		2	9		Joints of 0°, 5°,15°, 80°	▨	28		8	>15				■			18	
258.442	18.00	░		90	1	2	7		Joints of 0°, 5°,10°, 15°	▨	41		7	>15				■			16	
256.942	19.50	░		81	2		17			▨	36		16	>15				■			15	
255.442	21.00	░		76		4		20		▨	45		20	>15				■			15	
253.942	22.50	░		80		5	15			▨	30		15	>15				■			15	
252.442	24.00	░		88	1	5	6		Joints of 0°, 5°,10°, 35°	▨	36		0	>15				■			14	
250.942	25.50	░		99	1				Joints of 0°, 5°,10°, 15°	▨	27		0	>15				■		Grey	15	
249.442	27.00	░		83		2	15			▨	40		15	>15				■		Light Brown	16	
247.942	28.50	░		77			23			▨	32		23	>15				■			14	
246.442	30.00	░		87		13				▨	34		0	>15				■			16	
244.942	31.50	░		78			22			▨	34		22	>15				■			15	
243.442	33.00	░		83			17			▨	30		15	>15				■			14	
241.942	34.50	░		90		2	8		Joints of 0°, 5°,10°, 70°	▨	30		8	>15				■			13	
240.442	36.00	░		94		6				▨	36		0	>15				■			15	
238.942	37.50	░		97		3			Joints of 0°, 5°,10°, 15°	▨	37		23	>15				■			15	

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

Geological Log of Borehole 15(A)

BORE HOLE NO : 15A (Ditch)
CHAINAGE Km. : 25488
COLLAR ELEVATION : ---
RAIL LEVEL : ---
START DATE : 15-09-2021

CO-ORDINATES X: 700374.567
Y: 3122232.68
GROUND ELEVATION : 276.442
AZIMUTH : ---
ANGLE WITH HORIZONTAL: 0°
DATE COMPLETED: 01-10-2021

LOCATION Sohna
TOTAL DEPTH 50.0 m
TYPE OF CORE BARREL Double Tube
DEPTH OF WATER TABLE (m) 10.0 m
DRILLING AGENCY S.M Consultants
NAME OF GEOLOGIST Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery 20 40 60 80 100	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
238.942																						
237.442	39.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Very Fine Grained Pyrite Crystals)	89	1	10			Joints of 0°, 5°,10°, 15°		40	Diamond Bit	7	>15				▨		Light Brown	15	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
235.942	40.50			90			10				50		10	>15				▨			13	
234.442	42.00			90		10					34		0	>15				▨			14	
232.942	43.50			84		2	14				32		8	>15				▨			13	
231.442	45.00			81		6	13				35		0	>15				▨			16	
229.942	46.50			98	2						30		0	>15				▨			13	
228.442	48.00			92	1		7		Joints of 0°, 5°,10°, 70°		36		7	>15				▨			15	
226.942	49.50			86	2	4	8				40		8	>15				▨			15	
226.442	50.00			98			2		Joints of 0°, 5°,10°, 15°		40		0	>15				▨			15	

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BHUBANESWAR

Geological Log of Borehole 16

BORE HOLE NO	: 16		CO-ORDINATES X:	700297.426		LOCATION	Sohna
CHAINAGE Km.	: 25586		Y:	3122294.327		TOTAL DEPTH	62.0 m
COLLAR ELEVATION	: ---	---	GROUND ELEVATION :	287.324		TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	---	AZIMUTH :	---		DEPTH OF WATER TABLE (m)	50.0 m
START DATE	: 26-08-2021		ANGLE WITH HORIZONTAL:	0°		DRILLING AGENCY	S.M Consultants
			DATE COMPLETED :	10-09-2021		NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					Structural condition	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss			Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description		20 40 60 80 100						Nil	Partial	Complete			
287.324	0.00																					
285.824	1.50		Moderately Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite (DS and DS Wash Collected)	93		2	5		Highly Fractured	▨	16	Diamond Bit	0	>15	NX				■	Light Brown	12.5	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
284.324	3.00		Moderately Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	93			7			▨	25		0	>15					■		14.8	
282.824	4.50			90		4	6			▨	32		0	>15					■		13.63	
281.324	6.00			88		5	7			▨	32		0	>15					■		13.63	
279.824	7.50			97		3				▨	30		0	>15					■		12.5	
278.324	9.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	84			16		Joints of 0°,10°,15°,20°	▨	31		10	>15					■		14.28	
276.824	10.50			83	1	3	13			▨	30		0	>15					■		12.5	
275.324	12.00			78		6	16			▨	34		0	>15					■		16.6	
273.824	13.50			74		4	9	13		▨	31		15.33	>15					■		12.5	
272.324	15.00		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	74			11	15		▨	27		10.3	>15					■		13.04	
270.824	16.50			80				20	Closed Joint of 80°	▨	36		19	>15					■		13.63	
269.324	18.00			85				15	Joints of 0°,10°,15°,20°	▨	28		15.3	>15					■		15	
267.824	19.50			56	1		10	33		▨	46		36.3	15-8					■		12.5	
266.324	21.00			71			19	10		▨	48		0	>15					■		11.53	
264.824	22.50			72				28		▨	44		14	>15				■		Light Brown	12.5	
263.324	24.00			74			26		Joints of 0°,10°,15°,45°	▨	43		11	>15				■			13.63	
261.824	25.50			65			6	29	Joints of 0°,10°,15°,20°	▨	42		28	15-8				■			13.04	
260.324	27.00			78			22			▨	34		15	>15				■			13.63	
258.824	28.50			53				47		▨	53		47	15-8				■			15	
257.324	30.00			76			24		Joints of 0°,10°,15°, 70°	▨	31		8	>15					■		11.5	
255.824	31.50			79				21	Joints of 0°,10°,15°	▨	39		34	15-8					■		15	
254.324	33.00			83			17			▨	30		14	>15					■		12.5	
252.824	34.50			71		2		27		▨	36		25	>15					■		16.6	
251.324	36.00			78				22		▨	30		22	>15					■		13.6	
249.824	37.50			65			5	30		▨	37		22	>15					■		15	

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BHUBANESHWAR

Geological Log of Borehole 16

BORE HOLE NO	: 16	CO-ORDINATES	X:	700297.426		LOCATION	Sohna
CHAINAGE Km.	: 25586		Y:	3122294.327		TOTAL DEPTH	62.0 m
COLLAR ELEVATION	: ---	--- GROUND ELEVATION	:	287.324		TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	--- AZIMUTH	:	---		DEPTH OF WATER TABLE (m)	50.0 m
START DATE	: 26-08-2021	ANGLE WITH HORIZONTAL:		0°		DRILLING AGENCY	S.M Consultants
		DATE COMPLETED:		10-09-2021		NAME OF GEOLOGIST	Gaurav Chunekar

				Size of Core Pieces					Structural condition	Log	% of Core-Recovery										Water Loss					
Elevation (m)	Depth (m)	Litho-Log	Lithological Description	<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description		20	40	60	80	100	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
249.824																										
248.324	39.00	░	Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	85			15		Joints of 0°,10°,15°	▨	30					Diamond Bit	8	>15				■		Light Brown	12.5	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
246.824	40.50			69		3	5	23		▨	34						20	>15				■			10.71	
245.324	42.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	86			14		Highly Fractured	▨	36						0	>15					■		12.5	
243.824	43.50		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	64			18	18	Joints of 0°,10°,15°, 75°	▨	42						16.6	>15					■		13.63	
242.324	45.00			55				45	Joints of 0°,10°,15°	▨	44						44	15-8					■		11.53	
240.824	46.50		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	85			15		Highly Fractured	▨	37						0	>15					■		14.28	
239.324	48.00		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	46				54	Joints of 0°,10°,15°	▨	53						51.3	8-5					■		12.5	
237.824	49.50			62	1		26	11		▨	45						15.3	>15					■		11.53	
236.324	51.00			68		4		28		▨	38						26.6	15-8				■		Light Brown	12.5	
234.824	52.50		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Weathered Medium Grained Garnet Grains, Contact of Phyllite Band Noticed)	60		3		37	Open Joint 80° (Phyllite Band Contact)	▨	40						29.3	15-8				■			10.71	
233.324	54.00			72			16	12		▨	43						16.3	>15					■		10.71	
231.824	55.50		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	60			17	23	Joints of 0°,10°,15°	▨	43						21	>15					■		12.5	
230.324	57.00			76			24			▨	31						8	>15					■		13.63	
228.824	58.50			80				20		▨	30						17.6	>15					■		13.63	
227.324	60.00			75				25		▨	25						20	>15				■		Light Brown	12.5	
225.824	61.50			70			10	20		▨	32						24.3	>15					■		11.53	
224.324	62.00			83			17		Closed Joint of 70°	▨	66						8.6	>15					■		14.28	

Geological Log of Borehole 17

BORE HOLE NO : 17
CHAINAGE Km. : 25785
COLLAR ELEVATION : --- ---
RAIL LEVEL : 232.394 ---
START DATE : 22-12-2021

CO-ORDINATES X: 700117.355
Y: 3122388.462
GROUND ELEVATION : 282.461
AZIMUTH : ---
ANGLE WITH HORIZONTAL: 90°
DATE COMPLETED : 27-01-2022

LOCATION Sohna
TOTAL DEPTH 62.0 m
TYPE OF CORE BARREL Double Tube
DEPTH OF WATER TABLE (m) 38.6 m
DRILLING AGENCY S.M Consultants
NAME OF GEOLOGIST Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					Structural condition		% of Core-Recovery	Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss			Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description	Log	20 40 60 80 100	N Value	Depth of Penetration in cm						Nil	Partial	Complete			
282.461	0.00																							
280.961	1.50		Brown colour, very fine to fine grained, clayey silt deposit						very fine to fine grained, clayey silt deposit		0			Diamond Bit	NA	NA	NX			■		Brown	30.61	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
279.461	3.00		Brown colour, very fine to fine grained, clayey silt deposit						very fine to fine grained, clayey silt deposit		0	12	45		NA	NA				■			33.3	
277.961	4.50										0				NA	NA				■			27.27	
276.461	6.00										0	16	45		NA	NA				■			27.27	
274.961	9.00										30				NA	NA				■			30	
273.461	12.00		Brown colour, very fine to fine grained, clayey silt with gravels..						very fine to fine grained, clayey silt with gravels..		0	26	45		NA	NA				■			31.57	
271.961	15.00										0	21	45		NA	NA				■			30	
270.461	16.50										0	37	45		NA	NA				■			21.42	
268.961	18.00		Brown colour, very fine to fine grained, sub angular to sub rounded pebbels with clayey silt.						It shows very fine to fine grained, sub angular to sub rounded pebbels clayey silt.		0	>50	23		NA	NA				■			21.12	
267.461	19.50		Highly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Hard Quartzite.	<10	23	35			Joints of 0°,45°		17				0	>15					■		12	
265.961	20.50			<10	20	31			Closed Joint of 10°		22				0	>15					■		6.89	
264.461	22.00			<10				174	It shows highly fractured weathered rock		25				11.6	>15					■		10	
262.961	23.00			<10		70					32				0	15-8					■		11.11	
261.461	24.50			<10			175				33				0	>15					■		10.71	
259.961	25.00		Moderately Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite.			35	125		Joints of 0°,10°,15°		48				25	15 to 8					■		5.5	
258.461	26.00			<10		42		376	Joints of 0°, 15°,80°		59				32.6	15 to 8					■		7.4	
256.961	27.50			<10		66	175	190	Joints of 0°,10°,15°,20°		44				12.66	15 to 8					■		12.5	
255.461	28.00					70	214				68				25.8	15 to 8					■		6.6	
253.961	29.50		Highly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Hard Quartzite.	<10		130			It shows highly fractured weathered rock		58				7.6	15 to 8					■		11.53	
252.461	30.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	<10		49	93		Joints of 0°,10°,15°, 70°		70				0	>15					■		7.14	
250.961	31.00			<10		30	191	153	It shows highly angular fractured and jointed, weak strength		47				17.13	>15					■		7.4	
249.461	32.50			<10		60	80				64				0	>15					■		11.53	
247.961	33.50		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	<10		50	395				54				15.53	>15					■		11.11	
246.461	35.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite.(crushed zone)	<10	17	75	90				34.66				0	15 to 8					■		11.53	
244.961	36.50		Light Brown colour, Coarse grained, Sand. (SPT Rebounded)						Coarse grained, Sand. (SPT Rebounded)		0	>50	3		NA	NA				■		Brown	21.42	

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S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

Geological Log of Borehole 17

BORE HOLE NO	: 17	CO-ORDINATES	X:	700117.355	LOCATION	Sohna
CHAINAGE Km.	: 25785		Y:	3122388.462	TOTAL DEPTH	62.0 m
COLLAR ELEVATION	: ---	--- GROUND ELEVATION	:	282.461	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: 232.394	--- AZIMUTH	:	---	DEPTH OF WATER TABLE (m)	38.6 m
START DATE	: 22-12-2021	ANGLE WITH HORIZONTAL:		90°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED	:	27-01-2022	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					Structural condition		% of Core-Recovery	Standard Penetration		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss			Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	Description	Log	20 40 60 80 100	N Value	Depth of Penetration in cm						Nil	Partial	Complete			
244.961																								
243.461	38.00		Light Brown colour, Coarse grained, Sand. (SPT Rebounded)						Coarse grained, Sand. (SPT Rebounded)		0	>50	2	Diamond Bit	NA	NA				■		Brown	23	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
241.961	39.50										0	>50	2		NA	NA				■			14.28	
240.461	41.00		Moderatey to Slightly Weathered, Moderately to Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	<10		60		165	Highly Fractured		32				11	15 to 8					■		10.71	
238.961	42.50			<10			110	180	Joints of 0°,10°,15°		41.33				19.33	15 to 8					■		12.5	
237.461	44.00			<10			150	473	Joints of 0°		54				41.53	15 to 8					■		11.11	
235.961	45.50			<10		107	257		Highly Fractured, Joints of 0°		30				16.66	15 to 8					■		12	
234.461	47.00			<10			180		Highly Fractured, Joints of 0°,10°,15°		37.33				0	15 to 8					■		11.53	
232.961	48.50			<10		56	316				41.33				21.06	15 to 8					■		10.86	
231.461	50.00			<10		279					30				0	15 to 8					■		10.34	
229.961	51.50			<10	25	383					36.66				0	15 to 8					■		12	
228.461	53.00			<10		71	323	180			34.66				12	15 to 8					■		11.53	
226.961	54.50			<10		135	192		Highly Fractured, Joints of 0°		33.33				6.8	15 to 8					■		11.11	
225.461	56.00		Highly Weathered, Light Brown, Moderately Fractured, Loose material, Red, very fine to Fine Grained, weak silt stone with clay material (Crushed zone)	<10			181		very fine to Fine Grained, weak silt stone with clay material		28				6.73	15 to 8					■		15	
223.961	58.00			<10		50		160			38				8	15 to 8					■		12.96	
222.461	59.50			<10		70					38.33				0	15 to 8					■		13	
220.961	61.00		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	<10		30	235	180	Joints of 0°,10°,15°		40.6				27.66	15 to 8					■		12	
220.461	62.00			<10		48	345	190			70				12.66	15 to 8					■		9.5	

Geotechnical Investigation Report

Consultant:		Client :
S.M. CONSULTANTS BHUBANESWAR	Job No:- 830	Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-18

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-18	CO-ORDINATES	X	: 699961.797	LOCATION	:	Patuka
CHAINAGE (m.)	: 25990		Y	: 3122515.204	TOTAL DEPTH	:	55m
COLLAR ELEVATION	: ---	GROUND ELEVATION		: 280.253	TYPE OF CORE BARREL	:	Double Tube
RAIL LEVEL	: ---	AZIMUTH		: ---	DEPTH OF WATER TABLE (m)	:	26.20m
START DATE	: 02-02-2022	ANGLE WITH HORIZONTAL		: 90°	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	: 07-02-2022				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
280.253																								
279.753	0.50		Brown colour, fine grained,medium to dense compacted, silty clay with none to low plasticity													Nx	---	---			Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 280.253 m. The stratigraphy of area is prominently of Silty clay which comes under Alluvial Type of Category. Silty clay and with gravels is majorly tracked in the borehole.
278.753	1.50																---	---						
277.253	3.00													11	45		---	---						
275.753	4.50																---	---						
274.253	6.00													20	45		---	---						
271.253	9.00																---	---						
268.253	12.00													24	45		---	---						
265.253	15.00													31	45		---	---						
262.253	18.00													35	45		---	---						
259.253	21.00													40	45		---	---						
256.253	24.00													47	45		---	---						
253.253	27.00		Brown colour, fine grained, dense to very densed compacted, Silty clay with gravels.											49	45		---	---						
250.253	30.00													57	45		---	---						
247.253	33.00													64	45		---	---						
244.253	36.00													69	45		---	---						
241.253	39.00													77	45		---	---						
238.253	42.00													84	45		---	---						
235.253	45.00													>50	41		---	---						
233.253	47.00													>50	36									
230.253	50.00													>50	29		---	---						
227.253	53.00													>50	22									
225.253	55.00													>50	17		---	---						

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-19

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESWAR

BORE HOLE NO	: BH-19	CO-ORDINATES	X	: 699776.449	LOCATION	:	Patuka
CHAINAGE (m.)	: 26210		Y	: 3122635.179	TOTAL DEPTH	:	50m
COLLAR ELEVATION	: ---	GROUND ELEVATION		: 278.116	TYPE OF CORE BARREL	:	Double Tube
RAIL LEVEL	: ---	AZIMUTH		: ---	DEPTH OF WATER TABLE (m)	:	Not found
START DATE	: 25-07-2021	ANGLE WITH HORIZONTAL		: ---	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	: 26-07-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
278.116																								
277.616	0.50		Brown colour, fine grained,medium to dense compacted,clayey silt with none to low plasticity														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 278.116 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
276.616	1.50													17	45		---	---						
275.116	3.00																---	---						
273.616	4.50													23	45		---	---						
272.116	6.00																---	---						
269.116	9.00													30	45		---	---						
266.116	12.00																---	---						
263.116	15.00													35	45		---	---						
260.116	18.00																---	---						
257.116	21.00													35	45		---	---						
254.116	24.00																---	---						
251.116	27.00													39	45		---	---						
248.116	30.00																---	---						
245.116	33.00													43	45		---	---						
242.116	36.00		Brown colour, fine grained, dense to very densed compacted,Silty sand														---	---						
239.116	39.00													52	45		---	---						
236.116	42.00																---	---						
233.116	45.00													65	45		---	---						
230.116	48.00																							
228.116	50.00													80	45		---	---						

Geotechnical Investigation Report

Consultant:		Client :
S.M. CONSULTANTS **BHUBANESWAR**	**Job No:- 830** | **Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-20

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESWAR

BORE HOLE NO	:	BH-20	CO-ORDINATES	X	: 699630.8892	LOCATION	:	Patuka
CHAINAGE (m.)	:	26387		Y	: 3122738.2273	TOTAL DEPTH	:	48.00 m
COLLAR ELEVATION	:	---	GROUND ELEVATION		: 276.795 m	TYPE OF CORE BARREL	:	
RAIL LEVEL	:	---	AZIMUTH		:	DEPTH OF WATER TABLE (m)	:	Absent
START DATE	:	16-02-2021	ANGLE WITH HORIZONTAL		:	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	:	25-03-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
276.795																								
276.295	0.50		Brown Colour, Fine Grained, medium to Dense Compacted , Clayey Silt with None to Low Plasticity														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 276.795 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
275.295	1.50													18	45		---	---						
273.795	3.00																---	---						
272.295	4.50													32	45		---	---						
270.795	6.00																---	---						
267.795	9.00													48	45		---	---						
264.795	12.00		Brown Colour, Fine Grained, Dense Compacted, Silty Sand														---	---						
261.795	15.00		Brown Colour, Fine Grained, Very Dense Compacted, Clayey Silt with None to Low Plasticity											60	45		---	---						
258.795	18.00																---	---						
255.795	21.00													67	45		---	---						
252.795	24.00													76	45		---	---						
249.795	27.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility														---	---						
246.795	30.00													58	45		---	---						
243.795	33.00																---	---						
240.795	36.00													67	45		---	---						
237.795	39.00																---	---						
234.795	42.00													75	45		---	---						
231.795	45.00																---	---						
228.795	48.00													79	45		---	---						

Geotechnical Investigation Report

Consultant:		Client :
S.M. CONSULTANTS BHUBANESWAR	Job No:- 830 | Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-21

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	:	21	CO-ORDINATES X	:	699457.333	LOCATION	:	Patuka
CHAINAGE (m.)	:	26587	Y	:	3122837.409	TOTAL DEPTH	:	45
COLLAR ELEVATION	:		GROUND ELEVATION	:	274.993 m	TYPE OF CORE BARREL	:	
RAIL LEVEL	:		AZIMUTH	:		DEPTH OF WATER TABLE (m)	:	Absent
START DATE	:	19-02-2021	ANGLE WITH HORIZONTAL	:		DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	:	28-03-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
274.993																								
274.493	0.50		Brown Colour, Very Fine Grained, Medium to dense Compacted, Clayey Silt with none to Low Plasticity														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 274.993 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole. Fragmented and bouldered rock strata of Sandstone and Quartzite has also been noticed from 18.0m to 36.0m. However sandstone was more prominent in both of them.
273.493	1.50													14	45		---	---						
271.993	3.00																---	---						
270.493	4.50													20	45		---	---						
268.993	6.00																---	---						
265.993	9.00													31	45		---	---						
262.993	12.00																---	---						
259.993	15.00													38	45		---	---						
256.993	18.00		Fragmented Rock Strata of Yeollwish Brown, Fine Grained, Hard to Medium Hard, Sandstone	▨					6								4.50	---						
253.993	21.00		Fragmented Rock Strata of Yeollwish Brown, Medium to Coarse Grained, Hard Sandstone	▨					3.5								Nil	---						
250.993	24.00		Fragmented Rock Strata of Yeollwish Brown, Fine Grained, Medium Hard, Sandstone	▨					4								Nil	---						
247.993	27.00		Fragmented Rock Strata of Yeollwish Brown, Very Fine to Fine Grained, Medium Hard, Sandstone	▨					6								Nil	---						
244.993	30.00		Fragmented Rock Strata of Very Fine to Fine Grained, Hard to Medium Hard, Sandstone and Qaurtzite	▨					9								Nil	---						
241.993	33.00		Fragmented Rock Strata of Yeollwish Brown, Medium to Coarse Grained, Hard Sandstone	▨					6								Nil	---						
238.993	36.00		Fragmented Rock Strata of Yeollwish Brown, Medium to Coarse Grained, Hard Sandstone	▨					4.6								Nil	---						
235.993	39.00		Brown Coour, Very Fine Grained,Very dense Compacted, Clayey Silt with none to Low Plasticity														---	---						
232.993	42.00													75	45		---	---						
229.993	45.00																---	---						

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-22

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESWAR

BORE HOLE NO	: BH-22	CO-ORDINATES	X	: 699273.757	LOCATION	:	Patuka
CHAINAGE (m.)	: 26787		Y	: 3122916.536	TOTAL DEPTH	:	45.00 m
COLLAR ELEVATION	:	GROUND ELEVATION		: 274.321 m	TYPE OF CORE BARREL	:	
RAIL LEVEL	:	AZIMUTH		:	DEPTH OF WATER TABLE (m)	:	Absent
START DATE	: 08-04-2021	ANGLE WITH HORIZONTAL		:	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	: 11-04-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
274.321																								
273.821	0.50		Brown Colour, Very Fine Grained, Silt and Clay with Low Compressibility														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 274.321 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole. Fragmented and bouldered rock strata of Sandstone and Quartzite has also been noticed from 18 m. to 39 m. However sandstone was more prominent in both of them.
272.821	1.50		Brown Colour, Fine Grained, Medium Compacted, Clayey Silt with none to Low Plasticity											15	45		---	---						
271.321	3.00																---	---						
269.821	4.50													21	45		---	---						
268.321	6.00																---	---						
265.321	9.00													28	45		---	---						
262.321	12.00		Gravels and Pebbles of Quartzite and Sanstone														---	---						
259.321	15.00																---	---						
256.321	18.00		Fragmented Rock Strata of Yeollwish Brown, Medium to Coarse Grained, Hard Sandstone						3.0								Nil	---						
253.321	21.00								2.3								Nil	---						
250.321	24.00		Fragmented Rock Strata of Yeollwish Brown, Fine Grained, Hard Sandstone						3.0								Nil	---						
247.321	27.00								2.0								Nil	---						
244.321	30.00								3.0								Nil	---						
241.321	33.00								2.3								Nil	---						
238.321	36.00								4.0								Nil							
235.321	39.00								4.0								Nil							
232.321	42.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with Low Compressibility																					
229.321	45.00													91	45									

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-23

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESWAR

BORE HOLE NO : Bh 23
CHAINAGE (m.) : 26980
COLLAR ELEVATION :
RAIL LEVEL :
START DATE : 04-04-2021
ENDING DATE : 06-04-2021

CO-ORDINATES X : 699087.908
Y : 3122972.138
GROUND ELEVATION : 274.850 M
AZIMUTH :
ANGLE WITH HORIZONTAL :

LOCATION : Patuka
TOTAL DEPTH : 45 m
TYPE OF CORE BARREL :
DEPTH OF WATER TABLE (m) : Absent
DRILLING AGENCY : S.M. Consultants
NAME OF GEOLOGIST : Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
274.850																								
274.350	0.50		Brown Colour, Very Fine Grained, stiff to very stiff Consitency, Silt and Clay with Low Compressibilty														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 274.850 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
273.350	1.50													16	45		---	---						
271.850	3.00																---	---						
270.350	4.50													23	45		---	---						
268.850	6.00																---	---						
265.850	9.00		Brown Colour, Fine grained, Dense Compacted, Clayey Silt with None to Low Plasticity											34	45		---	---						
262.850	12.00		Brown Colour, Very Fine Grained, Hard Consitency, Silt and Clay with Low Compressibilty														---	---						
259.850	15.00													38	45		---	---						
256.850	18.00																---	---						
253.850	21.00		Brown Colour, Fine grained, Dense Compacted, Silty Sand											50	45		---	---						
250.850	24.00		Brown Colour, Very Fine Grained, Silt and Clay with low Compressibility														---	---						
247.850	27.00		Brown Colour, Fine grained, Very Dense Compacted, Silty Sand											63	45		---	---						
244.850	30.00		Brown Colour, Fine Grained, Clayey Silt with None to Low Plasticity														---	---						
241.850	33.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low											73	45		---	---						
238.850	36.00		Brown Colour, Fine grained, Silty Sand														---	---						
235.850	39.00		Brown Colour, Very Fine Grained, Hard Consistencey, Silt and Clay with low Compressibility											77	45		---	---						
232.850	42.00																---	---						
229.850	45.00													85	45		---	---						

Geotechnical Investigation Report

Consultant:			*Client :*
S.M. CONSULTANTS BHUBANESWAR	Job No:- 830	Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-24

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESWAR

BORE HOLE NO	: BH-24	CO-ORDINATES	X	: 698885.647	LOCATION	:	Patuka
CHAINAGE (m.)	: 27187		Y	: 3123009.681	TOTAL DEPTH	:	40.00 m
COLLAR ELEVATION	:	GROUND ELEVATION		: 274.075 M	TYPE OF CORE BARREL	:	
RAIL LEVEL	:	AZIMUTH		:	DEPTH OF WATER TABLE (m)	:	Absent
START DATE	: 04-04-2021	ANGLE WITH HORIZONTAL		:	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	: 08-04-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
274.075																								
273.575	0.50		Brown Colour, Fine Grained, Medium to dense Compacted, Clayey Silt with None to Low Plasticity														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 274.075 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
272.575	1.50													14	45		---	---						
271.075	3.00																---	---						
269.575	4.50													21	45		---	---						
268.075	6.00																---	---						
265.075	9.00													27	45		---	---						
262.075	12.00																---	---						
259.075	15.00													33	45		---	---						
256.075	18.00																	---						
253.075	21.00													43	45		---	---						
250.075	24.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility														---	---						
247.075	27.00													58	45		---	---						
244.075	30.00																---	---						
241.075	33.00													72	45		---	---						
238.075	36.00																---	---						
235.075	39.00													89	45		---	---						
232.075	40.00																---	---						

Geotechnical Investigation Report

Consultant:		Client :
S.M. CONSULTANTS BHUBANESWAR	Job No:- 830	Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-25

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESWAR

BORE HOLE NO	:	BH-25	CO-ORDINATES	X :	698666.173	LOCATION	:	Patuka
CHAINAGE (m.)	:	27410		Y :	3123023.037	TOTAL DEPTH	:	40.00 m
COLLAR ELEVATION	:		GROUND ELEVATION	:	273.565 m	TYPE OF CORE BARREL	:	
RAIL LEVEL	:		AZIMUTH	:		DEPTH OF WATER TABLE (m)	:	Absent
START DATE	:	12-04-2021	ANGLE WITH HORIZONTAL	:		DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	:	14-04-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
273.565																								
273.065	0.50		Brown Colour, Very Fine Grained, stiff to Hard Consistency, Silt and Clay with low Compressibility														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 273.565 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
272.065	1.50													13	45		---	---						
270.565	3.00																---	---						
269.065	4.50													20	45		---	---						
267.565	6.00																---	---						
264.565	9.00													30	45		---	---						
261.565	12.00																---	---						
258.565	15.00													31	45		---	---						
255.565	18.00																	---						
252.565	21.00													33	45		---	---						
249.565	24.00																---	---						
246.565	27.00													48	45		---	---						
243.565	30.00																---	---						
240.565	33.00													68	45		---	---						
237.565	36.00																---	---						
234.565	39.00													81	45		---	---						
231.565	40.00																---	---						

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-26

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-26	CO-ORDINATES	X	: 698526.193	LOCATION	:	Patuka
CHAINAGE (m.)	: 26880		Y	: 3123024.419	TOTAL DEPTH	:	35.00 m
COLLAR ELEVATION	:	GROUND ELEVATION		: 273.112 M	TYPE OF CORE BARREL	:	
RAIL LEVEL	:	AZIMUTH		:	DEPTH OF WATER TABLE (m)	:	Absent
START DATE	: 12-04-2021	ANGLE WITH HORIZONTAL		:	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	: 14-04-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
273.112																								
272.612	0.50		Brown Colour, Very Fine Grained,stiff to Hard Consistency, Silt and Clay with low Compressibility														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 273.565 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
271.612	1.50													11	45		---	---						
270.112	3.00																---	---						
268.612	4.50													19	45		---	---						
267.112	6.00																---	---						
264.112	9.00													28	45		---	---						
261.112	12.00																---	---						
258.112	15.00													34	45		---	---						
255.112	18.00																	---						
252.112	21.00													41	45		---	---						
249.112	24.00																---	---						
246.112	27.00													53	45		---	---						
243.112	30.00																---	---						
240.112	33.00													65	45		---	---						
237.112	35.00																---	---						

Geotechnical Investigation Report

Consultant:		Client :
S.M. CONSULTANTS **BHUBANESWAR**	Job No:- 830	Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-27

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESWAR

BORE HOLE NO	: BH 27	CO-ORDINATES X	: 698026.203	LOCATION	: Patuka
CHAINAGE (m.)	: 28050	Y	: 3123029.181	TOTAL DEPTH	: 30.00 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 272.210	TYPE OF CORE BARREL	: ---
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 14-04-2021	ANGLE WITH HORIZONTAL	: 90°	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 16-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
272.210																								
271.710	0.50		Brown Colour, Fine grained, Low Dense to Medium Densed Compactness, Silty Sand														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 272.210. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Sandy Clay is majorly tracked in the borehole.
270.710	1.50													14	45		---	---						
269.210	3.00																---	---						
267.710	4.50													24	45		---	---						
266.210	6.00																---	---						
263.210	9.00													27	45		---	---						
260.210	12.00																---	---						
257.210	15.00		Brown Colour, Very Fine to Fine Grained, Hard Consitency, Sand and Clay with Low Compressibilty											36	45		---	---						
254.210	18.00																---	---						
251.210	21.00													45	45		---	---						
248.210	24.00																---	---						
245.210	27.00		Brown Colour, Very Fine to Fine Grained, Hard Consitency, Sand and Clay with Low Compressibilty											54	45		---	---						
242.210	30.00																---	---						

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-28

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-28	CO-ORDINATES	X	: 697726.217	LOCATION	:	Patuka
CHAINAGE (m.)	: 27680		Y	: 3123032.039	TOTAL DEPTH	:	45.00 m
COLLAR ELEVATION	: ---	GROUND ELEVATION		: 272.799	TYPE OF CORE BARREL	:	---
RAIL LEVEL	: ---	AZIMUTH		: ---	DEPTH OF WATER TABLE (m)	:	Absent
START DATE	: 04-04-2021	ANGLE WITH HORIZONTAL		: 90°	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	: 08-04-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
272.799																								
272.299	0.50		Brown Colour, Fine grained, Low Dense to Medium Densed Compactness, Silty Sand														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 272.799 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
271.299	1.50													12	45		---	---						
269.799	3.00																---	---						
268.299	4.50													21	45		---	---						
266.799	6.00																---	---						
263.799	9.00													28	45		---	---						
260.799	12.00																---	---						
257.799	15.00													38	45		---	---						
254.799	18.00																	---						
251.799	21.00		Brown Colour, Fine Grained, Hard Consitency, Sand and Clay with Low Compressibilty.											47	45		---	---						
248.799	24.00																---	---						
245.799	27.00													53	45		---	---						
242.799	30.00																---	---						
239.799	33.00		Brown Colour, Fine Grained, Hard Consitency, Sand and Clay with Low Compressibilty.											70	45		---	---						
236.799	36.00																---	---						
233.799	39.00													81	45		---	---						
230.799	42.00																---	---						
227.799	45.00													92	45		---	---						

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-29

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO : BH-29
CHAINAGE (m.) : 28550
COLLAR ELEVATION : ---
RAIL LEVEL : ---
START DATE : 17-04-2021
ENDING DATE : 18-04-2021

CO-ORDINATES X : 697526.227
Y : 3123034.057
GROUND ELEVATION : 269.964 m
AZIMUTH : ---
ANGLE WITH HORIZONTAL : 90°

LOCATION : Patuka
TOTAL DEPTH : 30.00 m
TYPE OF CORE BARREL : ---
DEPTH OF WATER TABLE (m) : Absent
DRILLING AGENCY : S.M. Consultants
NAME OF GEOLOGIST : Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
269.964																								
269.464	0.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 269.964 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
268.464	1.50													12	45		---	---						
266.964	3.00																---	---						
265.464	4.50													24	45		---	---						
263.964	6.00																---	---						
260.964	9.00													27	45		---	---						
257.964	12.00																---	---						
254.964	15.00													38	45		---	---						
251.964	18.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility															---						
248.964	21.00													47	45		---	---						
245.964	24.00																---	---						
242.964	27.00													61	45		---	---						
239.964	30.00																---	---						

Geotechnical Investigation Report

Consultant:		Client :
S.M. CONSULTANTS BHUBANESWAR	Job No:- 830	Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-30

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	:	BH-30	CO-ORDINATES	X	:	697326.462	LOCATION	:	Patuka
CHAINAGE (m.)	:	28750		Y	:	3123043.286	TOTAL DEPTH	:	45.00 m
COLLAR ELEVATION	:	---	GROUND ELEVATION		:	270.808 m	TYPE OF CORE BARREL	:	---
RAIL LEVEL	:	---	AZIMUTH		:	---	DEPTH OF WATER TABLE (m)	:	Absent
START DATE	:	17-04-2021	ANGLE WITH HORIZONTAL		:	90°	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	:	19-04-2021					NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
270.808																								
270.308	0.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 270.808 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
269.308	1.50													17	45		---	---						
267.808	3.00																---	---						
266.308	4.50													22	45		---	---						
264.808	6.00																---	---						
261.808	9.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											30	45		---	---						
258.808	12.00																---	---						
255.808	15.00													38	45		---	---						
252.808	18.00																	---						
249.808	21.00													44	45		---	---						
246.808	24.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---						
243.808	27.00													56	45		---	---						
240.808	30.00																---	---						
237.808	33.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											64	45		---	---						
234.808	36.00																---	---						
231.808	39.00													73	45		---	---						
228.808	42.00																---	---						
225.808	45.00													84	45		---	---						

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-31

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESWAR

BORE HOLE NO	: BH-31	CO-ORDINATES	X	: 697028.617	LOCATION	:	Patuka
CHAINAGE (m.)	: 29050		Y	: 3123078.475	TOTAL DEPTH	:	20.00 m
COLLAR ELEVATION	: ---	GROUND ELEVATION		: 267.159 m	TYPE OF CORE BARREL	:	---
RAIL LEVEL	: ---	AZIMUTH		: ---	DEPTH OF WATER TABLE (m)	:	Absent
START DATE	: 19-04-2021	ANGLE WITH HORIZONTAL		: 90°	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	: 19-04-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
267.159																								
266.659	0.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 267.159 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
265.659	1.50													16	45		---	---						
264.159	3.00																---	---						
262.659	4.50													23	45		---	---						
261.159	6.00																---	---						
258.159	9.00													32	45		---	---						
255.159	12.00																---	---						
252.159	15.00													40	45		---	---						
249.159	18.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility															---						
247.159	20.00													51	45		---	---						

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-32

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO : BH-32
CHAINAGE (m.) : 29550
COLLAR ELEVATION : ---
RAIL LEVEL : ---
START DATE : 19-04-2021
ENDING DATE : 20-04-2021

CO-ORDINATES X : 696542.399
Y : 3123193.287
GROUND ELEVATION : 266.684 m
AZIMUTH : ---
ANGLE WITH HORIZONTAL : 90°

LOCATION : Patuka
TOTAL DEPTH : 30.00 m
TYPE OF CORE BARREL : ---
DEPTH OF WATER TABLE (m) : Absent
DRILLING AGENCY : S.M. Consultants
NAME OF GEOLOGIST : Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
266.684																								
266.184	0.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 266.684 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
265.184	1.50													17	45		---	---						
263.684	3.00																---	---						
262.184	4.50													27	45		---	---						
260.684	6.00																---	---						
257.684	9.00													35	45		---	---						
254.684	12.00																---	---						
251.684	15.00													44	45		---	---						
248.684	18.00																---	---						
246.684	21.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											54	45		---	---						
243.684	24.00																---	---						
240.684	27.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											63	45		---	---						
238.684	30.00																---	---						

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-33

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	:	BH-33	CO-ORDINATES X	:	696072.339	LOCATION	:	Patuka
CHAINAGE (m.)	:	30125	Y	:	3123363.526	TOTAL DEPTH	:	20.00 m
COLLAR ELEVATION	:	---	GROUND ELEVATION	:	265.581 m	TYPE OF CORE BARREL	:	---
RAIL LEVEL	:	---	AZIMUTH	:	---	DEPTH OF WATER TABLE (m)	:	Absent
START DATE	:	20-04-2021	ANGLE WITH HORIZONTAL	:	90°	DRILLING AGENCY	:	S.M. Consultants
ENDING DATE	:	21-04-2021				NAME OF GEOLOGIST	:	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
265.581																								
265.081	0.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 265.581 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
264.081	1.50													18	45		---	---						
262.581	3.00																---	---						
261.081	4.50													28	45		---	---						
259.581	6.00																---	---						
256.581	9.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											39	45		---	---						
253.581	12.00																---	---						
250.581	15.00													50	45		---	---						
247.581	18.00																	---						
245.581	20.00													63	45		---	---						

ANNEXURE L

CORE SAMPLES

Borehole 13 (Ch no. 25000)

BH 13. Box 1 (Depth 0m-15.0m).

BH 13. Box 2 (Depth 15.0m-28.50m)

BH13. Box 3. (Depth 28.5m-43.5m)

BH13. Box 4. (Depth 43.5m- 60.0m)

Borehole 14 (Ch no. 25195)

BH 14. Box 1. (Depth 0m-10.5m)

BH 14. Box2. (Depth 10.5m-27.5m)

BH 14. Box 3. (Depth 27.5m-43.5m)

BH 14. Box 4. (Depth 43.5m-63.0m)

Borehole 15 (Ch no. 25380)

BH 15. Box 1. (Depth 0m- 16.5m)

BH 15. Box 2. (Depth 16.5m -33.0m)

BH 15. Box 3. (Depth 33.0m- 48.0m)

BH 15. Box 4. (Depth 48m-66m)

BH 15. Box 5. (Depth 66.0m-70.0m)

Borehole 15(A) (Ch no. 25488)

BH 15(A) Box 1. (Depth 0-13.5m)

BH 15(A) Box 2. (Depth 13.5m-27.0m)

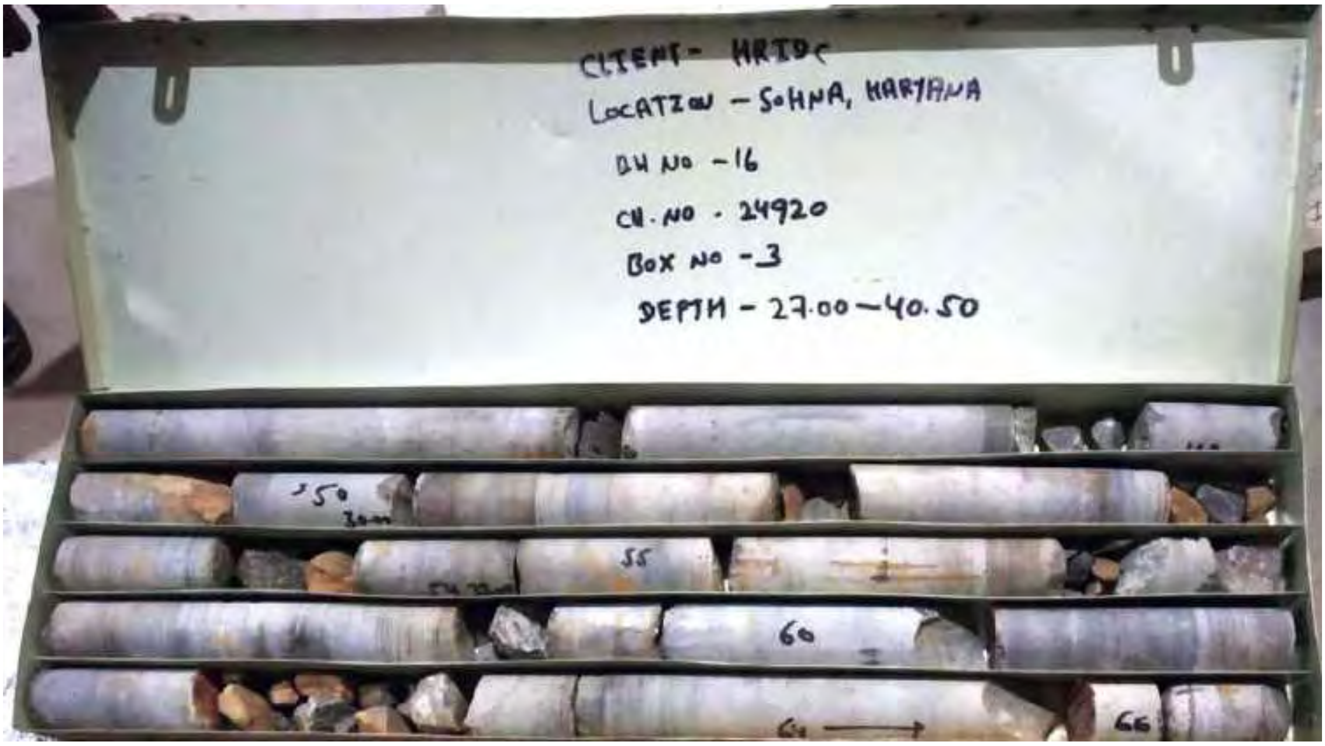
Bh 15(A) Box 3. (Depth 27.0m-40.5m)

BH 15(A) Box 4. (Depth 40.5m-50.0m)

Borehole 16. (Ch no. 25586)

BH 16. Box 1. (Depth 0 m- 15.0m)

BH 16. Box 2. (Depth 15.0m-27.0m)



BH 16. Box 3. (Depth 27.0m- 40.5m)

BH 16. Box 4. (Depth 40.5m -51.0m)

Bh 16. Box 5. (Depth 51.0m- 62.0

Borehole 17. (Ch no. 25785)

BH 17 Box 1. (Depth 0.00m -27.50m)

BH 17 Box 2. (Depth 27.50m -39.50m)

BH 17 Box 3. (Depth 39.50m -51.50m)

BH 17 Box 4. (Depth 51.50m -62.00m)

ii. Geological Interpretive Report No. SMC/2050

GEOLOGICAL INTERPRETIVE REPORT

EXPLORING ALTERNATE ALIGNMENTS, FINAL LOCATION SURVEY, GEOLOGICAL MAPPING, GEO-TECHNICAL INVESTIGATION, DETAIL DESIGN OF TUNNEL & ITS APPROACHES INCLUDING VIADUCT IF ANY AND OTHER ANCILLARY WORK IN SOHNA-MANESAR SECTION OF HRDC PROJECT.

Client:

HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LIMITED.

Prepared By:

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
MANCHESWAR INDUSTRIAL ESTATE,
RASULGARH, BHUBANESWAR-751010, ODISHA

GEOLOGICAL INTERPRETIVE REPORT

Prepared & Submitted By	
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CPM/HRIDCL		
DGM/CIVIL/S/ HRIDCL		
EXE/CIVIL/ HRIDCL		

Client:

HRIDC

HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION
LIMITED.

Consultant:

S. M. C.

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1 Introduction:

1.1 Scope of the Geological Interpretative Report

This GIR presents the status of knowledge regarding the geological, structural and hydrogeological conditions along the alignment. In order to optimize the design, a geological assessment was done as part of the work. The assessment included field and laboratory work. This report summarizes subsurface and site conditions that are expected to be encountered during the tunnelling works. The subsurface and site conditions are derived from geotechnical information and data gathered from field.

1.2 Reference of Published Literature

[1] Bieniawski, Z. T. (1989). Engineering rock mass classifications: a complete manual for engineers and geologists in mining, civil, and petroleum engineering. John Wiley & Sons.

[2] Heron, A. M. (1953). The geology of central Rajputana. Mem. Geol. Soc. Ind., 79.

[3] Karol, R. H. (1960). Soils and soil engineering.

[4] Naha, K., Mukhopadhyay, D. K., Mohanty, R., Mitra, S. K., & Biswal, T. K. (1984). Significance of contrast in the early stages of the structural history of the Delhi and the pre-Delhi rock groups in the Proterozoic of Rajasthan, western India. Tectonophysics, 105(1-4), 193-206.

[5] Naha, K., & Mohanty, S. (1988). Response of basement and cover rocks to multiple deformations: a study from the Precambrian of Rajasthan, western India. Precambrian research, 42(1-2), 77-96.

[6] Roy, A. B., & Das, A. R. (1985). A study on the time relations between movements, metamorphism and Granite emplacement in the Middle Proterozoic Delhi Supergroup rocks of Rajasthan. Journal of Geological Society of India (Online archive from Vol 1 to Vol 78), 26(10), 726-733.

[7] Wei, B. Z., Pezeshk, S., Chang, T. S., Hall, K. H., & Liu, H. P. (1996). An empirical method to estimate shear wave velocity of soils in the New Madrid seismic zone. Soil Dynamics and Earthquake Engineering, 15(6), 399-408.

1.3 Indian Standard codes

[1] IS 1893 (part-1): 2016, Criteria for earthquake resistance design of structure.
[2] IS: 2720(part-1)-1983 (Reaffirmed 2015): Preparation of soil sample
[3] IS: 2720(part-2)-1973 (Reaffirmed 2015): Moisture Content
[4] IS: 2720(part-3) (sec-1)-1980 (Reaffirmed 2016): Specific Gravity
[5] IS: 2720(part-4)-1985 (Reaffirmed 2015): Grain Size Analysis
[6] IS: 2720(part-5)-1985 (Reaffirmed 2015): Atterberg’s Limits
[7] IS: 2720(part-11)-1993 (Reaffirmed 2016): Triaxial Shear Strength
[8] IS: 2720(part-13)-1986 (Reaffirmed 2016): Direct Shear Strength
[9] IS: 2720(part-15)-1986 (Reaffirmed 2016): Consolidation Test

2 Geological Overview:

2.1 Introduction:

The area in the report lies within the district of Gurgaon of Haryana. The concerned region is a part of the survey of India toposheet No. 53H/04 and spanned between longitude 77°58′36″& 77°06′00″and latitude 28°14′0″ & 28°10′30″ (Figure 2.1). The area is 20km away from Gurgaon. The important towns in the area are Sohna, Gurgaon, Palwal. These towns are connected with important cities of the state and Delhi by metaled roads.

Figure 2.1: District Map of Haryana.

Delhi Bombay National Highway (NH-6) passes through Gurgaon State Highway No 43 passes through Sohna. Gurgaon is a railway station on the Delhi Rewari section of the meter gauge line of the Northern Railway whereas Faridabad and Palwal are on Delhi Bombay broad gauge line. Most of the villages in the area are connected by all-weather metaled roads. The area has a semi-arid type of climate. Summer is extremely hot with the temperature up to 47°C. The winters are quite cold. The minimum temperature recorded in Gurgaon during

1968-70 was 2.0°C. The related humidity is maximum in August (above 80%) and minimum in June (above 35%). In the month of November, the wind velocity in the morning remains about2.5km/hr. whereas in June it is generally 8 km/hr. The general wind direction is westerly. The summer monsoon starts at the end of June or early July and lasts up to September. Rainfall is generally restricted to this monsoon, though winter months also get some scanty rains.

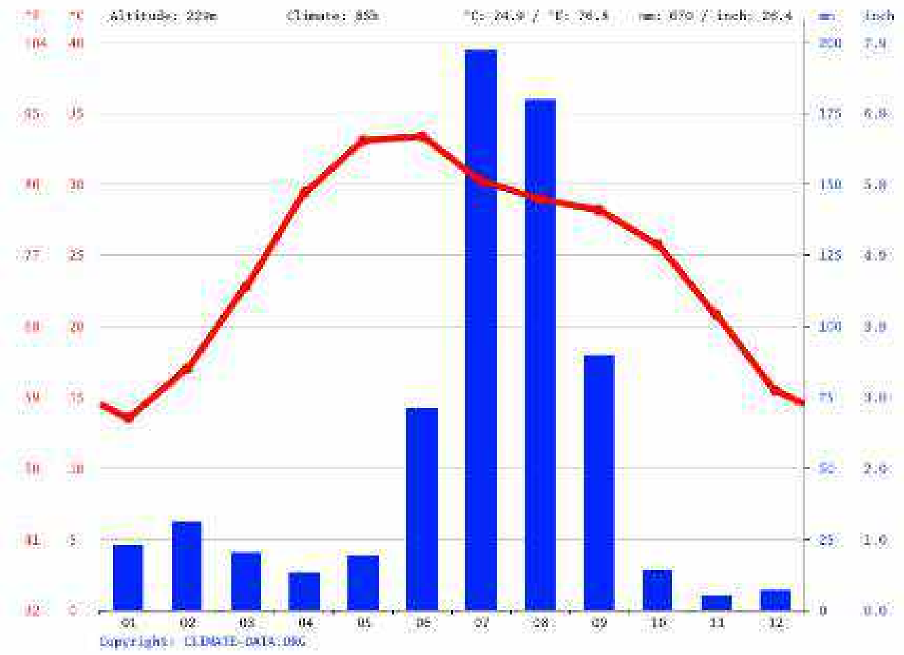


Figure 2.2: Graph showing month wise rainy days for Gurgaon district. (Climate-data.org).

The average annual rainfall is about 600 mm. The climatic condition of the area is much varied characterized by hot and moist sub-humid climate. It has mainly 4 seasons. The summer season is from March to Mid-June, the period from Mid-June to September is the Rainy season, October and November constitute the post-monsoon season, and winter is from December to February as shown inFigure 2.2. The best time to visit this district is during winter. Ministry of housing and urban affair, Government of India has done vulnerability mapping for Haryana state which includes multiple hazard zonation maps. The results are given below inFigure 2.3.

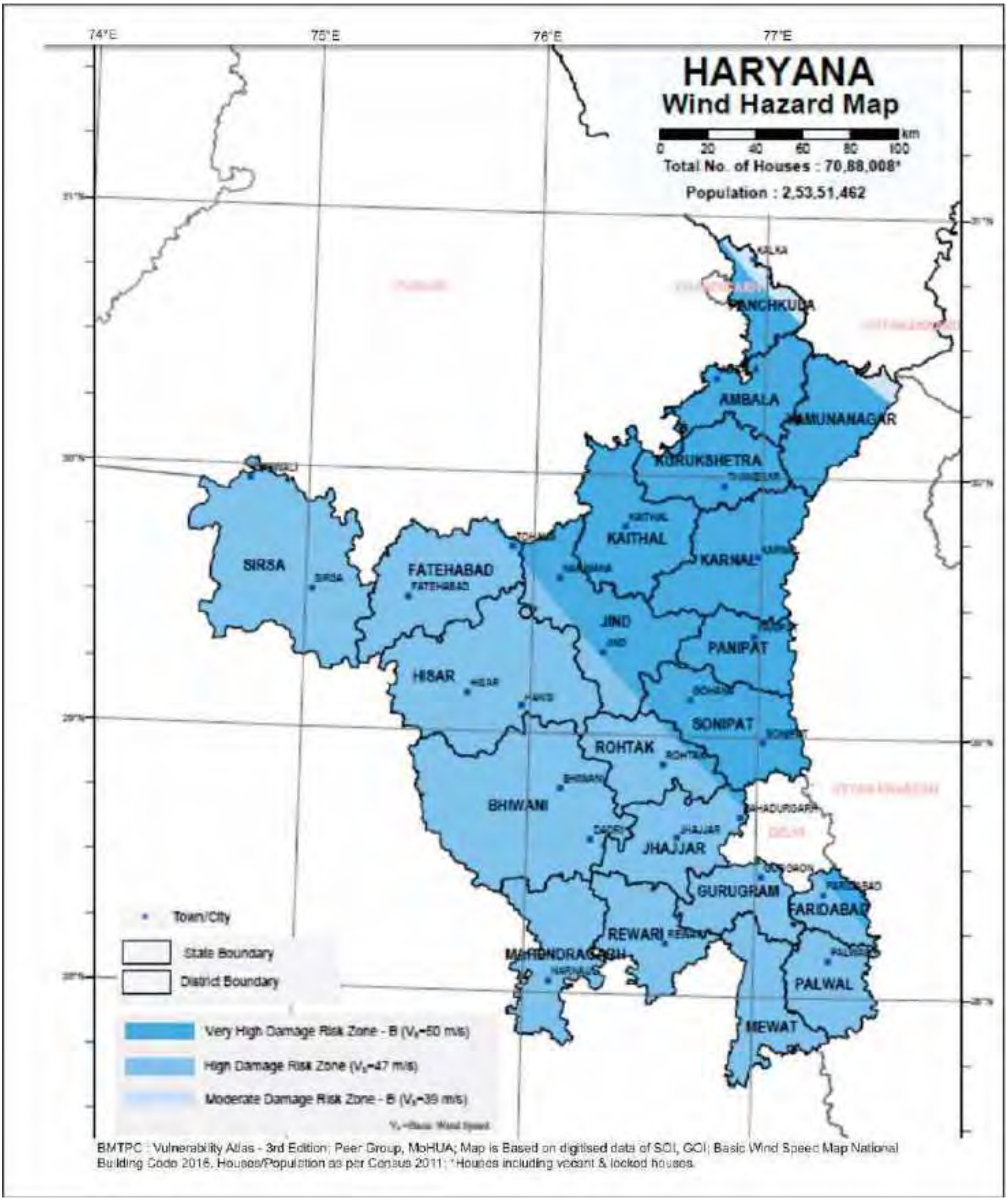


Figure 2.3: Wind Hazard map of Haryana (adopted from BMTPC.

2.2 Seismicity

According to National Center for Seismology the state of Haryana comprises three earthquake zone. The western part comes under zone II, the central part zone III and the eastern- south-eastern part in zone IV. The region around the site of construction comes under the zone IV of earthquake. Being within the earthquake zone IV the area of interest is at high risk with reference to the seismic activity. This region is liable to MSK VIII on Medvedev–Sponheuer–Karnik Scale, a macro seismic intensity scale or lower, and is classified as the High Damage Risk Zone. Map below shows the seismic zones of Haryana State (Figure 2.4).

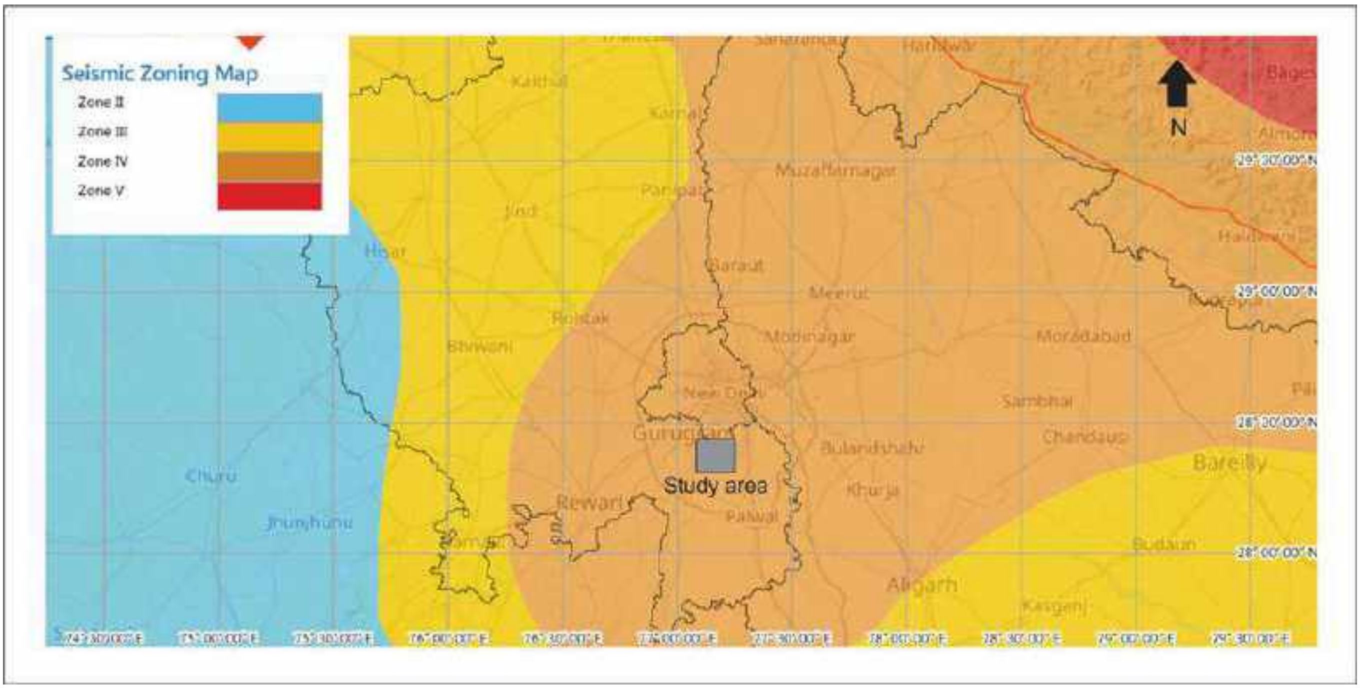


Figure 2.4: Seismic map of state Haryana (adopted from National Centre for seismology).

2.3 Regional Geology:

The rocks exposed in the area consist of Mesoproterozoic rocks of the North Delhi Fold belt which occur as long, linear, discontinuous chain of hills. The overall Delhi fold belt shows a NE-SW trend and extends from Gujrat (Deri- Ambaji) in the south to Delhi in the north. In the north and south the belt is overlain by Indo-Gangatic alluvium with sparse outcrop jutting out from the plain. Towards west it shows an unconformable contact with Marwar craton along a Phulad lineament and in the east the belt shows a faulted contact with Banded Gneissic Complex of pre-Delhi origin along Kaliguman lineament. The North Delhi Fold Belt has been divided into two groups by Heron (1935): the lower arenaceous Alwar Group and the upper argillaceous Use the "Insert Citation" button to add citations to this document.

Ajabgarh Group. The Alwar Group comprises arkosic schists, phyllites, quartzites and meta- conglomerates whereas, the Ajabgarh Group comprises calc-schists, biotite schists, calc-silicates and marbles.

The regional structure of Delhi fold belt is considered as a broad synclinorium having N to NNE trend (Heron 1953) with core occupied by Delhi group, within the broad synclinorium four generations of deformation (D1 – D4) (Figure 2.5) are seen in Delhi fold belt (Naha and Mohanty 1988). D1 and D2 are ubiquitous in all scales while D3 and D4 are seen only in some sectors. D1 folds are tight to isoclinal with a pervasive axial planar cleavage (S1). There are multiple occurrences of boudinage in D1 fold, which are parallel to axial planer cleavage (Naha et al.,1984). D2 folds ranges from open to isoclinal with vertical axial plane striking NNE -SSW to NE-SW. A crenulation cleavage (S2) is developed parallel to axial planes of the fold. D2 fold is coaxial with DF1 fold. Due to D2 various superposed folds have been developed in DFB, most common is Ramsay Type III fold (non-planar cylindrical) (Roy and Das 1985). DF3 folds are kink folds with sub horizontal axial planes. It has affected S1 and S2 cleavages and axial surfaces of DF1 and DF2 folds. At some places DF3 has conjugate axial plane striking NE-SW and SE-NW. It is formed by vertical compression (Naha and Mohanty 1988). Due to interference from D3 fold there is development of Ramsay Type II fold (non-planer non-cylindrical fold) in the DF1 and Ramsay Type-I fold (planer non-cylindrical fold) in DF2 (Roy and Das 1985).DF4 fold are upright chevron fold, having NW-SE striking axial plane. They are formed by horizontal compression in an NE-SW direction (Naha and Mohanty 1988).

The different phases of deformation have led to metamorphism ranging from greenschist to amphibolite facies.

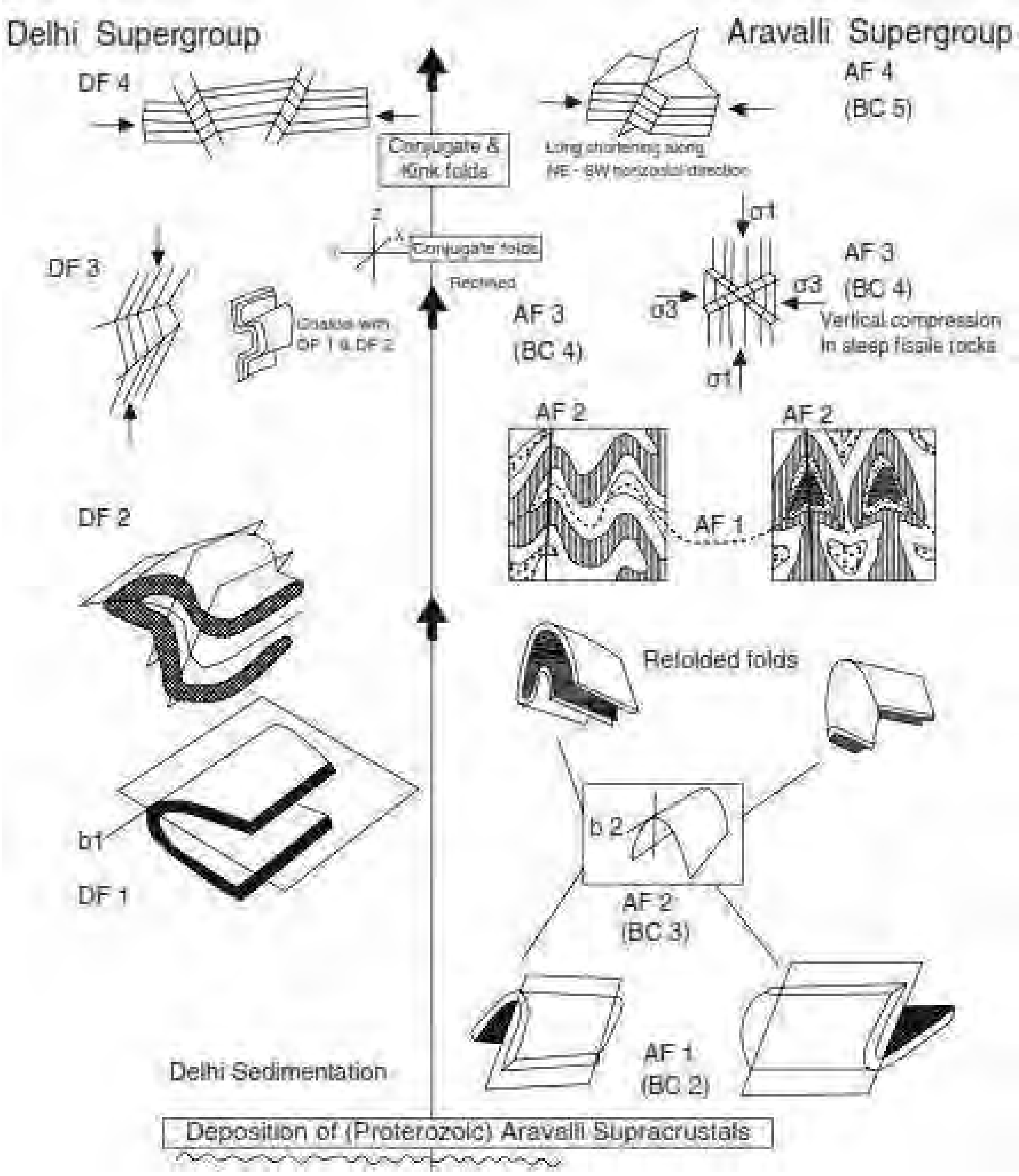


Figure 2.5: Regional structure of Delhi fold belt (Naha and Mohanty 1988).

3 PROJECT GEOLOGY

3.1 Local Site Geology:

The region around the site consists of metamorphosed arenaceous rocks of the Alwar group. The Lithology is dominated by Quartzites with some intercalations of phyllites near the southern portal.

The Quartzites are metasedimentary rocks that comprise greater than 80% quartz along with feldspar and mica minerals, the mineral grains show an equigranular interlocking texture.

The phyllites are low-grade metamorphic rocks, they have a marked fissility (a tendency to split into sheets or slabs) due to the parallel alignment of platy minerals; they have a sheen on their surfaces due to tiny plates of micas.

The quartzites near to surface showed high weathering and were highly friable and non-cohesive while as we move deeper (> 15 m) the quartzite becomes more resistive and less weathered. Quartz is a tectosilicate mineral that ranks 7 on the Mohr hardness scale, since it crystallizes later according to the Bowen reaction series it is also resistive to weathering. Feldspar on the other hand ranks 6 on the Mohr hardness scale and crystallizes earlier thus is prone to weathering.

In the southern part intercalation of phyllites/schist along with quartzite are observed.

3.2 Structural Study:

The compositional changes in quartzite beds defines the bedding in the area and the regional trend of bedding plane is NE-SW with a steep dip towards SE.

A superposed fold was observed at 28°12′33.57″, 77°02′57.08″. DF2 and DF3 deformation phases of Delhi group was observed in the area. DF1 is the prominent fold pattern which was super posed with DF2 folding phase. Signatures of later brittle shearing, possibly related to DF4 phase, was also observed near the proposed portal face. The fold showed Ramsay’s Type III folding pattern i.e., nonplanar cylindrical (Figure 3.1). The fold hinge showed a plunge of 20° towards 220. The Type III fold pattern in the rest of the Delhi system of rocks are result of superposition of DF2 over DF3 deformation. The portal face lies perpendicular to the axial plane of the fold. The earlier generation of fold is isoclinal in nature where both the limbs dip towards south.

Near the fold area some quartz tension gashes were observed. Gash veins open up when rock gets stretched due to shearing and the tension fractures forms oblique to the shear zone which is later filled with mineral precipitate. In the present area the gash veins indicate a dextral shearing.

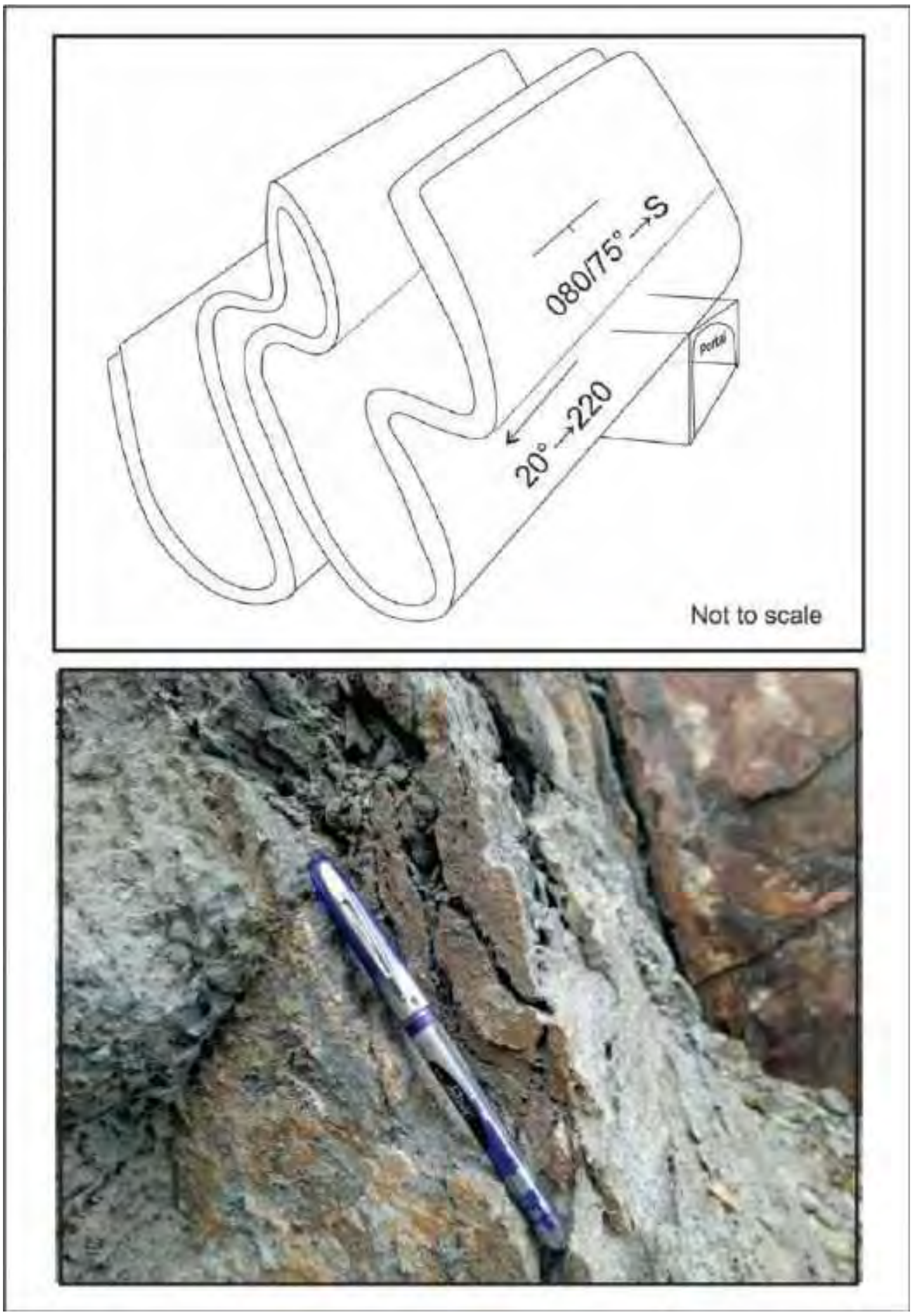


Figure 3.1: Superposed fold observed at 28 12' 33.57'', 77 02'57.08''

At location 28° 12' 20.93'', 77° 02' 40.50'' another evidence of brittle-ductile shear zone was observed within the quartzite outcrop (Figure 3.2). Prominent en-echelon fractures were observed within the outcrop which were rotated to form a sigmoidal structure, the fractures were not filled with mineral precipitate. The shear plane was dipping towards NE with a normal slip where the eastern block was showing a downthrown movement and the western block an upthrown movement. The last phase, in the mode of brittle shearing, led to the DF4 deformation. The joints are also encountered persistently at places around the site (Figure 3.4, Figure 3.5).

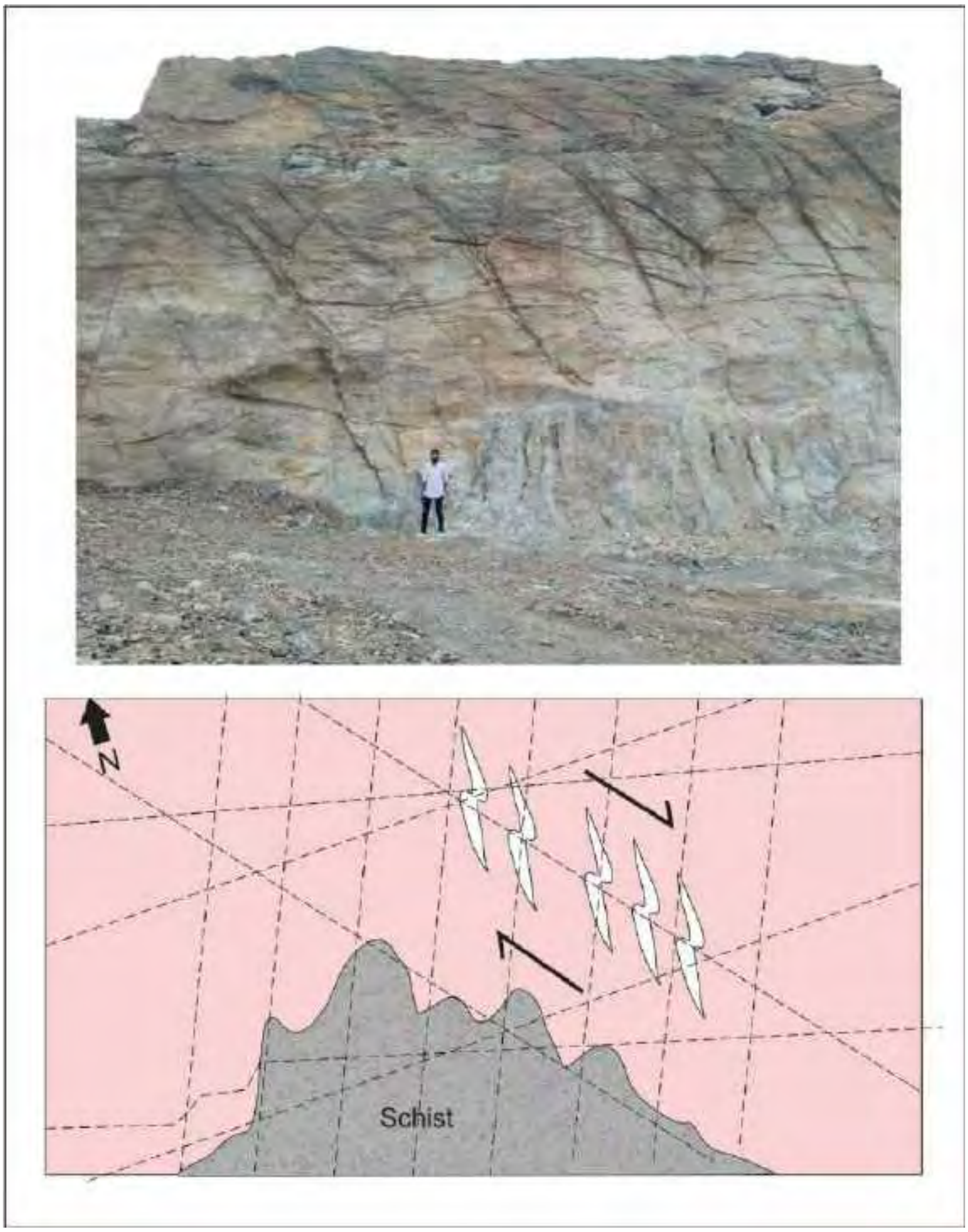


Figure 3.2: Shear zone observed at location 28 12’ 20.93’’, 77 02’ 40.

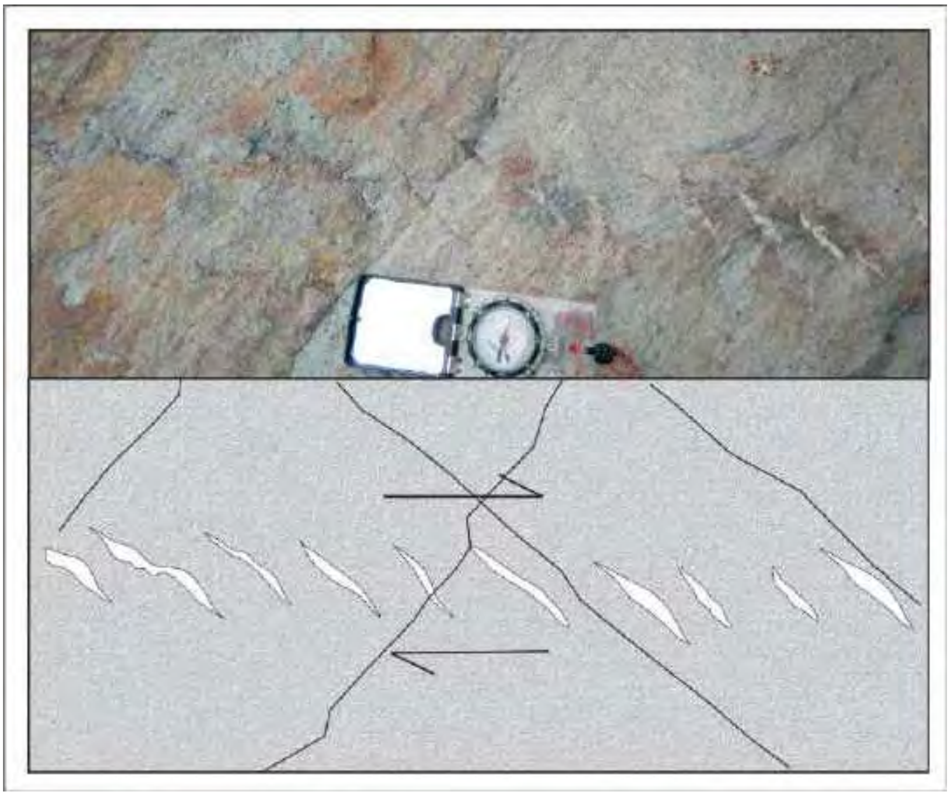


Figure 3.3: Gash veins showing a dextral slip.

Figure 3.4: Multiple joint sets observed throughout the area.

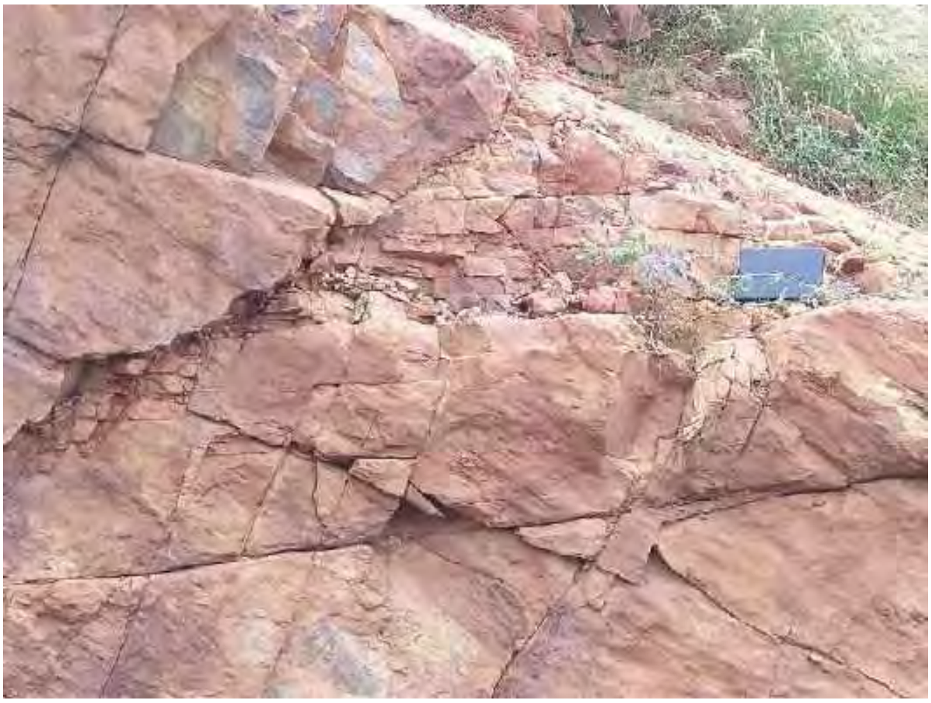


Figure 3.5: Multiple joint sets were observed throughout the area.

Orientation of the joints measured in field (Table 3.1) has been plotted on stereonet and contouring was done following Schimidt's 1% area rule (Figure 3.6) .The diagram shows 6 distinct cluster of the poles to the joint planes, hence we designate the sets as J1, J2, J3, J4, J5, and J6 (Table 3.2).

Table 3.1: Orientation of the joints at places around the site.

S. NO	Strike	Dip	Dip Direction
1.	034	11	NW
2.	028	13	NW
3.	029	13	NW
4.	027	15	NW
5.	027	15	NW
6.	026	16	NW
7.	029	18	NW
8.	033	18	NW
9.	028	19	NW
10.	032	19	NW
11.	042	21	NW
12.	040	22	NW
13.	036	23	NW
14.	041	24	NW
15.	037	25	NW

S. NO	Strike	Dip	Dip Direction
16.	036	26	NW
17.	043	27	NW
18.	040	28	NW
19.	037	30	NW
20.	038	30	NW
21.	178	31	W
22.	172	32	W
23.	175	32	W
24.	170	34	W
25.	174	34	W
26.	172	36	W
27.	178	37	W
28.	172	38	W
29.	178	38	W
30.	178	39	W
31.	003	40	W
32.	006	40	W
33.	004	41	W
34.	005	43	W
35.	008	43	W
36.	119	45	NE
37.	008	46	W
38.	009	46	W
39.	119	46	NE
40.	008	47	W
41.	002	49	W
42.	116	49	NE
43.	007	50	W
44.	110	50	NE
45.	110	51	NE
46.	111	51	NE
47.	114	51	NE
48.	117	51	NE
49.	115	52	NE
50.	119	52	NE
51.	122	57	NE
52.	126	59	NE
53.	127	60	NE
54.	130	60	NE
55.	121	62	NE
56.	129	62	NE

S. NO	Strike	Dip	Dip Direction
57.	122	63	NE
58.	128	63	NE
59.	124	64	NE
60.	126	65	NE
61.	117	70	NE
62.	117	70	NE
63.	029	71	SE
64.	032	71	SE
65.	026	72	SE
66.	111	72	NE
67.	028	73	SE
68.	030	73	SE
69.	035	73	SE
70.	116	73	NE
71.	119	74	NE
72.	117	75	NE
73.	178	76	E
74.	030	76	SE
75.	170	77	E
76.	174	77	E
77.	030	77	SE
78.	110	77	NE
79.	113	77	NE
80.	171	79	E
81.	178	79	E
82.	179	79	E
83.	027	79	SE
84.	032	79	SE
85.	174	80	E
86.	176	80	E
87.	114	80	NE
88.	116	80	NE
89.	040	81	SE
90.	042	81	SE
91.	122	81	NE
92.	171	82	E
93.	175	82	E
94.	045	82	SE
95.	126	82	NE
96.	039	83	SE
97.	122	83	NE

S. NO	Strike	Dip	Dip Direction
98.	125	83	NE
99.	125	83	NE
100.	005	84	E
101.	038	84	SE
102.	001	85	E
103.	008	85	E
104.	129	85	NE
105.	124	86	NE
106.	127	86	NE
107.	002	87	E
108.	006	87	E
109.	037	87	SE
110.	042	87	SE
111.	127	87	NE
112.	009	88	E
113.	002	89	E
114.	043	89	SE
115.	130	89	NE
116.	001	90	E
117.	036	90	SE
118.	040	90	SE
119.	006	91	E
120.	007	93	E
121.	045	82	SE
122.	126	82	NE
123.	039	83	SE
124.	122	83	NE
125.	130	89	NW

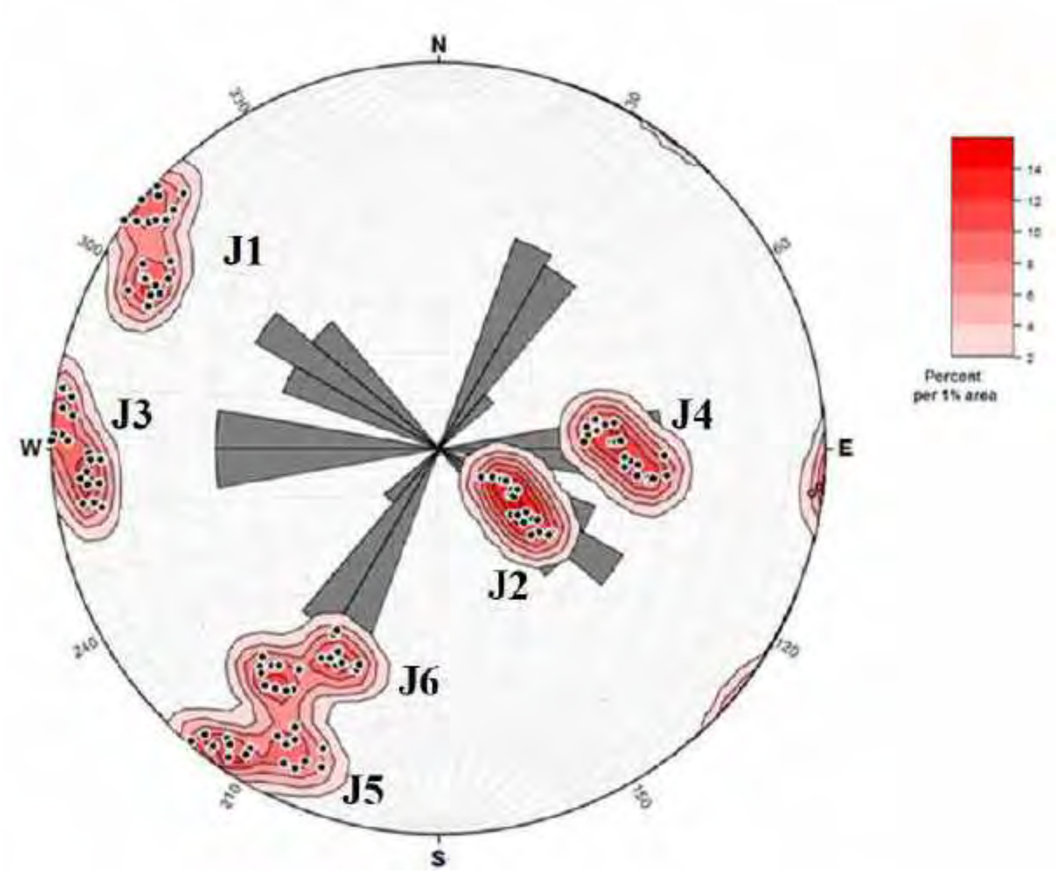
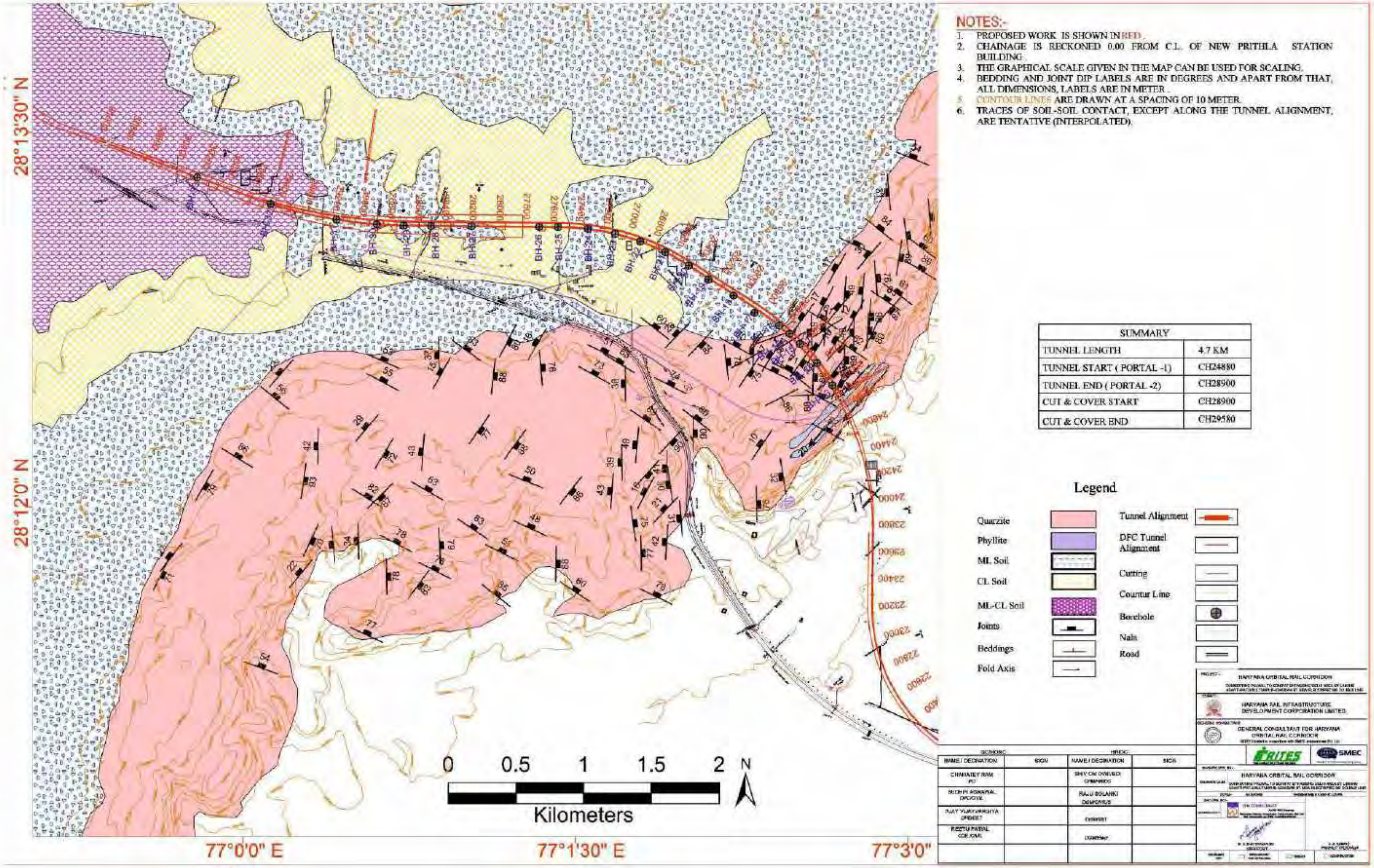


Figure 3.6: Rose and contour diagram of the orientation of the 6 sets of joints (no. of samples N=125)

Table 3.2: Details of joint sets.

Joint Set	Average Strike	Average True Dip amount	Average True Dip direction
J1	035	80	SE
J2	035	20	NW
J3	000	84	E
J4	000	40	W
J5	300	55	NE
J6	300	80	NE

A detailed geological map in a scale 1:25000 (Figure 3.7) and in 1:2000 scale (Figure 3.8) showing all structural elements which includes faults, thrusts, shear zones, folds, joints, lithological boundaries along with finalized tunnel alignment, L-Section (Figure 3.9) along the hilly terrain (1:25000 H and 1:2500 V), Graphical representation of the distribution of RQD, Core Recovery, SPT N Values and Soil types along each boreholes intersecting the tunnel (Figure 3.10), magnified parts of the L section showing chainage wise variation in RMR and RQD values in rock portion and C and phi values in soil portion (Figure 3.11 to Figure 3.15) a detailed cross section of the portal face on the mountain front (Figure 3.16),cross-section of the exit end of the NATM structure in soil (Figure 3.17), and the cross section of the portal 2 in the cut and cover region (Figure 3.18) are given below;

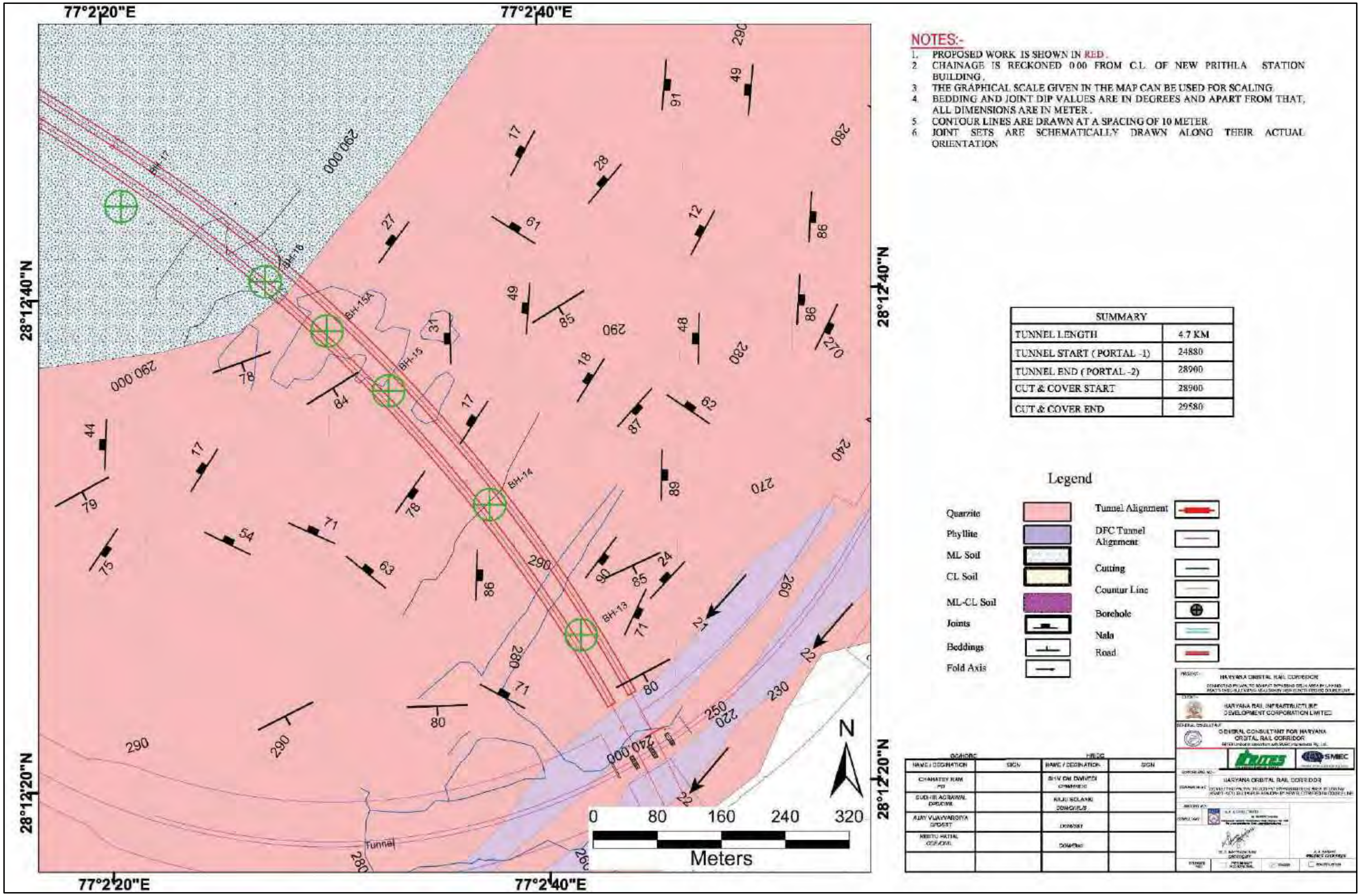


NOTES:-

1. PROPOSED WORK IS SHOWN IN RED.
2. CHAINAGE IS RECKONED 0.00 FROM C.L. OF NEW PRITHLA STATION BUILDING.
3. THE GRAPHICAL SCALE GIVEN IN THE MAP CAN BE USED FOR SCALING.
4. BEDDING AND JOINT DIP LABELS ARE IN DEGREES AND APART FROM THAT, ALL DIMENSIONS, LABELS ARE IN METER.
5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. TRACES OF SOIL-SOIL CONTACT, EXCEPT ALONG THE TUNNEL ALIGNMENT, ARE TENTATIVE (INTERPOLATED).

SUMMARY	
TUNNEL LENGTH	4.7 KM
TUNNEL START (PORTAL -1)	CH24880
TUNNEL END (PORTAL -2)	CH28900
CUT & COVER START	CH28900
CUT & COVER END	CH29580

Figure 3.7: Geological map of the area at 1:25000 scale.



NOTES:-

1. PROPOSED WORK IS SHOWN IN RED.
2. CHAINAGE IS RECKONED 0.00 FROM C.L. OF NEW PRITHLA STATION BUILDING.
3. THE GRAPHICAL SCALE GIVEN IN THE MAP CAN BE USED FOR SCALING.
4. BEDDING AND JOINT DIP VALUES ARE IN DEGREES AND APART FROM THAT, ALL DIMENSIONS ARE IN METER.
5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. JOINT SETS ARE SCHEMATICALLY DRAWN ALONG THEIR ACTUAL ORIENTATION

SUMMARY	
TUNNEL LENGTH	4.7 KM
TUNNEL START (PORTAL -1)	24880
TUNNEL END (PORTAL -2)	28900
CUT & COVER START	28900
CUT & COVER END	29580

Figure 3.8: Detailed structural map of the major rocky area at 1:2000 scale. Joint sets are schematically drawn with their actual orientation. Average spacing between the joints are as follows J_1: 300 cm, J_2:252.78cm, J_3:160cm, J_4:80cm, J_5:32cm, J_6:100cm.

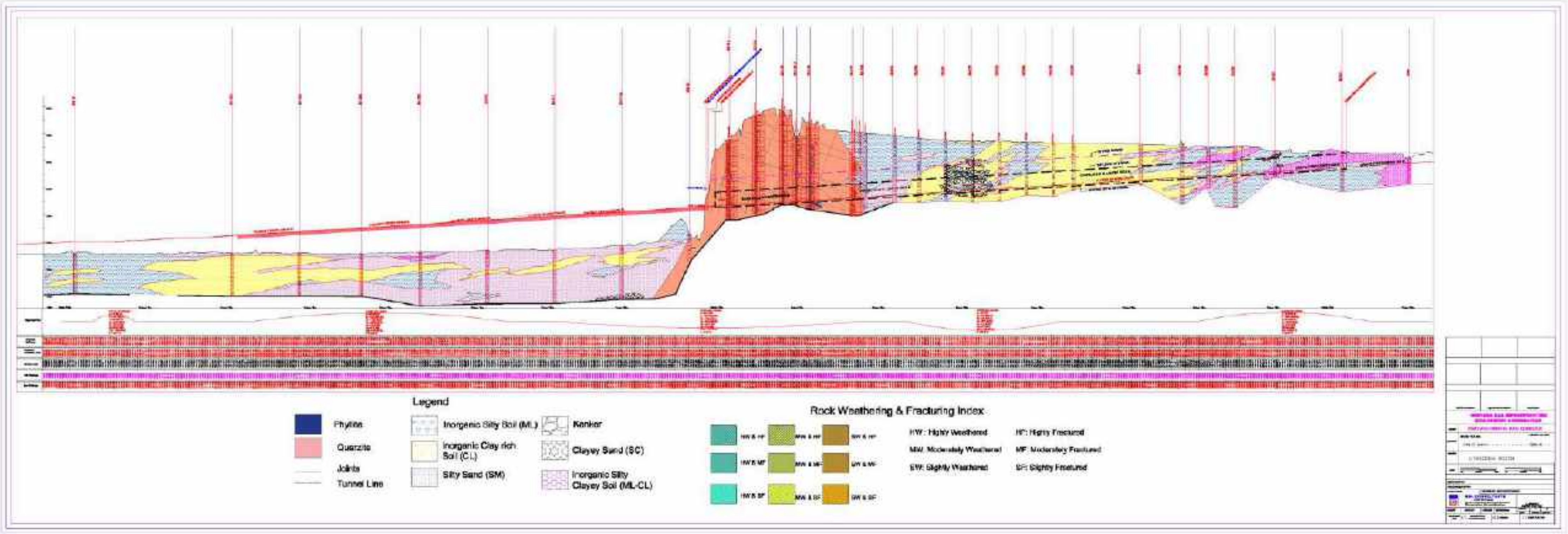


Figure 3.9: L-Section along the tunnel alignment (1:25000 H and 1:2500 V). Joint sets are schematically drawn with their actual orientation.

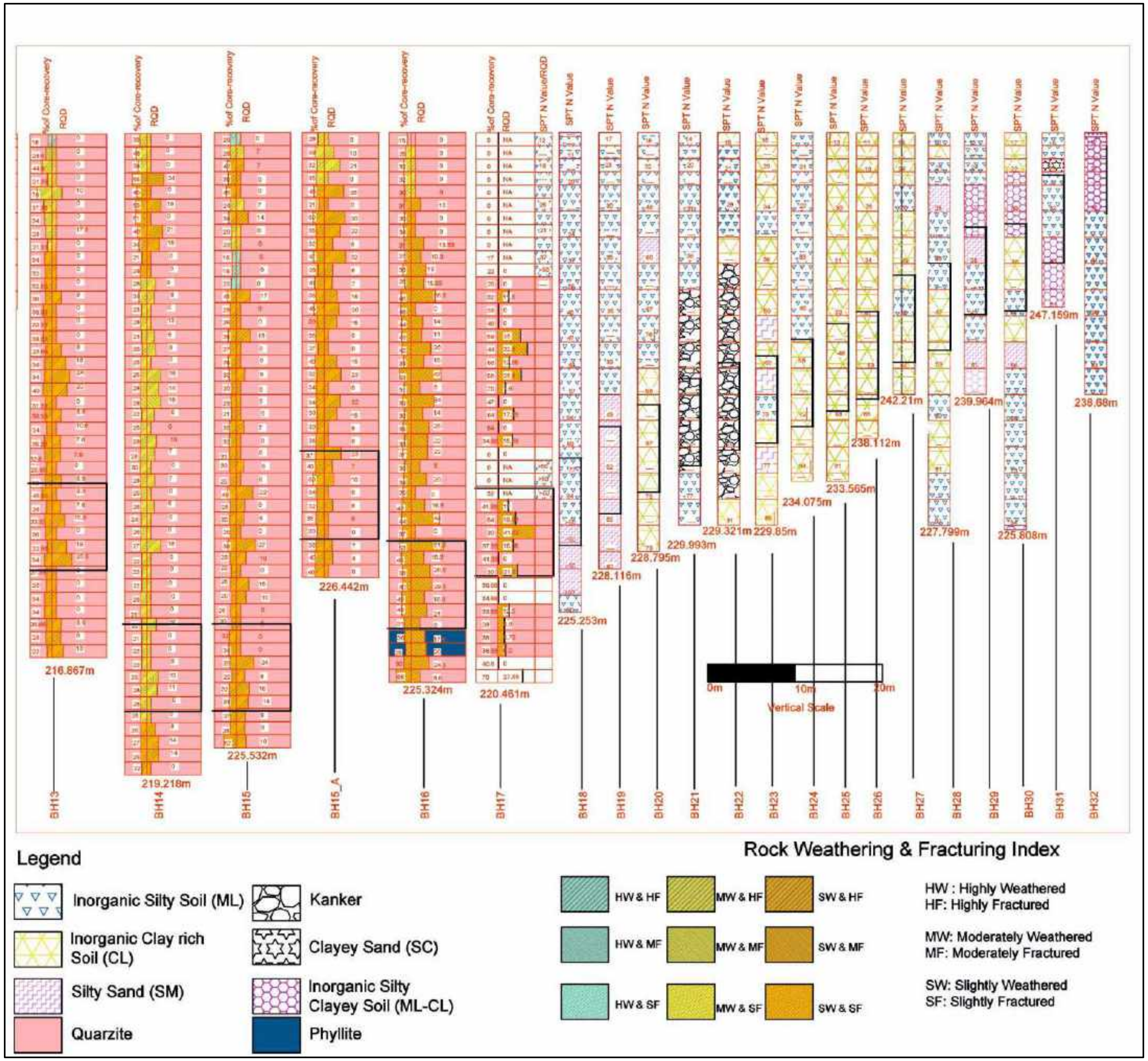
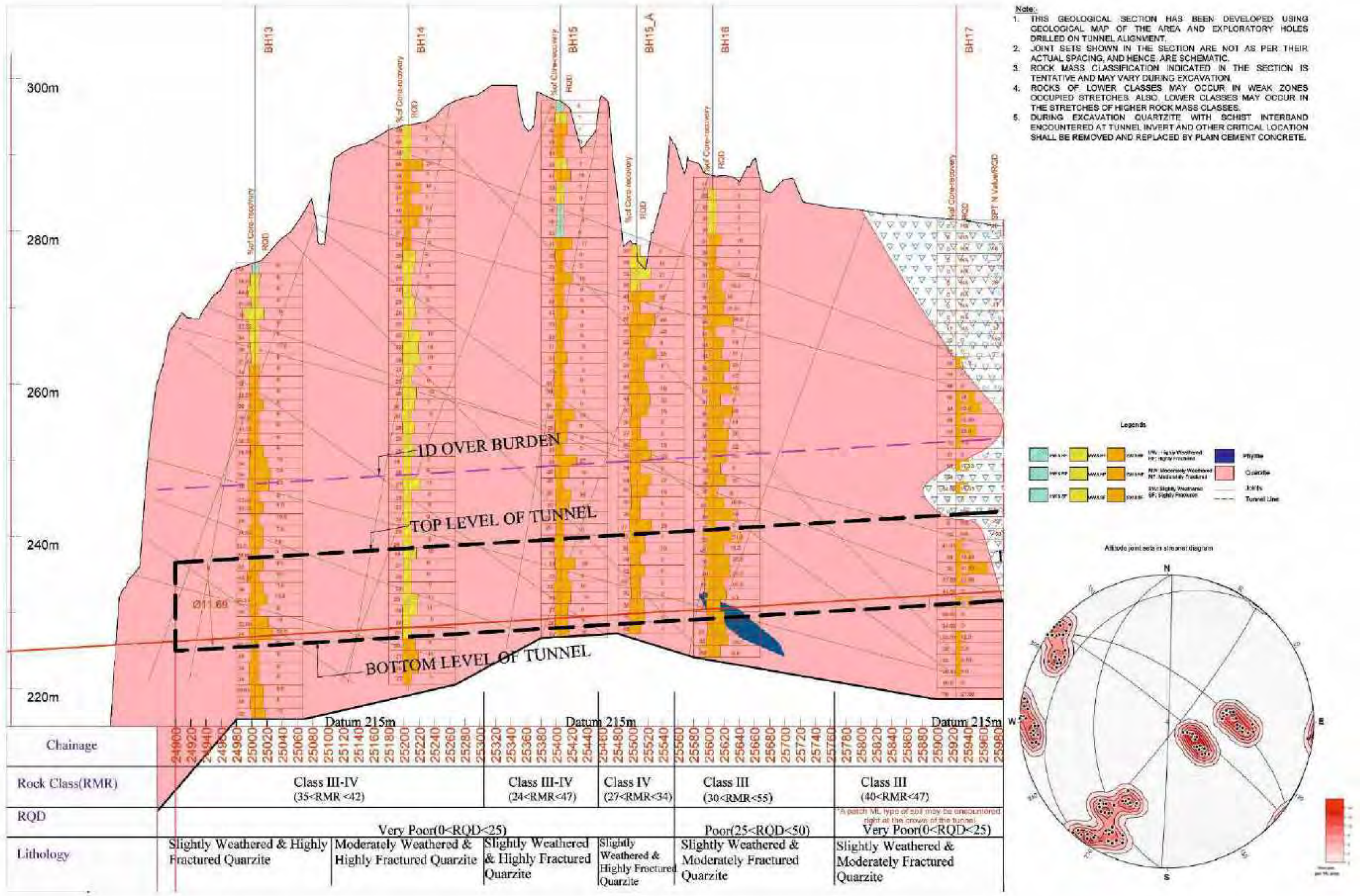


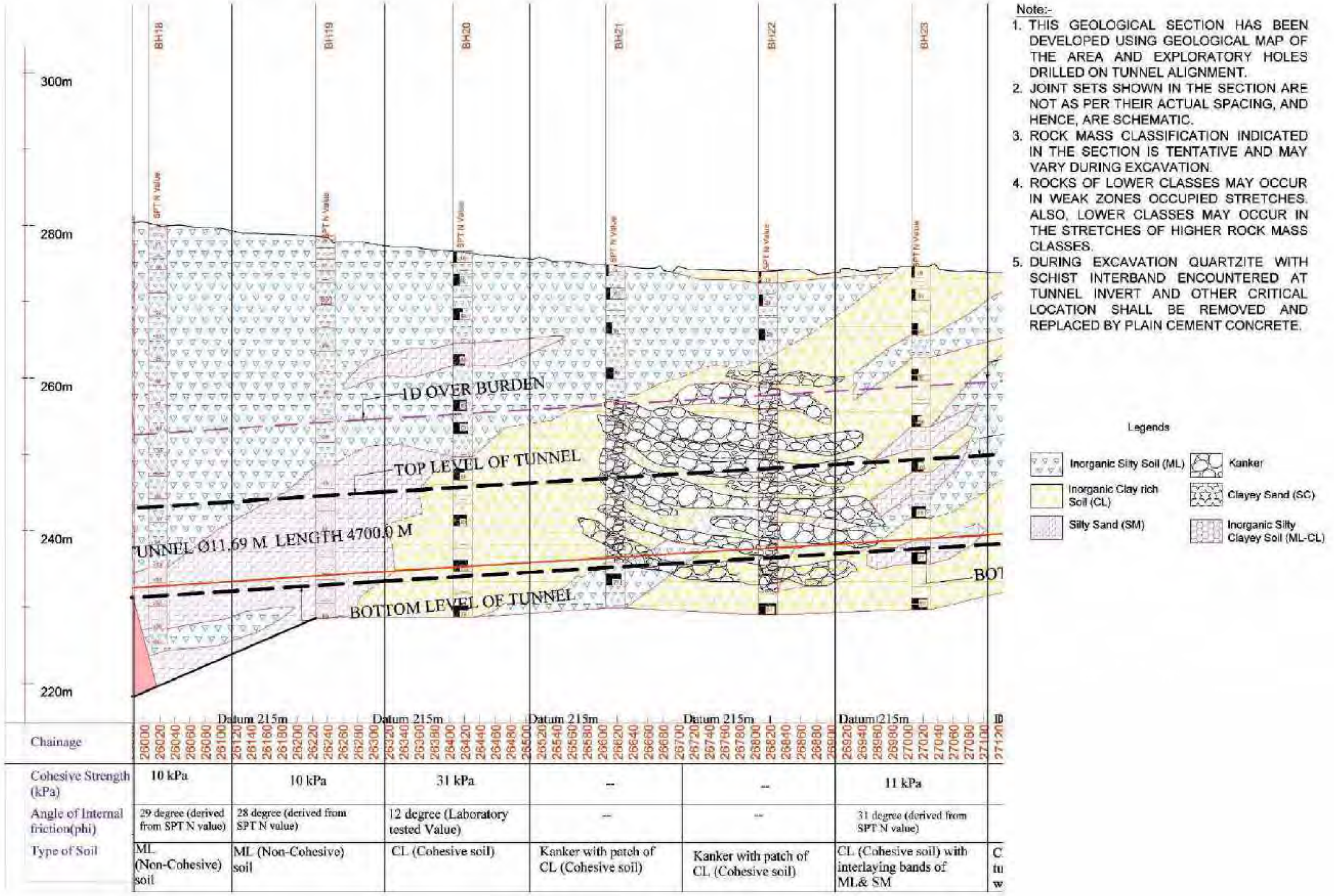
Figure 3.10: Graphical representation of the distribution of RQD, Core Recovery, SPTN Values and Soil types along each boreholes intersecting the tunnel (BH13-BH32). Thick black lines indicate the position of the tunnel.



Note:-

1. THIS GEOLOGICAL SECTION HAS BEEN DEVELOPED USING GEOLOGICAL MAP OF THE AREA AND EXPLORATORY HOLES DRILLED ON TUNNEL ALIGNMENT.
2. JOINT SETS SHOWN IN THE SECTION ARE NOT AS PER THEIR ACTUAL SPACING, AND HENCE, ARE SCHEMATIC.
3. ROCK MASS CLASSIFICATION INDICATED IN THE SECTION IS TENTATIVE AND MAY VARY DURING EXCAVATION.
4. ROCKS OF LOWER CLASSES MAY OCCUR IN WEAK ZONES OCCUPIED STRETCHES. ALSO, LOWER CLASSES MAY OCCUR IN THE STRETCHES OF HIGHER ROCK MASS CLASSES.
5. DURING EXCAVATION QUARTZITE WITH SCHIST INTERBAND ENCOUNTERED AT TUNNEL INVERT AND OTHER CRITICAL LOCATION SHALL BE REMOVED AND REPLACED BY PLAIN CEMENT CONCRETE.

Figure 3.11: Chainage-wise variation in RQD and RMR (Samples from 2D depth considered only).



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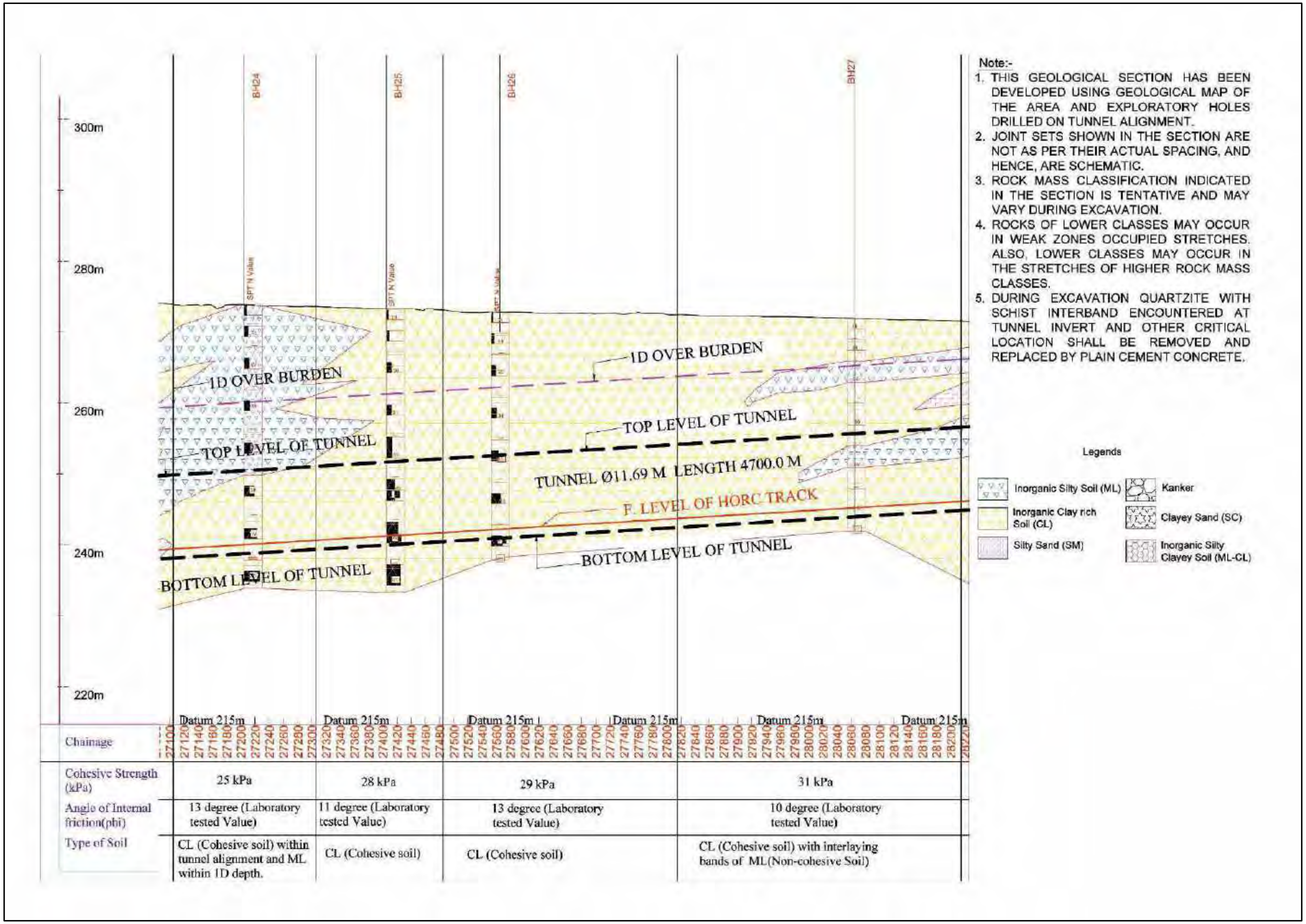
5. DURING EXCAVATION QUARTZITE WITH SCHIST INTERBAND ENCOUNTERED AT TUNNEL INVERT AND OTHER CRITICAL LOCATION SHALL BE REMOVED AND REPLACED BY PLAIN CEMENT CONCRETE.

Cohesive Strength (kPa)	10 kPa	10 kPa	31 kPa	--	--	11 kPa	
Angle of Internal friction(phi)	29 degree (derived from SPT N value)	28 degree (derived from SPT N value)	12 degree (Laboratory tested Value)	--	--	31 degree (derived from SPT N value)	
Type of Soil	ML (Non-Cohesive) soil	ML (Non-Cohesive) soil	CL (Cohesive soil)	Kanker with patch of CL (Cohesive soil)	Kanker with patch of CL (Cohesive soil)	CL (Cohesive soil) with interlaying bands of ML& SM	C tu w

Figure 3.12: Chainage-wise variation in C and ϕ. (Samples from 2D depth considered only).



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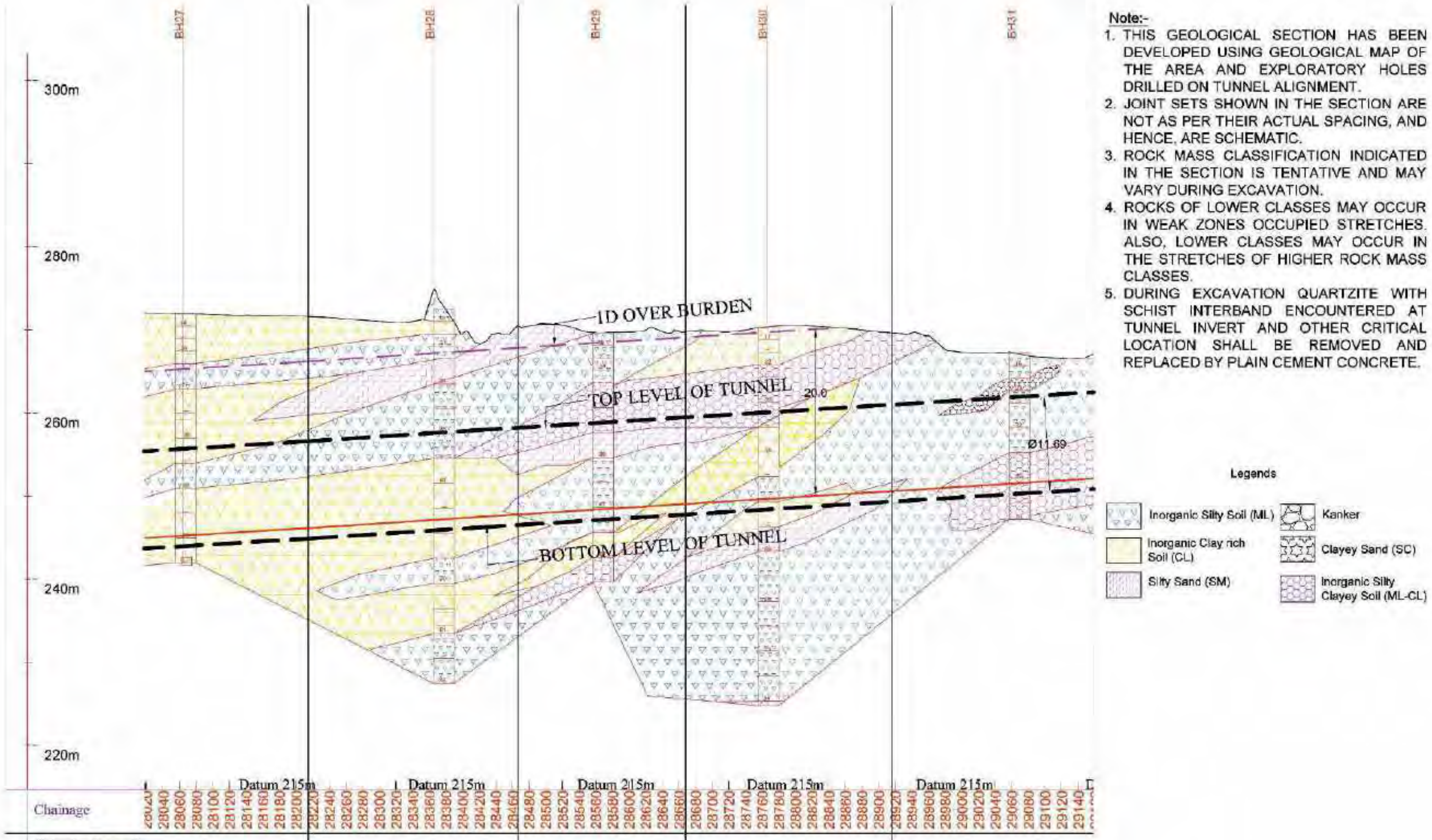
5. DURING EXCAVATION QUARTZITE WITH SCHIST INTERBAND ENCOUNTERED AT TUNNEL INVERT AND OTHER CRITICAL LOCATION SHALL BE REMOVED AND REPLACED BY PLAIN CEMENT CONCRETE.

Cohesive Strength (kPa)	25 kPa	28 kPa	29 kPa	31 kPa
Angle of Internal friction(phi)	13 degree (Laboratory tested Value)	11 degree (Laboratory tested Value)	13 degree (Laboratory tested Value)	10 degree (Laboratory tested Value)
Type of Soil	CL (Cohesive soil) within tunnel alignment and ML within 1D depth.	CL (Cohesive soil)	CL (Cohesive soil)	CL (Cohesive soil) with interlaying bands of ML(Non-cohesive Soil)

Figure 3.13: Chainage-wise variation in C and ϕ. (Samples from 2D depth considered only).



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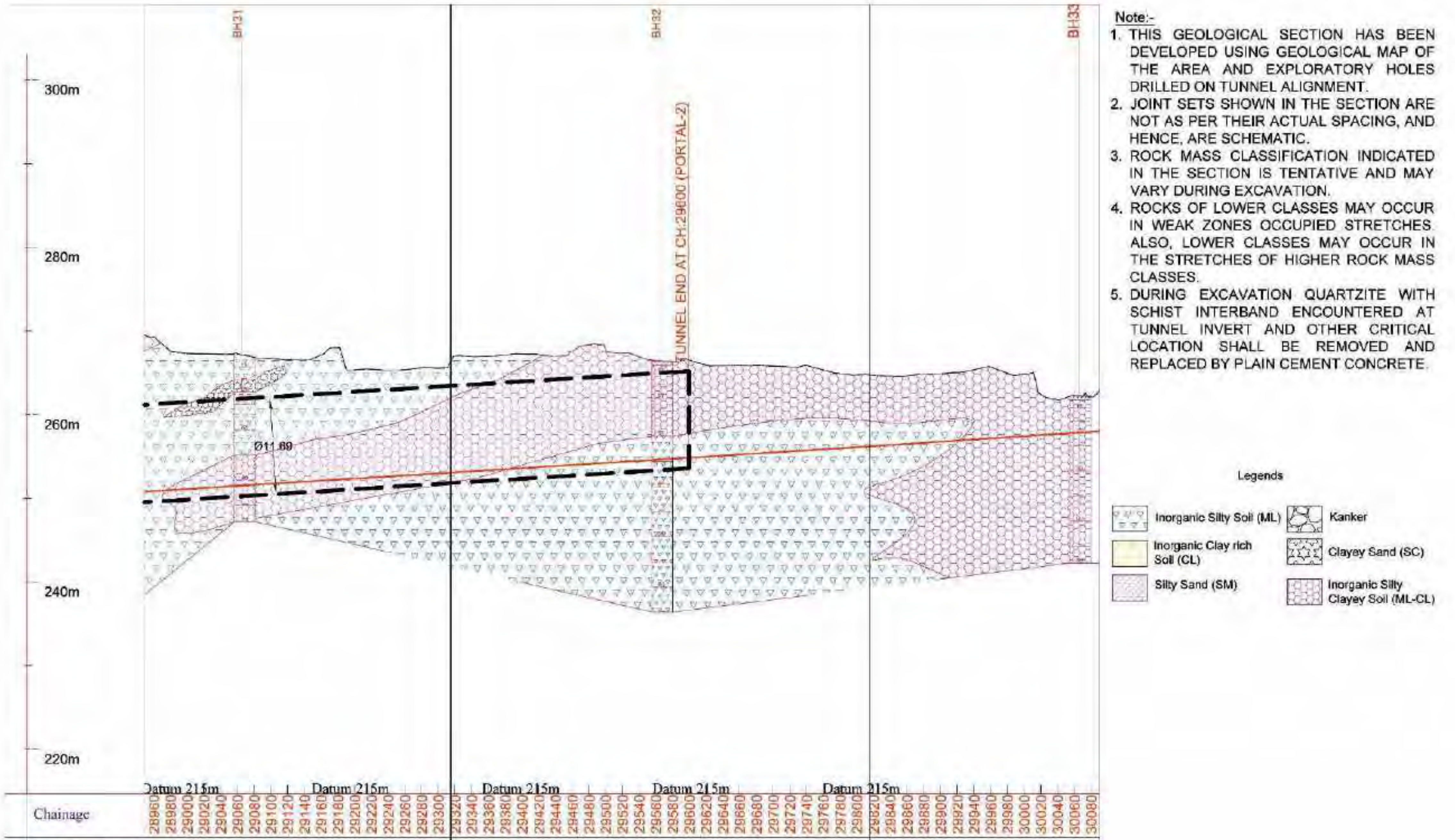
5. DURING EXCAVATION QUARTZITE WITH SCHIST INTERBAND ENCOUNTERED AT TUNNEL INVERT AND OTHER CRITICAL LOCATION SHALL BE REMOVED AND REPLACED BY PLAIN CEMENT CONCRETE.

Cohesive Strength (kPa)	Pa	27 kPa	12 kPa	32 kPa	14 kPa
Angle of Internal friction(phi)	(Laboratory ue)	10 degree (Laboratory tested Value)	31 degree (derived from SPT N value)	10 degree (Laboratory tested Value)	30 degree (derived from SPT N value)
Type of Soil	interlaying sive Soil)	CL (Cohesive soil) within tunnel alignment and ML within 1D depth.	Interlayering of ML, SM, ML-CL (all Non cohesive soil) within the 2D depth.	CL (Cohesive soil) within tunnel alignment and ML-CL(Non-Cohesive)	Interlayering of ML, SM, ML-CL (all Non cohesive soil) within the 2D depth.

Figure 3.14: Chainage-wise variation in C and ϕ. (Samples from 2D depth considered only).



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5. DURING EXCAVATION QUARTZITE WITH SCHIST INTERBAND ENCOUNTERED AT TUNNEL INVERT AND OTHER CRITICAL LOCATION SHALL BE REMOVED AND REPLACED BY PLAIN CEMENT CONCRETE.

Cohesive Strength (kPa)	4 kPa	4 kPa	8 kPa
Angle of Internal friction(phi)	30 degree (derived from SPT N value)	26 degree (derived from SPT N value)	26 degree (derived from SPT N value)
Type of Soil	ML-CL (Non-Cohesive soil)	ML (Non-Cohesive soil)	ML-CL (Non-Cohesive soil)

Figure 3.15: Chainage-wise variation in C and ϕ values, along the cut & cover region, for the strata below formation level.

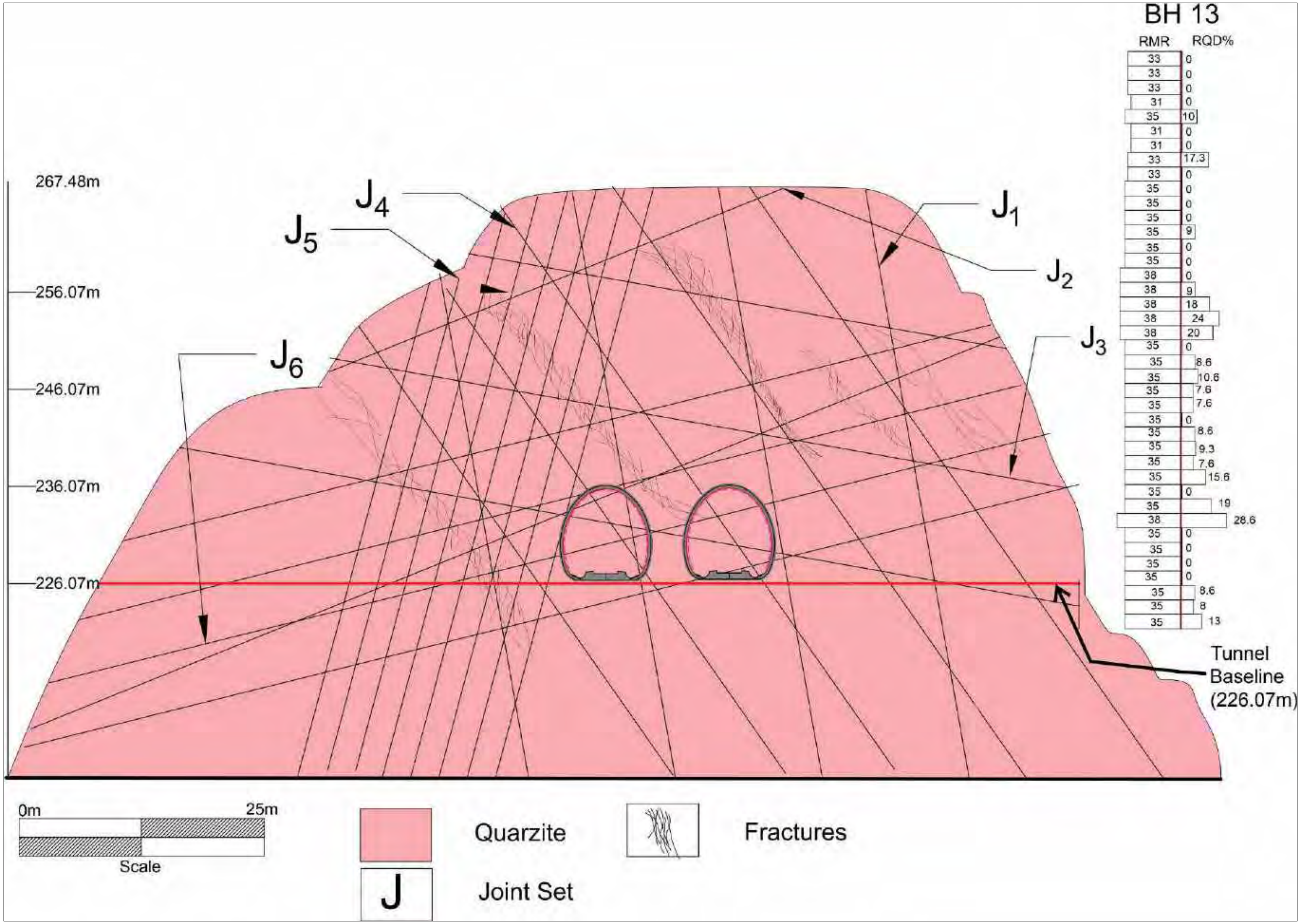

Figure 3.16: Detailed cross section of the Portal-I, on the mountain front. Joint sets are schematically drawn maintaining their actual orientation. Average spacing between the joints are as follows J_1: 300 cm, J_2:252.78cm, J_3:160cm, J_4:80cm, J_5:32cm, J_6:100cm.

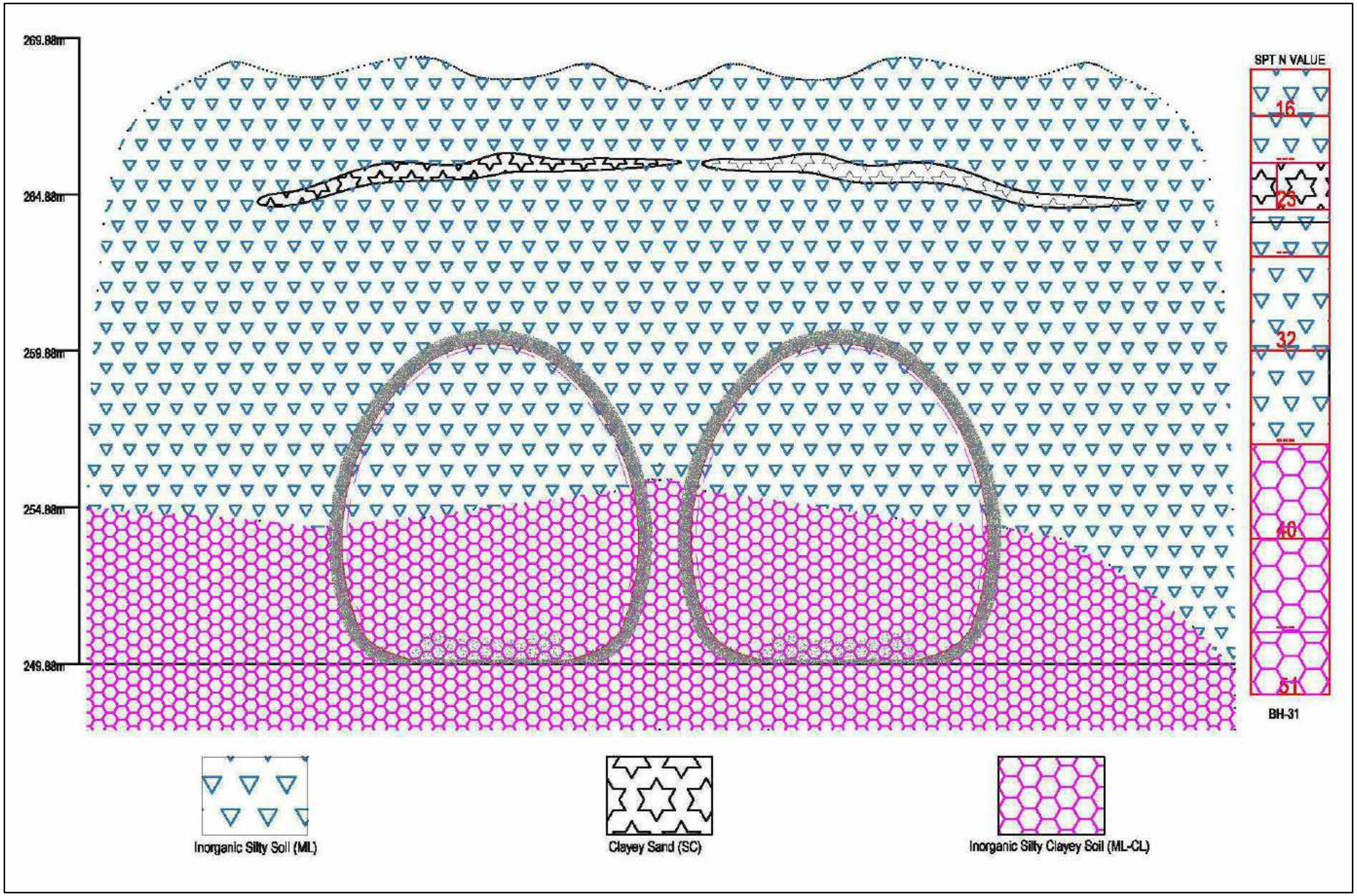

Figure 3.17: Detailed lithological cross section at the end of NATM Structure in soil (CH 28900).

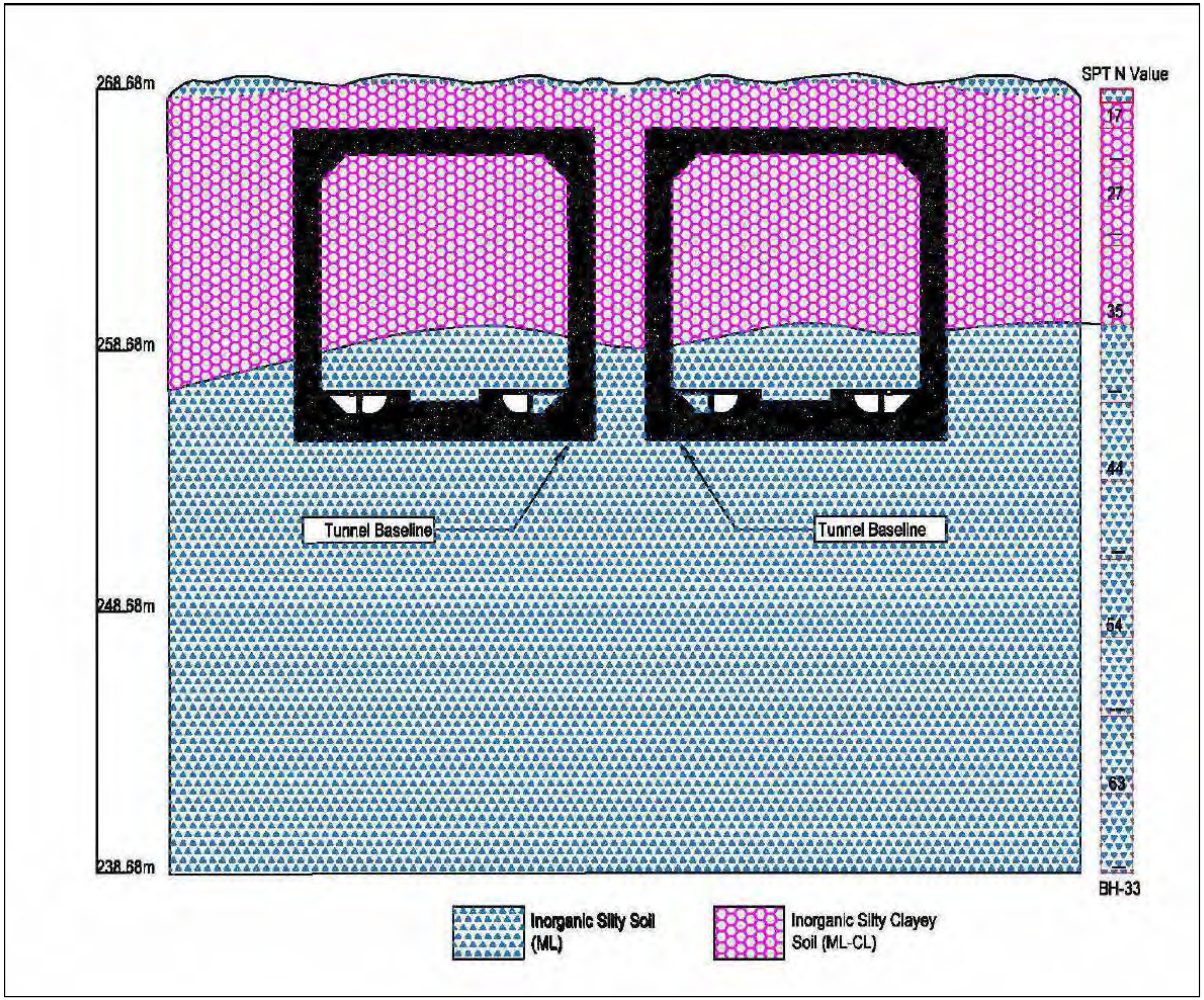

Figure 3.18: Cut and Cover structure at the end of tunnel – Portal II (CH29600).

Table 3.3: Abstract of Safe Bearing Pressure for cut and cover portion (BH-32 & 33).

Location	Depth from N.G.L in m.	Type of Soil	Field SPT value	Group of sample	Cohesion (C) in KPa	Angle of internal friction (ϕ))	E (in MPa)	Net Safe Bearing Capacity in T/m^2	Settlement in mm	Safe Bearing Pressure for 25 mm settlement in T/m^2	Recom mended SBC in T/m^2
BH-32	21.0	S.P.T	N>50	ML	4	26	31	1100	709	39.0	35
	24.0	S.P.T	N>50					1101	793	35.0	35
BH-33	20.0	SPT	N>30	ML-CL	8	26	27.6	262	245	27	27

4 GEOTECHNICAL INVESTIGATION OF ROCK MASS:

Based on the available information from Geotechnical Report, geotechnical investigations have been carried out at different locations along the tunnel alignment and at stations.

4.1 Summary of the Boreholes within ROCK MASS:

The boreholes relevant to this project are mentioned in table below (Table 4.1).

Table 4.1: Details of Boreholes drilled for the project along the tunnel line.

BH No.	Chainage No.	Ground Elevation, RL (m)	Formation Level as Per Alt.2A	Total depth (m)
BH-13	25000	276.867	226.801	60
BH-14	25195	294.218	228.013	75
BH-15	25380	295.532	229.225	70
BH-15A	25488	276.442	229.833	50
BH-16	25586	287.324	230.437	62
BH-17	25785	282.461	231.650	62

4.2 Field Tests for ROCK MASS:

Field tests are conducted in boreholes that are taken along the proposed tunnel alignment and the station locations. The following table shows the summary of field tests conducted in Rock mass

Table 4.2: Details of test conducted at site.

Field Tests	Type of Test
In Rock	Core recovery and RQD
	Permeability Test

4.3 Field Test Result for ROCK MASS:

For the rock masses, during the drilling activity the percentage of core recovery and RQD has been calculated. These on field results has been summarized in Table 4.3.

Table 4.3: Result for the field tests.

BH No.	Chainage No.	Ground Elevation, RL (m)	Depth (m)	For Rock		
				% of Core recovery	RQD %	Avg. RMR from 2D Depth (*refer to section 5.5.2)
BH-13	25000	276.867	0.5-60	30.96	6.5	38
BH-14	25195	294.218	0.5-75	28.94	5.9	37
BH-15	25380	295.532	0.5-70	28.91	5.91	34
BH-15A	25488	276.442	0.5-50	35.79	10.67	29
BH-16	25586	287.324	0.5-62	36.52	16.02	41
BH-17	25785	282.461	0.5-62	30.02	10.98	42

The packer test method was carried out as per IS 5529 (Part 2): 2006 to determine the permeability of the rock strata at site presented in Table 4.4.

Table 4.4: Result for permeability tests

BH No.	Packer test section 1		Lugeon Value	Packer test section 2		Lugeon Value
	Upper part (m)	Lower part (m)		Upper part (m)	Lower part (m)	
BH-13	36	39	30.20	48	51	25.62
BH-14	54	57	24.46	63	66	21.88
BG-15	55	58	24.34	64	67	18.42
BH-16	44	47	27.38	56	59	21.14

4.4 Laboratory Tests:

Laboratory tests were also carried out on rock samples, the details of different laboratory tests conducted as part of the project are given in the table below (Table 4.5)

Table 4.5: The laboratory tests conducted for rock.

Laboratory tests conducted for rock	1. Unconfined Compressive Strength,
	2. Point Load Index Test
	3. Tensile Strength
	4. Specific Gravity
	5. Modulus of elasticity
	6. Water absorption
	7. Poisons' ratio
	8. Triaxial Test
	9. Hardness test
	10. Abrasive test

4.5 Laboratory Test Result for Rock Mass:

This section comprises depth wise results of the tests conducted in laboratory for rock masses in accordance with relevant standard codes of practices. Multiple tests in laboratory (Table 4.5) are adopted to ascertain the different essential characteristics of sub-surface using field samples obtained in during field investigations and borehole drilling. The tests as under have been conducted to ascertain the parameters indicated in the test. The findings of these test are required for use in relevant engineering designs and summarized in following tables (Table 6.1).

Representative core samples have been taken from the boreholes along the tunnel alignment. The samples were properly labelled and packed carefully and sent NABL accredited laboratory for determining the physico-mechanical engineering properties as per Indian standardized regulation. Summary of results from the laboratory testing has been graphically presented below.

4.5.1 Uniaxial Compressive Strength

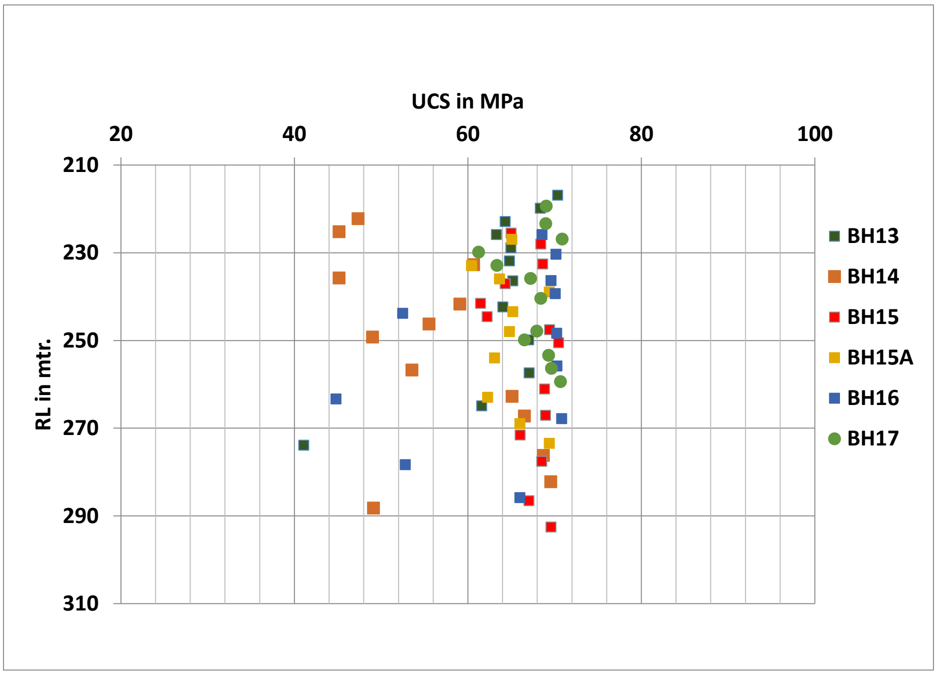

Figure 4.1: Unconfined Compressive Strength (UCS) of rock mass from entire borehole length vs RL (Refer to Annexure C in Geotechnical Report for detail).

To make recommendation related to the engineering property of the surrounding rock material, which is going to directly influence the tunnel built, samples from 2D has been considered. Pareto chart has been prepared to identify the most frequent and categorically influential data set out of the scattered values. It is based on 80/20 rule, i.e., “Vital few and trivial many” principle. The idea is that the few identified vital values will always statistically dominate over many.

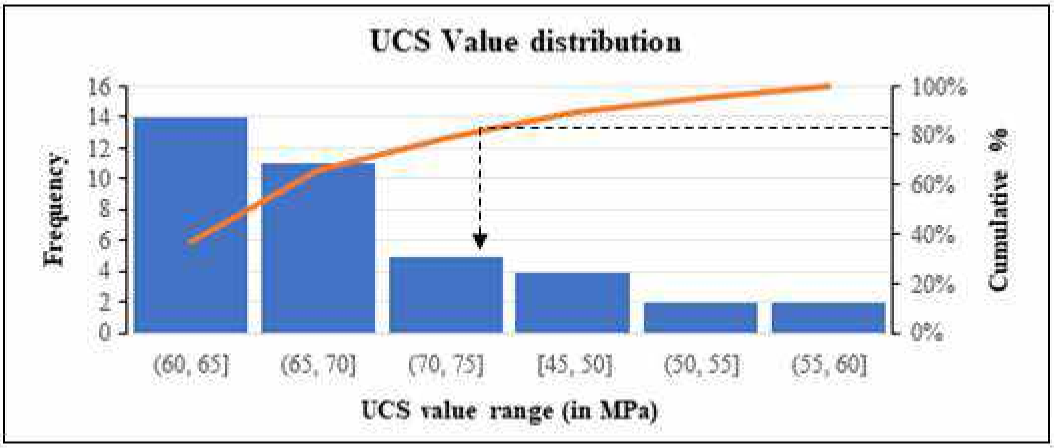

Figure 4.2: Pareto Chart showing recommended UCS value for the rock mass from 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the UCS value ranging 60-75 MPa. For safer construction the lower value of the range **60 MPa** is recommended as UCS value for the rock mass.

4.5.2 Assessment of Rock Mass Rating (RMR):

The outcrops encountered along the stretch of the alignment in this project is homogenously Quartzite. The classification of rock types with Rock Mass Rating (RMR) is done based on RQD%, Uniaxial compressive strength of rock material, spacing of discontinuities/joints, Smoothness, Infilling, Alteration/weathering along the discontinuity/joints and ground water condition and borehole wise average index values are tabulated below (For detailed result refer Annexure from Geotechnical Report on this project). Based on the results the rock mass has been broadly classified as **CLASS IV (Poor Rock Mass)**. However, in some of the cases, the RMR value being close to 40, it may be considered as Class III.

Q tunnelling index was also evaluated and the rock mass were found to be in same “POOR ROCK MASS” category. However, accessing Q parameters from boreholes, instead of excavated wall, is considerably subjective and unprecise. Therefore, the Q parameters has not been used for recommending the tunnel support.

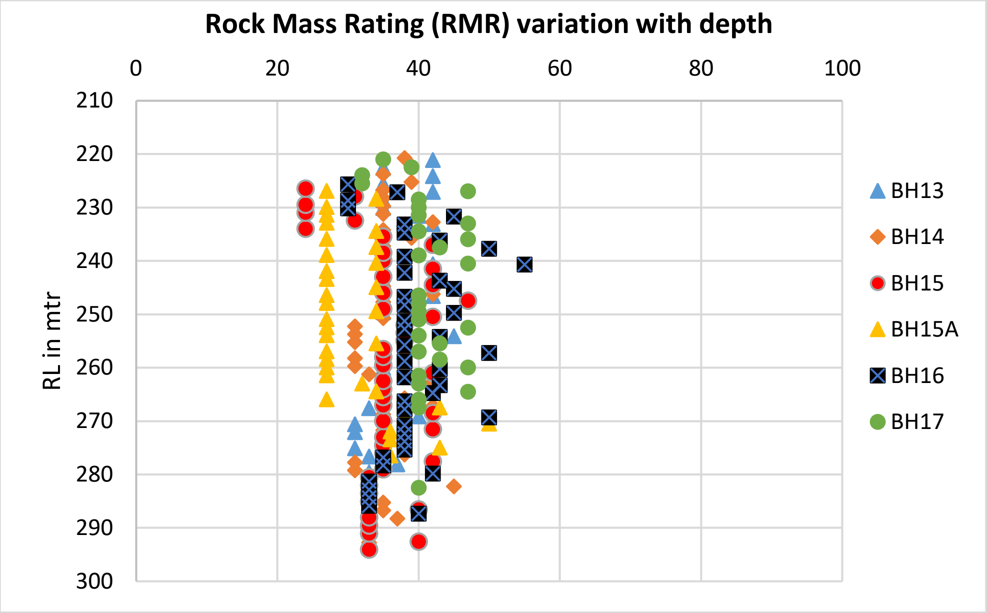

Figure 4.3: Graphical representation of RMR of rock mass from entire borehole length with depth. (Refer to Annexure A in Geotechnical Report for detail).

RMR value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

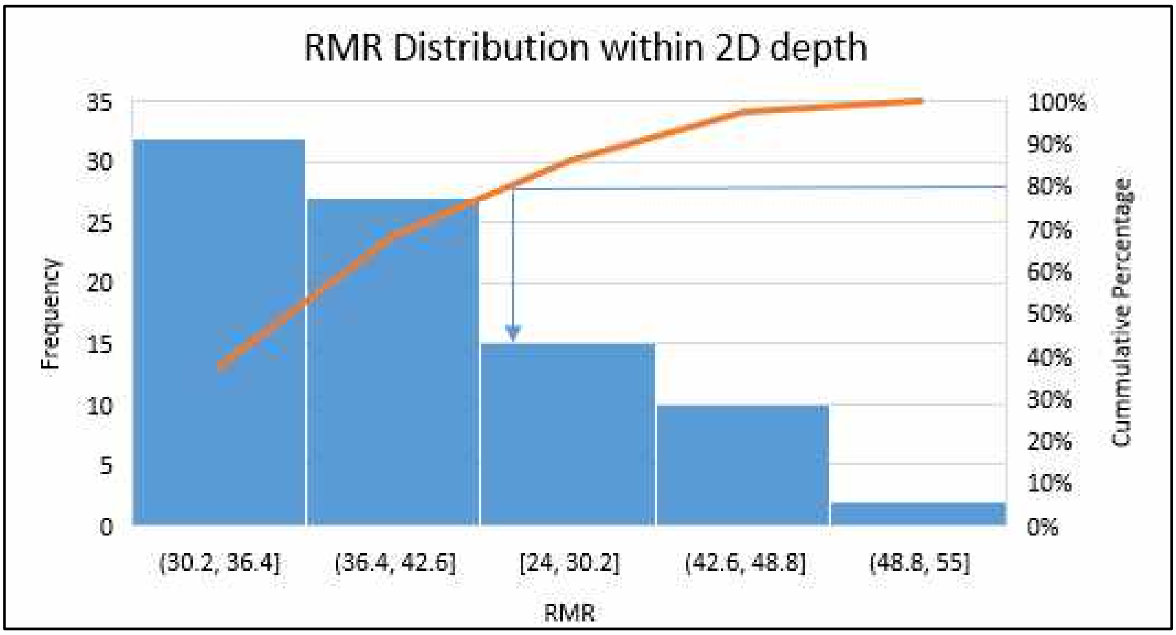

Figure 4.4: Pareto Chart showing recommended RMR value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the RMR value ranging 24-43, only 20% data has RMR value >40. Therefore, the entire rock mass up to 2D height from the formation level statistically belong to **“CLASS IV”**. Hence, as per Bieniawski, 1989, systematic bolts 4-5m long, spaced 1-1.5 m in crown and walls with wire mesh, 100-150 mm shotcrete in crown and 100mm shotcrete in sides, light to medium steel ribs spaced 1.5 m is recommended as tunnel support. However, along some chainage interval the support system of Class III may be used by the discretion of the design engineer.

****For chainage wise variation in RMR value refer to Figure 3.11**.

4.5.3 Point Load Index:

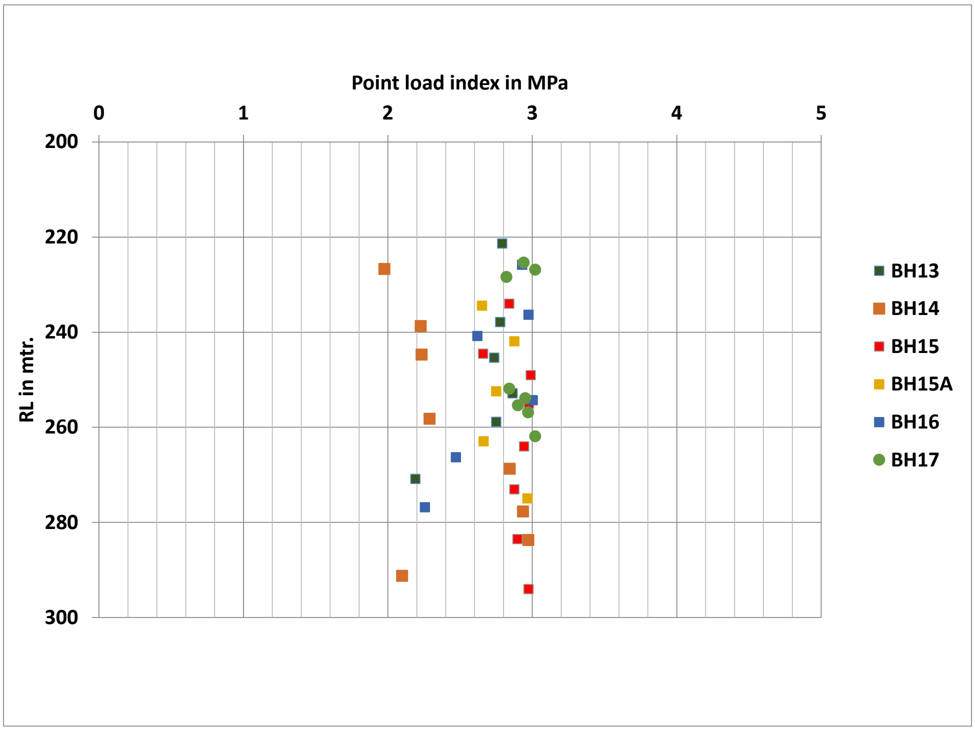

Figure 4.5:Point Load Index (PLI) of rock mass from entire borehole length vs RL. (Refer to Annexure E in Geotechnical Report for detail).

PLI value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

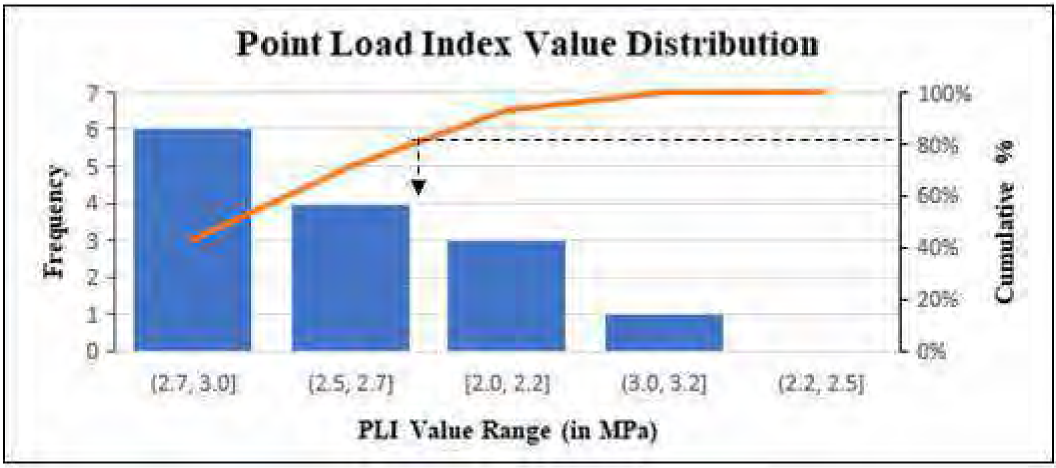

Figure 4.6: Pareto Chart showing recommended PLI value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the PLI values are ranging 2.5 to 3.0 MPa. For safer construction the lower value of the range **2.5 MPa** is recommended as PLI value for the rock mass.

4.5.4 Tensile Strength:

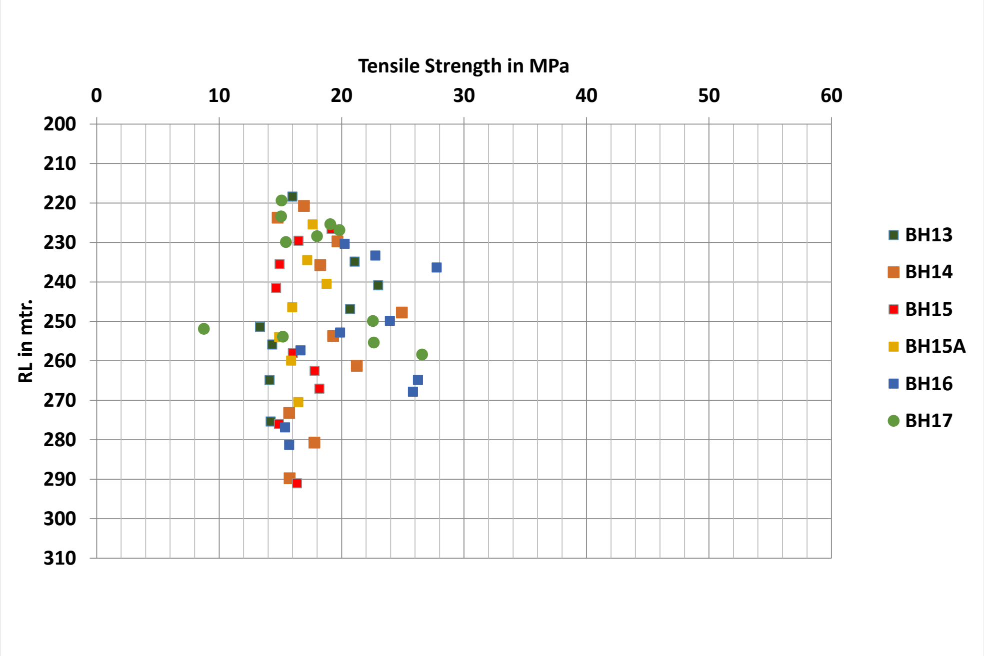

Figure 4.7:Tensile Strength of rock mass from entire borehole length vs RL. (Refer to Annexure B in Geotechnical Report for detail).

Tensile strength value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

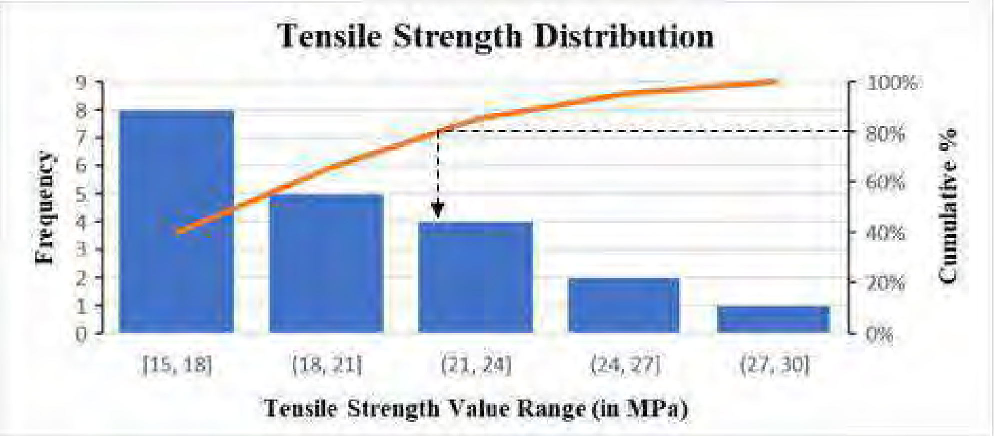

Figure 4.8: Pareto Chart showing recommended tensile strength value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Tensile strength value ranging 15-21 MPa. For safer construction the lower value of the range **15 MPa** is recommended as Tensile Strength value for the rock mass.

4.5.5 Modulus of Elasticity:

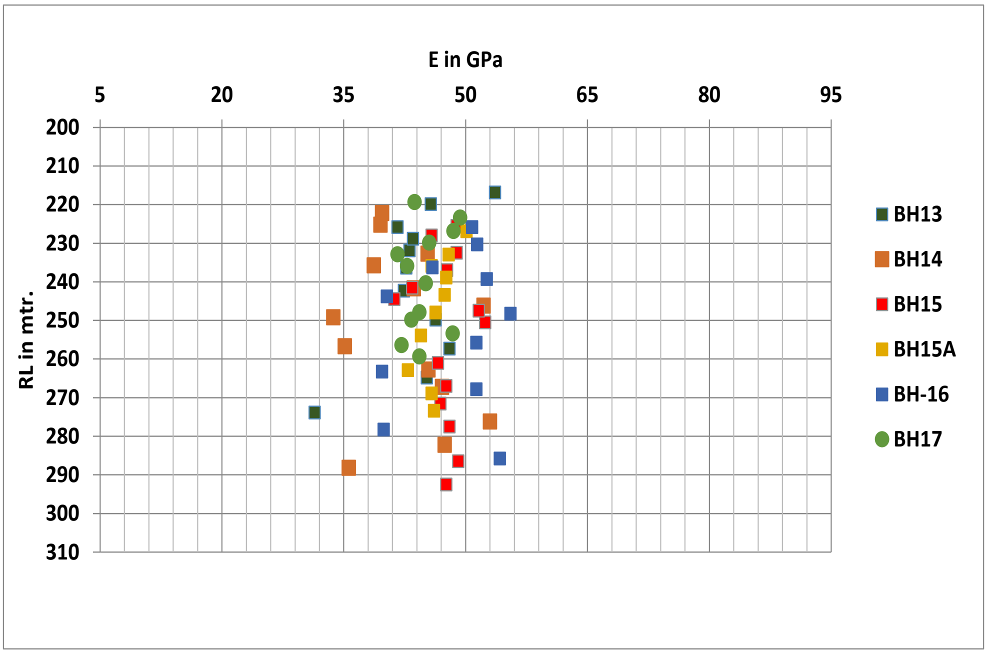

Figure 4.9: Modulus of Elasticity (E) of rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).

Modulus of Elasticity value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

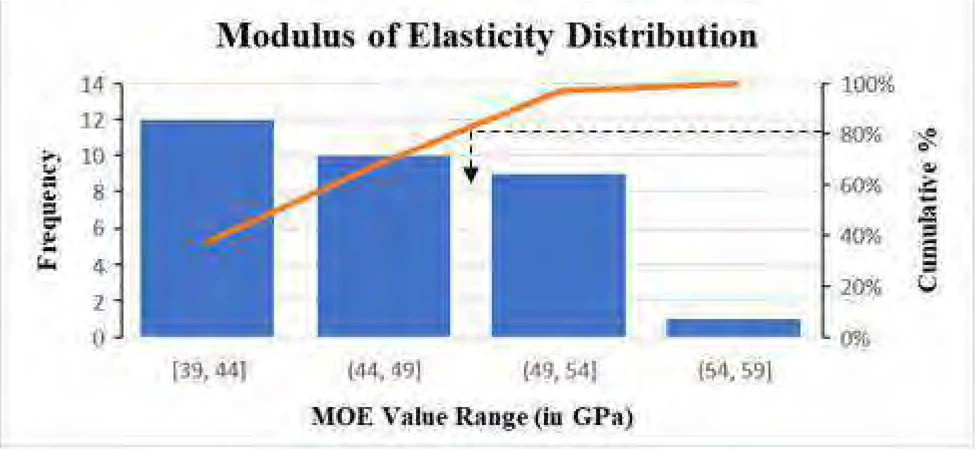

Figure 4.10: Pareto Chart showing recommended Modulus of Elasticity (E) value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Modulus of Elasticity value ranging 39-49 GPa. For safer construction the lower value of the range **39 GPa** is recommended as Modulus of Elasticity value for the rock mass.

4.5.6 Poison's ratio:

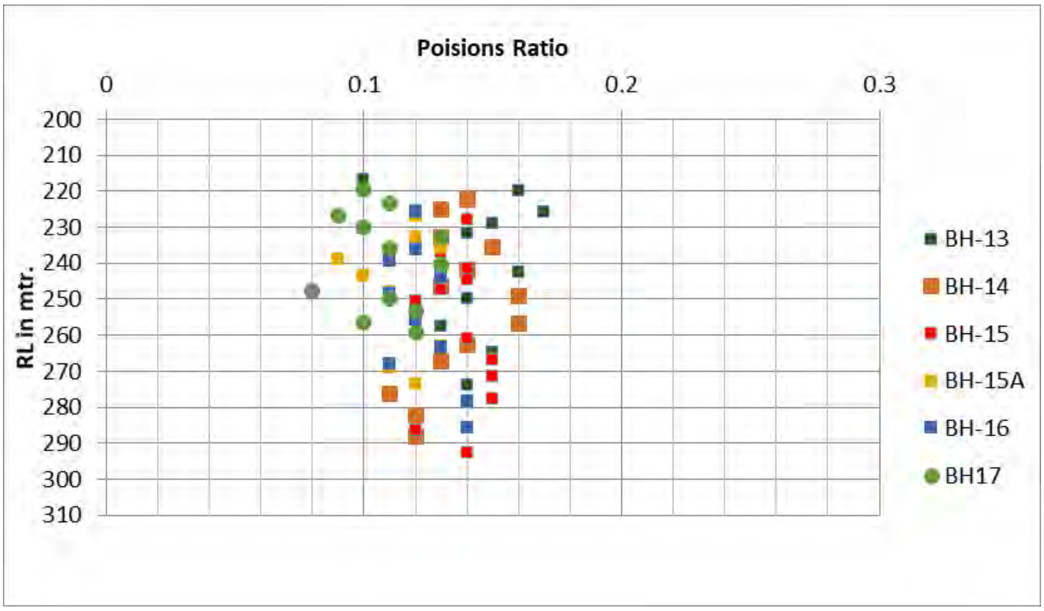

Figure 4.11: Poisson's Ratio distribution for the entire rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).

Poison's ratio value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

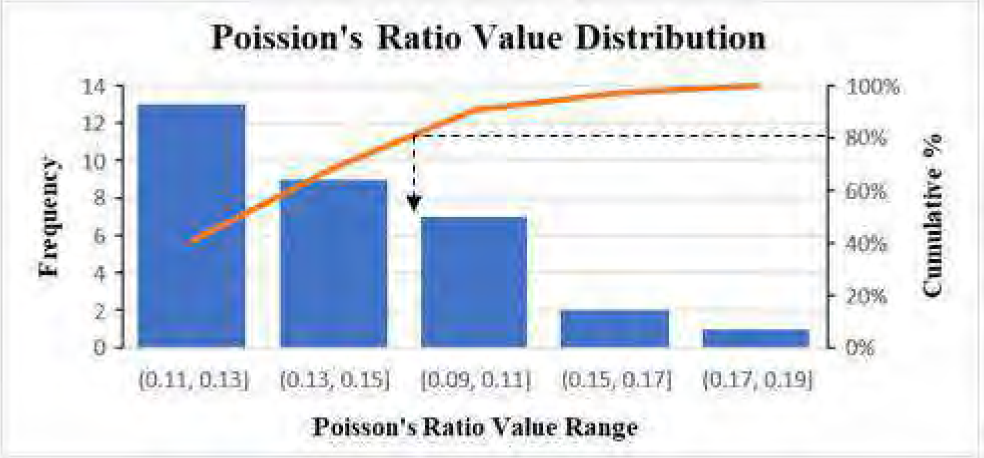

Figure 4.12: Pareto Chart showing recommended Poisson's Ratio value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Tensile strength value ranging 0.11-0.15. For safer construction the higher value of the range **0.15** is recommended as Poisson's Ratio value for the rock mass.

4.5.7 Hardness:

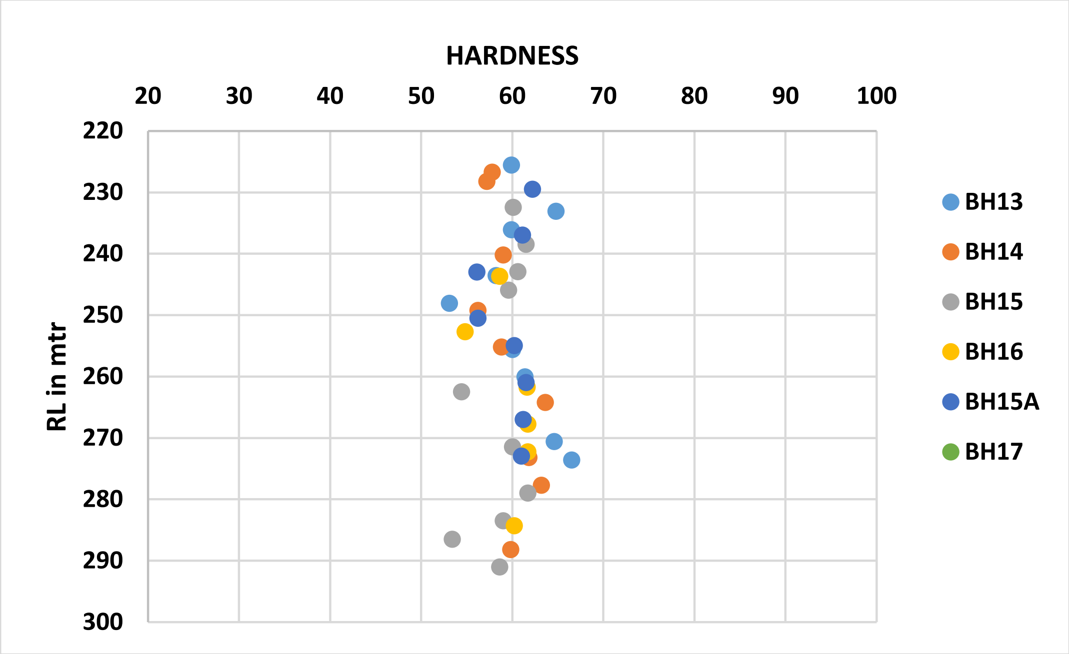

Figure 4.13: Hardness of rock mass from entire borehole length vs RL. (Refer to Annexure H in Geotechnical Report for detail).

Hardness value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

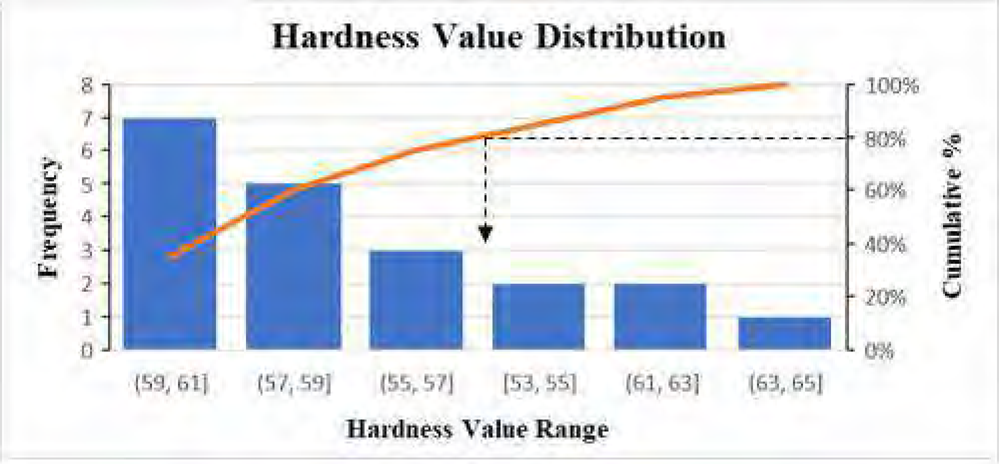

Figure 4.14: Pareto Chart showing recommended Hardness value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Hardness value ranging 55-61. For safer construction the lower value of the range **55** is recommended as Hardness value for the rock mass.

4.5.8 Abrasive Index:

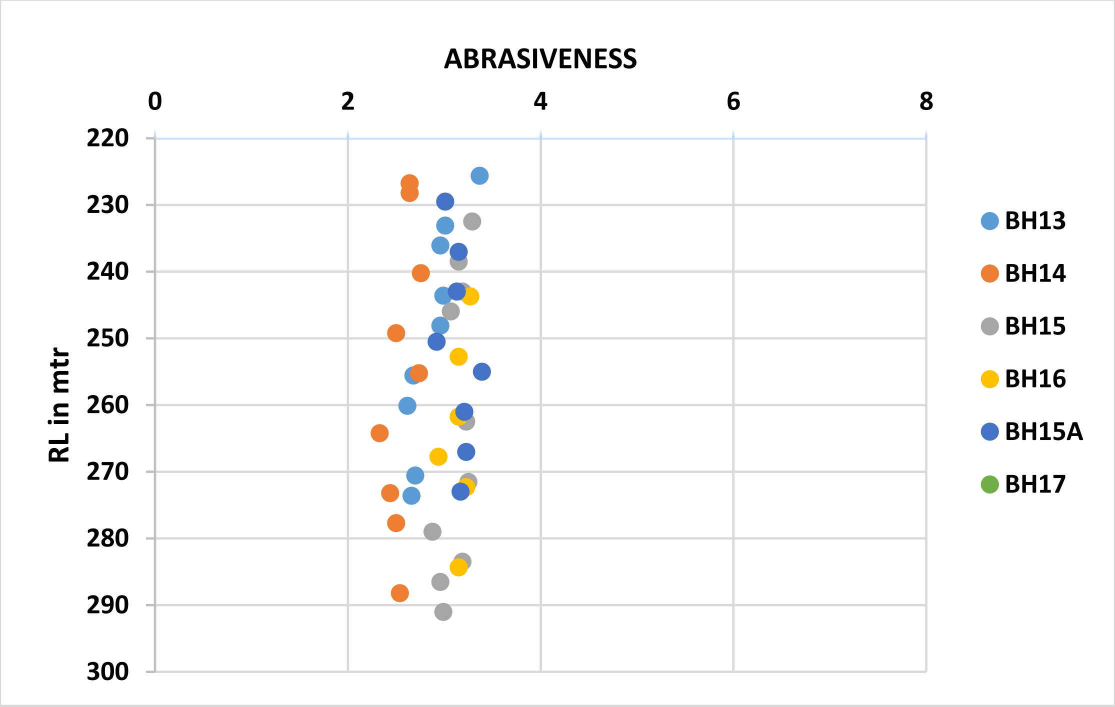

Figure 4.15:Abrasiveness of rock mass from entire borehole length vs RL. (Refer to Annexure I in Geotechnical Report for detail).

Abrasive Index value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

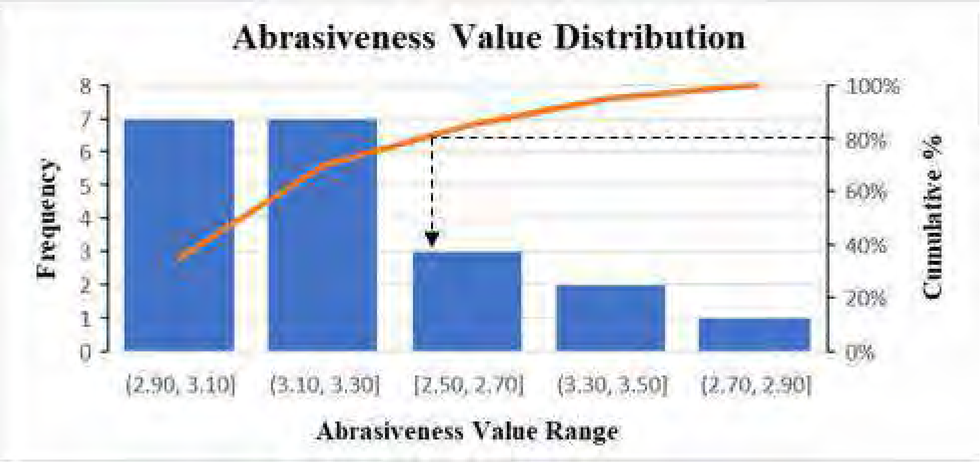

Figure 4.16: Pareto Chart showing recommended Abrasiveness index value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Hardness value ranging 2.50-3.30. For safer construction the higher value of the range **3.30** is recommended as Abrasiveness index value for the rock mass.

4.5.9 Angle of Internal Friction (ϕ):

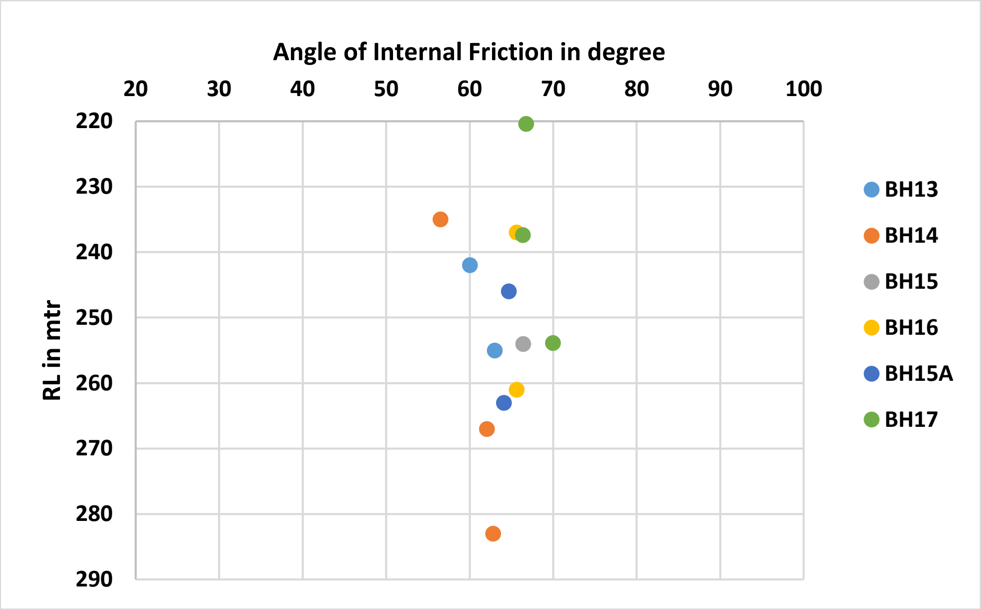

Figure 4.17: Angle of internal friction of rock mass from entire borehole length vs RL (Refer to Annexure G in Geotechnical Report for detail).

Angle of Internal Friction (ϕ) value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

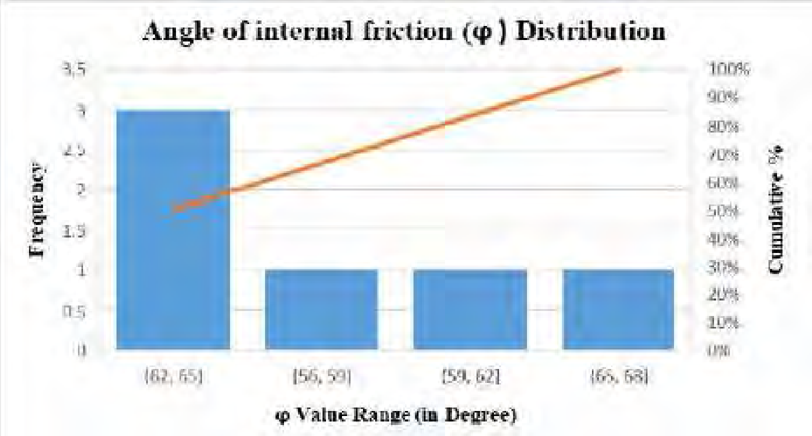

Figure 4.18: Pareto Chart showing recommended angle of internal friction value for the rock mass within 2D depth. (The straight cumulative frequency curve, in orange, indicates that all of the classes contribute significantly. Therefore, entire range of the population needs to be considered.)

Laboratory tested angle of internal friction value for the rock mass samples from 2D depth are quite scattered ranges between 55°-65°. For safer construction the Lower value of the range **55°** is recommended as angle of internal friction value for the rock mass.

4.5.10 Cohesion:

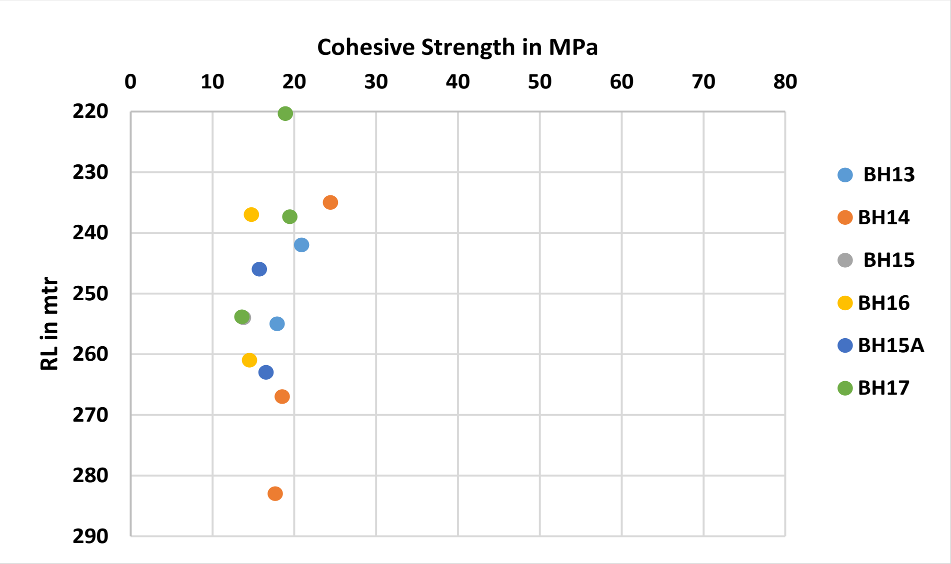

Figure 4.19: Cohesive strength of rock mass from entire borehole length vs RL (Refer to Annexure F in Geotechnical Report for detail).

Cohesion value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

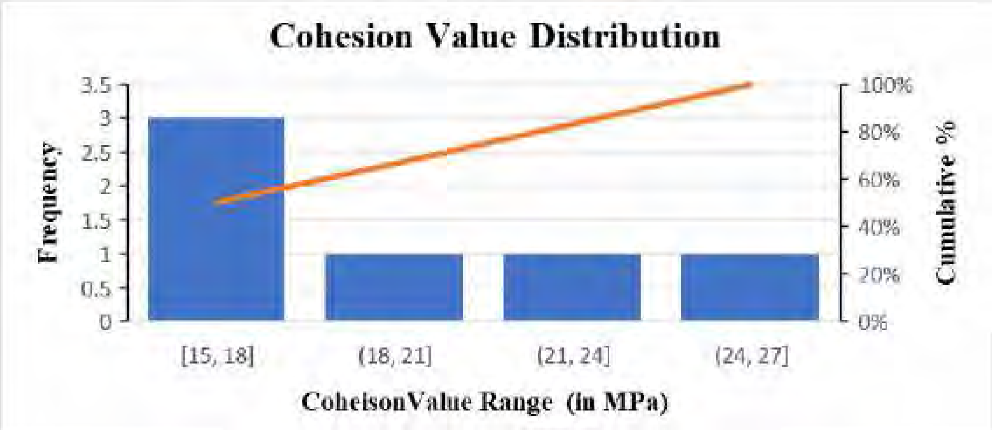

Figure 4.20: Pareto Chart showing recommended Cohesion value for the rock mass within 2D depth. (The straight cumulative frequency curve, in orange, indicates that all of the classes contribute significantly. Therefore, entire range of the population needs to be considered.)

Laboratory tested cohesion value for the rock mass sample from 2D depth are quite scattered ranges between 15-25 MPa. For safer construction the Lower value of the range **15 MPa** is recommended as Cohesion value for the rock mass.

4.5.11 Lugen Value:

Lugen value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

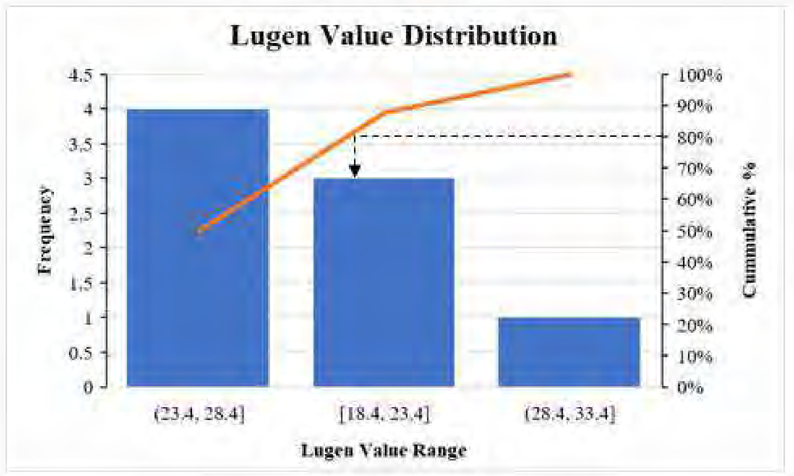

Figure 4.21: Pareto Chart showing recommended Lugeon value for the rock mass within 2D depth

As shown in the *Pareto Chart* above, 80% of the total collected samples has the Packer test Lugeon value ranging 18.4-28.4. For safer construction the higher value of the range 28.4 is recommended as Lugeon value for the rock mass.

4.5.12 Wet Density:

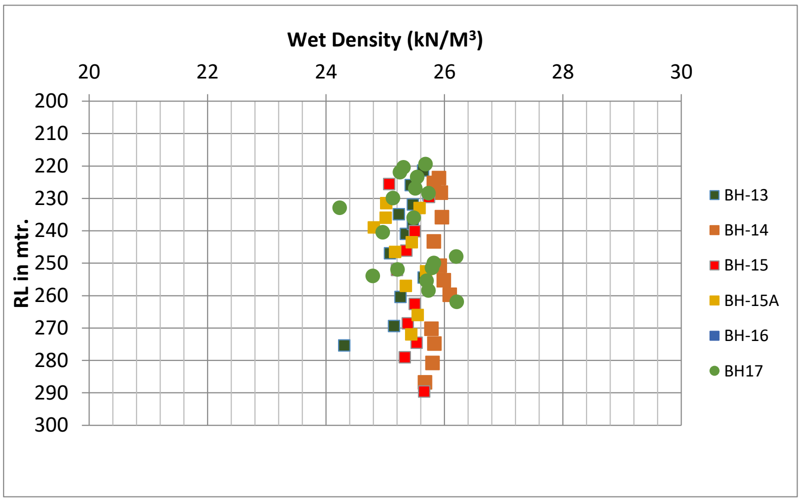

Figure 4.22: Wet Density for rock mass from entire bore hole length vs RL. (Refer to Annexure D in Geotechnical Report for detail).

Wet density value being clustered between a maximum of 26.52 kN/m^3 and minimum of 24.23 kN/m^3, we can safely recommend the average value 25.55 kN/m^3 as the representative of the entire rock mass.

4.6 Petrographic Test:

Petrographic test performed to study the mineralogical, textural and micro-structural property of rock. The rock samples are cut up to 30-micron size and their optical properties are observed. In the present test Grain size analysis is done to study the textural property of rock and the relative abundance of minerals are calculated to study the chemical and mineralogical property of the rock.

Quartz is the most abundant mineral (mostly 94% ± 5%) found in most of the samples from the drillhole and Feldspar followed by Mica is present as accessory minerals. Borehole BH-16 shows an abrupt compositional change with depth. Abundance of mica raises steeply with depth, from the accessory mineral of 2% volume at 46.5m to second most abundant mineral (after Quartz with volume 55%) with 27% volume at 52m depth. Garnet with volume of 8% is also found at 52m depth of same borehole. Grain size analysis of the samples from all the boreholes exhibit a negatively skewed distribution of mineral grains in the sample mostly with a mean radius of 0.3 mm.

***** All the recommended values for different rock parameters are tabulated in Table 6.1, Chapter-6: Conclusion and Recommendations**.

5 GEOTECHNICAL INVESTIGATION OF SOIL MASS:

Soil mass encountered along the tunnel alignment has been categorised in two group i.e., 1) Noncohesive Soil comprising Silty Sand (SM) and Inorganic Silt (ML) and 2) Cohesive Soil comprising Inorganic clay (CL). The values for the engineering property of soil have been interpretated categorically from the pareto chart presented below. Based on the available information from Geotechnical Report, geotechnical investigations have been carried out at different locations along the tunnel alignment and at stations.

5.1 Summary of the Boreholes within SOIL:

The boreholes relevant to this project are mentioned in table below Table 5.1.

Table 5.1: Details of Boreholes drilled for the project along the tunnel line within SOIL.

BH No.	Chainage No.	Ground Elevation, RL (m)	Formation Level as Per Alt.2A	Total depth (m)
BH-18	25990	280.253	232.939	55
BH-19	26210	278.116	234.379	50
BH-20	26387	276.795	235.522	48
BH-21	26587	274.993	236.734	45
BH-22	26787	274.321	237.946	45
BH-23	26980	274.85	239.158	45
BH-24	27187	274.075	240.370	40
BH-25	27410	273.565	241.582	40
BH-26	27550	273.112	242.588	35
BH-27	28050	272.210	245.878	30
BH-28	28350	272.799	247.851	45

BH No.	Chainage No.	Ground Elevation, RL (m)	Formation Level as Per Alt.2A	Total depth (m)
BH-29	28550	269.964	249.134	30
BH-30	28750	270.808	250.384	45
BH-31	29050	267.159	252.259	20
BH-32	29550	266.684	255.384	30
BH-33	30125	265.581	258.588	20

5.2 Field Tests for SOIL:

Field tests are conducted in boreholes that are taken along the proposed tunnel alignment and the station locations. The following table shows the summary of field tests conducted in Soil & Rock as part of the

Field Tests	Type of Test
In Soil	Standard Penetration Test

5.3 Laboratory Tests for SOIL:

Laboratory tests were also carried out on soil and rock samples, the details of different laboratory tests conducted as part of the project are given in the table below

Table 5.2: Details of laboratory test conducted for soil.

Sl. No.	Laboratory tests	IS Codes
1	Preparation of soil sample	IS: 2720(part-1)-1983 (Reaffirmed 2015)
2	Moisture Content	IS: 2720(part-2)-1973 (Reaffirmed 2015)
3	Specific Gravity	IS: 2720(part-3)(sec-1)-1980 (Reaffirmed 2016)
4	Grain Size Analysis	IS: 2720(part-4)-1985 (Reaffirmed 2015)
5	Atterberg’s Limits	IS: 2720(part-5)-1985 (Reaffirmed 2015)
6	Bulk Density	----
7	Triaxial Shear Strength	IS: 2720(part-11)-1993 (Reaffirmed 2016)
8	Direct Shear Strength	IS: 2720(part-13)-1986 (Reaffirmed 2016)
9	Consolidation Test	IS: 2720(part-15)-1986 (Reaffirmed 2016)

5.4 Laboratory Test Result of SOIL:

This section comprises depth wise results of the tests conducted in laboratory for soil masses in accordance with relevant standard codes of practices. Multiple tests in laboratory (Table 5.2)are adopted to ascertain the different essential characteristics of sub-surface using field samples obtained in during field investigations and borehole drilling. The tests as under have been conducted to ascertain the parameters indicated in the test.

Representative core samples have been taken from the boreholes (**BH18-BH33**) along the tunnel alignment. The samples were properly labelled and packed carefully and sent NABL accredited laboratory for determining the physico-mechanical engineering properties as per Indian standardized regulation. Summary of results from the laboratory testing has been graphically presented below.

5.4.1 Cohesion:

Cohesion values from all the all kinds of soil are found to 2 group. As shown in Figure 5.1 CL type soil mass has higher cohesion value (clustered green dots in graph) ranging between 25-35 kPa and other 3 types of soil are comprised of another group with values ranging from 4-12 kPa.

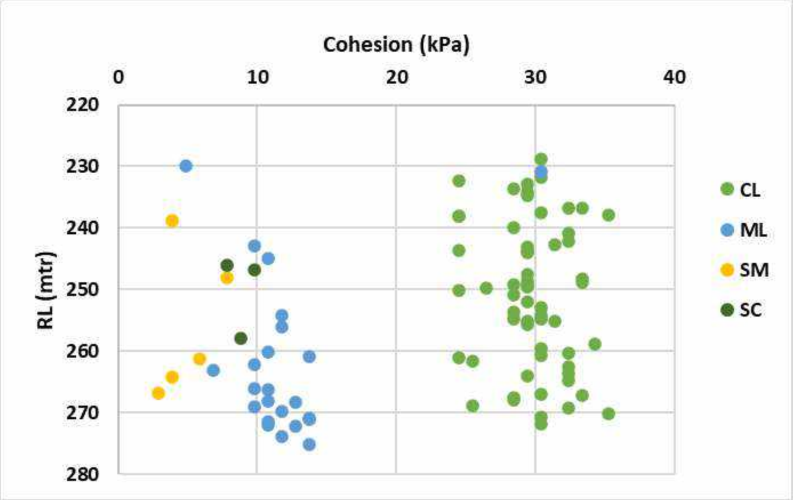

Figure 5.1 Graph showing laboratory tested cohesion for soil from entire borehole length vs RL. (Refer to Annexure J in Geotechnical Report for detail).

To make recommendation related to the engineering property of the surrounding soil, which is going to directly influence the tunnel built, samples from 2D has been considered. Pareto chart has been prepared to identify the most frequent and categorically influential data set out of the scattered values. It is based on 80/20 rule, i.e., “Vital few and trivial many” principle. The idea is that the few identified vital values will always statistically dominate over many.

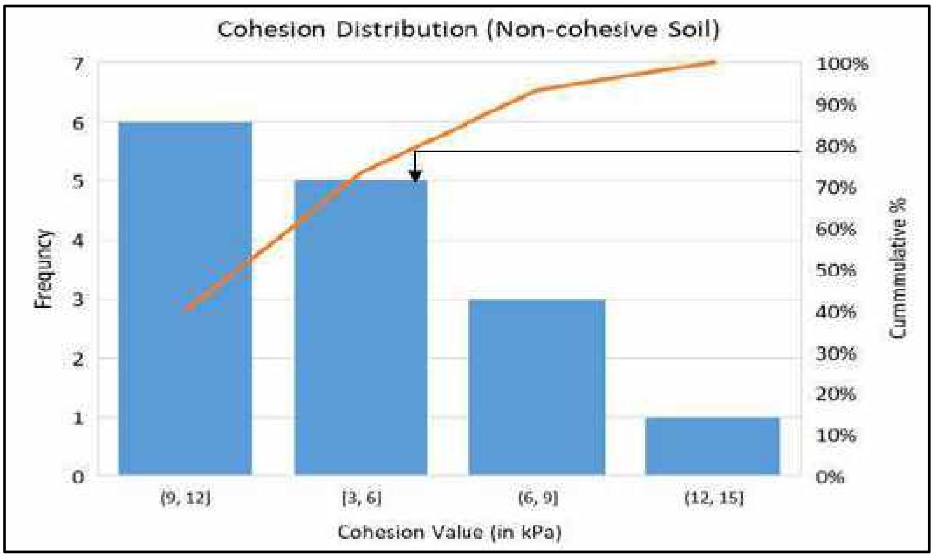

Figure 5.2: Pareto Chart showing recommended cohesion value for the non-cohesive soil within 2D depth.

80% of the laboratory tested cohesion value for SM and ML type of soil samples from 2D depth shows a scattered range of values ranging from 3-12 kPa. For safer construction the lower value of the range **3 kPa** is recommended for cohesive strength of the noncohesive soil.

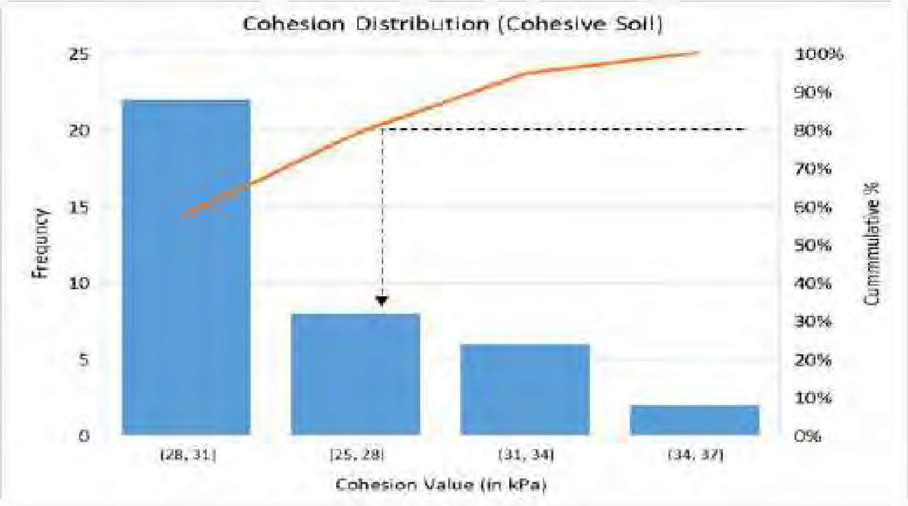

Figure 5.3: Pareto Chart showing recommended cohesion value for the cohesive soil within 2D depth.

80% of the laboratory tested cohesion value for the CL type of soil sample from 2D depth ranges between 25-31 kPa. For safer construction the lower value of the range **25 kPa** is recommended for cohesive strength of the cohesive soil.

5.4.2 Natural Weight:

Density (Natural Weight) of all kind of soil found to be linearly increasing with depth. The trend of variation with depth is shown below in Figure 5.4.

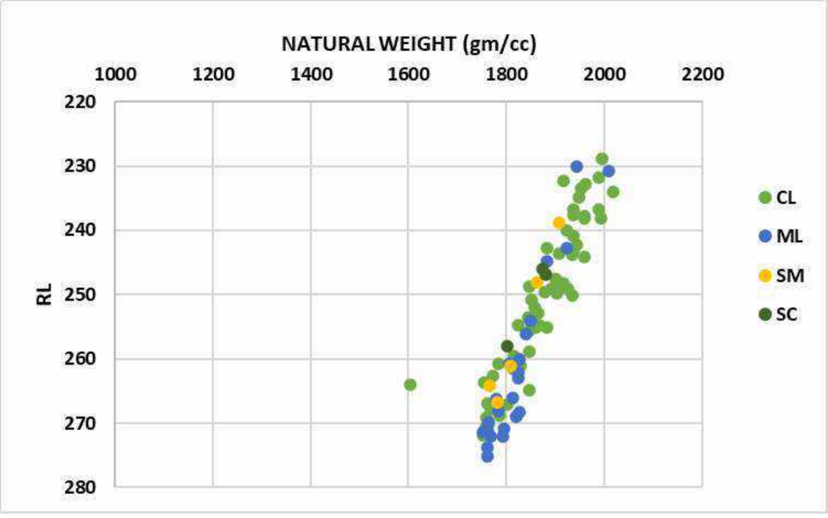

Figure 5.4: graph for Natural weight of soil from entire borehole length vs RL (Refer to Annexure J in Geotechnical Report for detail).

Natural weight value has been recommended (separately for both group of soil) using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

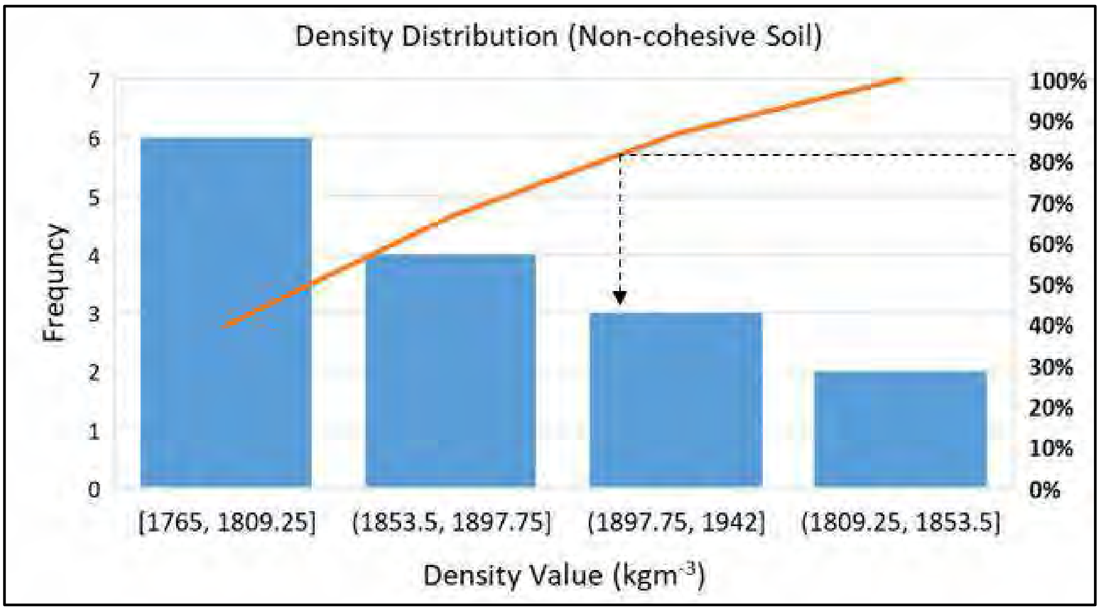

Figure 5.5: Pareto Chart showing recommended density value for the non-cohesive soil within 2D depth.

80% of the laboratory tested Density value for the SM and ML type of soil samples from 2D depth ranges between 1765 - 1942 kgm^{-3}. For safer construction the lower value of the range **1765 kgm^{-3}** is recommended for density of the noncohesive soil.

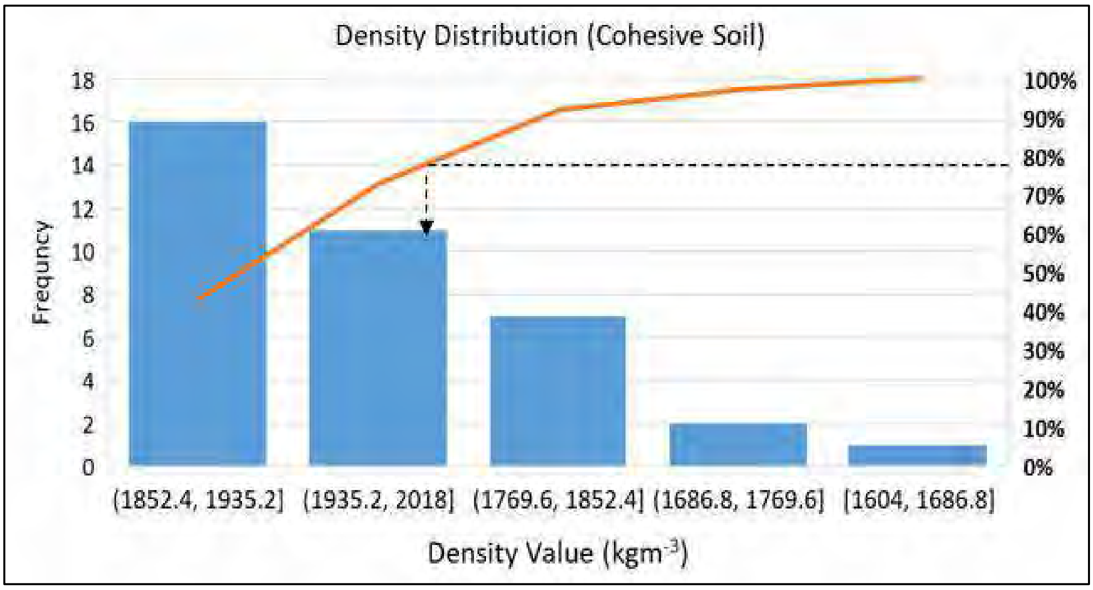

Figure 5.6: Pareto Chart for recommended density value for the cohesive soil within 2D depth.

80% of the laboratory tested density value for the CL type of soil samples from 2D depth ranges between 1852 -2018 kgm^{-3}. For safer construction the lower value of the range **1852 kgm^{-3}** is recommended for density of the cohesive soil.

5.4.3 Modulus of Elasticity (E):

The drained modulus (E') values are determined based on the corrected SPT N value –N_{60} for granular as well as cohesive soils. For cohesive soil– **$E' = 1.2\times N_{60}$ (MPa)**, and for cohesionless soil– **$E' = 1.0\times N_{60}$ (MPa). Modulus of elasticity** was found to be increasing from 10 MPa to 15 MPa with depth up-to first 15 meter from the surface (Figure 5.7), after which it falls within a constant range of value around 30±1 MPa up-to the floor of the tunnel.

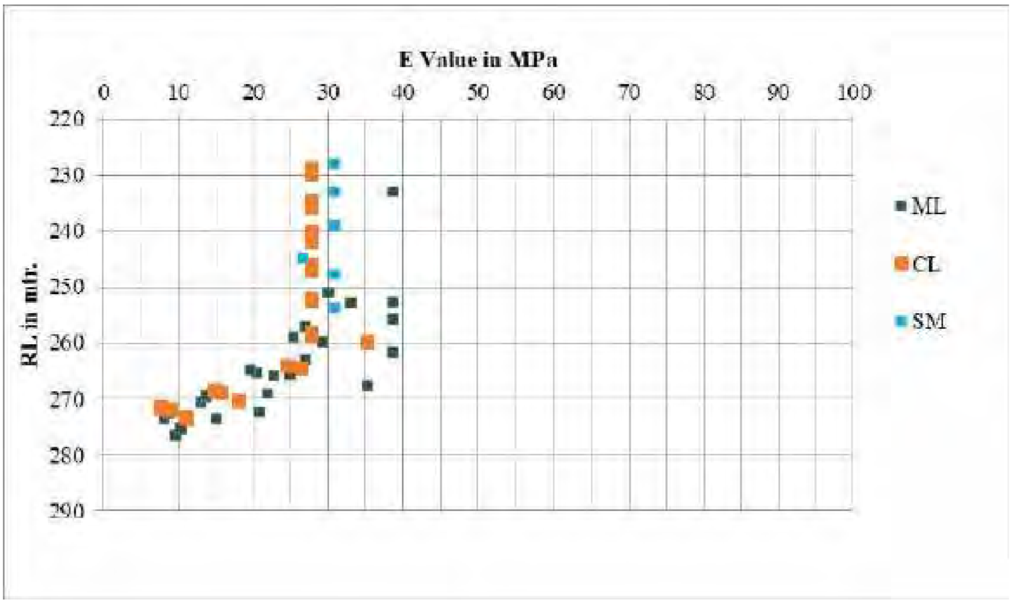

Figure 5.7: graph for Modulus of elasticity for soil from entire borehole length vs RL. (Refer to Annexure J in Geotechnical Report for detail).

Natural weight value has been recommended (separately for both group of soil) using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

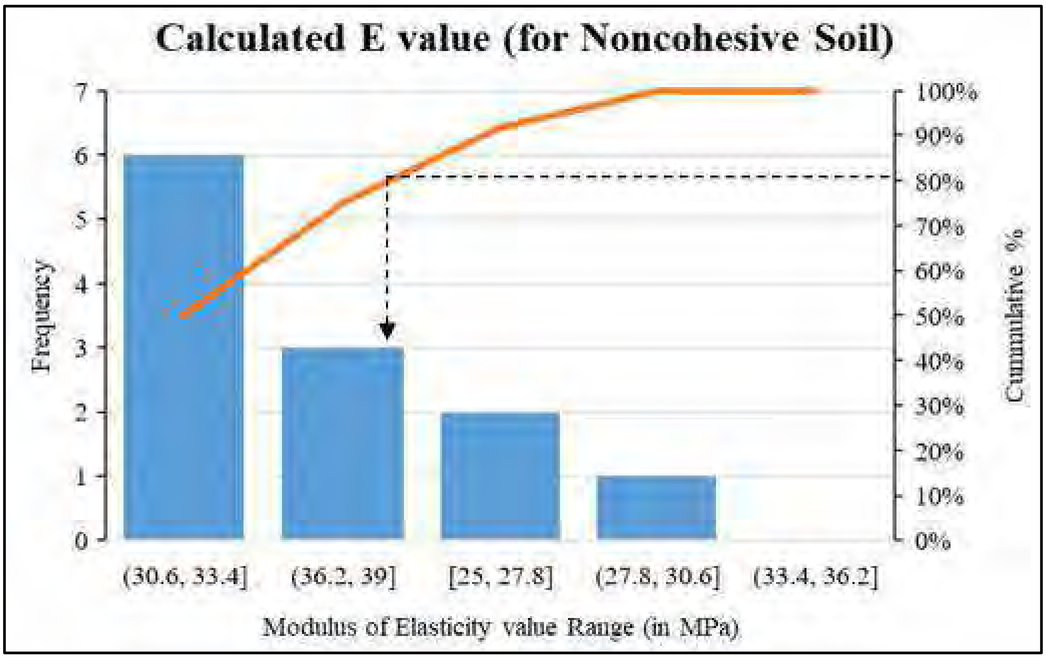

Figure 5.8: Pareto Chart for recommended E value for the non-cohesive soil within 2D depth.

As shown in the *Pareto Chart* above, 80% of the calculated Modulus of Elasticity (based on the equation $E=N_{60}$) for the noncohesive (SM & ML) soil sample from 2D depth ranges between 30.6-39 MPa. For safer construction, the lower value of the range **30 MPa** is recommended as the E value for the noncohesive soil. No pareto chart has been constructed for Cohesive Soil (CL), because they have consistent E value of 28 MPa for all the samples from 2D depth. Hence, **28 MPa** is the recommended Modulus of Elasticity for the cohesive soil.

5.4.4 Angle of internal friction (ϕ) for non-cohesive soil

Angle of internal friction (ϕ) for non-cohesive soil has been determined depth wise from the corrected field SPT N value as per IS2131. To make a recommendation for the phi value of non-cohesive soil samples (**from BH18-BH33**) were analyzed from 2D elevation from the tunnel formation level. As shown below in the Figure 5.9 , 95% of the phi values (2 Sigma) in the 2D lies within a range of ***31.53 ±2.72.*** The variation in phi values within the range being absolutely normally distributed, we can safely consider the mean value (rounded up) ***32°*** as the recommended phi value for construction.

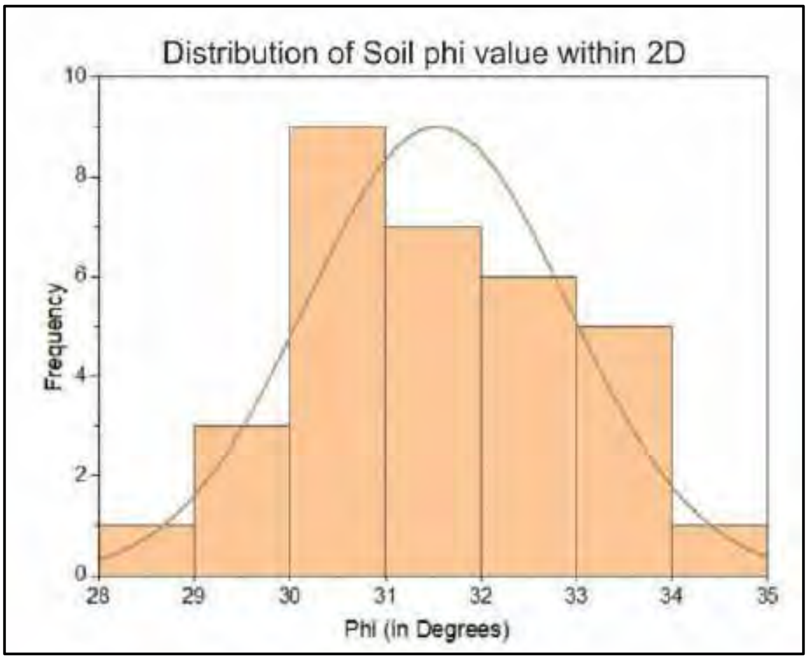

Figure 5.9: Distribution of non-cohesive soil Phi value within 2D overburden depth (Detail distribution of phi values along chainage are graphically shown in the Figure 4.12 to 4.14).

To be even more precise similar statistical analysis were carried out separately for the soil samples along the tunnel alignment and those are form 1D elevation from the crown. Results are graphically shown in the Figure 5.10 and Figure 5.11.

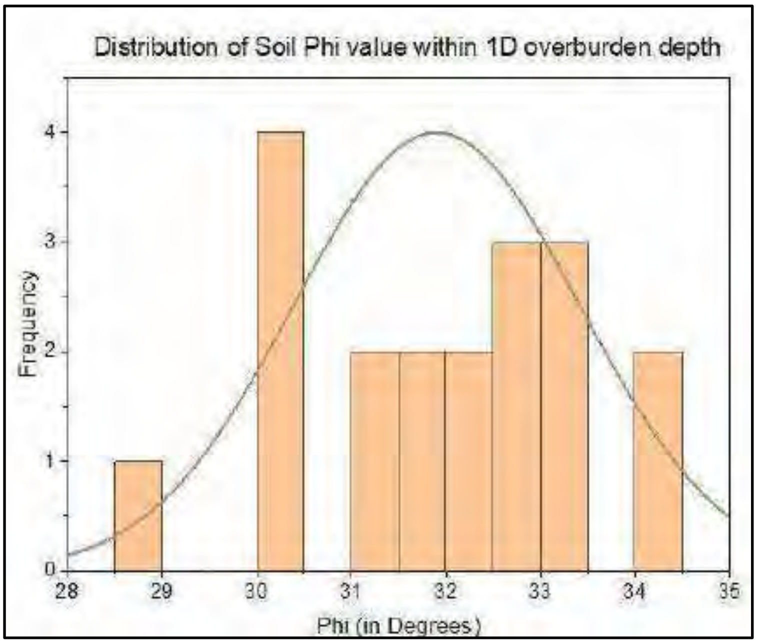

Figure 5.10: Distribution of non-cohesive soil Phi value within 1D overburden depth

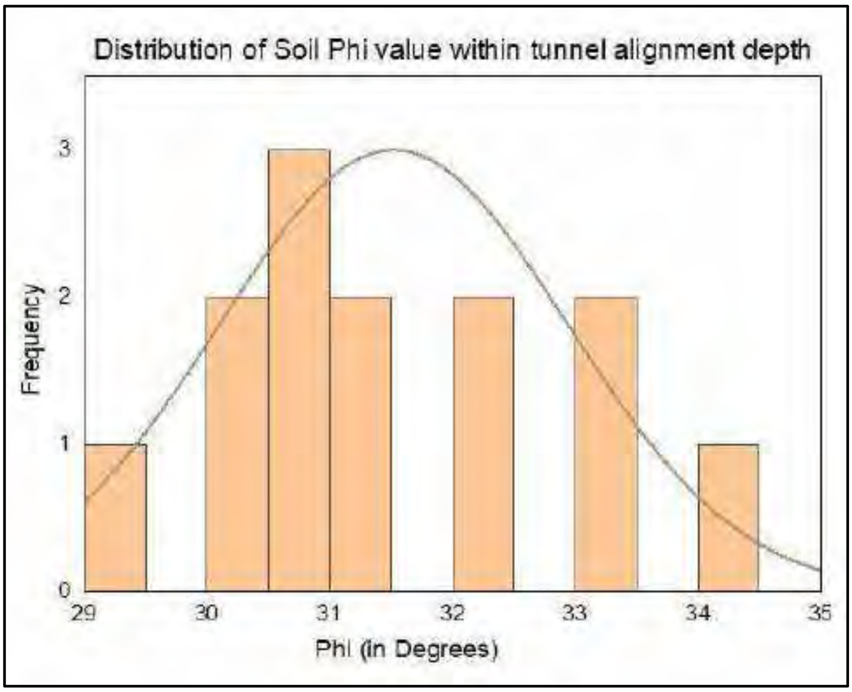

Figure 5.11: Distribution of non-cohesive soil Phi value within tunnel alignment.

It was found from above two graphs that, 95% of the samples have phi values in the range of ***31.68±2.8*** for the 1D depth (Figure 5.10), while ***31.32 ±2.64*** for the tunnel alignment (Figure 5.11). Therefore, **the recommended phi value of *32°*** still remains valid even if tunnel alignment and 1D above it are considered separately.

5.4.5 Angle of internal friction (ϕ) for cohesive soil

Angle of internal friction (ϕ) for cohesive soil has been determined depth wise from laboratory test. To make a recommendation for the phi value of cohesive soil samples (from **BH18-BH33**) were analysed from 2D and 1D elevation from the tunnel formation level. As shown below in the Figure 5.12 & Figure 5.13, 95% of the phi values (2 Sigma) in the 2D and 1D lies within a range of 11.6 ±2.06 and having a modal value of 10. Therefore, as a representative value of phi for the cohesive soil is recommended to be **12°.**

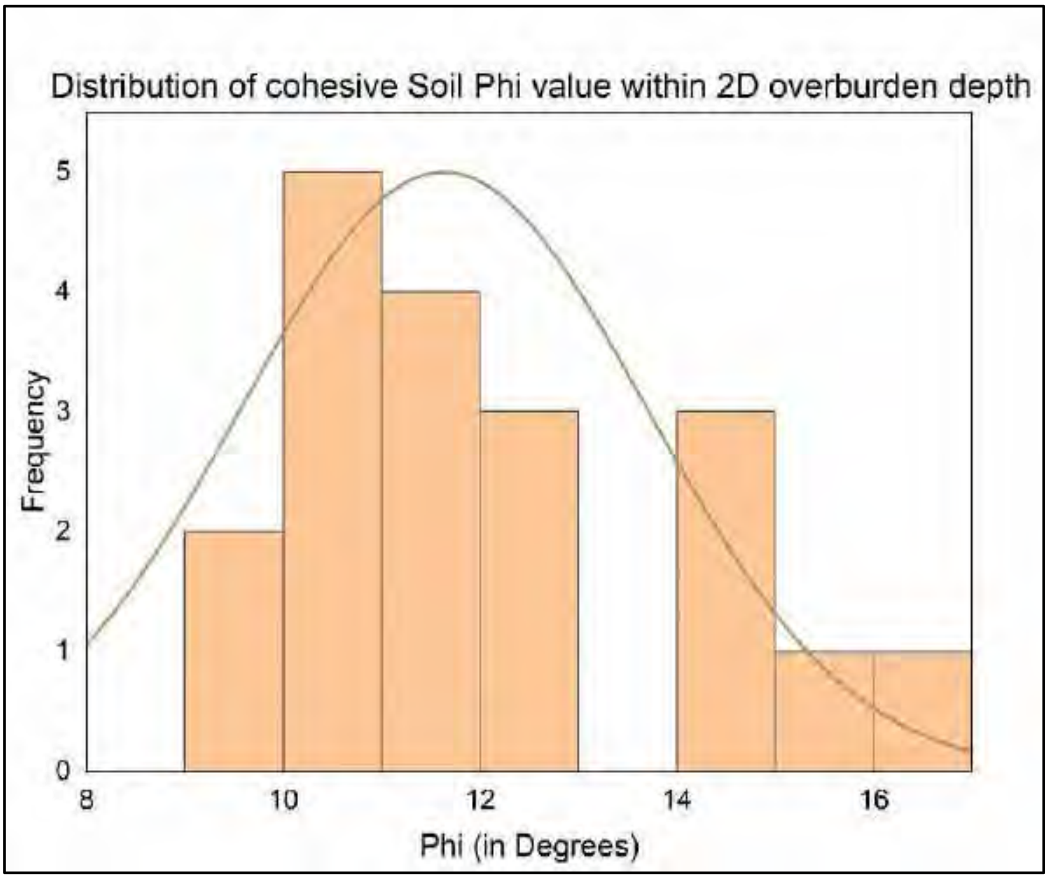

Figure 5.12: Distribution of cohesive soil Phi value within 2D overburden depth (Detail distribution of phi values along chainage are graphically shown in the Figure 4.12 to 4.14).

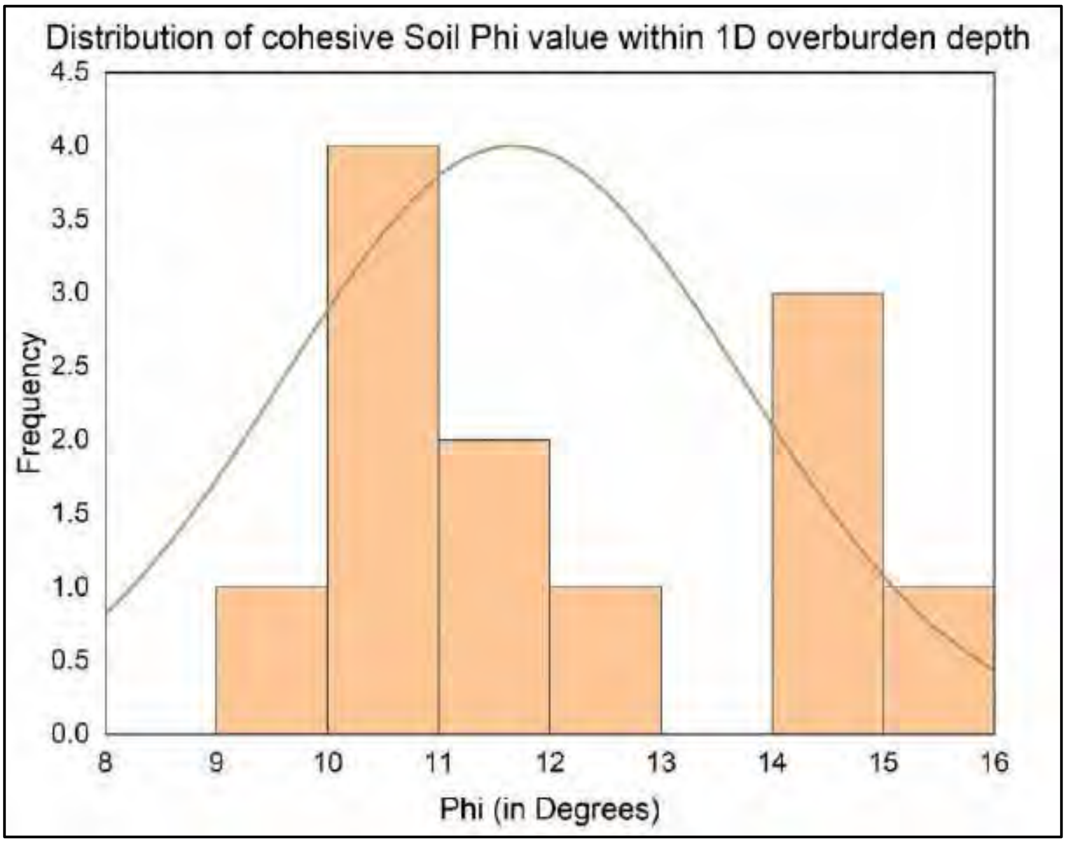

Figure 5.13: Distribution of cohesive soil Phi value within 1D overburden depth (Detail distribution of phi values along chainage are graphically shown in the Figure 4.12 to 4.14).

** **for chainage wise variation in C and ϕ values refer Figure 3.12 to Figure 3.15**

***** All the recommended values for different soil parameters are tabulated in Table 6.2, Chapter-6: Conclusion and Recommendations**.

6 Conclusion and Recommendations:

The total tunnel length is 4.7 km (CH24900-CH29600), out of which 1.1 km (CH24900-CH25980) km of tunnel will be within the quartzite rock mass of Delhi Supergroup with Portal-I at CH24900. 2.9 km (CH25980-CH28900) km of the tunnel will be through soil and a NATM structure will be built at CH28900. 700m after this structure will be cut & cover in soil and the Portal-II will be built at CH29600.

Based on the available surface information from the geological field investigation and close observation of the drilled cores from the litho-logs, it has been observed that after crossing the soil the tunnel will enter into a folded rock mass where the axis of the tunnel will be perpendicular to the fold axis, thus favorably oriented with respect to the folded bedding planes. However, the folded rock layer has suffered extreme level of later brittle fracturing, which has been testified by the presence of 6 sets of joints of different orientation and a few late brittle discrete shear zones (which is certainly not active in nature). These joints and the fractures have significantly reduced the strength of the otherwise sufficiently cohesive metamorphic rock mass. Presence of the intersecting closely spaced joint sets make the tunnel part within the rock body highly susceptible to wedge failure.

From the results of different on-site and laboratory tests of the rock samples, the recommended values for the different parameters are tabulated below;

Table 6.1: Recommended values for engineering properties of rock

ROCK	
Properties	**Values**
Lugeon Value	28.4
UCS (MPa)	60 MPa
RMR	20-40 (CLASS IV)
Tensile Strength (MPa)	15 MPa
Point Load Strength (MPa)	2.5 MPa
Modulus of Elasticity (GPa)	39 GPa
Poisson’s Ratio	0.15
Hardness	55
Abrasion index	3.30
Cohesion (MPa)	15 MPa
Phi (degree)	55°
Water absorption	0.54 %

The rock mass as a whole statistically belong to Class-IV. Therefore, as per Bieniawski, 1989, systematic bolts 4-5m long, spaced 1-1.5 m in crown and walls with wire mesh, 100-150 mm shotcrete in crown and 100mm shotcrete in sides, light to medium steel ribs spaced 1.5 m is recommended as tunnel support. However, along some chainage interval the support system of Class III may be used by the discretion of the design engineer. For chainage wise variation in RMR value refer to Figure 3.11.

Almost 2.5 km of tunnel will be running through the soil, which constitutes 44% of Inorganic Clay rich Soil (CL), 33% of Inorganic Silty Soil (ML) and kanker and 23% is Silty Sand (SM). The recommended values for the different parameters for soil are tabulated below;

Table 6.2:Recommended values for engineering properties of soil.

	TYPE OF SOIL	MIN.	MAX.	Recommended Values
FIELD N VALUE		11	50	
CORRECTED N VALUE		5.75	29	
Cohesion (C) (from Laboratory Test)	CL	23.54 kPa	35.30 kPa	25 kPa
	ML	1.96 kPa	18.63 kPa	3 kPa
	ML-CL	7.85 kPa	19.61 kPa	
	SM	1.96 kPa	3.92 kPa	
Φ for cohesive soil (from Laboratory Test)	CL	9°	16°	12°
Φ for non-cohesive soil (from corrected N Value)	ML	28°	36°	32°
	ML-CL	29°	34°	
	SM	29°	32°	
Modulus of Elasticity (E)	Cohesive (CL)	28 MPa	28 MPa	28 MPa
	Non-Cohesive (ML, SM, ML-CL)	25 MPa	39 MPa	30 MPa
Density	Cohesive (CL)	1604 kg/m^3	2018 kg/m^3	1852 kg/m^3
	Non-Cohesive (ML, SM, ML-CL)	1752 kg/m^3	2009 kg/m^3	1765 kg/m^3

None of the boreholes reached the ground water table. Therefore, based on the preliminary survey, it can be predicted that the tunnel will not face any difficulty due to encounter of ground water table during the construction. However, the overlying rock strata having significant nos. of joint set is quite capable of percolating rain waters during the rainy seasons. There is also a ditch around CH 25500, which is situated almost 31.87m above the roof of the tunnel. This ditch may be connected to a perched water table with a limited water resource. The joint sets and the ditch may act as efficient path ways of rainwater recharge into the tunnel during the rainy season. Therefore, it may be recommended that suitable drainage system should be designed along with the tunnel to drain out that percolated water to avoid water logging during and after the construction of the tunnel. However, such kind of ingress of water is purely seasonal and temporary. Therefore, the water-proofing membrane may also be dispensed with.

iii. Geotechnical Investigation Report
SR NO.: 544_21-22
Old Ch. 27+620 to Old Ch.28+900 km

Geotechnical Investigation Report

Old Ch. 27+620 to Old Ch. 28+900 km
(New CH: 28+287 to 29+567) km

SR NO. : 544_21-22

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA

CLIENT

M/S. HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION LTD. (HRIDCL)

PROGRAMME

JUNE - 2022

SR. No.	Report No.	Revision No.	Date
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/938_(18 BHs)	00	03.10.2022

CEGTH
CEG TEST HOUSE
AND RESEARCH CENTRE PVT LTD

B-11(G), Malviya Industrial Area, Jaipur-302017
Tel. : 91-141-4046599, Fax : 91-141-2751806
E-mail : info@cegtesthouse.com., www.cegtesthouse.com

CEGTH/HRIDCL/SR-544/2022-23/938 Date:- 03.10.2022

To,

Haryana Rail Infrastructure Development
Corporation Ltd. (HRIDCL)
SCO No.-17-19, 3rd & 4th Floor,
Sector - 17-A,
Chandigarh - 160017
Tele:- 0172-2715644
Email: hridc2017@gmail.com

Subject :- Geotechnical investigation work for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana.

Dear Sir,

We are pleased to submit this report of the subject work based on 18 borehole carried out at Old Ch. 27+620 to Old Ch. 28+900 (New CH: 28+287 to 29+567) for the proposed project site.

The accompanying report presents results of various field tests and laboratory tests conducted on selected soil samples and their interpretation.

Should there be any clarifications regarding the contents please contact us at your most convenient time.

We value the opportunity to participate in this project and look forward a pleasant association on future projects.

Very truly yours,
CEG Test House & Research Centre Pvt. Ltd.

Nehal Jain
General Manager - Geotechnical
Authorized Signatory

Prepared By:-

Ankur Mudgal
Sr. Manager

SR. No.	Report Ref. No.	Revision No.	Date
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/938_(18 BHs)	00	03.10.2022

CONTENTS

LIST OF FIGURES / TABLES

CHAPTER 1 GENERAL

1.0 INTRODUCTION:

The work of conducting "**Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana"** was awarded to "**CEG Test House & Research Centre Pvt. Ltd., Jaipur" by M/S.** "**Haryana Rail Infrastructure Development Corporation Ltd. (HRIDCL)"** as per work order no. HRIDC/ HORC/ GT/ CEG/ 237/ 2021/ 577-M dated 29th July 2021.

Field work including drilling of boreholes, conducting field tests such as Electrical Resistivity Test, & Plate Load Test and sample collection was carried out in the presence of representative of Client. Laboratory tests were conducted on selected soil samples to determine the design parameters, confirming to relevant IS specifications and the guidelines received from time to time from representative of Client.

This report includes the details of Methodology of Investigation, collection of samples of soil, field test results, laboratory test results, analysis of results and recommendations for proposed structure carried out at Old Ch. 27+620 to Old Ch. 28+900 (New CH: 28+287 to 29+567). based on soil sample collected from the locations of 18 boreholes.

2.0 SITE LOCATION & GENERAL GEOLOGICAL HISTORY:

The details of the site & test locations for the proposed project are shown in location plan attached vide **Appendix A-1**. The site of proposed project is located from Palwal to Harsana Kalan (Sonipat) in the State of Haryana falls in seismic zone – IV (Zone factor=0.24) of India.

Soil of the Haryana Sub-Region have been classified and described under the following major soil types as shown below:-

- Typic Ustochrepts : Soil of old alluvial plains
- Typic Ustipsamments : Soil of Aravali plains
- Typic Ustifluvents : Soil of recent alluvial plains and flood plains
- Typic Torripsamments : Soil of Aeofluvial plains
- Rocky Outcrops : Aravali rocky hills

The district wise details of soil characteristics are described below:-

Panipat: The soils are well drained, Sandy loam to clay loam/silty clay loam in plains and loam to clay loam/ silty/ loose clay loam in relic channels/depressions/basins.

Sonipat: The district comprises of recent flood plains, young meander plains, old meander plains and old alluvial plains. Recent flood plains occur along the Yamuna River and clearly show fluvial features. The soils are loamy sand to sandy loam on the surface and sandy loam to clay loam in the sub surface.

Rohtak: The district mainly comprises of old alluvial plains. The soils are loamy sand to sandy loam on the surface and sandy loam to clay loam in the sub surface. Old meander plains are almost flat with loamy sand to silty clay loam soils. Oldest among all the land forms are old alluvial plains, which cover major areas in the district. These soils are sand to loamy sand/sandy loam (surface) to silt loam/silty clay loam (sub-surface).

Jhajjar: The district mainly comprises of old alluvial plains and some parts of the district also have soil belonging to Aravali plains.

Rewari: The soils of the district fall under Entisols and Inceptisols orders. The surface soil texture varies from sand to fine loamy sand.

Gurgaon: The district comprises of sand dunes, sandy plains, alluvial plains, salt affected areas, low lands, lakes, hills and pediments. The soil varies from sand to loamy sand in sand dunes and sandy plain areas, sandy loam to clay loam / silty clay loam in alluvial plains, calcareous, loamy sand to loam in salt affected plains, silty loam to loam in low lands and calcareous, loamy sand to loam in hills.

Mewat: The soils of the area are generally sandy loam to loam. In parts of the low-lying areas, they are clayey and saline. The upper hills are mostly barren.

Faridabad and Palwal: The district comprises of recent Yamuna flood plains, low lying plains, depressions, sand dunes and hills. The texture of the soil is sand to loamy sand in recent Yamuna flood plains, sandy loam in plains, sandy loam to clay loam in alluvial plains, sandy loam to loam (surface), clay loam/silty clay (sub-surface) in low lying plains and depressions.

3.0 SCOPE OF WORK:

The stipulated scope of work involved carrying out the following operations:-

a) Mobilisation of necessary plant equipment, men and materials for the complete Geotechnical investigation work as per specifications, drawings and instructions of the Engineer and to complete the same within the stipulated time schedule and demobilisation after completion of field work.

b) Shifting of Equipments from one structure location to another including Ereaction, installation of rigs at site and dismantling of the same after completion of field work. Shifting of setup for each borehole location and associated preparation for borehole under water

c) Making 150 mm nominal diameter boreholes at various locations in all types of soils except hard rock and large boulders using suitable approved method of boring including chiselling, cleaning, providing casing pipe as required; performing Standard Penetration Test at every 3.0m interval and at change of strata; collection of water samples and disturbed soil samples, observation such as ground water, etc., collection of undisturbed soil samples at every 3.0 m interval and at change of strata; transportation of all the collected samples to the laboratory and back filling of boreholes on completion of the same, complete as per specification and instructions of the Engineer, for depths below natural ground level.

d) Conducting Electrical resistivity tests at various locations all complete as per specification and directions of the Engineer.

e) Conducting plate load test at various locations, all complete as per specification and directions of the Engineer.

f) Drilling of Nx size boreholes (75mm dia.) in all types of hard rock, collection of core samples, maintaining continuous record of core recovery/ RQD, keeping the cores in wooden core boxes, transporting to laboratory, backfilling on completion of the same, all complete as per specification and instructions of the EIC.

g) Conducting various laboratory tests on soil samples at an approved laboratory including preparation of soil samples to determine the following properties of soil, all complete as per specification.

On soil Samples

- Dry density test
- Bulk Density and Moisture Content.
- Sieve Analysis
- Hydrometer Analysis
- Liquid Limit and Plastic Limit
- Specific gravity
- Shrinkage Limit

  - Free Swell Index
  - Direct Shear Test
  - Triaxial Shear Test
  - One Dimensional consolidation test
  - Chemical Analysis of soil samples (pH, chloride, Sulphate)

h) Conducting laboratory tests on rock samples including preparation of the samples to determine the following properties, all complete as per specification

On Rock Samples

  - Moisture content, porosity & Density
  - Specific gravity
  - Hardness
  - Unconfined compression test
  - Point load strength index
  - Modulus of Elasticity and Poission's Ratio
  - Abrasion Test

i) Conducting chemical tests on water samples to determine the Sulphate, chloride and pH value all complete as per specification.

j) Submitting draft report in soft copy including all field records and laboratory test results, graphs, etc., all complete as per specifications.

k) Submitting final report in three hard copies in after the approval of the draft report including all field records and laboratory test results, graphs, etc., all complete as per specifications.

4. FIELD INVESTIGATION IN SOIL STRATA:

The investigation was planned to obtain the subsurface stratification in the proposed project site and collect soil / rock core samples for laboratory testing to determine the engineering properties such as shear strength, along with basic engineering classification of the subsurface stratum.

For geotechnical investigation work, required equipements along with rotary drilling rigs and manpower were mobilized at site to carry out various field activities as per the scope of work. These were shifted from one test location to another location during execution of field work and were demobilized on satisfactory completion of field work.

For conducting the field investigations the following practices were followed at site:

- The locations of 18 boreholes carried out at Old Ch. 27+620 to Old Ch. 28+900 (New CH: 28+287 to 29+567) were marked at site at specified locations. These locations are shown in **Appendix A-1** attached subsequently.

The details of various boreholes along with their coordinates are provided herein below:

Table 1.1: Details of Borehole Locations

S. No.	Chainage Old (km)	Chainage New (km)	Structure	BH.No.	Depth of Water Table below EGL (m)	Depth of Borehole below EGL (m)	Co-ordinates (m)		(+) R.L. (m)
							E	N	
1.	27+620	28+287	Major Bridge	BH-A1	33.10	40.00	697786.663	3123079.115	270.946
2.				BH-P1	32.90	40.00	697786.520	3123062.116	271.001
3.				BH-P2	33.00	60.00	697786.377	3123047.116	271.080
4.				BH-P3	33.13	60.00	697786.129	3123021.117	270.749
5.				BH-P4	33.14	50.00	697785.986	3123006.118	271.774
6.				BH-A2	33.12	40.00	697785.825	3122989.119	271.929
7.	28+075	28+743		BH-A1	32.67	55.00	697330.702	3123086.726	269.806
8.				BH-P1	32.68	55.00	697330.717	3123064.726	270.070
9.				BH-P2	33.20	55.00	697330.724	3123026.726	270.499
10.				BH-A2	33.21	55.00	697330.724	3123004.726	270.616
11.	28+360	29+028		BH-A1	34.78	40.00	697053.722	3123109.166	268.602
12.				BH-P1	34.10	50.00	697050.915	3123091.386	267.861
13.				BH-P2	33.85	50.00	697046.700	3123064.680	267.285
14.				BH-A2	34.20	40.00	697043.901	3123046.953	267.528
15.	28+900	29+567		BH-A1	36.90	40.00	696531.197	3123223.834	262.678
16.				BH-P1	38.10	50.00	696528.146	3123214.311	263.022
17.				BH-P2	34.55	50.00	696520.214	3123189.550	263.955
18.				BH-A2	34.50	40.00	696517.163	3123180.027	263.847

***Not Encountered:-NE**

- In soil, boreholes of 150mm dia. were drilled as per the standard procedure laid in IS: 1892.
- Borehole was properly cleaned before taking any sample in soil.
- Casing was used as per the prevailing soil conditions, to stabilize the borehole.
- Standard Penetration Tests were conducted in bore holes at regular intervals or at every change of strata as per Technical specification.
- Undisturbed were collected wherevery feasible as per the requirements and at specified depths. The same has been discussed in detail in soil characteristics sheets attached with the report.
- The Ground Water Table was met at depths of from 32.67m to 38.10 m below EGL. The detailed procedure adopted for conducting various field tests is given here in below:

(i) Standard Penetration Test:

The Standard Penetration Test was conducted in boreholes as per IS 2131. The test was carried out using the standard split spoon sampler to measure the number of blows 'N'.

Standard split spoon sampler was attached to an 'A' rod. It was driven from borehole bottom to a distance of 45 cm using a standard hammer of 63.5 kg falling freely from a height of 75 cm to the required depth. While driving, the number of blows required to penetrate every 15 cm are recorded. The total number of blows required for the last 30 cm is taken as 'N' value at that particular depth of the borehole. Wherever the total penetration was less than 45cm, the no. of blows & the depth penetrated is recorded in the respective borelog.

SPT 'N' values were correlated with relative density of non-cohesive stratum and with consistency of cohesive stratum as given below:-

Table 1.2: Soil compactness as per SPT N values (cl. 9.7, table 9.3 & 9.4, page 330_text book of V.N.S. Murthy)

Correlation for Clay / Plastic silt		Correlation for Sand / Non-Plastic silt	
Consistency	**SPT "N" Value**	**Compactness**	**SPT "N" Value**
Very Soft	0 - 2	Very Loose	0 - 4
Soft	2 - 4	Loose	4 - 10
Medium	4 - 8	Medium	10 - 30
Stiff	8 - 15	Dense	30 - 50
Very Stiff	15 - 30	Very Dense	> 50
Hard	> 30		

The field SPT N values obtained were further corrected as per the guidelines given in IS: 2131 as follows:

(a) For overburden: - The N value for cohesionless soil is corrected with the help of fig. 1 given in IS-2131.

(b) Due to dilatancy :- Wherever N values observed below water table in fine sand, silty sand or silt was greater than 15, then corrected N values were corrected as under:

$$N' = 15 + \frac{1}{2}(N-15)$$

(ii) Undisturbed Sampling (Soil) in boreholes:

Undisturbed samples were collected using MS tubes of suitable diameter and length with Area ratio as per clause 4.1.1 (c) of IS: 1892 (latest) fitted to an adopter with ball and socket arrangement. Before taking any sample, sampling tube was properly greased. Immediately after taking on undisturbed sample in a tube, the adopter head was removed along with the disturbed material. The visible ends of the sample were trimmed off any wet disturbed soil. The ends were coated alternately with four layers of just molten wax. More molten wax was added to give a total thickness of min. 25

mm. The samples were carefully labeled and transported to the laboratory for testing. Undisturbed samples wherever slipped during lifting were duly marked in the field logs as well as in the soil profile.

5.0 LABORATORY TESTS ON SOIL SAMPLES:

The following laboratory tests were conducted on selected soil samples:

Table 1.3: Description of Tests

Description of Test	Reference	Undisturbed (UDS) Soil Samples	Disturbed (DS/SPT) Soil Samples
Grain Size Analysis / Hydrometer	IS: 2720 (Part - 4)	√	√
Natural Moisture Content / Bulk / Dry density	IS : 2720 (Part – 2)	√	-
Atterberg Limits • Liquid Limit • Plastic Limit	 IS: 2720 (Part - 5) IS: 2720 (Part - 5)	 √ √	 √ √
Specific Gravity	IS : 2720 (Part – 3)	√	√
Direct Shear Test	IS : 2720 (Part – 13)	√	√
Triaxial compressive shear test	IS : 2720 (Part – 11 & 12)	√	√
Chemical Analysis of Soil Samples	IS : 2720 (Part – 26, 27)	√	-

Note:- The detailed procedure adopted for conducting various laboratory tests is described in the following paragraphs:

5.1.1 Dry density and Bulk density

For determination of bulk density and dry density, a sample of known volume ‘V’ was extracted from the undisturbed sampling tube and it’s bulk weight ‘W’ was noted down.Moisture content ‘Wn’ was determined by oven drying method.

The bulk density and dry density were determined by following equation-

Bulk density (γ_b) = W/V

Dry density (γ_d) = γ_b/ (1+Wn)

5.1.2 Natural water content

For this test, the soil sample of known quantity (Wm) was taken in a container.The container with soil sample was placed into an oven for drying at 105-110°c temperature for 16-24 hours. After drying, the dry sample was again weighted to determine the dry weight of sample (Wd).

The natural water content was computed by the following equation-

Wn = (Wm-Wd)*100/Wd

5.1.3 Grain Size Analysis (IS: 2720- Part-4)

Wet sieve analysis:

For determination of particle sizes finer than 75 micron, wet sieve analysis test was conducted. For this test, oven dried sample of known quantity was taken in a container and soaked with dispersing agent. The soaked soil sample was washed thoroughly over 75 micron IS sieve until the water passing sieve was substantially clean.

Fraction retained on 75 micron IS sieve was carefully collected in a container without any loss in material and placed into oven for drying.

Dry sieve analysis:

For this test, the oven dried soil sample after wet sieving was sieved through the set of IS sieves 20 mm, 10 mm, 4.75 mm, 2.0 mm, 1.0 m , 425 micron , 300 micron, 150 micron and 75micron. The amounts of soil retained on each sieve were noted down. The % retained, cumulative % retained and % passing were computed accordingly. Wherever the soil sample % passing 75 micron sieve was significant, Hydrometer method was used to find the percentage of silt and clay fraction.

Grain size analysis for the fraction passing 75 micron IS Sieve (Hydrometer method)

Calibration of Hydrometer

Hydrometer was calibrated to determine a relationship (an equation) between the effective depth H_R and corresponding hydrometer reading R_h (obtained during test).

50 to 100 gm of soil sample passing through 75 micron IS Sieve was taken. It was mixed with 100 ml of sodium hexametaphesphate solution and the mixture was warmed for about 10 minutes. It was then transferred to the cup of the mechanical mixer and the soil suspension was stirred for 15 minutes. The soil suspension was transferred into 1000 ml measuring cylinder and distilled water was added to make 1000ml solution. This solution was mixed vigorously. The measuring cylinder was then allowed to stand and the stopwatch was started. Hydrometer was immersed in the solution and reading were taken after half, one, two and four minutes. The hydrometer was then removed slowly and kept in distilled water at the same temperature as the soil suspension. Readings were taken after the periods of 8, 15 and 30 minutes, and one, two and four hours. Hydrometer was removed, rinsed and placed in the distilled water after each reading. After 4 hours reading was taken once or twice within 24 hours. Finally a reading was taken at the end of 24 hours. The temperature of the suspension was observed and recorded.

Calculations

Diameter of the particles (D):

$$D = \sqrt{\frac{30\mu}{980(G-1)}} \times \sqrt{\frac{H_R}{t}} = M\sqrt{\frac{H_R}{t}}$$

Where,

D = diameter of particle in suspension, in mm;

μ = co-efficient of viscosity of water at the temperature of the suspension at the time of taking the hydrometer reading, in poise;

G = specific gravity of the soil fraction used in the sedimentations analysis;

H_R = effective depth corresponding to R_n, in cm.

t = time elapsed between the beginning of sedimentation and taking of hydrometer reading in minutes

$M = \sqrt{\frac{30\mu}{980(G-1)}}$ = a constant factor for given values of μ and G at the temperature of the suspension.

Percentage finer than diameter D:

The percentage by mass (w) of particles smaller than corresponding equivalent particle diameters (D) was calculated from the formula:

$$w = \frac{100G_s}{W_b(G_s - 1)} \times R_h$$

Where

w = percentage finer

G_s = specific gravity of soil particle

W_b = weight of soil

R_h = Hydrometer reading

5.1.4 Specific Gravity (IS: 2720-Part-3 Sec-1)

The specific gravity of soil sample was determined by density bottle method. For this test 5-10g oven dried and cooled soil sample was taken in 50ml capacity density bottle and its weight was noted down as W_2 .The soil was covered with distilled water and left for sufficient period for suitable soaking. The entrapped air was removed by vacuum. The bottle with soil was filled fully with water and its weight was noted down (W_3). The mass of empty bottle and bottle filled with distilled water were noted down as W_1 and W_4 respectively.

The Specific Gravity was determined by using following equation :

$G=W_2-W_1/[(W_2-W_1)-(W_3-W_4)]$

5.1.5 Liquid Limit (IS: 2720- Part-5)

By Cone Penetrometer Method

The 'Cone Penetrometer Apparatus' is a variant of the fall-cone and consists of a cone with a smooth polished surface and angle of 30° ± 1/2°. The weight of the cone, together with its associated shaft is 80g ± 0.5g. A support assembly with an automatic cone release mechanism and cone height adjustment mechanism used to hold the cone vertically. The angle and weight of the cone were calibrated at regular intervals, and the sharpness of the cone tip was checked daily.

Distilled water was added and thoroughly mixed with the soil sample to produce a homogeneous paste. The paste was then placed in a cup with a diameter of at least 55mm and a depth of at least 40mm. The surface of the soil was smoothed off level and parallel to the base. The support assembly was used to position the tip of the cone so that it was just touching the top surface of the soil, and the automatic tripping mechanism was released. The cone was allowed to penetrate into the soil for a period of 5 (± 1) s, then the cone was locked off to stop further movement and the penetration was recorded. The cup was refilled and the test was repeated. The two recorded penetrations need to be within 0.5mm of each other, otherwise a third test is performed. when the three test vary by more than 1mm the test was repeated.

Further tests were conducted, at varying water contents, in order to produce a series of cone penetrations (usually 4) in the range 15mm to 25mm. The resulting cone penetrations were plotted verses the water content of the test specimens. The Liquid Limit (W_L) was read off the graph, being the water content at which the line of best fit through the test points crosses 20mm penetration.

5.1.6 Plastic Limit (IS: 2720-Part-5)

For this test, soil sample was prepared in the same way as for liquid limit test. A ball of soil sample weighed about 5 gm was formed. The ball was rolled between the fingers of one hand and the glass plate with pressure sufficient to reduce the mass into a thread of about 3 mm in 5 to 10 complete forward and back movements. When a diameter of 3 mm was reached, soil was again remolded into a ball. The process of rolling and remolding was repeated until the thread started just crumbing at a diameter of 3 mm. The crumbled thread was immediately transferred to an airtight container for determination of its moisture content by oven drying method.

This water content has been termed as plastic limit. (W_P)

5.1.7 Plasticity Index (IS: 2720-Part-5)

The plasticity index Ip was given by

$I_p = W_L - W_P$ (in percent)

5.1.8 Direct Shear Test (IS:2720-Part-13):

For this test shear box test apparatus was used. The prepared specimen from remolded/undisturbed sample was placed carefully in the box. The plain grid was kept on top of the specimen with its directions at right angles to the direction of shear. The upper porous stone was placed on the grid and loading pad on the stone. The box with specimen was gently placed in the container (water jacket). The specimen was submerged with water. The container was mounted with the shear box and the specimen inside, on the shearing machine. The upper part of the box was so adjusted that it touchéd the proving ring. The jack was brought forward to bear up against the box container. The proving ring dial gauge was set to read zero.

The steel ball was placed in the recess of the loading pad. The loading yoke was set in contact with the steel ball on the loading pad. Vertical displacement dial gauge to read zero in contact with the top of the yoke. The normal load was applied and any change in thickness of specimen was recorded. Shear displacement dial gauge was also set to read zero. The locking screw was now removed and two parts of the shear box were separated by advancing the spacing screws.

The specimen was sheared at constant rate of strain. The readings of the proving ring dial gauge were noted down every 15 seconds for the first one-minute and then every 30 seconds thereafter. The reading of change in the thickness dial gauge and shear displacement dial gauge were also recorded at the same time interval. The test was continued until the specimen fails. The specimen was assumed to fail when the proving ring dial gauge started receding or at shear displacement of approximately 15% of the length took place.

The soil was removed from the box and test was repeated on the identical specimen under increased normal load.

The rate of strain for conducting Direct Shear Test is kept as 0.25 mm/min as per codal/literature provision based on strata.

5.1.9 Triaxial Shear Test_UUT (IS: 2720-Part-11)

For this test, Triaxial Shear Test apparatus was used. The plain disc was placed on the pedestal of the triaxial cell. The specimen was placed centrally on the disc. A correct size rubber membrane was fitted inside the stretcher with ends of membrane folded over those of the stretcher. Vacuum was applied to stretch the membrane to the inside surface of the stretcher which was carefully slipped around the specimen kept on the pedestal. The vacuum on the membrane was released. Its bottom part was rolled down into the pedestal. plain disc was placed on the top of the specimen and then loading pad was placed. The top part of membrane was rolled on to the loading pad. Then the stretcher was removed and ends were sealed with 'O' rings. With the properly sealed specimen placed centrally on the pedestal, the cell was assembled, keeping the loading piston initially clear of the loading pad of the specimen, the assembly was placed in the loading frame.

For unconsolidated undrained test, the bottom drainage value (BDV) and top drainage value (TDV) of cell, was closed and air release valve (ARV) was opened. The cell was filled with water through the cell water value CWV. ARV was closed when water begins to escape through it. The cell pressure was raised to the desired value and kept constant till the end of the test.

When the cell pressure was applied, the load piston rises upward, the loading machine was operated at the anticipated rate to bring the load piston slightly above the loading pad of the specimen and the load measuring dial gauge on proving ring was set to zero.

The piston was brought just in contact with loading pad by hand operation of the machine. The axial compression dial gauge was mounted and set to read zero.

The axial loading was started at 1.25 mm/min rate of strain. Simultaneous readings on the load and compression dial gauges were noted down. The test was continued until a recession of the axial load is observed or 20% of strain.

After failure, the specimen was unloaded by reversing the loading machine, cell pressure was reduced and cell water was drained out through BRV. The cell was dismantled and the specimen was taken out, rubber membrane was removed and weight of the failed sample and its water content was determined. The test was repeated on two more identical specimens with increasing cell pressure.

The rate of strain for conducting UUT is kept as 1.25 mm/min as per codal/literature provision based on strata.

5.1.10 Chemical Testing

Chemical Testing was generally performed in accordance with IS: 2720, but the different parts of method as described below:

a) **Total Sulphate Content Of Soil**

Samples were tested according to IS 2720 (Part 27). The dried soil was extracted with a 10% solution of hydrochloric acid. The extract was adjusted to slightly alkaline pH with ammonia, and then barium chloride solution was added to precipitate the sulphate. The barium sulphate precipitate was collected by filtration, and it was washed, dried and weighed. The mass of barium sulphate recovered was used to calculate the sulphate content of the original soil.

b) **pH Value**

Samples were tested according to IS: 2720 (Part 26). The soil sample (30 ± 0.1g) was extracted with 75 ml of distilled water and the pH of the resulting suspension was measured with a calibrated (by means of Standard buffer solution) pH meter.

c) **Chloride Content**

For the water soluble content, soil samples were extracted with a volume of water equal to twice the mass of the soil. The extract was filtered and acidified with a small amount of nitric acid.

Standardized silver nitrate solution was then added to precipitate the chloride as its silver salt. The amount of precipitated silver remaining in solution was then determined by titration.

An acid-soluble version of the test was also available, with the initial extraction being with nitric acid instead of water.

CHAPTER 2 ANALYSIS OF TEST RESULTS AND INTERPRETATION

6.0 STRATIFICATION

From the study of the borehole carried out at Old Ch. 27+620 to Old Ch. 28+900 (New CH: 28+287 to 29+567).

At location of O.C. 27+620 (N.C. 28+287) :-

The sub strata of BH-A1 mainly consist of Silty Clay of low plasticity (CL) and sandy silt of low plasticity (ML-CL).

The sub strata of BH-A2 mainly consist of sandy silt of low plasticity (ML-CL) followed by Silty Clay of low plasticity (CL).

The sub strata of BH-P1 mainly consist of Silty Clay of low plasticity (CL).

The sub strata of BH-P2 mainly consist of sandy silt of low plasticity (ML-CL) followed by Silty Clay of low plasticity (CL).

The sub strata of BH-P3 mainly consist of Silty Clay of low plasticity (CL).

The sub strata of BH-P4 mainly consist of sandy silt of low plasticity (ML-CL) followed by Silty Clay of low plasticity (CL).

At location of O.C. 28+075 (N.C. 28+743) :-

The sub strata of BH-A1 mainly consist of Sandy silt of low plasticity (ML-CL) and Silty Clay of low plasticity (CL).

The sub strata of BH-A2 mainly consist of Sandy silt of low plasticity (ML-CL) and Silty Clay of low plasticity (CL).

The sub strata of BH- P1 mainly consist of Silty Clay of low plasticity (CL), Sandy silt of low plasticity (ML-CL) and Silty sand (SM).

The sub strata of BH-P2 mainly consist of sandy silt of low plasticity (ML-CL) and Silty sand with clay (SM-SC).

At location of O.C. 28+360 (N.C. 29+028):-

The sub strata of BH-A1 mainly consist of Sandy silt of low plasticity (ML-CL) Silty sand with clay (SM-SC) and Silty sand (SM).

The sub strata of BH-A2 mainly consist of Silty sand (SM) and Sandy silt of low plasticity (ML-CL).

The sub strata of BH-P1 mainly consist of Silty sand (SM) and Sandy silt of low plasticity (ML-CL) Silty sand with clay (SM-SC).

The sub strata of BH-P2 mainly consist of Sandy silt of low plasticity (ML-CL) Silty sand with clay (SM-SC).

At location of O.C. 28+900 (N.C. 29+567):-

From the study of the borehole logs of 04 BHs, it is revealed that the sub strata from EGL to 40.0-50.0m depth mostly consist of fine grained soil i.e. silty clay of low plasticity (CL) with some layers of coarse grained soil i.e. sandy silt of low plasticity (ML-CL) embedded in between.

6.1 GROUND WATER TABLE DEPTH

The Ground Water Table was met at depths of from 32.67m to 38.10 m below EGL as given in Table 2.1, it may rise up during heavy rains / rainy season. Therefore, for the analysis of various foundations, the water table has been considered to rise by about 2 to 3.0m at the locations of boreholes.

6.2 RESULTS OF CHEMICAL ANALYSIS

Results of chemical analysis of soil samples (as per **Appendix – B2**) indicates that the soil sample falls under Class I for sulphates and chlorides concentration (As per IS 456-2000 and CIRIA Sp. Publication No. 31). The results are summarized here in below :-

Summary of chemical analysis of soil samples

Chemical Property	Findings (Min. to Max.)	Remarks (Required limits as per IS 456-2000)
pH	6.85 to 8.61	> 6.0
Sulphite as SO_3^{2-} (%)	0.0022 (%) to 0.0035 (%)	< 0.2% (Class I)
Chlorides as Cl^- (%)	0.047 (%) to 0.078 (%)	No limit specified in IS 456. However, a limit of 0.10% specified for class I in CIRIA Sp. Publication No. 31)

Note :- All the chemical contents are within permissible limit hence no special precautions are required.

6.3 INTERPRETATION OF LAB TEST RESULTS

Grain Size Analysis

- **Clay content:** It generally varies from 4 to 14%.
- **Silt content:** It generally varies from 22 to 68%.
- **Sand content:** It generally varies from 23 to 86%.
- **Gravel content:** It generally varies from 2 to 10%.

Atterberg's Limit

- **Liquid limit:** The test results of liquid limit of the soil samples reveal that it generally varies from 27 to 29% in ML-CL type of soil, 30 to 35% in CL type of soil.

- **Plastic Limit*:*** The plastic limit of the soil sample varies from 20 to 21% in ML-CL type of soil, 20 to 23% in CL type of soil. However ML-CL type of soil is considered as non-plastic.
- **Plasticity index*:*** The plasticity index of the soil samples generally varies from 6 to 7% in ML-CL type of soil, 10 to 12% in CL type of soil whereas ML-CL and SM/ SM-SC/ SC type of soil are non-plastic.

Natural moisture content & Bulk density

The bulk density of soil samples generally varies from 1.64gm/cc to 1.98gm/cc whereas natural moisture content varies from 9.22% to 18.26%.

Direct shear tests:

Direct shear test under drained condition have been conducted in sandy silty (ML-CL) / sandy stratum (SM/ SM-SC/ SC) type of soil.

For Sandy strata (SM/ SM-SC/ SC), the value of angle of internal friction varies from 25^o to 32^o, whereas cohesion varies from 0.00 kg/cm^2 to 0.11 kg/cm^2.

For Silty strata (ML-CL), the value of angle of internal friction varies from 22^o to 27^o, whereas cohesion varies from 0.19 kg/cm^2 to 0.22 kg/cm^2.

Triaxial shear tests:

Triaxial shear test under undrained condition have been conducted in silty clay (CL) type of soil.

For silty clay (CL) strata, the value of angle of internal friction varies from 4^o to 5^o, whereas cohesion varies from 1.42kg/cm^2 to 2.24kg/cm^2.

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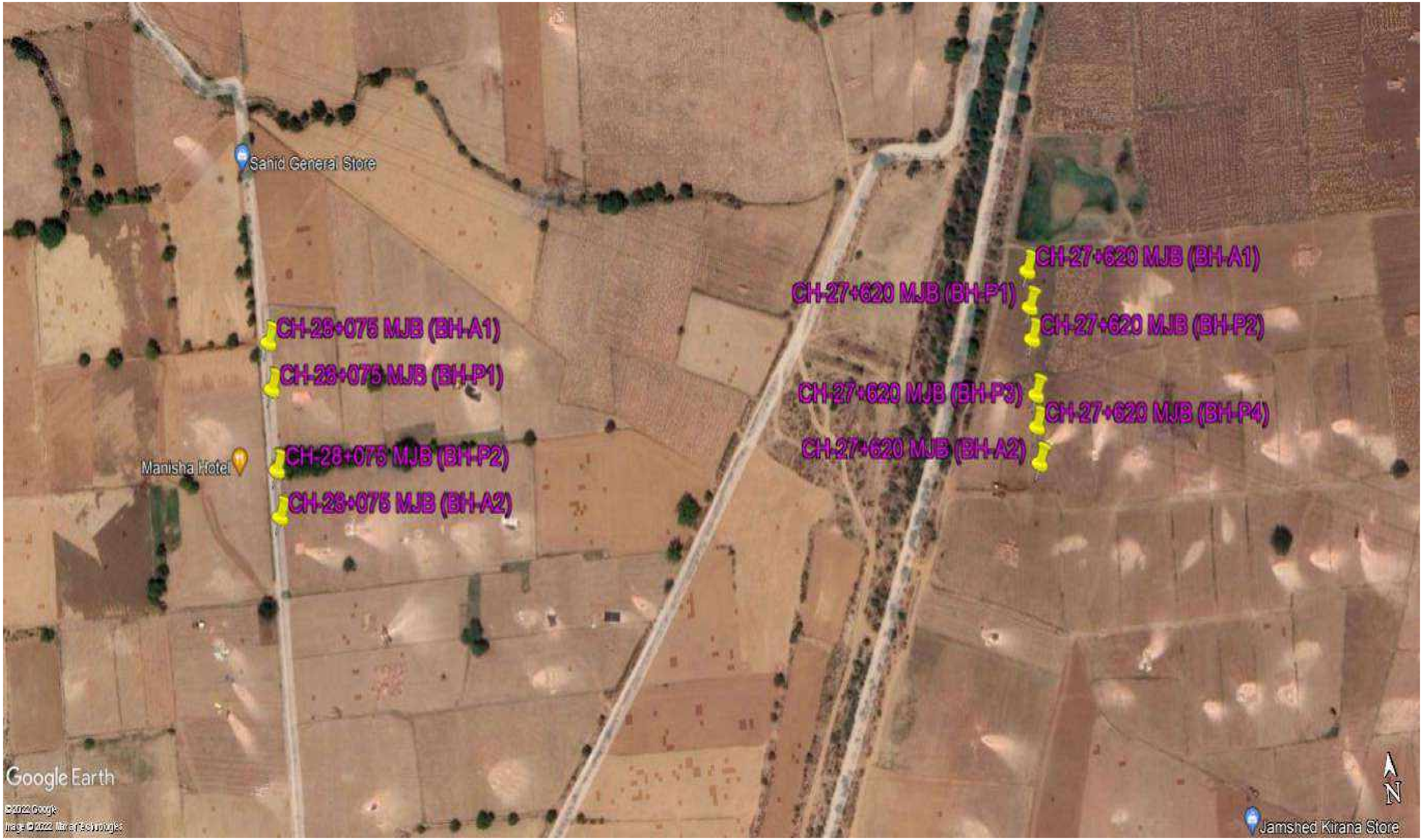
Abbreviations

BH	Borehole
ERT	Electrical Resistivity Test
EGL	Existing Ground Level
GWT	Ground Water Table
IS	Indian Standards
SPT	Standard Penetration Test
DS	Disturbed Soil
R.L.	Reduced Level
m	Metre
sp. gr.	Specific Gravity
%	Percentage
mg /l	Milligram per litre
mg /kg	Milligram per kilogram

APPENDIX – A (FIELD DATA RESULTS)

Appendix No.	**ITEMS**
A-1	LOCATION PLAN
A-2	FIELD BORE HOLE LOGS
A-3	SUB SOIL PROFILE DIAGRAM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CH-28+075 MJB (BH-A1)
CH-28+075 MJB (BH-P1)
Manisha Hotel
CH-28+075 MJB (BH-P2)
CH-28+075 MJB (BH-A2)
CH-27+620 MJB (BH-A1)
CH-27+620 MJB (BH-P1)
CH-27+620 MJB (BH-P2)
CH-27+620 MJB (BH-P3)
CH-27+620 MJB (BH-P4)
CH-27+620 MJB (BH-A2)
Google Earth
©2022 Google
Image ©2022 Maxar Technologies
N
Jamshed Kirana Store

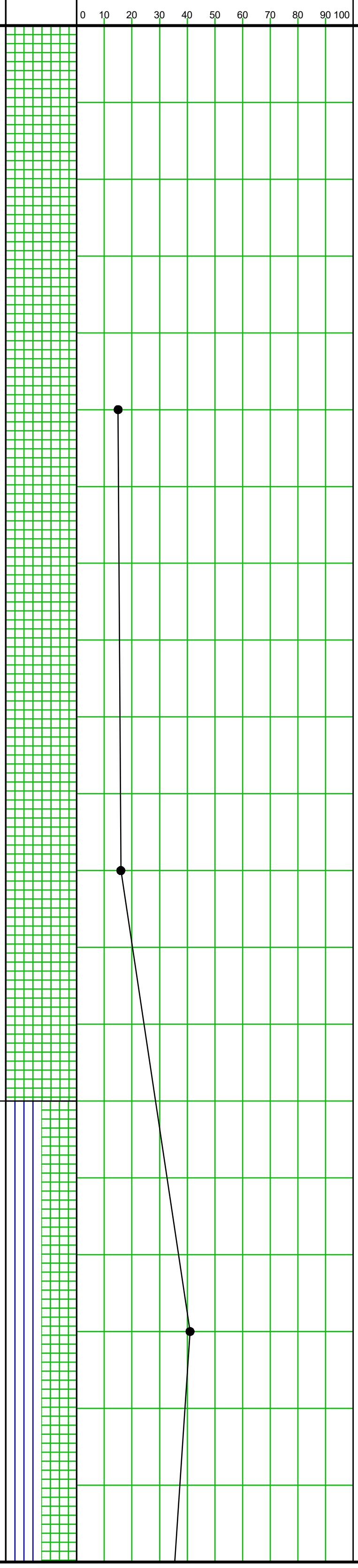

Majid Khan Shop
CH-28+900 MJB (BH-A1)
CH-28+900 MJB (BH-P1)
CH-28+900 MJB (BH-P2)
CH-28+900 MJB (BH-A2)
CH-28+360 MJB (BH-A1)
CH-28+360 MJB (BH-P1)
CH-28+360 MJB (BH-P2)
CH-28+360 MJB (BH-A2)
N
Google Earth
©2022 Google
Image ©2022 Maxar Technologies

-

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123079.115 m	*Easting :*697786.663 m
Reduced Level (m):(+)270.946	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS					Brown, Very stiff, Silty clay of low plasticity	CL			
0.5											
1.0	1	UDS-1									
1.5											
2.0											
2.5	2.5	SPT-1	2	7	8	15					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	7	7	9	16					
6.0											
6.5											
7.0	7	UDS-3					Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
7.5											
8.0											
8.5	8.5	SPT-3	12	17	24	41					
9.0											
9.5											
10.0	10	UDS-4									

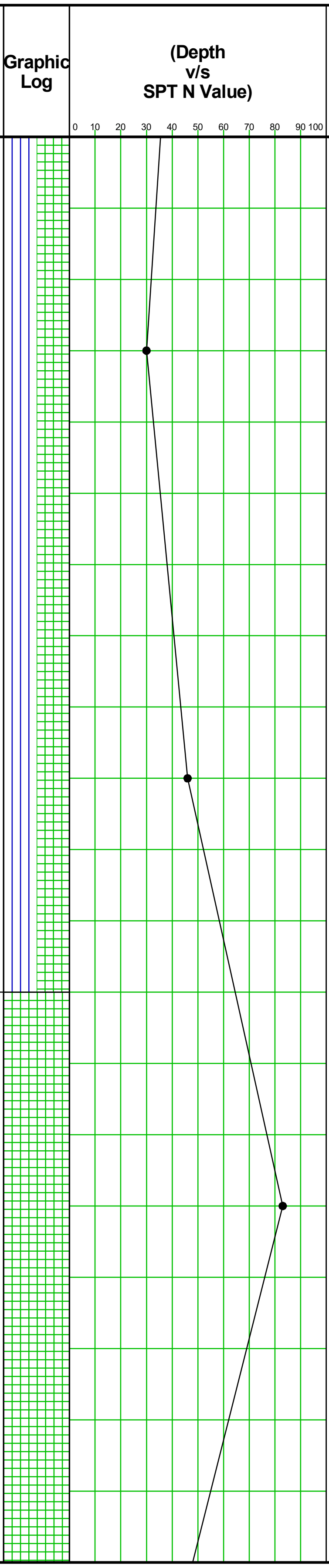


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123079.115 m	*Easting :*697786.663 m
Reduced Level (m):(+)270.946	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Special Observations
			N1	N2	N3				
10.0							Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL	
10.5									
11.0									
11.5	11.5	SPT-4	9	14	16	30			
12.0									
12.5									
13.0	13	UDS-5							
13.5									
14.0									
14.5	14.5	SPT-5	14	21	25	46			
15.0									
15.5									
16.0	16	UDS-6					Brown, Hard, Silty clay of low plasticity with gravel	CL	
16.5									
17.0									
17.5	17.5	SPT-6	22	40	43	83			
18.0									
18.5									
19.0	19	UDS-7							
19.5									
20.0									

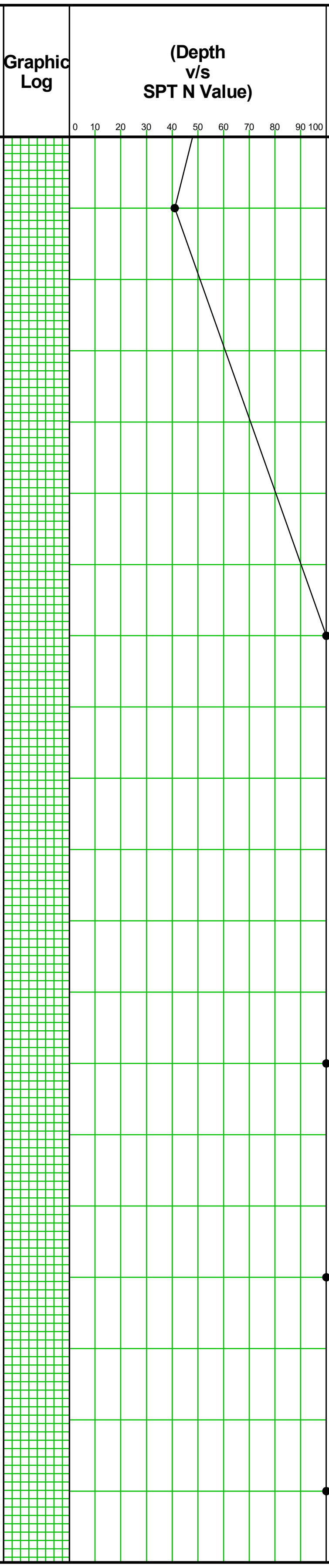


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123079.115 m	*Easting :*697786.663 m
Reduced Level (m):(+)270.946	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
20.0							Brown, Hard, Silty clay of low plasticity with gravel	CL	
20.5	20.5	SPT-7	14	19	22	41			
21.0									
21.5									
22.0	22	UDS-8							
22.5									
23.0									
23.5	23.5	SPT-8	32	69	31 (3cm)	>100			
24.0									
24.5									
25.0	25	UDS*							
25.5									
26.0									
26.5	26.5	SPT-9	27	40	60 (12cm)	>100			
27.0									
27.5									
28.0	28	SPT-10	36	74	26 (5cm)	>100			
28.5									
29.0									
29.5	29.5	SPT-11	38	68	32 (9cm)	>100			
30.0									



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.

*Client :*HRIDCL

*BH Location/Chainage :*27+620 km

*Northing :*3123079.115 m

*Easting :*697786.663 m

Reduced Level (m):(+)270.946

*BH. No. :*BH-A1

*BH Termination Depth (m):*40

*Proposed / Existing Structure :*Major Bridge

*Water Table (m):*33.10

Inclination : Vertical

*Boring type :*Rotary

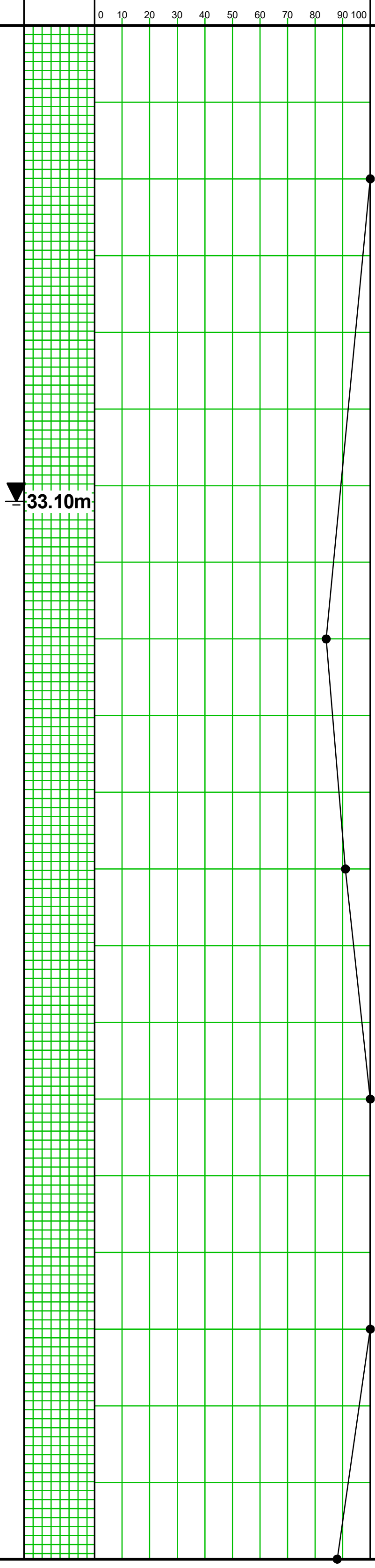
*Dia. of Boring :*150 mm

*Depth of Casing (m) :*Not Used

*Date of Start :*11-10-2021

*Date of Completion :*12-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
30.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
30.5											
31.0	31	SPT-12	40	100 (15cm)	-	>100					
31.5											
32.0											
32.5	32.5	UDS*									
33.0											
33.5											
34.0	34	SPT-13	32	36	48	84					
34.5											
35.0											
35.5	35.5	SPT-14	30	39	52	91					
36.0											
36.5											
37.0	37	SPT-15	46	100 (13cm)	-	>100					
37.5											
38.0											
38.5	38.5	SPT-16	30	82	18 (3cm)	>100					
39.0											
39.5											
40.0	40	SPT-17	25	40	48	88					

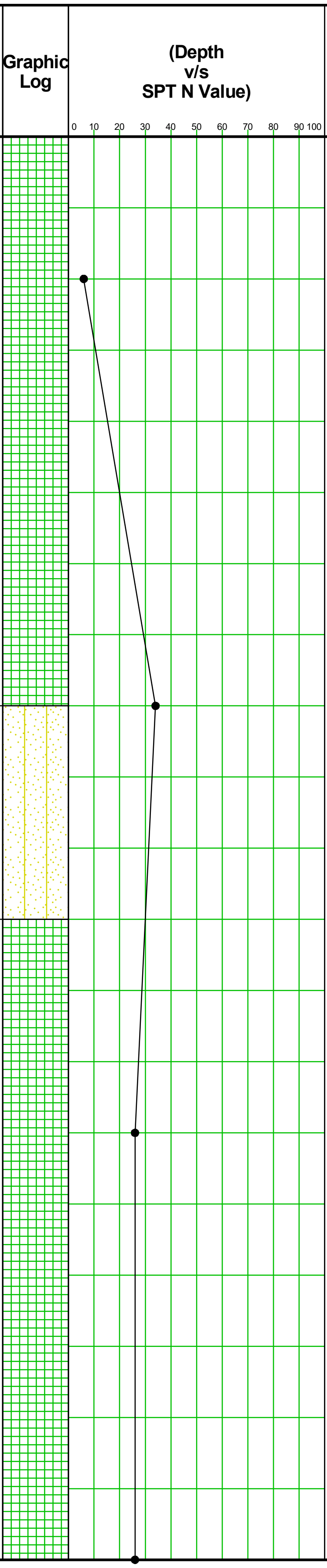


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123062.116 m	*Easting :*697786.52 m
Reduced Level (m):(+)271.001	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
0.0		DS					Brown, Medium stiff, Silty clay of low plasticity	CL	
0.5									
1.0	1	SPT-1	2	3	3	6			
1.5									
2.0									
2.5	2.5	UDS-1							
3.0									
3.5									
4.0	4	SPT-2	9	16	18	34			
4.5							Brown, Dense, Silty sand	SM	
5.0									
5.5	5.5	UDS-2							
6.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL	
6.5									
7.0	7	SPT-3	7	12	14	26			
7.5									
8.0									
8.5	8.5	UDS-3							
9.0									
9.5									
10.0	10	SPT-4	9	11	15	26			



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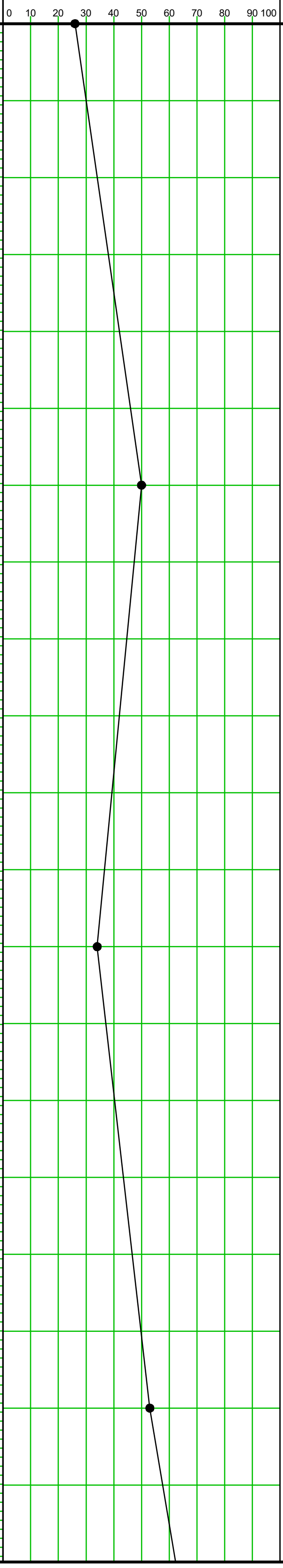
FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123062.116 m	*Easting :*697786.52 m
Reduced Level (m):(+)271.001	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
10.0											
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	18	24	26	50					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	SPT-6	10	14	20	34					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	18	21	32	53					
19.5											
20.0											

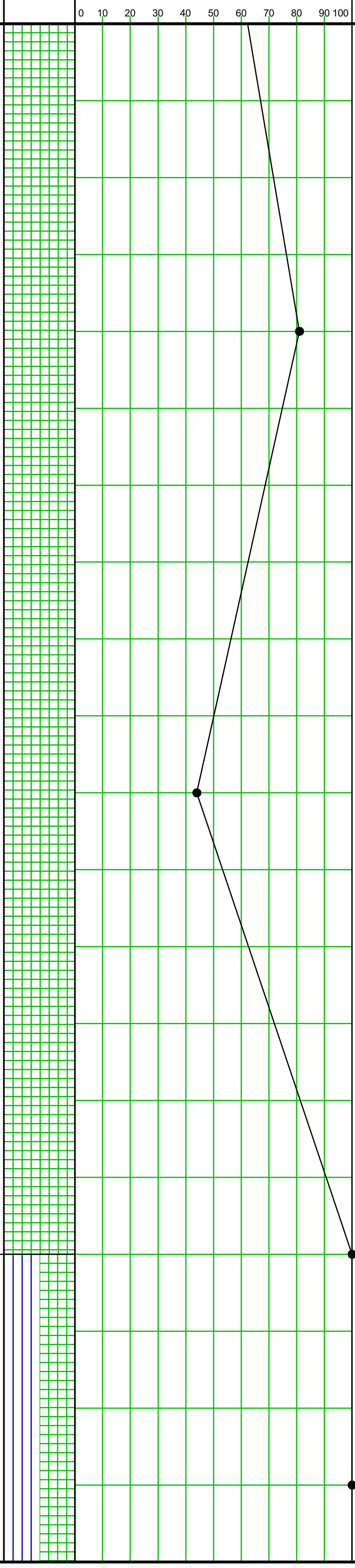


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123062.116 m	*Easting :*697786.52 m
Reduced Level (m):(+)271.001	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**	**Graphic Log**	**(Depth v/s SPT N Value)**	**Special Observations**
			N1	**N2**	**N3**						
20.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	24	38	43	81					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	13	20	24	44					
25.5											
26.0											
26.5	26.5	UDS-9									
27.0											
27.5											
28.0	28	SPT-10	32	52	48 (10cm)	>100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
28.5											
29.0											
29.5	29.5	SPT-11	40	65	35 (8cm)	>100					
30.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

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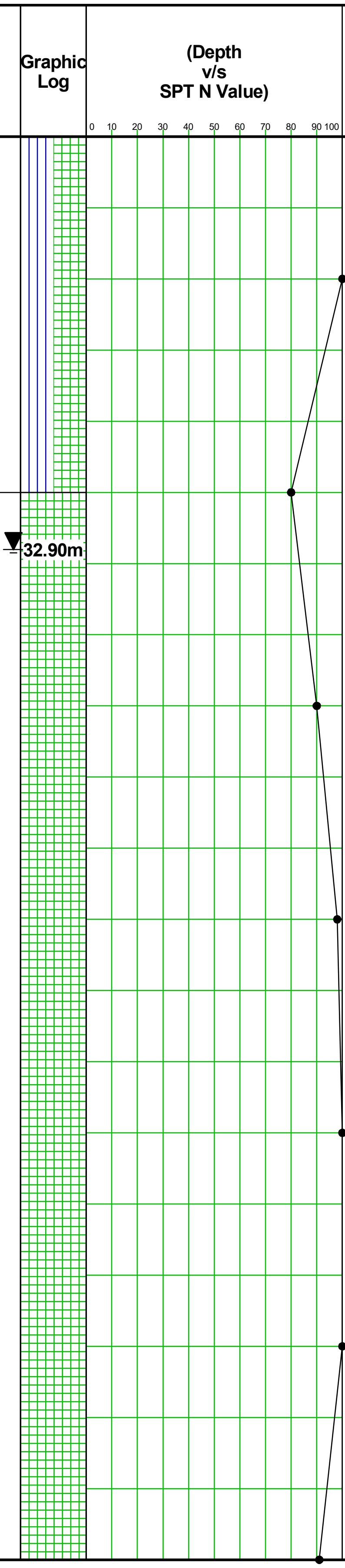
*BH Location/Chainage :*27+620 km	*Northing :*3123062.116 m	*Easting :*697786.52 m
Reduced Level (m):(+)271.001	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
30.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	
30.5									
31.0	31	SPT-12	53	75	25 (2cm)	>100			
31.5									
32.0									
32.5	32.5	SPT-13	21	34	46	80	Brown, Hard, Silty clay of low plasticity with gravel	CL	
33.0									
33.5									
34.0	34	SPT-14	26	38	52	90			
34.5									
35.0									
35.5	35.5	SPT-15	30	42	56	98			
36.0									
36.5									
37.0	37	SPT-16	25	46	54 (10cm)	>100			
37.5									
38.0									
38.5	38.5	SPT-17	30	52	48 (8cm)	>100			
39.0									
39.5									
40.0	40	SPT-18	24	42	49	91			

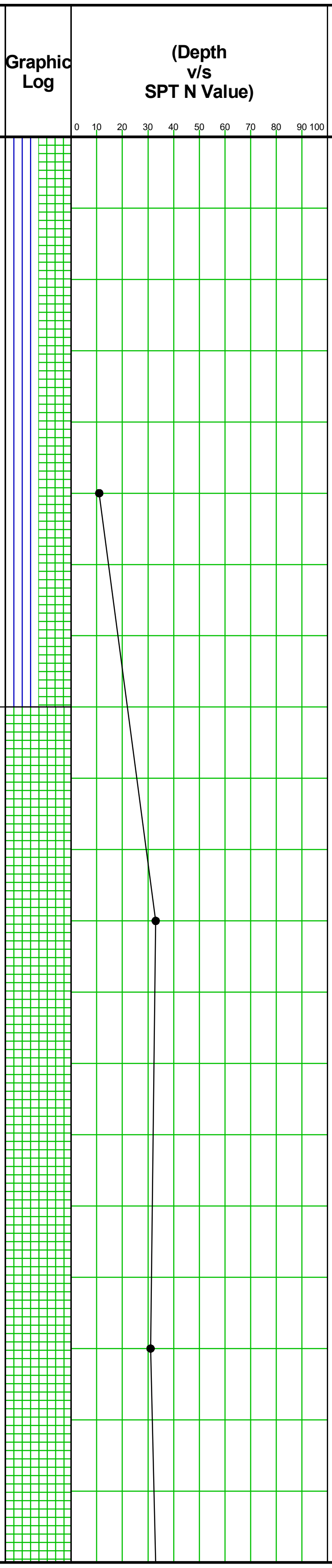


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

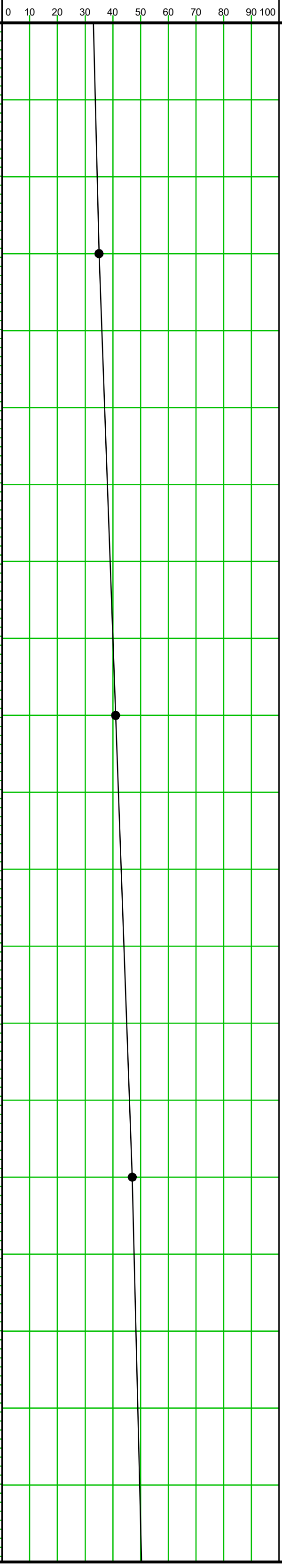
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
0.0		DS					Brown, Medium dense, Sandy silt of low plasticity	ML-CL	
0.5									
1.0	1	UDS-1							
1.5									
2.0									
2.5	2.5	SPT-1	3	5	6	11			
3.0									
3.5									
4.0	4	UDS-2					Brown, Hard, Silty clay of low plasticity with gravel	CL	
4.5									
5.0									
5.5	5.5	SPT-2	10	15	18	33			
6.0									
6.5									
7.0	7	UDS-3							
7.5									
8.0									
8.5	8.5	SPT-3	12	13	18	31			
9.0									
9.5									
10.0	10	UDS-4							



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

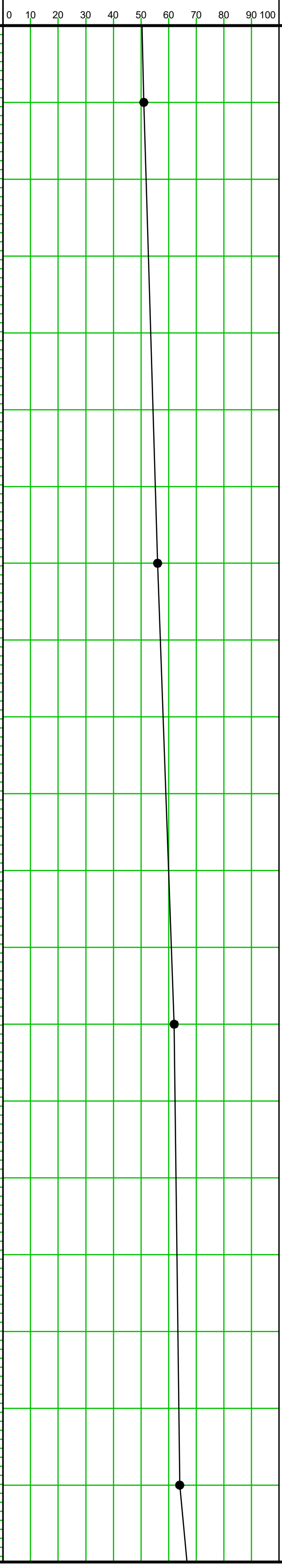
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3					0 10 20 30 40 50 60 70 80 90 100	
10.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
10.5											
11.0											
11.5	11.5	SPT-4	12	15	20	35					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	15	19	22	41					
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	16	19	28	47					
18.0											
18.5											
19.0	19	UDS-7									
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
20.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
20.5	20.5	SPT-7	18	21	30	51					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	22	26	30	56					
24.0											
24.5											
25.0	25	UDS-9									
25.5											
26.0											
26.5	26.5	SPT-9	25	28	34	62					
27.0											
27.5											
28.0	28	UDS-10									
28.5											
29.0											
29.5	29.5	SPT-10	25	29	35	64					
30.0											

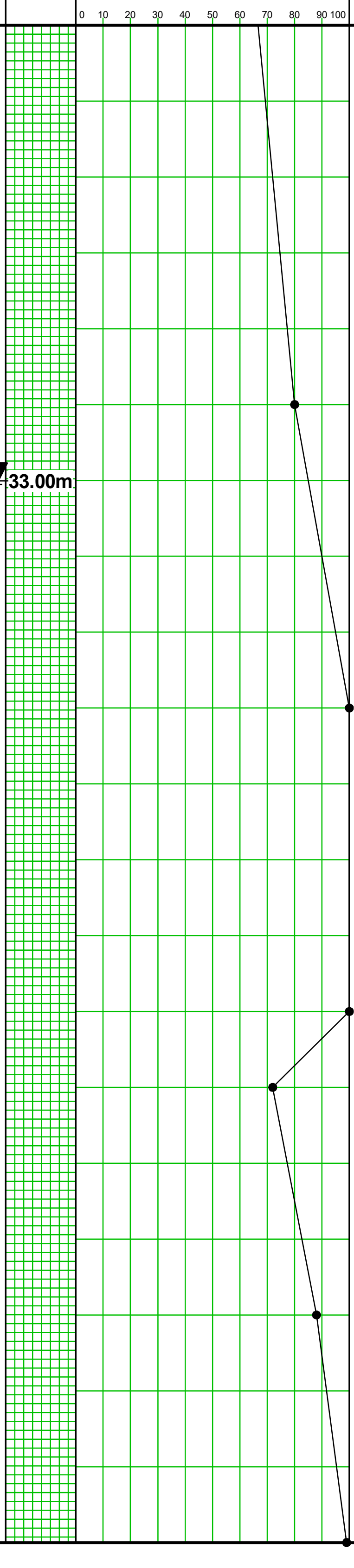


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
30.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
30.5											
31.0	31	UDS-11									
31.5											
32.0											
32.5	32.5	SPT-11	30	35	45	80					
33.0									33.00m		
33.5											
34.0	34	UDS-12									
34.5	34.5	SPT-12	39	51	49 (10cm)	>100					
35.0											
35.5											
36.0											
36.5	36.5	SPT-13	44	59	41 (7cm)	>100					
37.0	37	SPT-14	25	32	40	72					
37.5											
38.0											
38.5	38.5	SPT-15	32	40	48	88					
39.0											
39.5											
40.0	40	SPT-16	39	45	54	99					

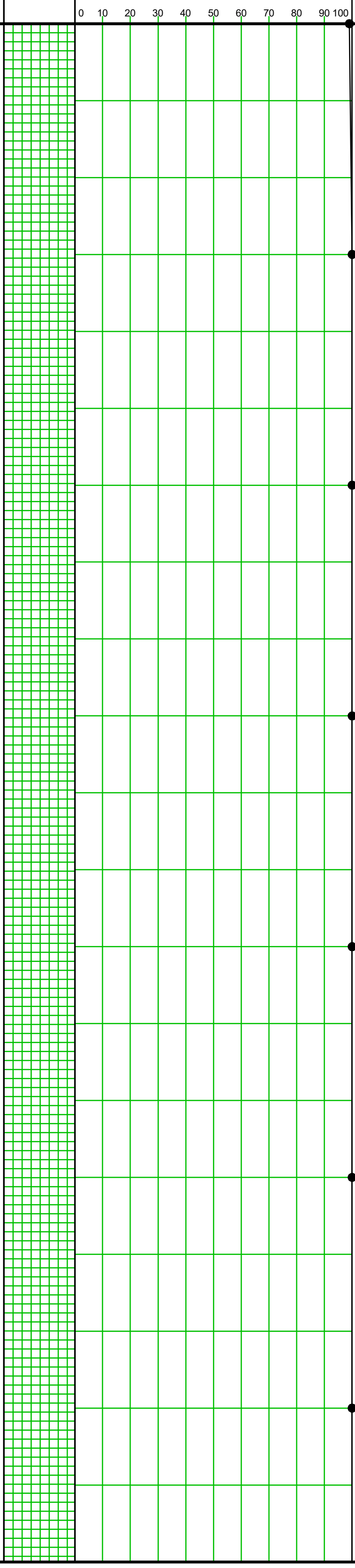


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0											
40.5											
41.0											
41.5	41.5	SPT-17	44	61	39 (8cm)	>100					
42.0											
42.5											
43.0	43	SPT-18	40	69	31 (8cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-19	48	75	25 (5cm)	>100					
45.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
45.5											
46.0	46	SPT-20	60	100 (6cm)	-	>100					
46.5											
47.0											
47.5	47.5	SPT-21	41	57	43 (9cm)	>100					
48.0											
48.5											
49.0	49	SPT-22	51	100 (7cm)	-	>100					
49.5											
50.0											

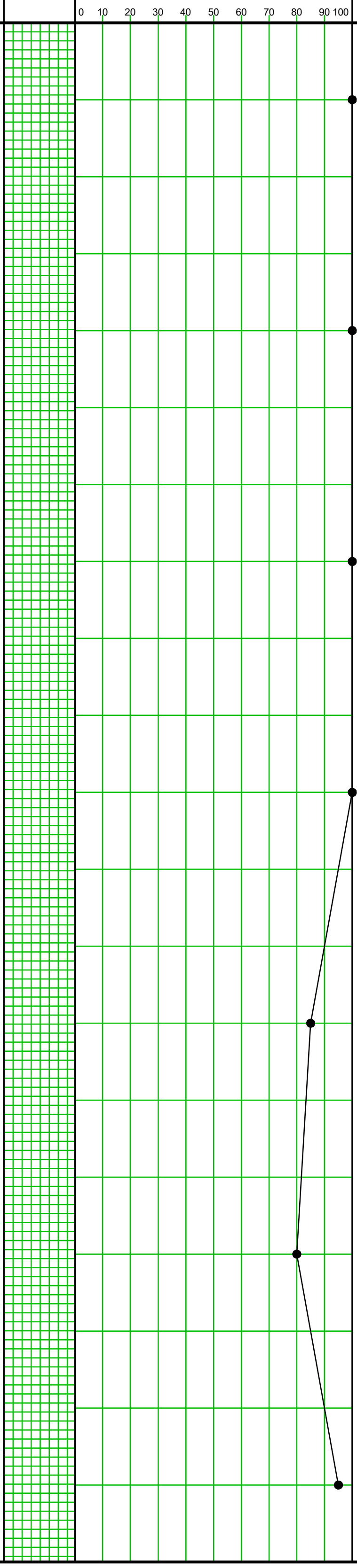


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*27+620 km
*Northing :*3123047.116 m
*Easting :*697786.377 m
Reduced Level (m):(+)271.080
*BH. No. :*BH-P2
*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*33.00
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021
*Date of Completion :*21-11-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
50.0											
50.5	50.5	SPT-23	43	55	45 (7cm)	>100					
51.0											
51.5											
52.0	52	SPT-24	40	61	39 (6cm)	>100					
52.5											
53.0											
53.5	53.5	SPT-25	47	100 (11cm)	-	>100					
54.0											
54.5											
55.0	55	SPT-26	52	100 (7cm)	-	>100	Brown, Hard, Silty clay of low plasticity with gravel	CL			
55.5											
56.0											
56.5	56.5	SPT-27	32	37	48	85					
57.0											
57.5											
58.0	58	SPT-28	27	33	47	80					
58.5											
59.0											
59.5	59.5	SPT-29	39	45	50	95					
60.0	60	-									

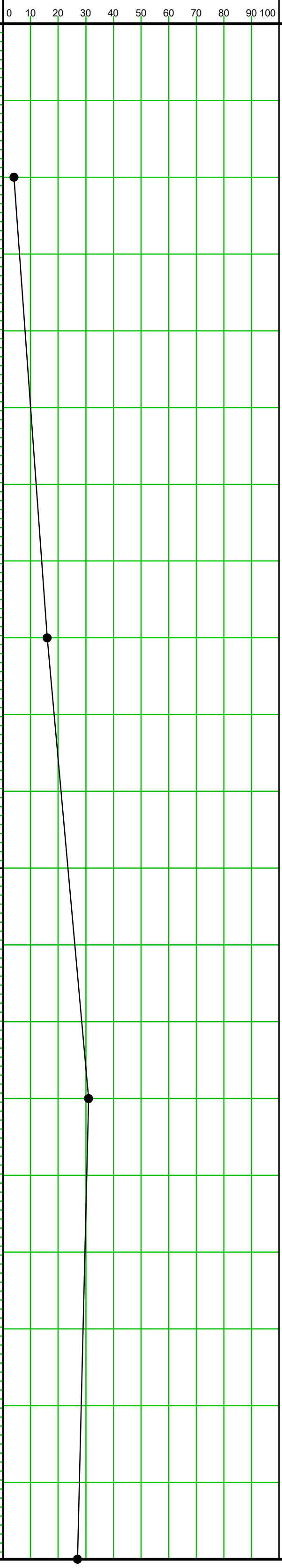


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS-1					Brown, Medium stiff to very stiff, Silty clay of low plasticity	CL			
0.5											
1.0	1	SPT-1	1	2	2	4					
1.5											
2.0											
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	5	7	9	16					
4.5											
5.0											
5.5	5.5	UDS-2					Brown, Hard, Silty clay of low plasticity with gravel	CL			
6.0											
6.5											
7.0	7	SPT-3	10	13	18	31					
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	9	12	15	27					

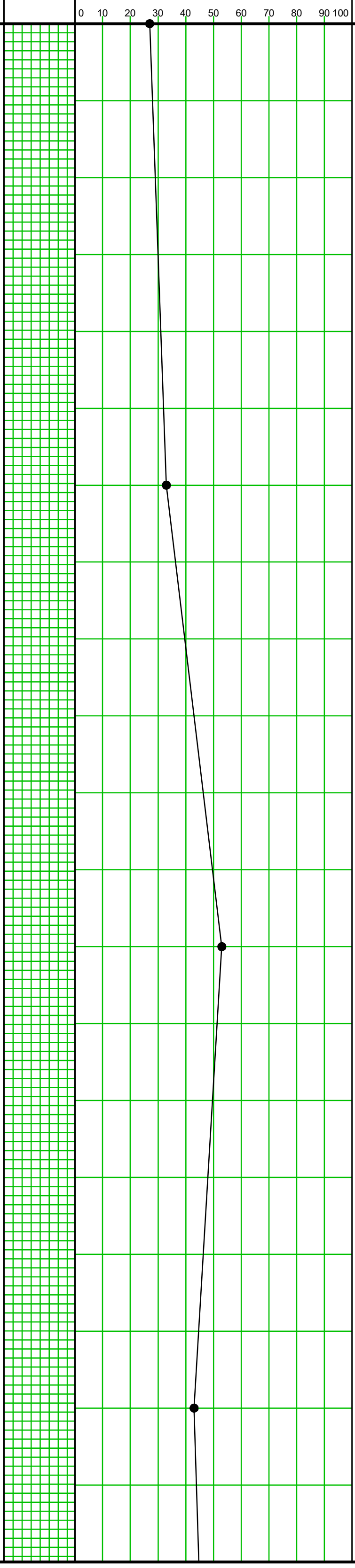


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	10	15	18	33					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	SPT-6	14	18	35	53					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	18	19	24	43					
19.5											
20.0											

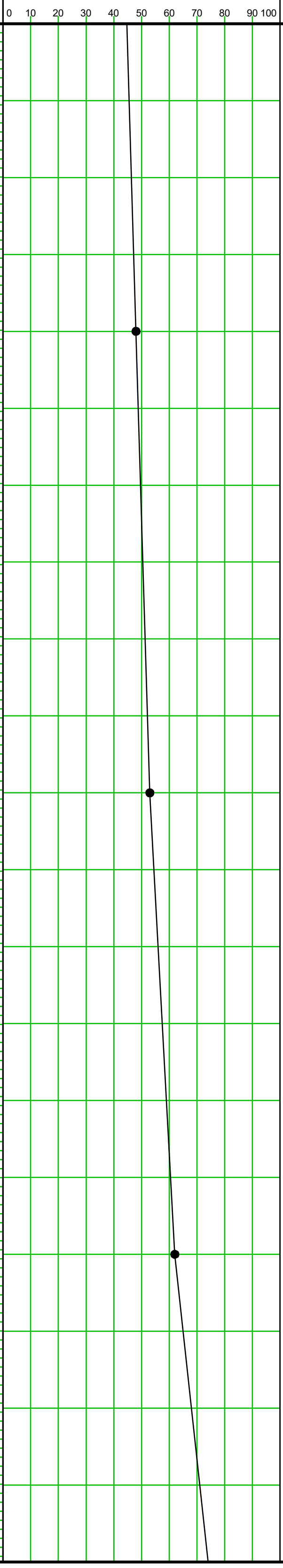


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
20.0											
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	16	22	26	48					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	18	25	28	53	Brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	UDS-9									
27.0											
27.5											
28.0	28	SPT-10	21	29	33	62					
28.5											
29.0											
29.5	29.5	UDS-10									
30.0											

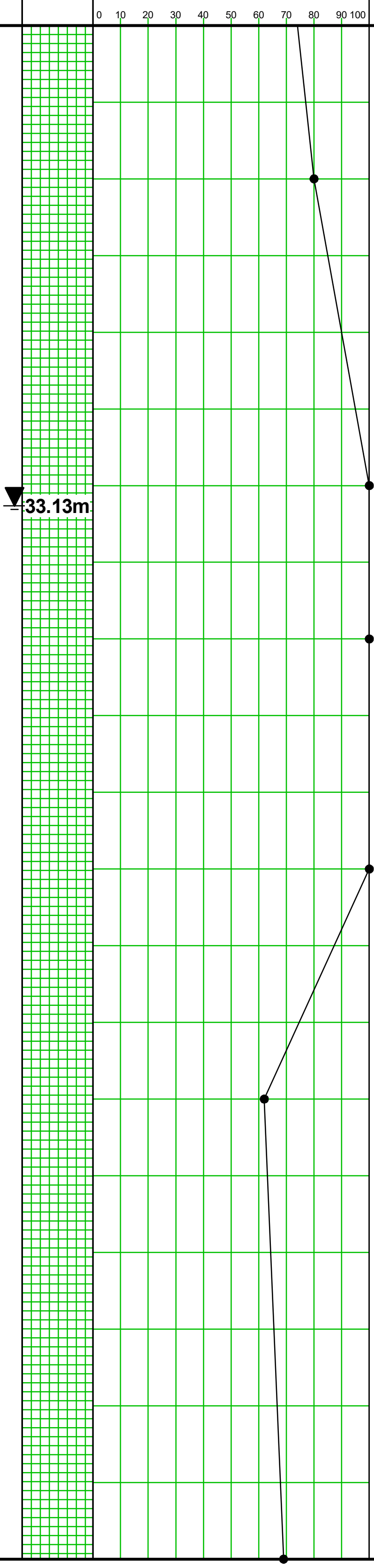


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

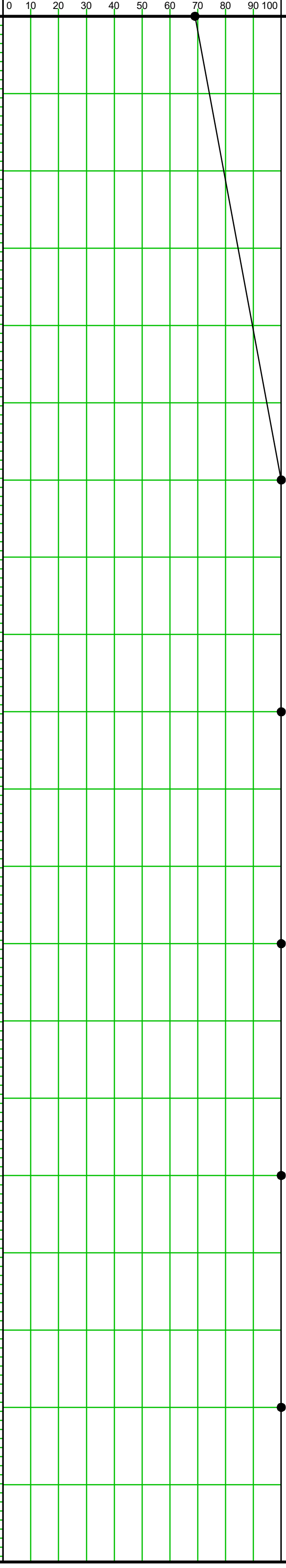
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
30.5											
31.0	31	SPT-11	27	38	42	80					
31.5											
32.0											
32.5	32.5	UDS*									
33.0	33	SPT-12	35	58	42 (5cm)	>100					
33.5											
34.0	34	SPT-13	48	69	31 (5cm)	>100					
34.5											
35.0											
35.5	35.5	SPT-14	44	75	25 (11cm)	>100					
36.0											
36.5											
37.0	37	SPT-15	22	28	34	62					
37.5											
38.0											
38.5	38.5	UDS-11									
39.0											
39.5											
40.0	40	SPT-16	29	32	37	69					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*27+620 km
*Northing :*3123021.117 m
*Easting :*697786.129 m
Reduced Level (m):(+)270.749
*BH. No. :*BH-P3
*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*33.13
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021
*Date of Completion :*20-11-2021

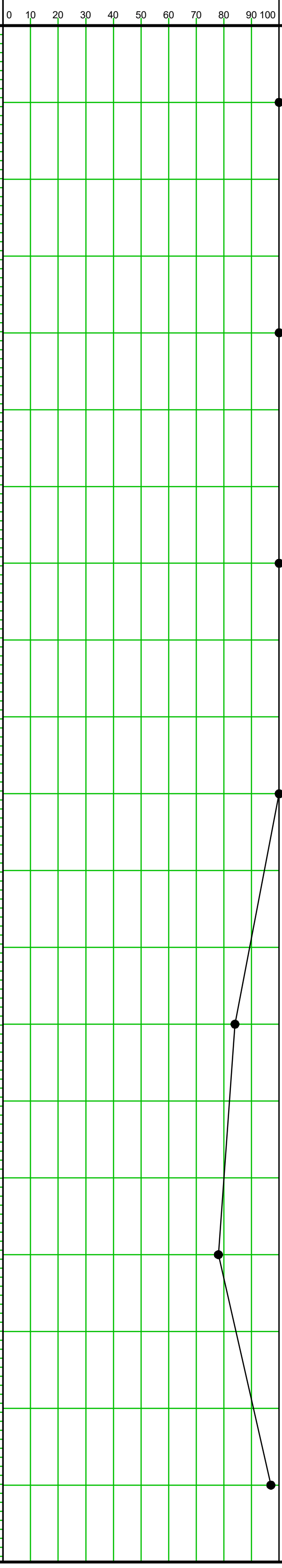
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
40.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
40.5											
41.0											
41.5	41.5	UDS-12									
42.0											
42.5											
43.0	43	SPT-17	46	73	27 (12cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-18	40	68	32 (8cm)	>100					
45.0											
45.5											
46.0	46	SPT-19	58	100 (5cm)	-	>100					
46.5											
47.0											
47.5	47.5	SPT-20	43	63	37 (5cm)	>100					
48.0											
48.5											
49.0	49	SPT-21	55	100 (7cm)	-	>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
50.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
50.5	50.5	SPT-22	43	60	40 (6cm)	>100					
51.0											
51.5											
52.0	52	SPT-23	35	66	34 (5cm)	>100					
52.5											
53.0											
53.5	53.5	SPT-24	47	100 (10cm)	-	>100					
54.0											
54.5											
55.0	55	SPT-25	55	100 (8cm)	-	>100					
55.5											
56.0											
56.5	56.5	SPT-26	34	39	45	84					
57.0											
57.5											
58.0	58	SPT-27	28	35	43	78					
58.5											
59.0											
59.5	59.5	SPT-28	36	45	52	97					
60.0	60	DS-2									

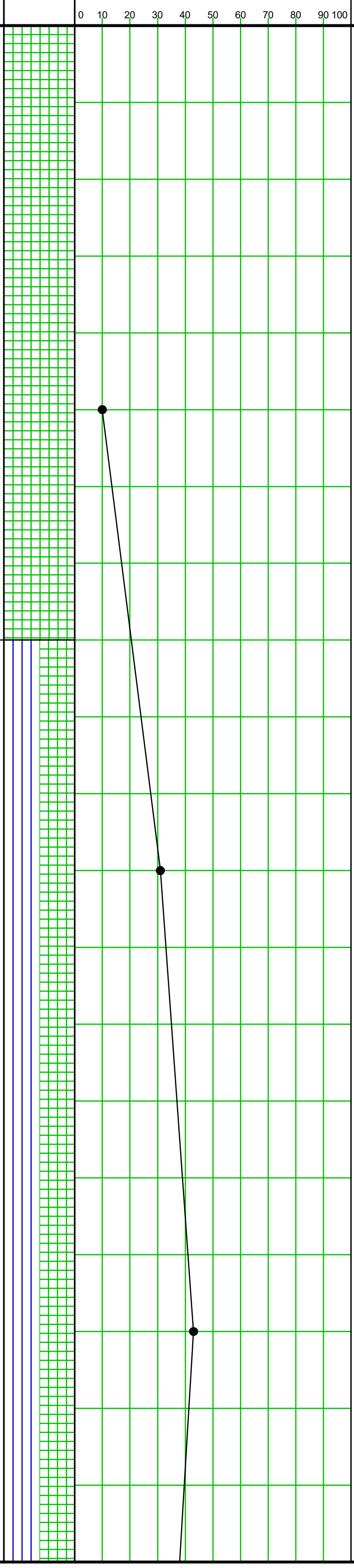


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123006.118 m	*Easting :*697785.986 m
Reduced Level (m):(+)271.774	*BH. No. :*BH-P4	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.14	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
0.0		DS					Brown, Stiff, Silty clay of low plasticity	CL			
0.5											
1.0	1	UDS-1									
1.5											
2.0											
2.5	2.5	SPT-1	3	4	6	10					
3.0											
3.5											
4.0	4	UDS-2					Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
4.5											
5.0											
5.5	5.5	SPT-2	10	14	17	31					
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	11	19	24	43					
9.0											
9.5											
10.0	10	UDS-4									

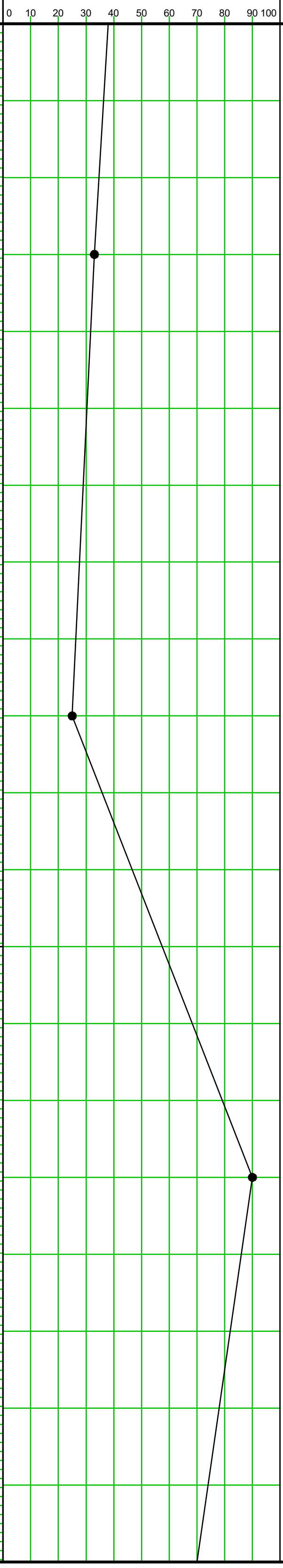


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123006.118 m	*Easting :*697785.986 m
Reduced Level (m):(+)271.774	*BH. No. :*BH-P4	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.14	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
10.0							Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
10.5											
11.0											
11.5	11.5	SPT-4	8	14	19	33					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	7	11	14	25					
15.0											
15.5											
16.0	16	UDS-6					Brown, Hard, Silty clay of low plasticity with gravel	CL			
16.5											
17.0											
17.5	17.5	SPT-6	23	39	51	90					
18.0											
18.5											
19.0	19	UDS-7									
19.5											
20.0											

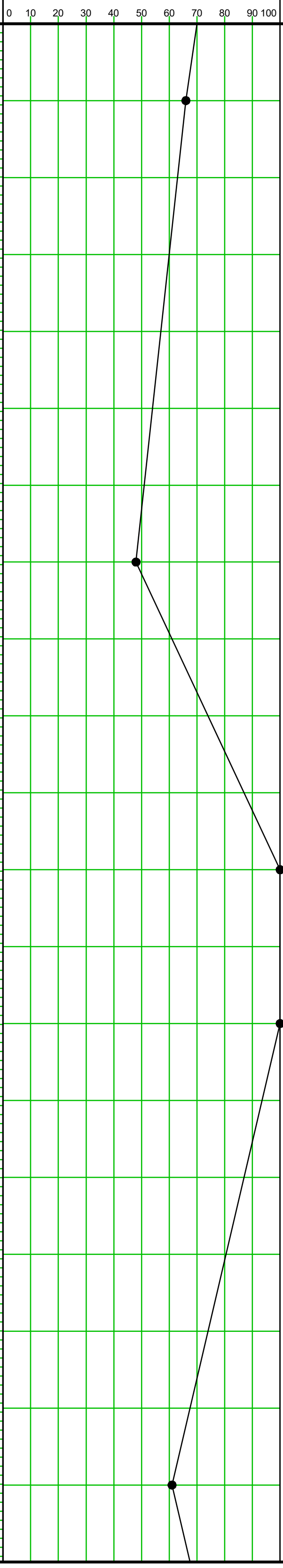


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123006.118 m	*Easting :*697785.986 m
Reduced Level (m):(+)271.774	*BH. No. :*BH-P4	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.14	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**	**Graphic Log**	**(Depth v/s SPT N Value)**	**Special Observations**
			N1	**N2**	**N3**						
20.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
20.5	20.5	SPT-7	24	32	34	66					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	16	21	27	48					
24.0											
24.5											
25.0	25	UDS*									
25.5	25.5	SPT-9	17	50	50 (10cm)	>100					
26.0											
26.5	26.5	SPT-10	22	57	43 (8cm)	>100					
27.0											
27.5											
28.0	28	UDS-9									
28.5											
29.0											
29.5	29.5	SPT-11	15	24	37	61					
30.0											

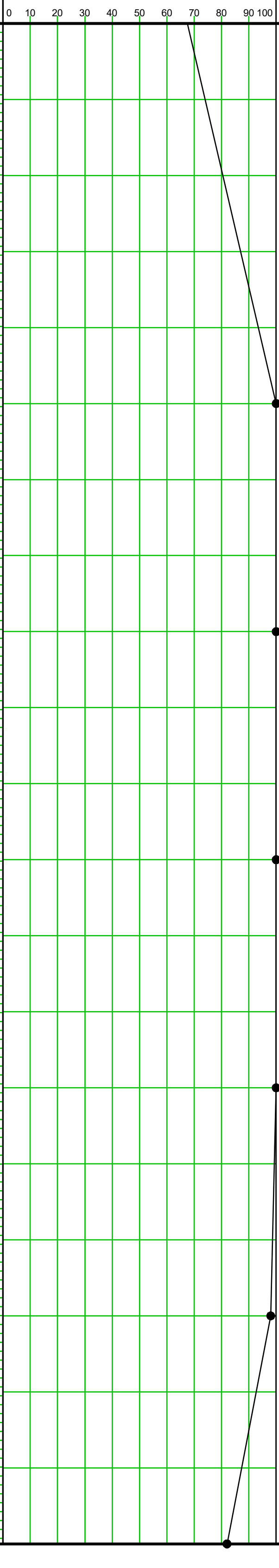


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123006.118 m	*Easting :*697785.986 m
Reduced Level (m):(+)271.774	*BH. No. :*BH-P4	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.14	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
30.5											
31.0	31	UDS-10									
31.5											
32.0											
32.5	32.5	SPT-12	27	43	57 (13cm)	>100					
33.0									▼33.14m		
33.5											
34.0	34	SPT-13	30	47	53 (11cm)	>100					
34.5											
35.0											
35.5	35.5	SPT-14	37	54	46 (9cm)	>100					
36.0											
36.5											
37.0	37	SPT-15	22	45	55 (15cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-16	25	43	55	98					
39.0											
39.5											
40.0	40	SPT-17	22	37	45	82					

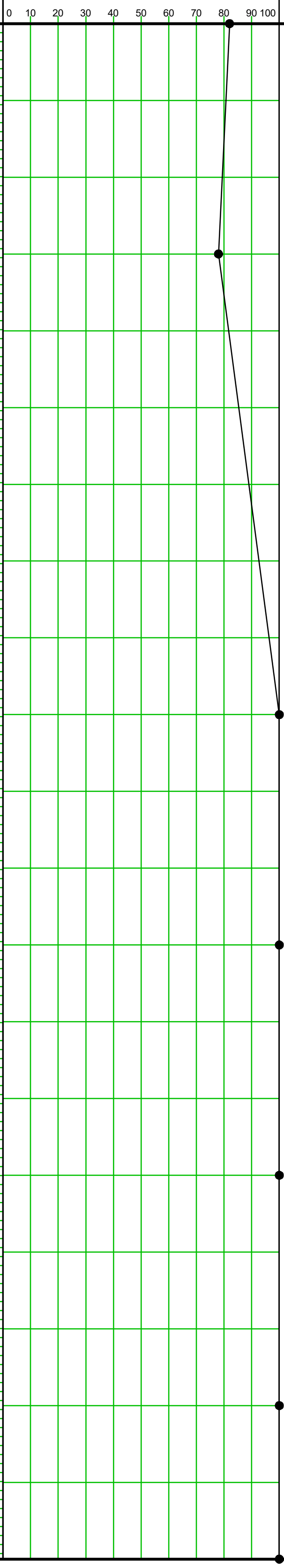


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*27+620 km
*Northing :*3123006.118 m
*Easting :*697785.986 m
Reduced Level (m):(+)271.774
*BH. No. :*BH-P4
*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*33.14
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021
*Date of Completion :*20-11-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
40.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
40.5											
41.0											
41.5	41.5	SPT-18	21	35	43	78					
42.0											
42.5											
43.0	43	UDS-11									
43.5											
44.0											
44.5	44.5	SPT-19	22	43	57 (11cm)	>100					
45.0											
45.5											
46.0	46	SPT-20	31	47	53 (8cm)	>100					
46.5											
47.0											
47.5	47.5	SPT-21	35	54	46 (7cm)	>100					
48.0											
48.5											
49.0	49	SPT-22	28	60	40 (7cm)	>100					
49.5											
50.0	50	SPT-23	25	65	35 (6cm)	>100					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL

*BH Location/Chainage :*27+620 km
*Northing :*3122989.119 m
*Easting :*697785.825 m

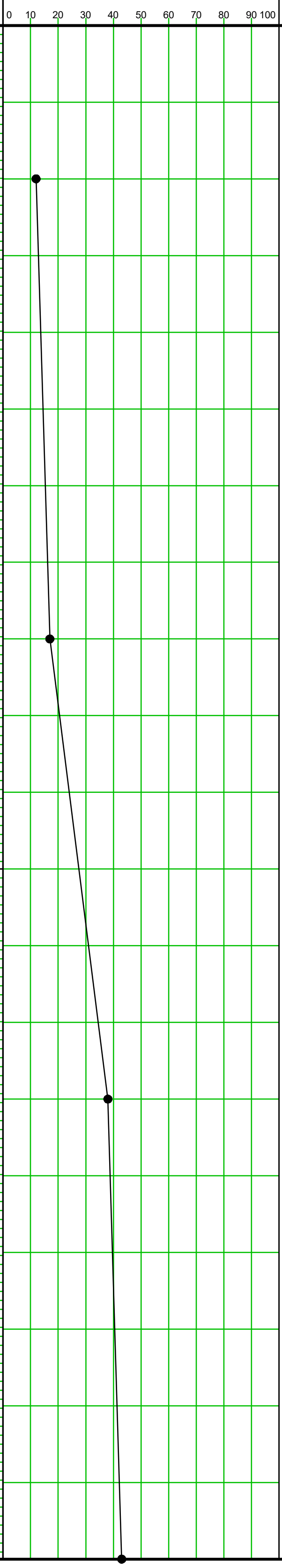
Reduced Level (m):(+)271.929
*BH. No. :*BH-A2
*BH Termination Depth (m):*40

*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*33.12
Inclination : Vertical

*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used

*Date of Start :*18-11-2021
*Date of Completion :*19-11-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
0.0		DS					Brown, Medium dense, Sandy silt of low plasticity	ML-CL	▥		
0.5											
1.0	1	SPT-1	4	5	7	12					
1.5											
2.0											
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	6	7	10	17					
4.5											
5.0											
5.5	5.5	UDS-2					Brown, Hard, Silty clay of low plasticity with gravel	CL	▦		
6.0											
6.5											
7.0	7	SPT-3	10	16	22	38					
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	12	18	25	43					

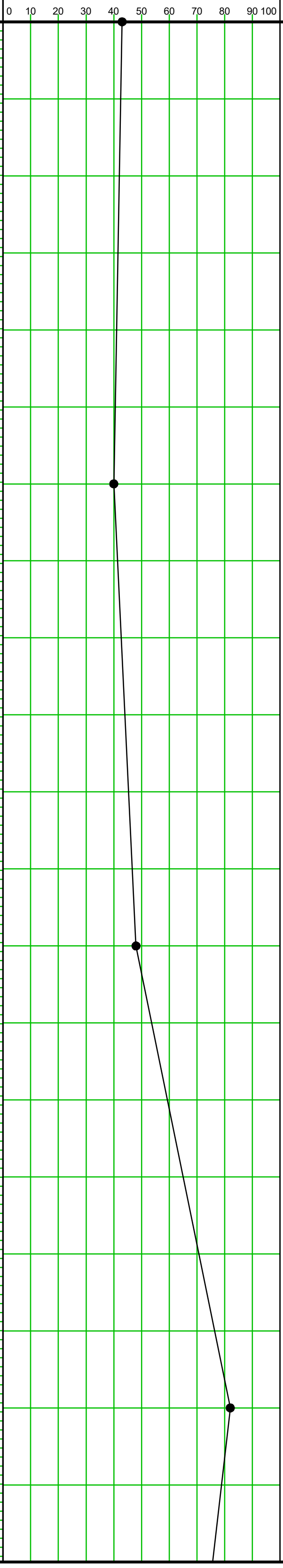


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3122989.119 m	*Easting :*697785.825 m
Reduced Level (m):(+)271.929	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.12	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*19-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	11	14	26	40					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0											
15.5											
16.0	16	SPT-6	13	20	28	48					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	24	35	47	82					
19.5											
20.0											

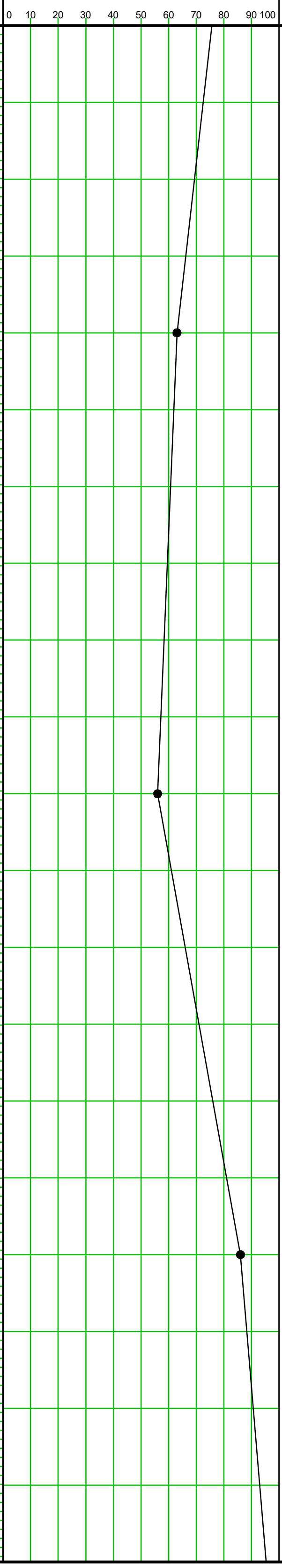


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3122989.119 m	*Easting :*697785.825 m
Reduced Level (m):(+)271.929	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.12	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*19-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
20.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	22	28	35	63					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	19	24	32	56					
25.5											
26.0											
26.5	26.5	UDS-9									
27.0											
27.5											
28.0	28	SPT-10	25	38	48	86					
28.5											
29.0											
29.5	29.5	UDS-10									
30.0											

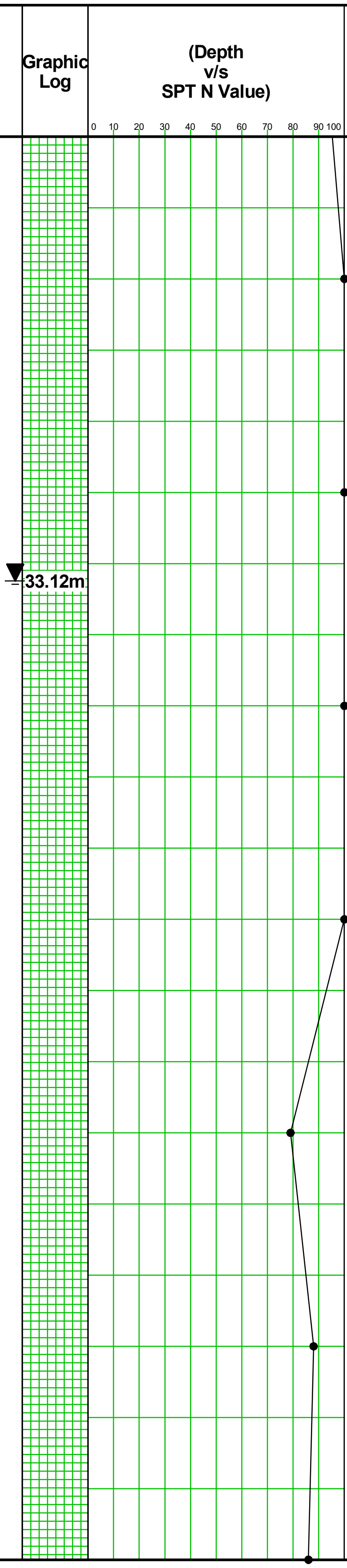


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3122989.119 m	*Easting :*697785.825 m
Reduced Level (m):(+)271.929	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.12	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*19-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
30.0							Brown, Hard, Silty clay of low plasticity with gravel	CL	
30.5									
31.0	31	SPT-11	33	52	48 (10cm)	>100			
31.5									
32.0									
32.5	32.5	SPT-12	32	59	41 (7cm)	>100			
33.0									
33.5									
34.0	34	SPT-13	36	62	38 (5cm)	>100			
34.5									
35.0									
35.5	35.5	SPT-14	54	56	44 (7cm)	>100			
36.0									
36.5									
37.0	37	SPT-15	20	34	45	79			
37.5									
38.0									
38.5	38.5	SPT-16	22	38	50	88			
39.0									
39.5									
40.0	40	SPT-17	29	38	48	86			

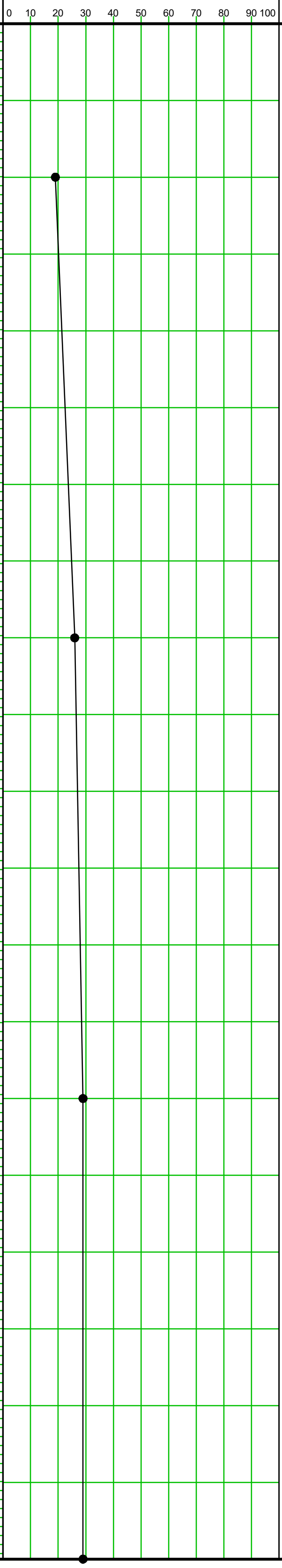


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+075 km
*Northing :*3123086.726 m
*Easting :*697330.702 m
Reduced Level (m):(+)269.806
*BH. No. :*BH-A1
*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*32.67
Inclination : Vertical
*Boring type :*Shell & Auger
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021
*Date of Completion :*18-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
0.0		DS					Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
0.5											
1.0	1	SPT-1	7	9	10	19					
1.5											
2.0											
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	7	12	14	26					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	10	14	15	29					
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	8	12	17	29					

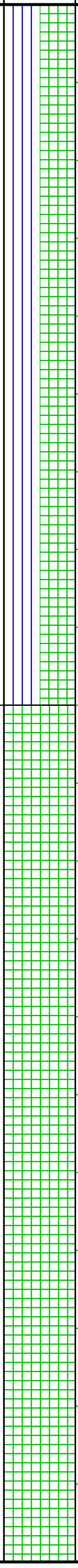


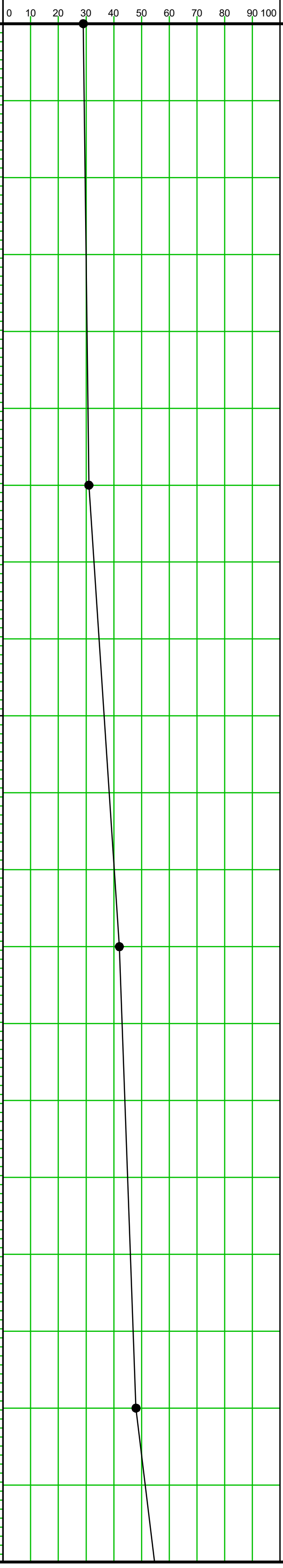
UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**	**Graphic Log**	**(Depth v/s SPT N Value)**	**Special Observations**
			N1	**N2**	**N3**						
10.0							Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	10	13	18	31					
13.5											
14.0											
14.5	14.5	UDS-5					Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.0											
15.5											
16.0	16	SPT-6	13	18	24	42					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	15	20	28	48					
19.5											
20.0											





UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.

*Client :*HRIDCL

*BH Location/Chainage :*28+075 km

*Northing :*3123086.726 m

*Easting :*697330.702 m

Reduced Level (m):(+)269.806

*BH. No. :*BH-A1

*BH Termination Depth (m):*55

*Proposed / Existing Structure :*Major Bridge

*Water Table (m):*32.67

Inclination : Vertical

*Boring type :*Shell & Auger

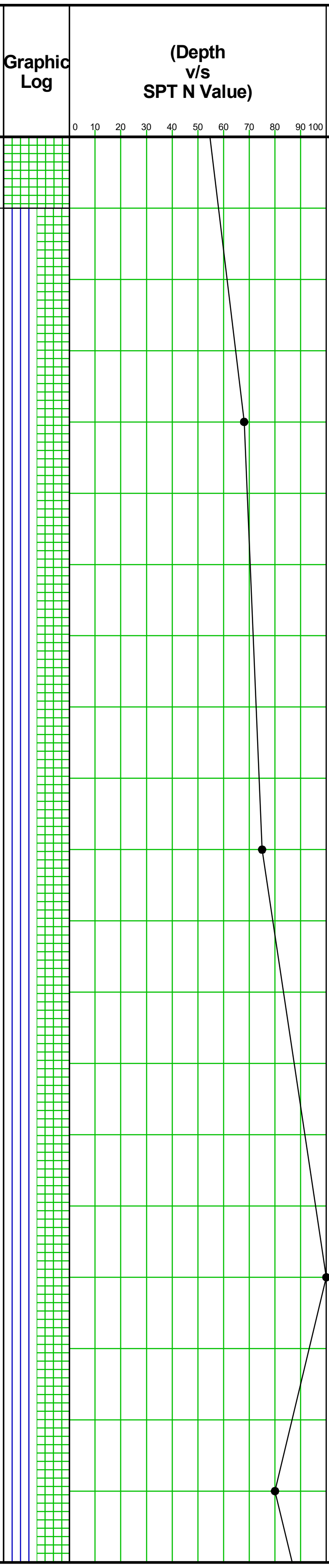
*Dia. of Boring :*150 mm

*Depth of Casing (m) :*Not Used

*Date of Start :*16-10-2021

*Date of Completion :*18-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Special Observations
			N1	N2	N3				
20.0							Brown, Hard, Silty clay of low plasticity with gravel	CL	
20.5	20.5	UDS-7					Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	
21.0									
21.5									
22.0	22	SPT-8	14	31	37	68			
22.5									
23.0									
23.5	23.5	UDS-8							
24.0									
24.5									
25.0	25	SPT-9	18	30	45	75			
25.5									
26.0									
26.5	26.5	UDS-9							
27.0									
27.5									
28.0	28	SPT-10	37	62	38 (5cm)	>100			
28.5									
29.0									
29.5	29.5	SPT-11	19	34	46	80			
30.0									

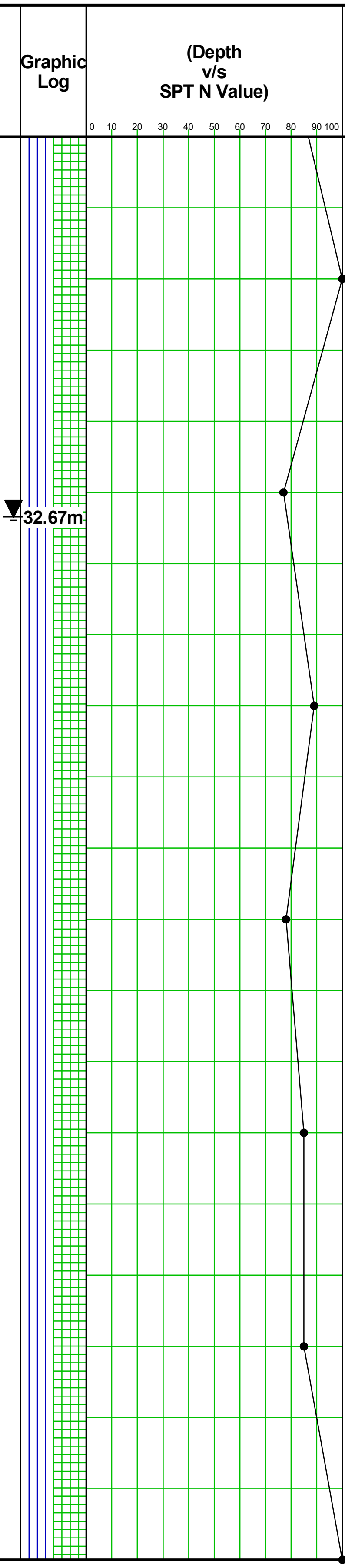


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Special Observations
			N1	N2	N3				
30.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	
30.5									
31.0	31	SPT-12	31	50	50 (10cm)	>100			
31.5									
32.0									
32.5	32.5	SPT-13	18	35	42	77			
33.0									
33.5									
34.0	34	SPT-14	20	41	48	89			
34.5									
35.0									
35.5	35.5	SPT-15	19	38	40	78			
36.0									
36.5									
37.0	37	SPT-16	19	35	50	85			
37.5									
38.0									
38.5	38.5	SPT-17	21	37	48	85			
39.0									
39.5									
40.0	40	SPT-18	18	48	52 (14cm)	>100			



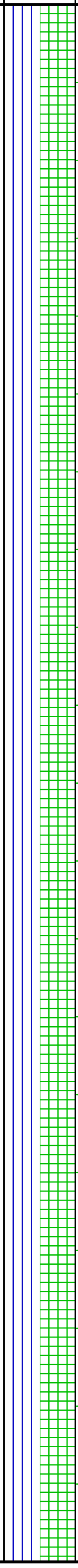
UDS*-UDS not recovered

FIELD BOREHOLE LOG

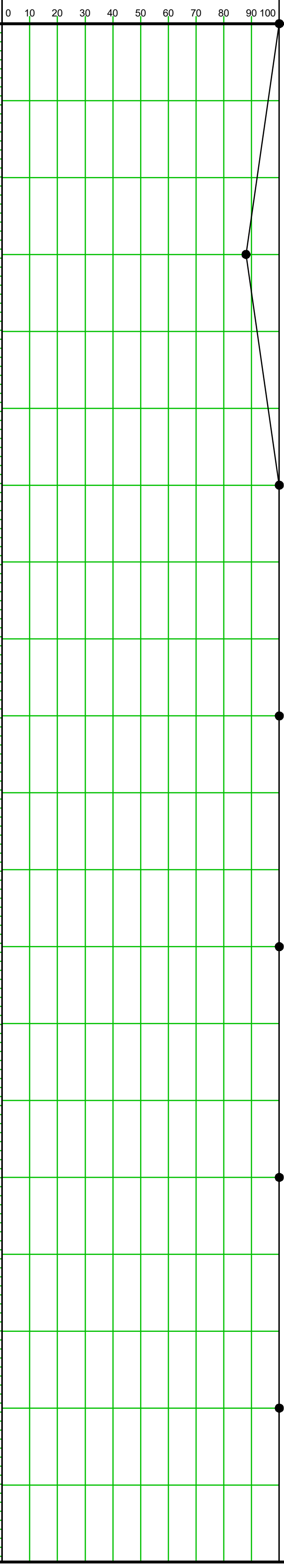
*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
40.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	
40.5									
41.0									
41.5	41.5	SPT-19	17	40	48	88			
42.0									
42.5									
43.0	43	SPT-20	22	43	57 (12cm)	>100			
43.5									
44.0									
44.5	44.5	SPT-21	25	59	38 (10cm)	>100			
45.0									
45.5									
46.0	46	SPT-22	27	51	49 (13cm)	>100			
46.5									
47.0									
47.5	47.5	SPT-23	37	53	47 (8cm)	>100			
48.0									
48.5									
49.0	49	SPT-24	36	100 (14cm)	-	>100			
49.5									
50.0									

Graphic Log



(Depth v/s SPT N Value)

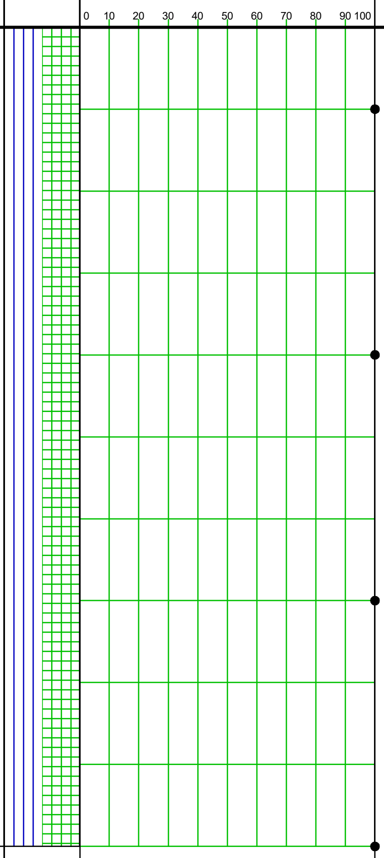


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

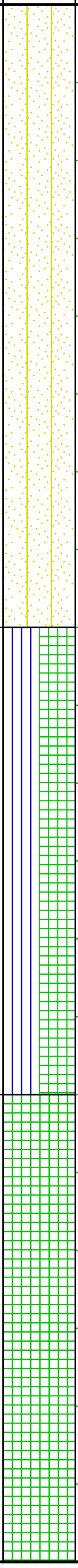
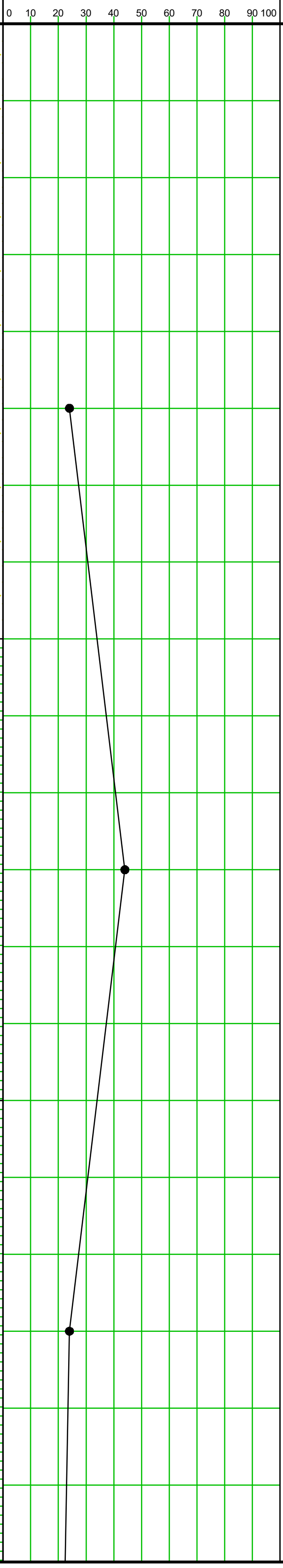
Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**	**Graphic Log**	**(Depth v/s SPT N Value)**	**Special Observations**
			N1	**N2**	**N3**						
50.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
50.5	50.5	SPT-25	30	80	20 (13cm)	>100					
51.0											
51.5											
52.0	52	SPT-26	39	75	25 (7cm)	>100					
52.5											
53.0											
53.5	53.5	SPT-27	38	73	27 (8cm)	>100					
54.0											
54.5											
55.0	55	SPT-28	40	70	30 (7cm)	>100					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

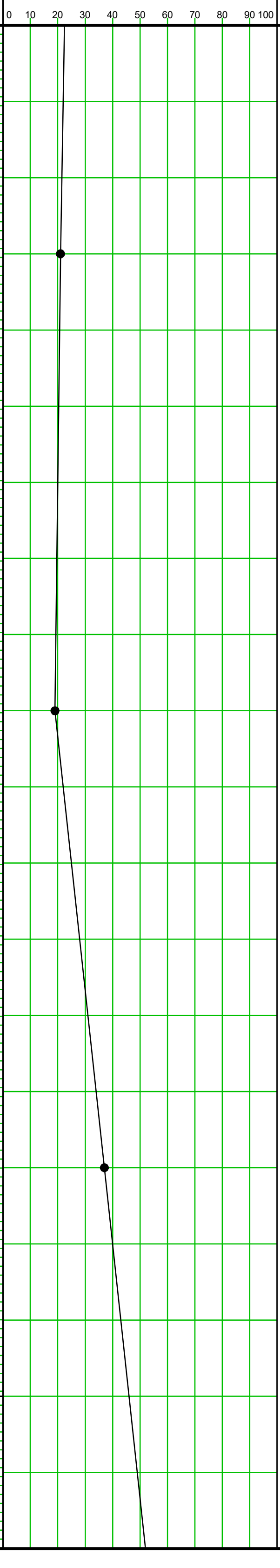
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Medium dense, Silty sand	SM			
2.5	2.5	SPT-1	8	11	13	24					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	14	20	24	44	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	8	10	14	24	Brown, Very stiff to hard, Silty clay of low plasticity	CL			
9.0											
9.5											
10.0	10	UDS-4									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
10.0							Brown, Very stiff to hard, Silty clay of low plasticity	CL			
10.5											
11.0											
11.5	11.5	SPT-4	7	10	11	21					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	5	9	10	19					
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	10	15	22	37					
18.0											
18.5											
19.0	19	UDS-7					Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
19.5											
20.0											

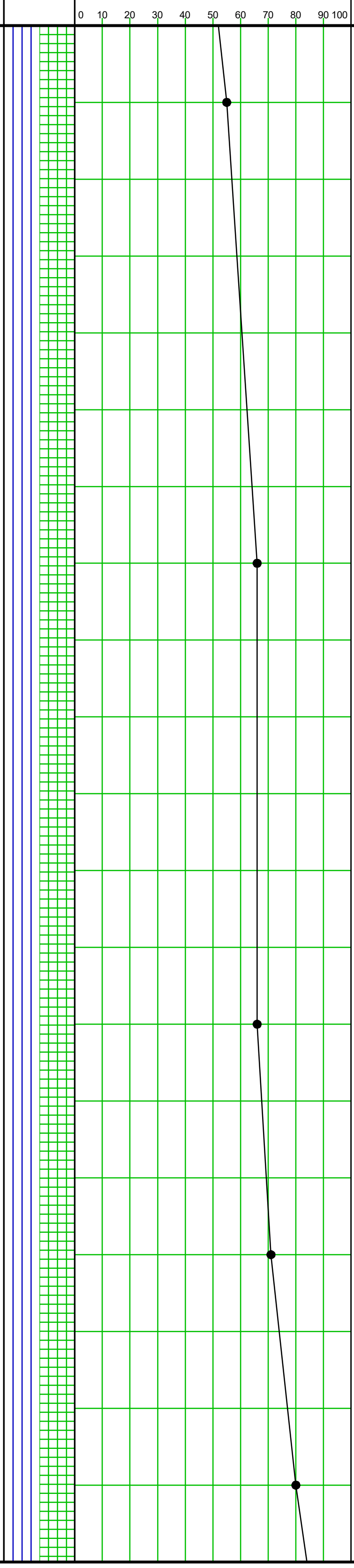


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
20.5	20.5	SPT-7	15	22	33	55					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	21	30	36	66					
24.0											
24.5											
25.0	25	UDS-9									
25.5											
26.0											
26.5	26.5	SPT-9	17	28	38	66					
27.0											
27.5											
28.0	28	SPT-10	18	30	41	71					
28.5											
29.0											
29.5	29.5	SPT-11	20	35	45	80					
30.0											

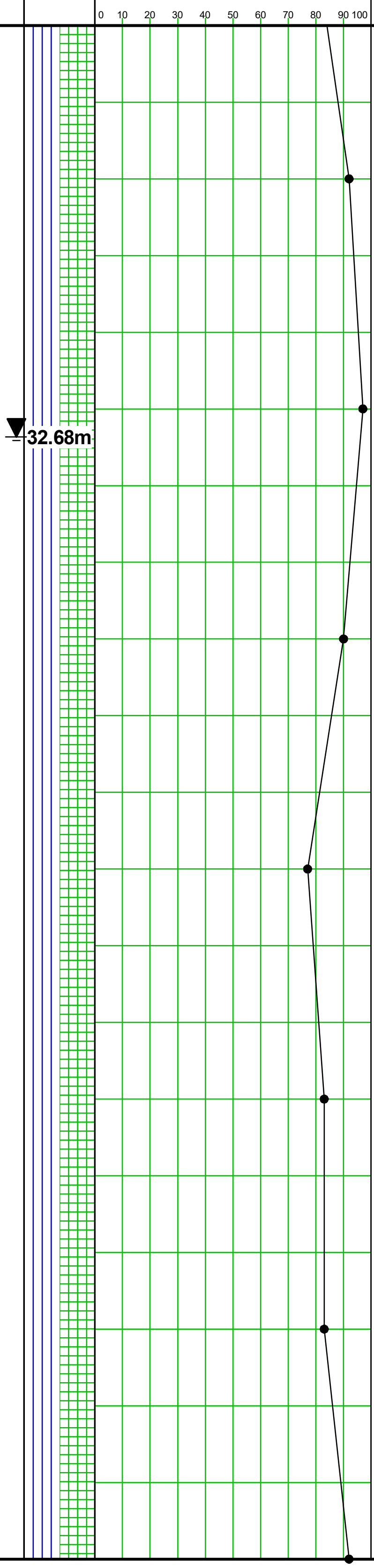


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+075 km
*Northing :*3123064.726 m
*Easting :*697330.717 m
Reduced Level (m):(+)270.070
*BH. No. :*BH-P1
*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*32.68
Inclination : Vertical
*Boring type :*Shell & Auger
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021
*Date of Completion :*15-10-2021

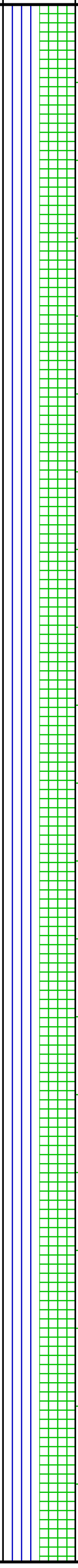
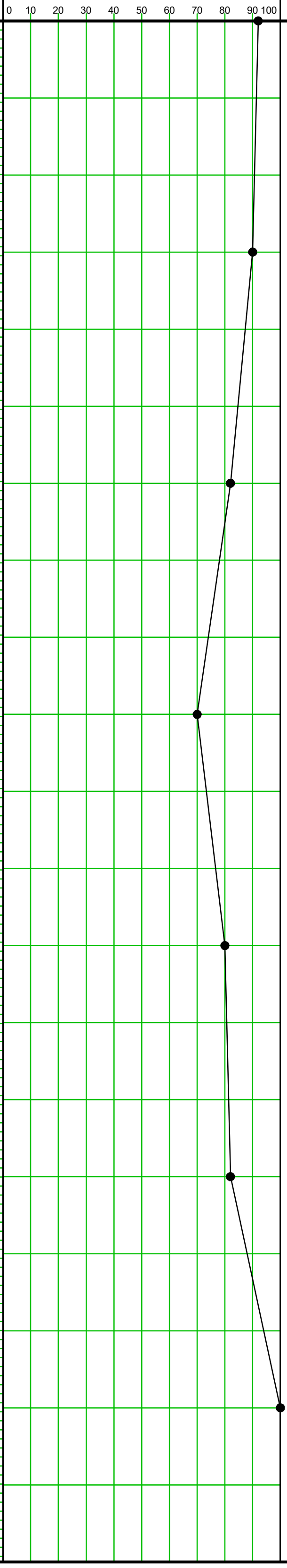
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
30.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
30.5											
31.0	31	SPT-12	27	42	50	92					
31.5											
32.0											
32.5	32.5	SPT-13	29	45	52	97					
33.0											
33.5											
34.0	34	SPT-14	18	40	50	90					
34.5											
35.0											
35.5	35.5	SPT-15	14	33	44	77					
36.0											
36.5											
37.0	37	SPT-16	18	35	48	83					
37.5											
38.0											
38.5	38.5	SPT-17	20	36	47	83					
39.0											
39.5											
40.0	40	SPT-18	22	40	52	92					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+075 km
*Northing :*3123064.726 m
*Easting :*697330.717 m
Reduced Level (m):(+)270.070
*BH. No. :*BH-P1
*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*32.68
Inclination : Vertical
*Boring type :*Shell & Auger
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021
*Date of Completion :*15-10-2021

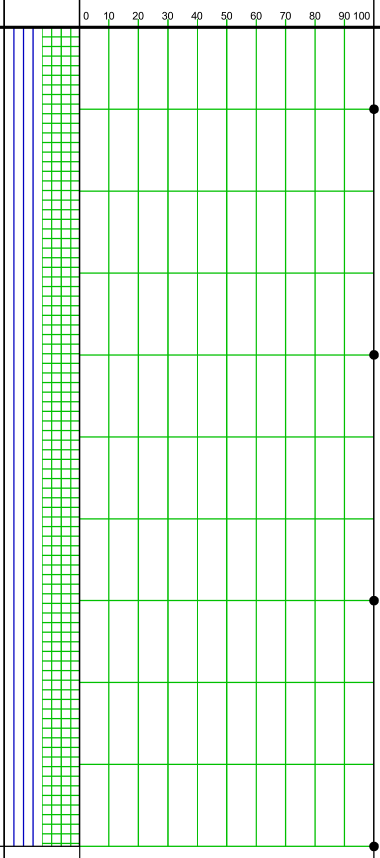
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
40.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
40.5											
41.0											
41.5	41.5	SPT-19	17	42	48	90					
42.0											
42.5											
43.0	43	SPT-20	16	40	42	82					
43.5											
44.0											
44.5	44.5	SPT-21	15	31	39	70					
45.0											
45.5											
46.0	46	SPT-22	17	35	45	80					
46.5											
47.0											
47.5	47.5	SPT-23	18	36	46	82					
48.0											
48.5											
49.0	49	SPT-24	34	54	46 (10cm)	>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**	**Graphic Log**	**(Depth v/s SPT N Value)**	**Special Observations**
			N1	**N2**	**N3**						
50.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
50.5	50.5	SPT-25	36	61	39 (7cm)	>100					
51.0											
51.5											
52.0	52	SPT-26	38	68	32 (5cm)	>100					
52.5											
53.0											
53.5	53.5	SPT-27	33	61	39 (8cm)	>100					
54.0											
54.5											
55.0	55	SPT-28	41	78	22 (3cm)	>100					

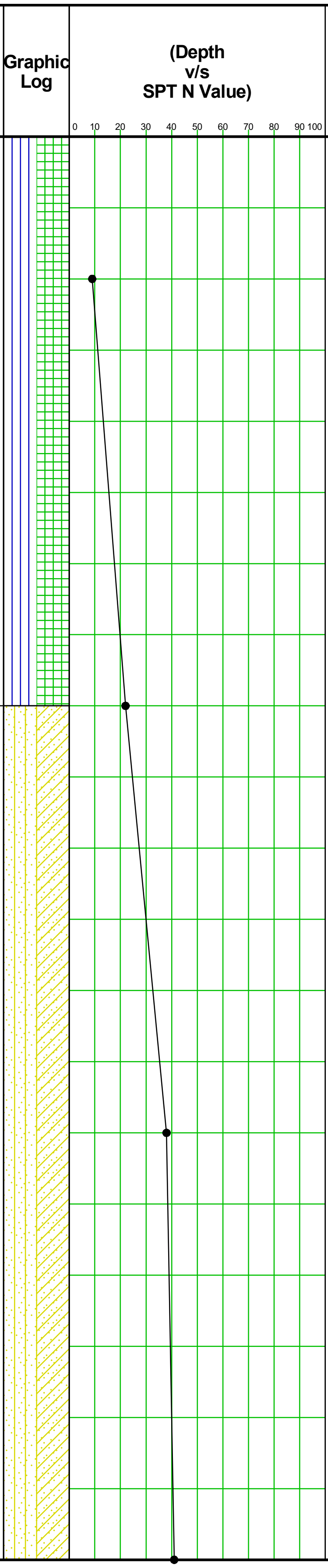


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
0.0		DS					Brown, Loose, Sandy silt of low plasticity	ML-CL	
0.5									
1.0	1	SPT-1	3	4	5	9			
1.5									
2.0									
2.5	2.5	UDS-1							
3.0									
3.5									
4.0	4	SPT-2	9	10	12	22			
4.5							Brown, Medium dense to dense, Silty sand with clay & gravel	SM-SC	
5.0									
5.5	5.5	UDS-2							
6.0									
6.5									
7.0	7	SPT-3	12	17	21	38			
7.5									
8.0									
8.5	8.5	UDS-3							
9.0									
9.5									
10.0	10	SPT-4	10	16	25	41			

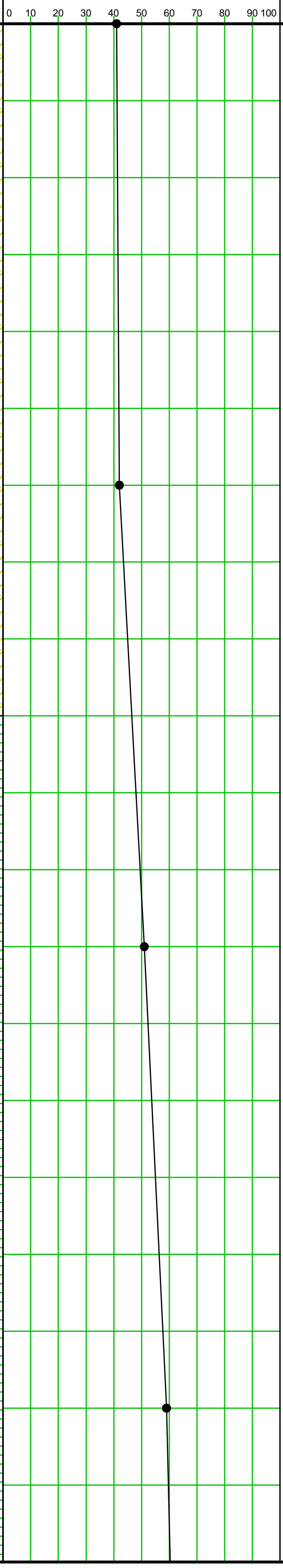


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
10.0							Brown, Medium dense to dense, Silty sand with clay & gravel	SM-SC			
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	10	20	22	42					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	SPT-6	14	21	30	51					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	16	24	35	59					
19.5											
20.0											

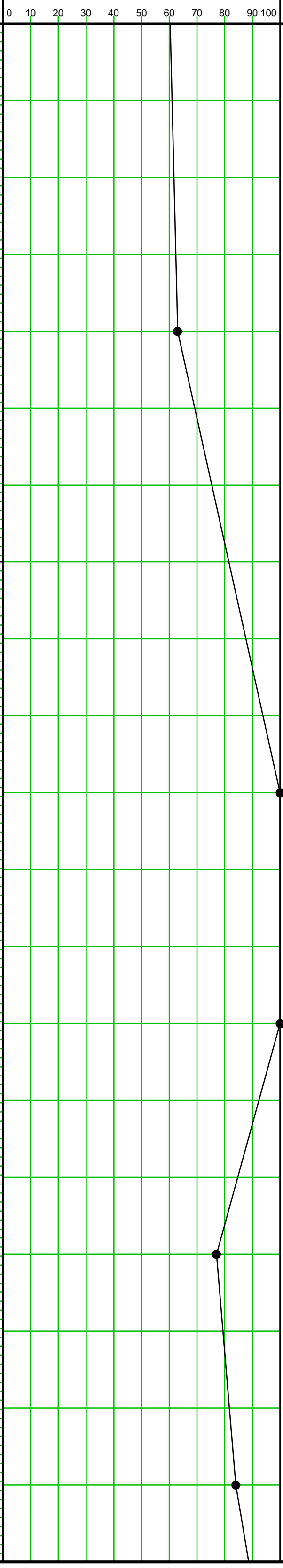


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**	**Graphic Log**	**(Depth v/s SPT N Value)**	**Special Observations**
			N1	**N2**	**N3**						
20.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	18	27	36	63					
22.5											
23.0											
23.5	23.5	UDS-8					Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
24.0											
24.5											
25.0	25	SPT-9	31	52	48 (9cm)	>100					
25.5											
26.0											
26.5	26.5	SPT-10	29	50	50 (9cm)	>100					
27.0											
27.5											
28.0	28	SPT-11	22	31	46	77					
28.5											
29.0											
29.5	29.5	SPT-12	24	34	50	84					
30.0											

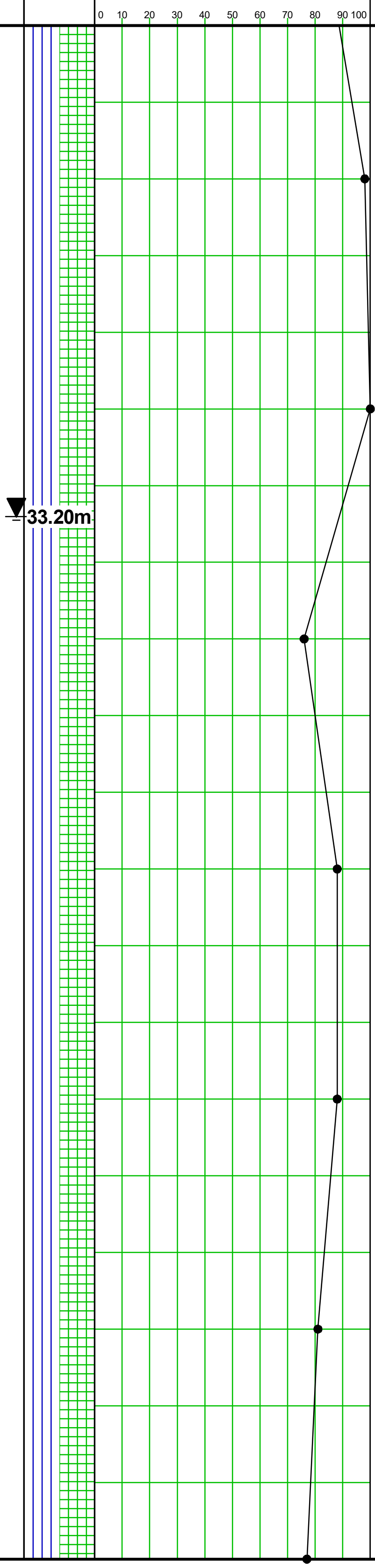


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
30.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
30.5											
31.0	31	SPT-13	40	44	54	98					
31.5											
32.0											
32.5	32.5	SPT-14	25	100 (12cm)	-	>100					
33.0											
33.5											
34.0	34	SPT-15	16	35	41	76					
34.5											
35.0											
35.5	35.5	SPT-16	18	38	50	88					
36.0											
36.5											
37.0	37	SPT-17	19	40	48	88					
37.5											
38.0											
38.5	38.5	SPT-18	18	36	45	81					
39.0											
39.5											
40.0	40	SPT-19	15	34	43	77					

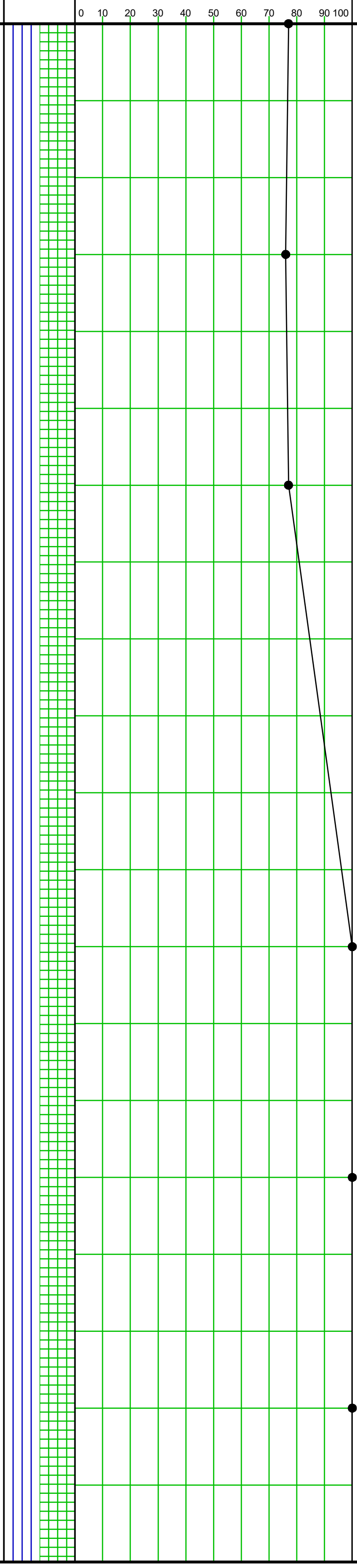


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.	*Client :*HRIDCL

*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	



Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
40.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
40.5											
41.0											
41.5	41.5	SPT-20	22	31	45	76					
42.0											
42.5											
43.0	43	SPT-21	24	32	45	77					
43.5											
44.0											
44.5	44.5	UDS-9									
45.0											
45.5											
46.0	46	SPT-22	40	40	60 (11cm)	>100					
46.5											
47.0											
47.5	47.5	SPT-23	32	62	38 (7cm)	>100					
48.0											
48.5											
49.0	49	SPT-24	36	73	27 (3cm)	>100					
49.5											
50.0											

UDS*-UDS not recovered

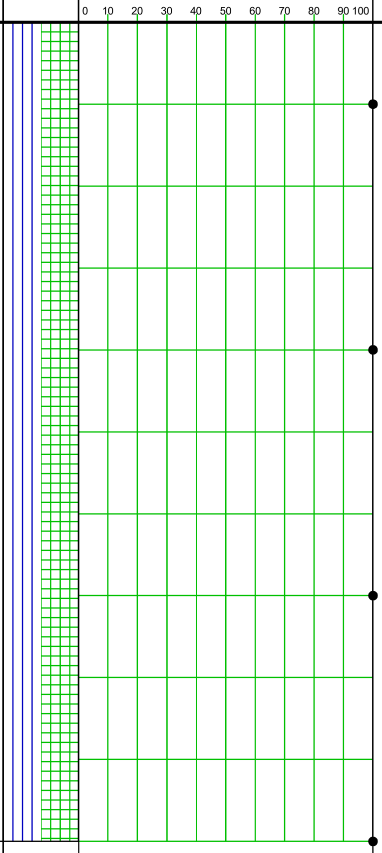
FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.

*Client :*HRIDCL

*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**	**Graphic Log**	**(Depth v/s SPT N Value)**	**Special Observations**
			N1	**N2**	**N3**					0 10 20 30 40 50 60 70 80 90 100	
50.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
50.5	50.5	SPT-25	34	66	34 (6cm)	>100					
51.0											
51.5											
52.0	52	SPT-26	39	58	42 (8cm)	>100					
52.5											
53.0											
53.5	53.5	SPT-27	43	75	25 (4cm)	>100					
54.0											
54.5											
55.0	55	SPT-28	33	51	49 (12cm)	>100					

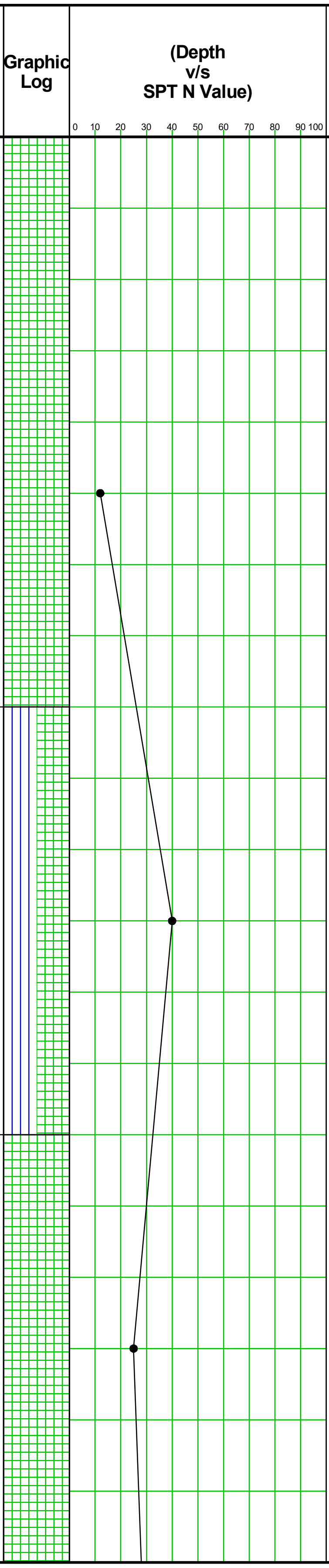


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm N1**	**N2**	**N3**	**SPT N Value**	**Strata Description**	**IS Classification**	**Special Observations**
0.0		DS							
0.5									
1.0	1	UDS-1							
1.5									
2.0							Brown, Stiff, Silty clay of low plasticity	CL	
2.5	2.5	SPT-1	5	6	6	12			
3.0									
3.5									
4.0	4	UDS-2							
4.5									
5.0									
5.5	5.5	SPT-2	12	18	22	40	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL	
6.0									
6.5									
7.0	7	UDS-3							
7.5									
8.0									
8.5	8.5	SPT-3	7	11	14	25	Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL	
9.0									
9.5									
10.0	10	UDS-4							

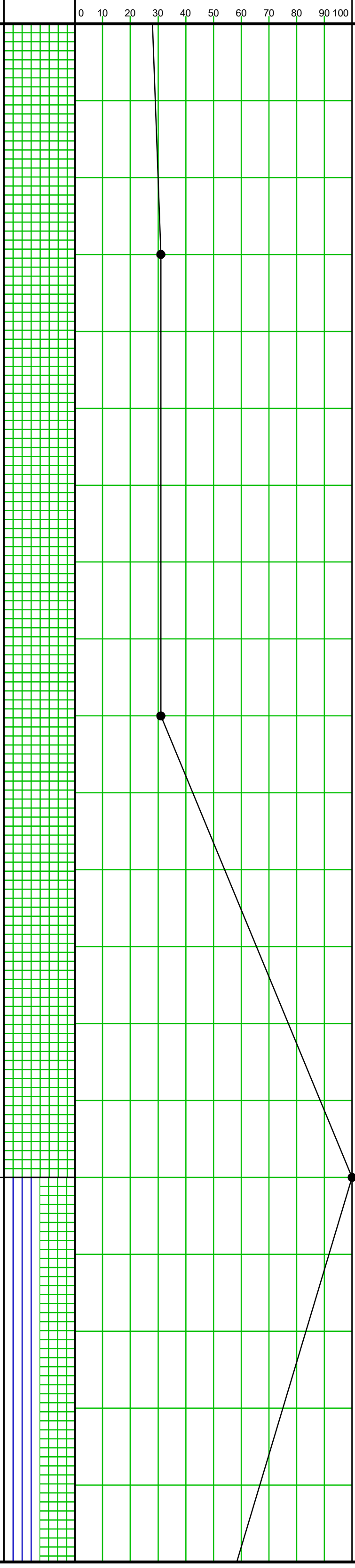


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
10.5											
11.0											
11.5	11.5	SPT-4	11	14	17	31					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	10	13	18	31					
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	100 (13cm)	-	-	>100					
18.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
18.5											
19.0	19	UDS-7									
19.5											
20.0											

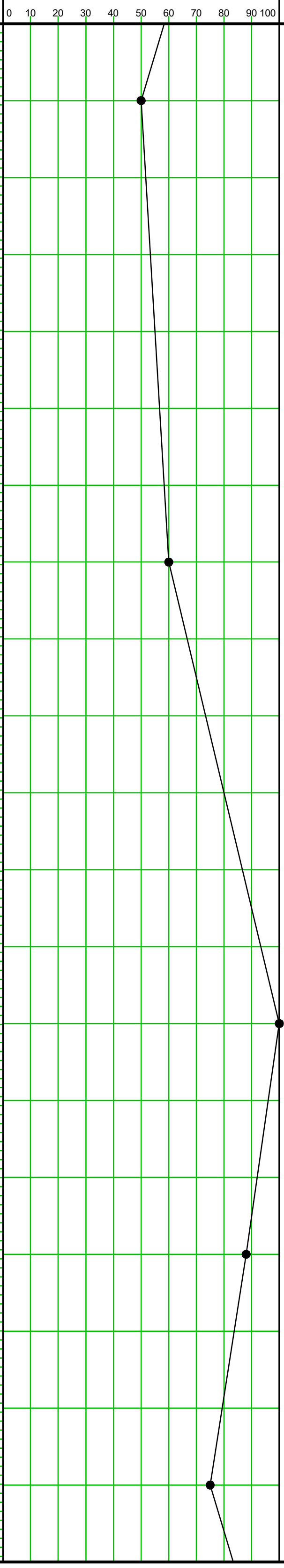


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+075 km
*Northing :*3123004.726 m
*Easting :*697330.724 m
Reduced Level (m):(+)270.616
*BH. No. :*BH-A2
*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*33.21
Inclination : Vertical
*Boring type :*Shell & Auger
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021
*Date of Completion :*18-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
20.0											
20.5	20.5	SPT-7	15	21	29	50					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	17	25	35	60					
24.0											
24.5											
25.0	25	UDS-9					Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	SPT-9	30	48	52 (14cm)	>100					
27.0											
27.5											
28.0	28	SPT-10	32	40	48	88					
28.5											
29.0											
29.5	29.5	SPT-11	21	32	43	75					
30.0											

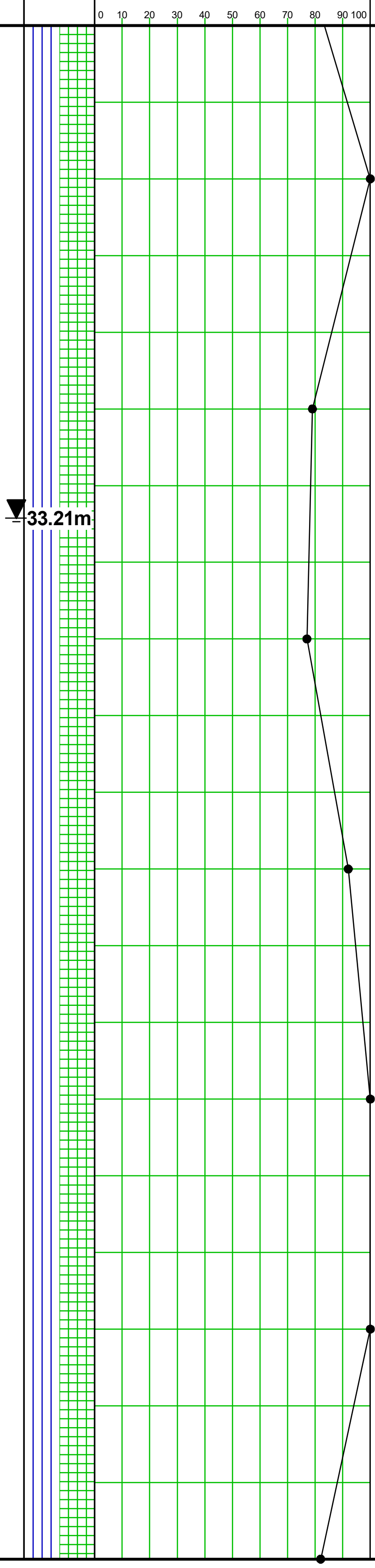


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-12	20	42	58 (14cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-13	19	34	45	79					
33.0											
33.5											
34.0	34	SPT-14	20	35	42	77					
34.5											
35.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
35.5	35.5	SPT-15	28	40	52	92					
36.0											
36.5											
37.0	37	SPT-16	42	64	36 (7cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-17	38	61	39 (8cm)	>100					
39.0											
39.5											
40.0	40	SPT-18	20	40	42	82					

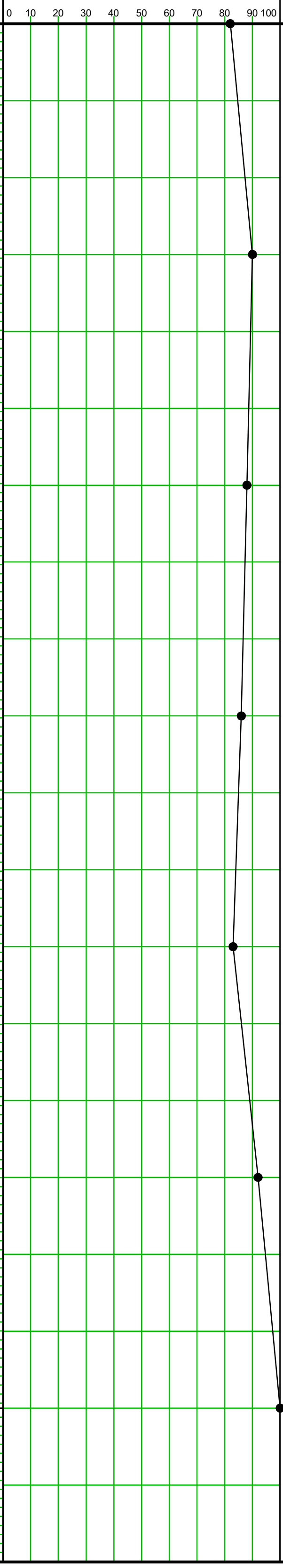


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	Blow counts per 15cm N2	Blow counts per 15cm N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
40.5											
41.0											
41.5	41.5	SPT-19	19	42	48	90					
42.0											
42.5											
43.0	43	SPT-20	22	41	47	88					
43.5											
44.0											
44.5	44.5	SPT-21	24	40	46	86					
45.0											
45.5											
46.0	46	SPT-22	21	38	45	83					
46.5											
47.0											
47.5	47.5	SPT-23	28	42	50	92					
48.0											
48.5											
49.0	49	SPT-24	30	70	30 (10cm)	>100					
49.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
50.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.

*Client :*HRIDCL

*BH Location/Chainage :*28+075 km

*Northing :*3123004.726 m

*Easting :*697330.724 m

Reduced Level (m):(+)270.616

*BH. No. :*BH-A2

*BH Termination Depth (m):*55

*Proposed / Existing Structure :*Major Bridge

*Water Table (m):*33.21

Inclination : Vertical

*Boring type :*Shell & Auger

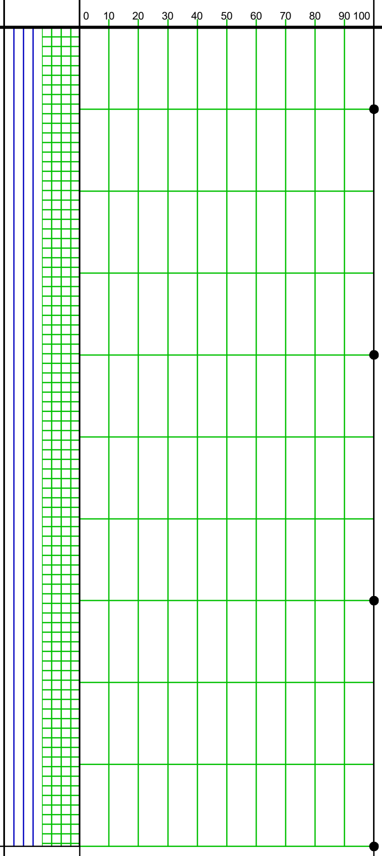
*Dia. of Boring :*150 mm

*Depth of Casing (m) :*Not Used

*Date of Start :*16-10-2021

*Date of Completion :*18-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
50.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
50.5	50.5	SPT-25	33	68	32 (9cm)	>100					
51.0											
51.5											
52.0	52	SPT-26	36	72	26 (7cm)	>100					
52.5											
53.0											
53.5	53.5	SPT-27	35	75	25 (8cm)	>100					
54.0											
54.5											
55.0	55	SPT-28	39	74	26 (8cm)	>100					



UDS*-UDS not recovered

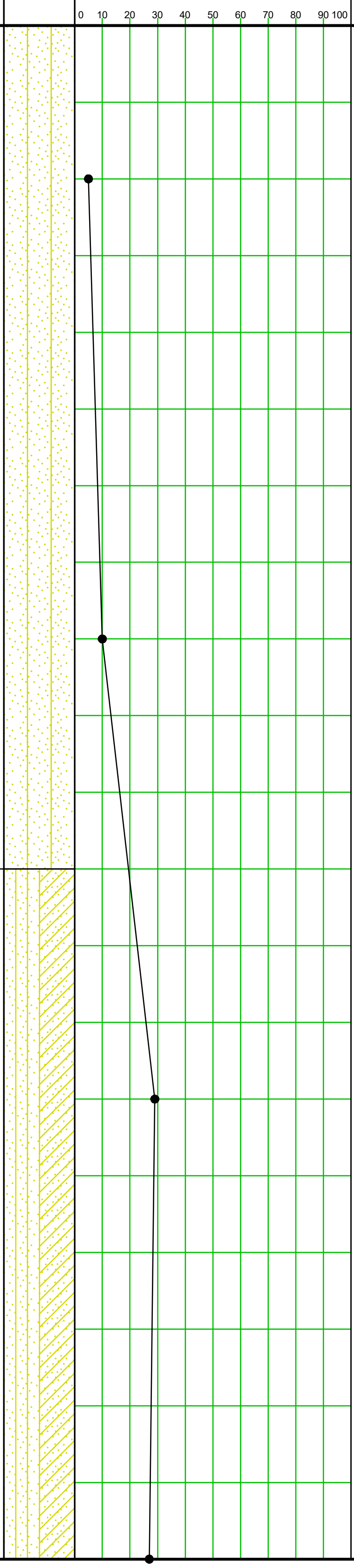
FIELD BOREHOLE LOG

Project Name : GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :* HRIDCL
BH Location/Chainage : 28+360 km	*Northing :* 3123109.166 m	*Easting :* 697053.722 m
Reduced Level (m): (+)268.602	*BH. No. :* BH-A1	*BH Termination Depth (m):* 40
Proposed / Existing Structure : Major Bridge	*Water Table (m):* 34.78	*Inclination :* Vertical
Boring type : Rotary	*Dia. of Boring :* 150 mm	*Depth of Casing (m) :* Not Used
Date of Start : 13-10-2021	*Date of Completion :* 14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
0.0		DS					Brown, Loose, Silty sand	SM	
0.5									
1.0	1	SPT-1	2	2	3	5			
1.5									
2.0									
2.5	2.5	UDS-1							
3.0									
3.5									
4.0	4	SPT-2	3	4	6	10			
4.5									
5.0									
5.5	5.5	UDS-2					Brown, Medium dense, Silty sand with clay	SM-SC	
6.0									
6.5									
7.0	7	SPT-3	8	12	17	29			
7.5									
8.0									
8.5	8.5	UDS-3							
9.0									
9.5									
10.0	10	SPT-4	7	12	15	27			

Graphic Log

(Depth v/s SPT N Value)

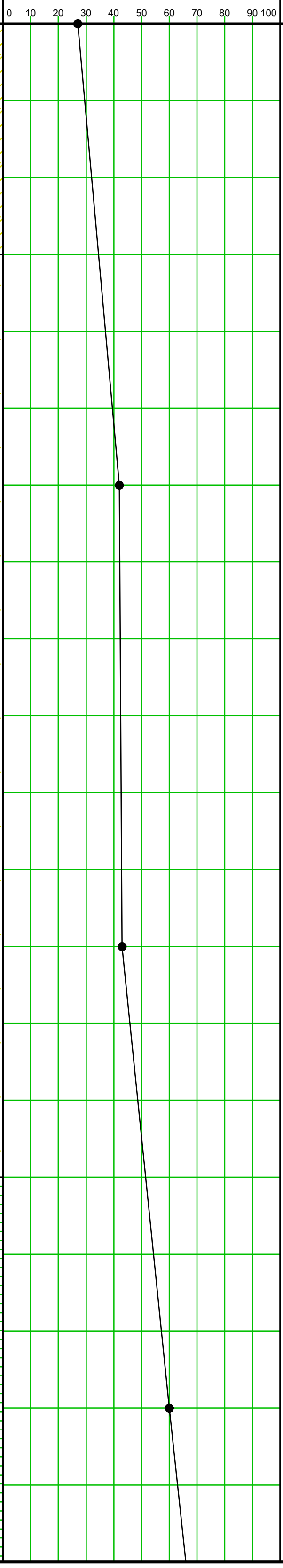


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123109.166 m	*Easting :*697053.722 m
Reduced Level (m):(+)268.602	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.78	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0							Brown, Medium dense, Silty sand with clay	SM-SC			
10.5											
11.0											
11.5	11.5	UDS-4					Brown, Dense, Silty sand with gravel	SM			
12.0											
12.5											
13.0	13	SPT-5	12	18	24	42					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0											
15.5											
16.0	16	SPT-6	10	16	27	43					
16.5											
17.0											
17.5	17.5	UDS-6					Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
18.0											
18.5											
19.0	19	SPT-7	20	27	33	60					
19.5											
20.0											

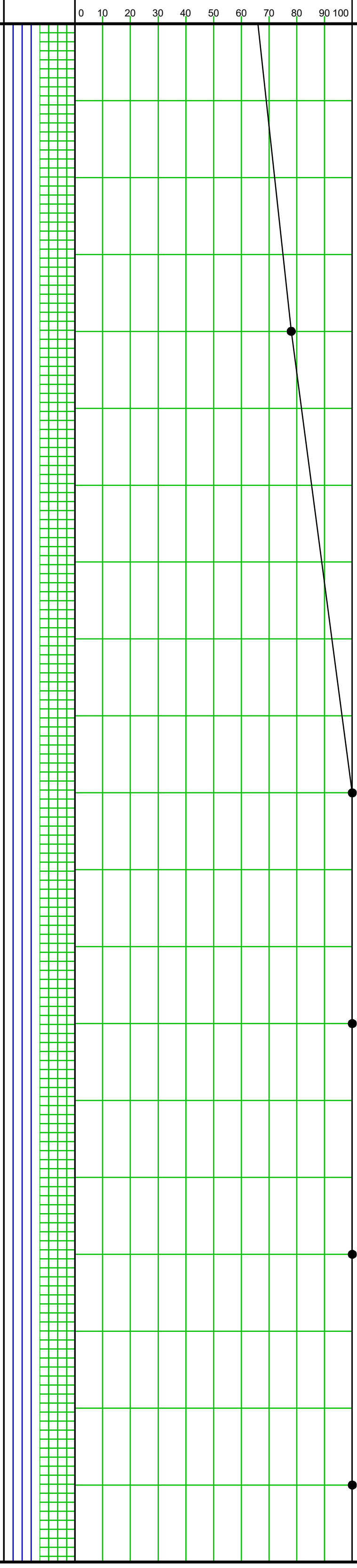


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+360 km
*Northing :*3123109.166 m
*Easting :*697053.722 m
Reduced Level (m):(+)268.602
*BH. No. :*BH-A1
*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*34.78
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021
*Date of Completion :*14-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
20.0											
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	24	33	45	78					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	22	42	58 (13cm)	>100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	SPT-10	31	49	52 (9cm)	>100					
27.0											
27.5											
28.0	28	SPT-11	28	58	42 (6cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-12	16	47	53 (8cm)	>100					
30.0											

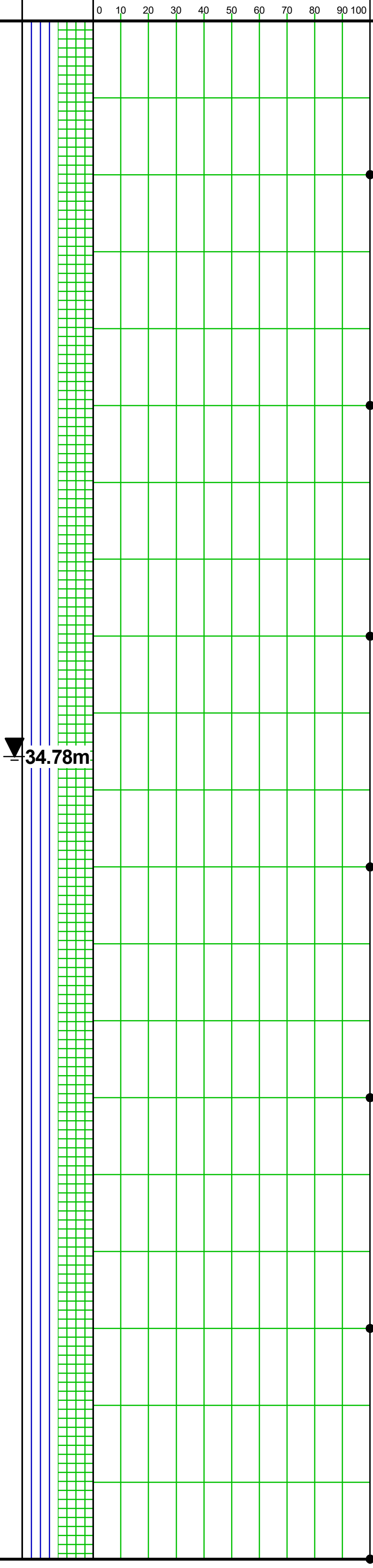


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123109.166 m	*Easting :*697053.722 m
Reduced Level (m):(+)268.602	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.78	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	 N2	 N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
30.5											
31.0	31	SPT-13	31	49	51 (7cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-14	23	54	46 (8cm)	>100					
33.0											
33.5											
34.0	34	SPT-15	38	74	26 (6cm)	>100					
34.5											
35.0											
35.5	35.5	SPT-16	24	55	46 (7cm)	>100					
36.0											
36.5											
37.0	37	SPT-17	27	64	36 (5cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-18	25	72	28 (8cm)	>100					
39.0											
39.5											
40.0	40	SPT-19	29	45	55 (13cm)	>100					

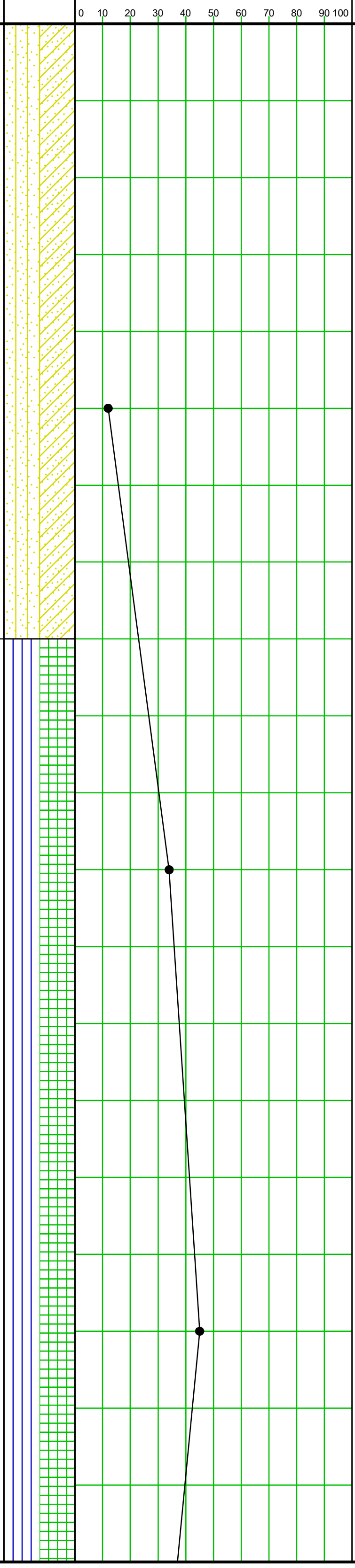


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123091.386 m	*Easting :*697050.915 m
Reduced Level (m):(+)267.861	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
0.0		DS					Brown, Medium dense, Silty sand with clay	SM-SC			
0.5											
1.0	1	UDS-1									
1.5											
2.0											
2.5	2.5	SPT-1	3	5	7	12					
3.0											
3.5											
4.0	4	UDS-2					Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
4.5											
5.0											
5.5	5.5	SPT-2	13	15	19	34					
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	16	20	25	45					
9.0											
9.5											
10.0	10	UDS-4									

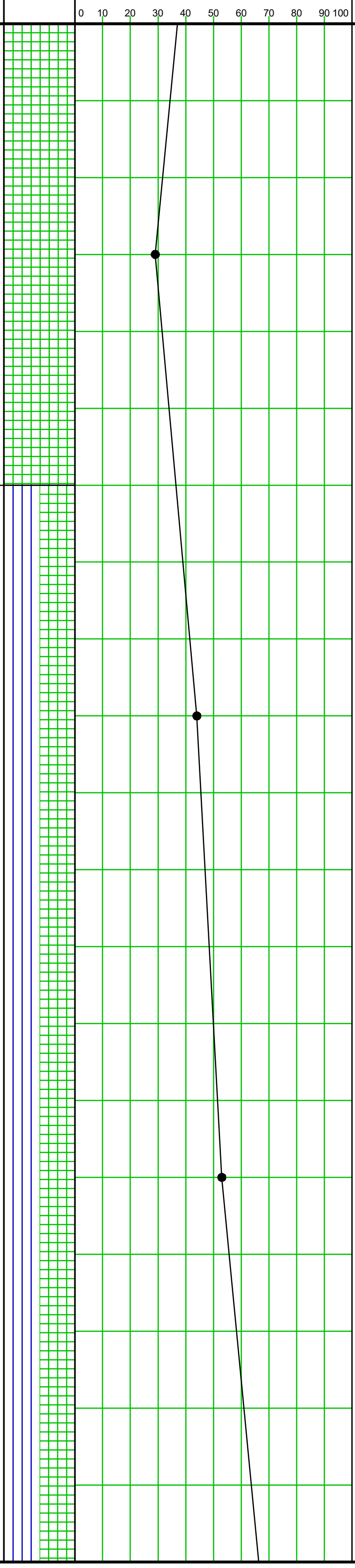


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123091.386 m	*Easting :*697050.915 m
Reduced Level (m):(+)267.861	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	10	13	16	29	Brown, Very stiff, Silty clay of low plasticity with gravel	CL			
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	15	21	23	44					
15.0											
15.5											
16.0	16	UDS-6									
16.5							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
17.0											
17.5	17.5	SPT-6	18	25	28	53					
18.0											
18.5											
19.0	19	UDS-7									
19.5											
20.0											

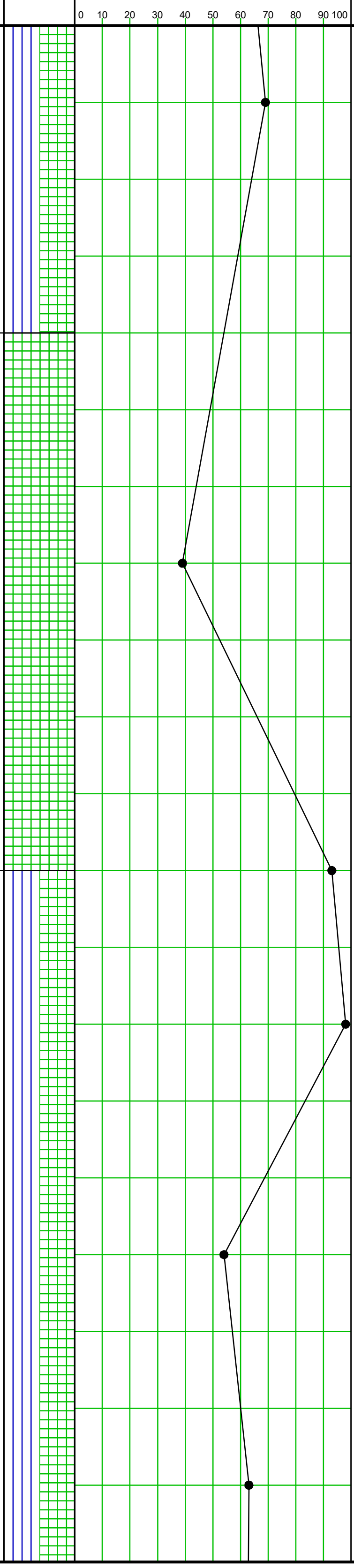


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+360 km
*Northing :*3123091.386 m
*Easting :*697050.915 m
Reduced Level (m):(+)267.861
*BH. No. :*BH-P1
*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*34.10
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021
*Date of Completion :*15-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
20.5	20.5	SPT-7	28	33	36	69					
21.0											
21.5											
22.0	22	UDS-8					Brown, Hard, Silty clay of low plasticity with gravel	CL			
22.5											
23.0											
23.5	23.5	SPT-8	16	18	21	39					
24.0											
24.5											
25.0	25	UDS*									
25.5	25.5	SPT-9	32	43	50	93	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
26.0											
26.5	26.5	SPT-10	31	45	53	98					
27.0											
27.5											
28.0	28	SPT-11	14	22	32	54					
28.5											
29.0											
29.5	29.5	SPT-12	18	26	37	63					
30.0											

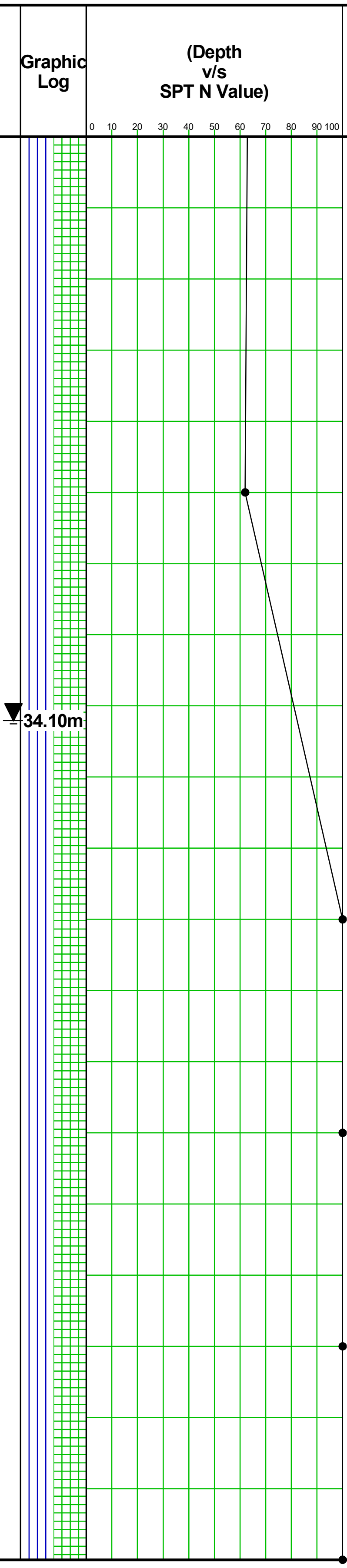


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123091.386 m	*Easting :*697050.915 m
Reduced Level (m):(+)267.861	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*15-10-2021	

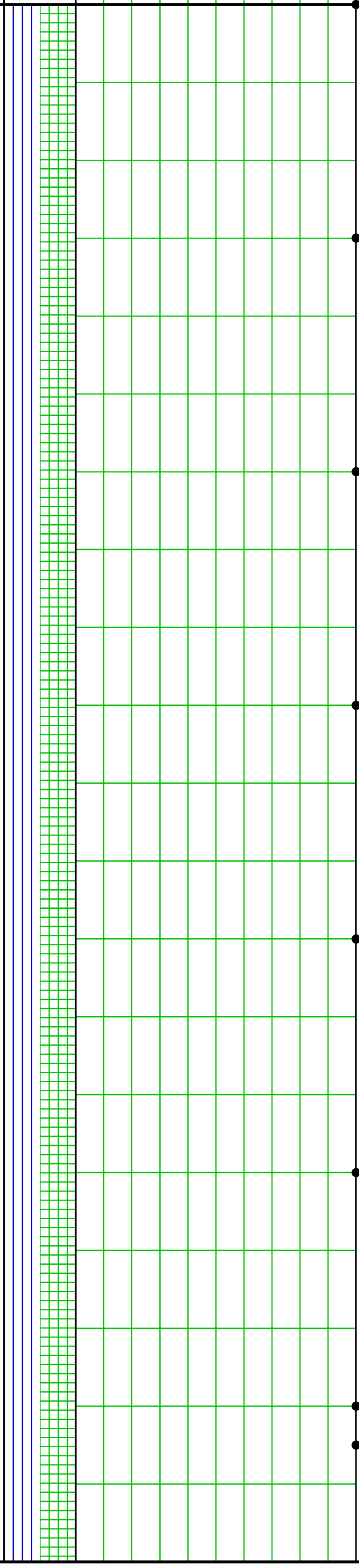
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
30.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	
30.5									
31.0	31	UDS-9							
31.5									
32.0									
32.5	32.5	SPT-13	21	27	35	62			
33.0									
33.5									
34.0	34	UDS-10							
34.5									
35.0									
35.5	35.5	SPT-14	40	53	47 (7cm)	>100			
36.0									
36.5									
37.0	37	SPT-15	45	57	43 (5cm)	>100			
37.5									
38.0									
38.5	38.5	SPT-16	44	65	35 (7cm)	>100			
39.0									
39.5									
40.0	40	SPT-17	48	69	31 (6cm)	>100			



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123091.386 m	*Easting :*697050.915 m
Reduced Level (m):(+)267.861	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*15-10-2021	



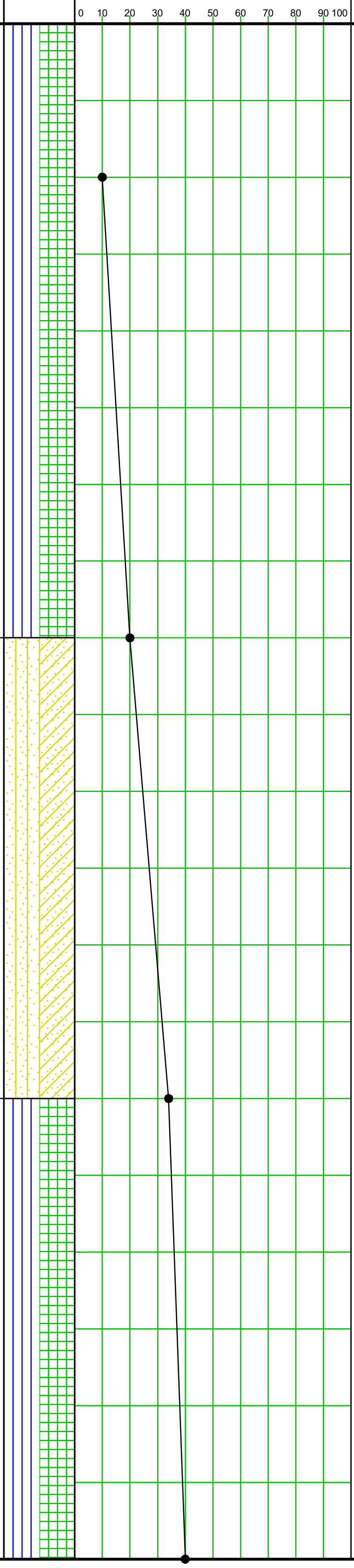
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
40.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
40.5											
41.0											
41.5	41.5	SPT-18	35	53	47 (5cm)	>100					
42.0											
42.5											
43.0	43	SPT-19	37	60	40 (5cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-20	40	64	36 (7cm)	>100					
45.0											
45.5											
46.0	46	SPT-21	50	80	20 (4cm)	>100					
46.5											
47.0											
47.5	47.5	SPT-22	40	70	30 (6cm)	>100					
48.0											
48.5											
49.0	49	SPT-23	40	100 (10cm)	-	>100					
	49.25	SPT-24				>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123064.68 m	*Easting :*697046.7 m
Reduced Level (m):(+)267.285	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.85	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	2	4	6	10					
1.5											
2.0							Brown, Loose, Sandy silt of low plasticity	ML-CL			
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	7	9	11	20					
4.5											
5.0											
5.5	5.5	UDS-2					Brown, Medium dense, Silty sand with clay	SM-SC			
6.0											
6.5											
7.0	7	SPT-3	11	15	19	34					
7.5											
8.0											
8.5	8.5	UDS-3					Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
9.0											
9.5											
10.0	10	SPT-4	13	17	23	40					

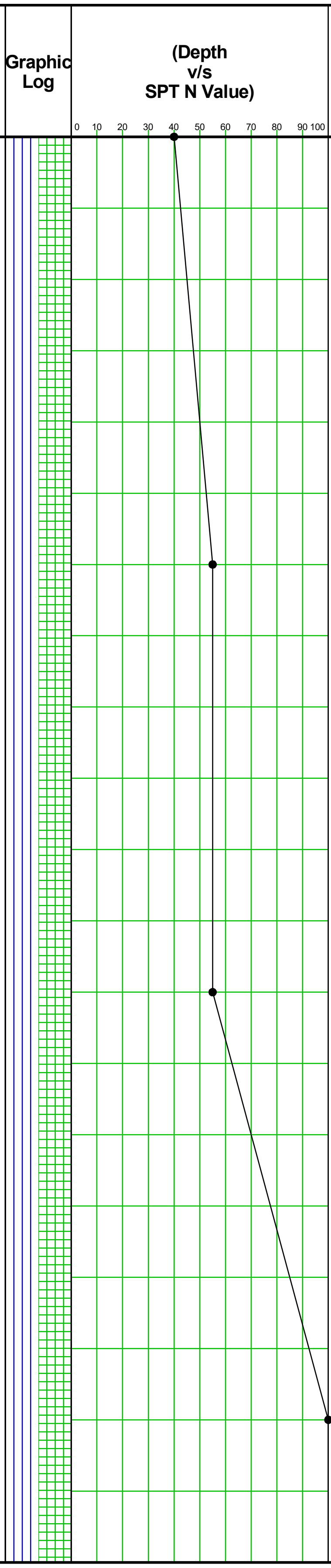


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+360 km
*Northing :*3123064.68 m
*Easting :*697046.7 m
Reduced Level (m):(+)267.285
*BH. No. :*BH-P2
*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*33.85
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021
*Date of Completion :*14-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Special Observations
			N1	N2	N3				
10.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL	
10.5									
11.0									
11.5	11.5	UDS-4							
12.0									
12.5									
13.0	13	SPT-5	16	26	29	55			
13.5									
14.0									
14.5	14.5	UDS-5							
15.0									
15.5									
16.0	16	SPT-6	19	24	31	55			
16.5									
17.0									
17.5	17.5	UDS-6							
18.0									
18.5									
19.0	19	SPT-7	31	60	40 (5cm)	>100			
19.5									
20.0									

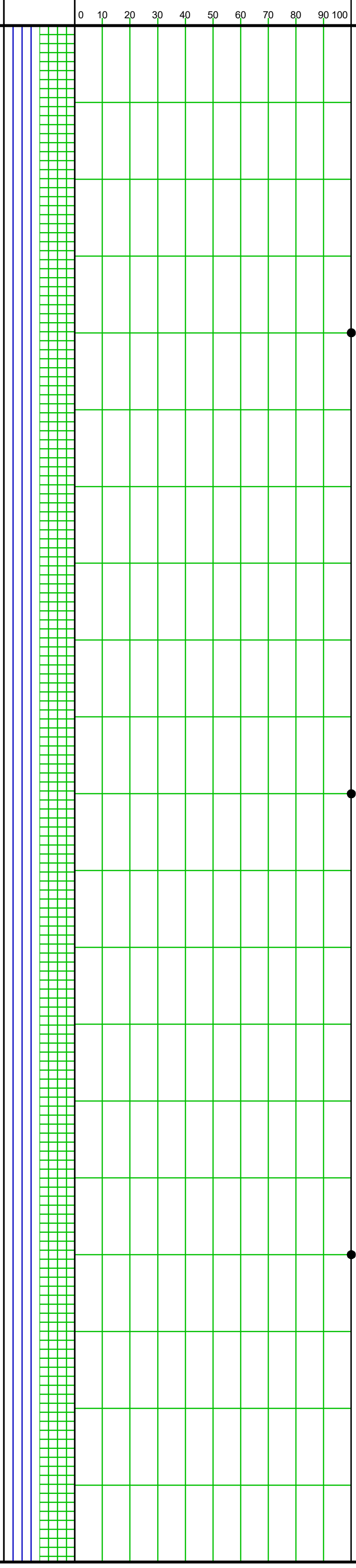


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123064.68 m	*Easting :*697046.7 m
Reduced Level (m):(+)267.285	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.85	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
20.5	20.5	UDS*									
21.0											
21.5											
22.0	22	SPT-8	39	55	45 (5cm)	>100					
22.5											
23.0											
23.5	23.5	UDS*									
24.0											
24.5											
25.0	25	SPT-9	45	79	21 (4cm)	>100					
25.5											
26.0											
26.5	26.5	UDS*									
27.0											
27.5											
28.0	28	SPT-10	43	65	35 (7cm)	>100					
28.5											
29.0											
29.5	29.5	UDS*									
30.0											

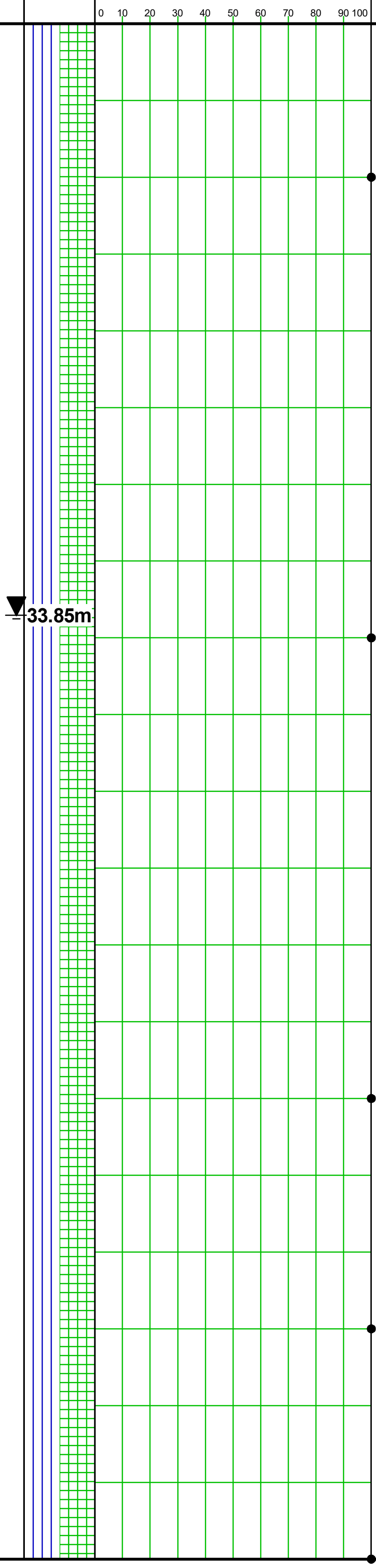


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+360 km
*Northing :*3123064.68 m
*Easting :*697046.7 m
Reduced Level (m):(+)267.285
*BH. No. :*BH-P2
*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*33.85
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021
*Date of Completion :*14-10-2021

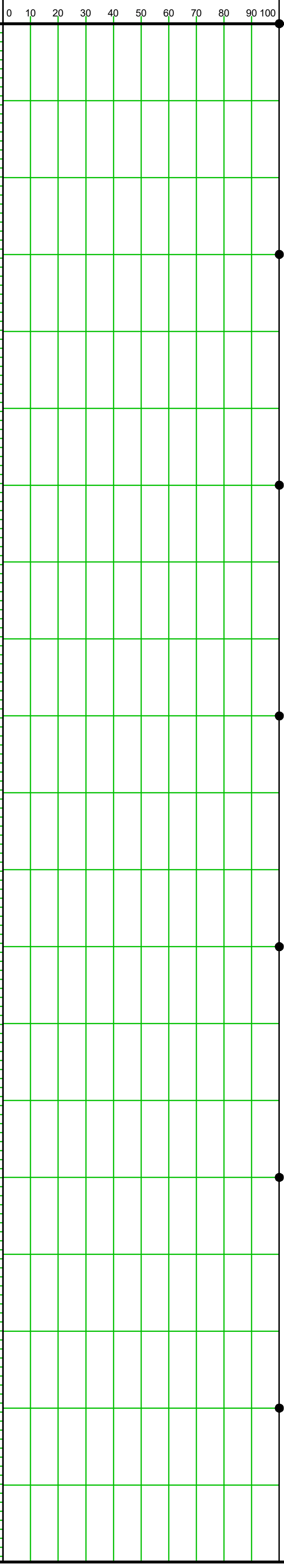
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
30.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
30.5											
31.0	31	SPT-11	38	63	37 (4cm)	>100					
31.5											
32.0											
32.5	32.5	UDS*									
33.0											
33.5											
34.0	34	SPT-12	49	53	47 (6cm)	>100					
34.5											
35.0											
35.5	35.5	UDS*									
36.0											
36.5											
37.0	37	SPT-13	39	63	37 (5cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-14	48	69	31 (8cm)	>100					
39.0											
39.5											
40.0	40	SPT-15	45	72	28 (5cm)	>100					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

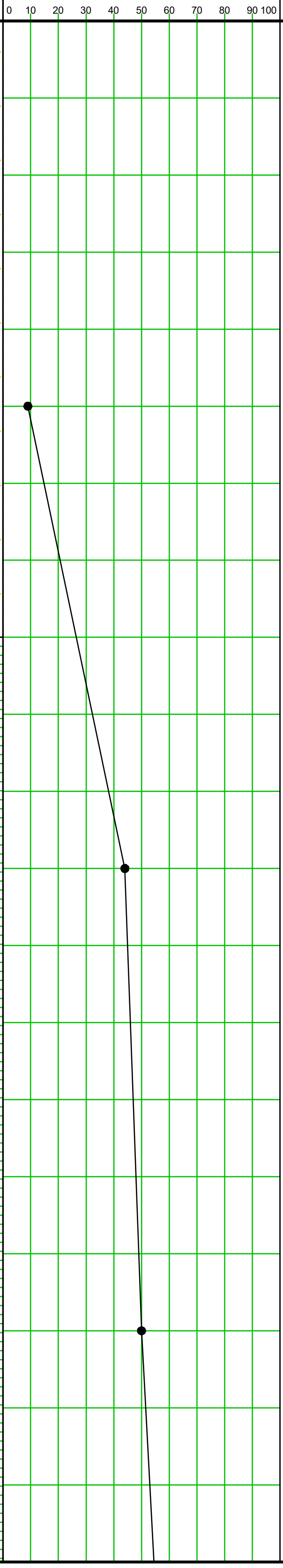
*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+360 km
*Northing :*3123064.68 m
*Easting :*697046.7 m
Reduced Level (m):(+)267.285
*BH. No. :*BH-P2
*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*33.85
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021
*Date of Completion :*14-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
40.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
40.5											
41.0											
41.5	41.5	SPT-16	42	68	32 (7cm)	>100					
42.0											
42.5											
43.0	43	SPT-17	49	75	25 (9cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-18	52	100 (10cm)	-	>100					
45.0											
45.5											
46.0	46	SPT-19	40	100 (15cm)	-	>100					
46.5											
47.0											
47.5	47.5	SPT-20	48	100 (3cm)	-	>100					
48.0											
48.5											
49.0	49 49.23	SPT-21	45	100 (8cm)	-	>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123046.953 m	*Easting :*697043.901 m
Reduced Level (m):(+)267.528	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.20	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*13-10-2021	

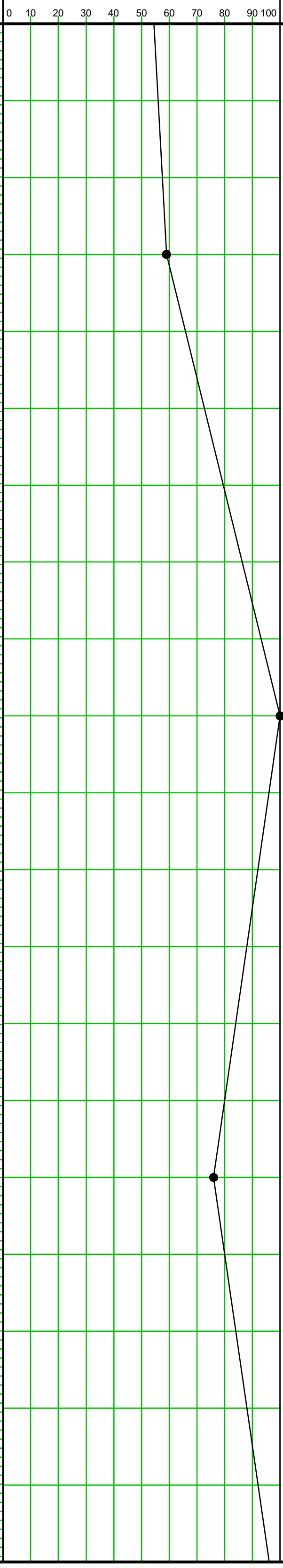
Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**	**Graphic Log**	**(Depth v/s SPT N Value)**	**Special Observations**
			N1	**N2**	**N3**						
0.0		DS					Brown, Loose, Silty sand	SM	░		
0.5											
1.0	1	UDS-1									
1.5											
2.0											
2.5	2.5	SPT-1	3	4	5	9					
3.0											
3.5											
4.0	4	UDS-2					Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL	▦		
4.5											
5.0											
5.5	5.5	SPT-2	12	19	25	44					
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	14	22	28	50					
9.0											
9.5											
10.0	10	UDS-4									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123046.953 m	*Easting :*697043.901 m
Reduced Level (m):(+)267.528	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.20	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*13-10-2021	

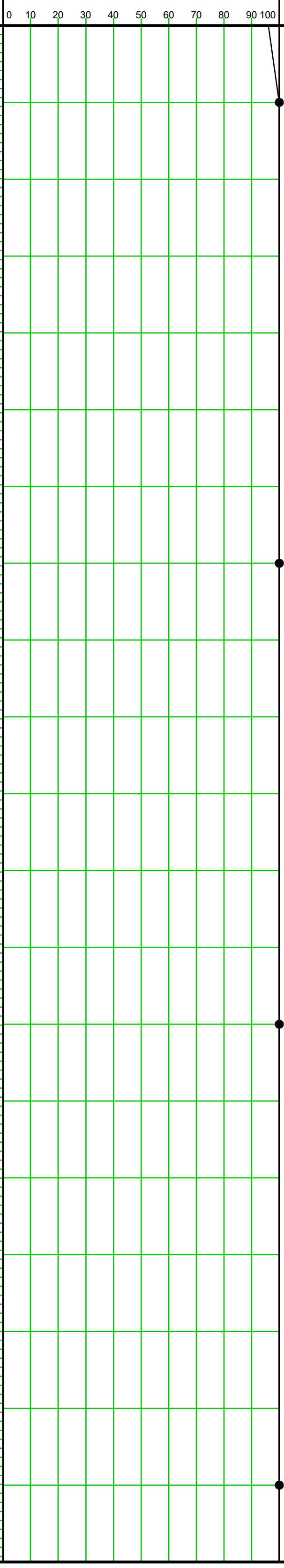
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	16	27	32	59					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	37	100 (15cm)	-	>100					
15.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
15.5											
16.0	16	UDS*									
16.5											
17.0											
17.5	17.5	SPT-6	16	33	43	76					
18.0											
18.5											
19.0	19	UDS*									
19.5											
20.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123046.953 m	*Easting :*697043.901 m
Reduced Level (m):(+)267.528	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.20	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*13-10-2021	

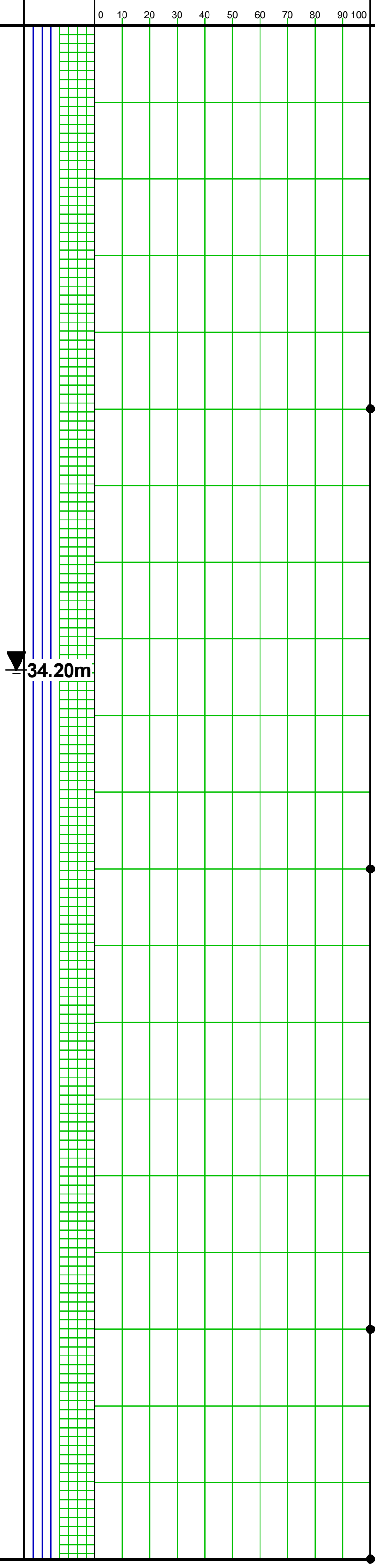
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
20.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
20.5	20.5	SPT-7	44	100 (15cm)	-	>100					
21.0											
21.5											
22.0	22	UDS*									
22.5											
23.0											
23.5	23.5	SPT-8	39	52	48 (6cm)	>100					
24.0											
24.5											
25.0	25	UDS*									
25.5											
26.0											
26.5	26.5	SPT-9	44	70	30 (5cm)	>100					
27.0											
27.5											
28.0	28	UDS*									
28.5											
29.0											
29.5	29.5	SPT-10	45	100 (10cm)	-	>100					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123046.953 m	*Easting :*697043.901 m
Reduced Level (m):(+)267.528	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.20	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*13-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
30.5											
31.0	31	UDS*									
31.5											
32.0											
32.5	32.5	SPT-11	48	75	25 (4cm)	>100					
33.0											
33.5											
34.0	34	UDS*									
34.5											
35.0											
35.5	35.5	SPT-12	38	63	37 (10cm)	>100					
36.0											
36.5											
37.0	37	UDS*									
37.5											
38.0											
38.5	38.5	SPT-13	32	49	51 (13cm)	>100					
39.0											
39.5											
40.0	40	SPT-14	54	69	31 (10cm)	>100					

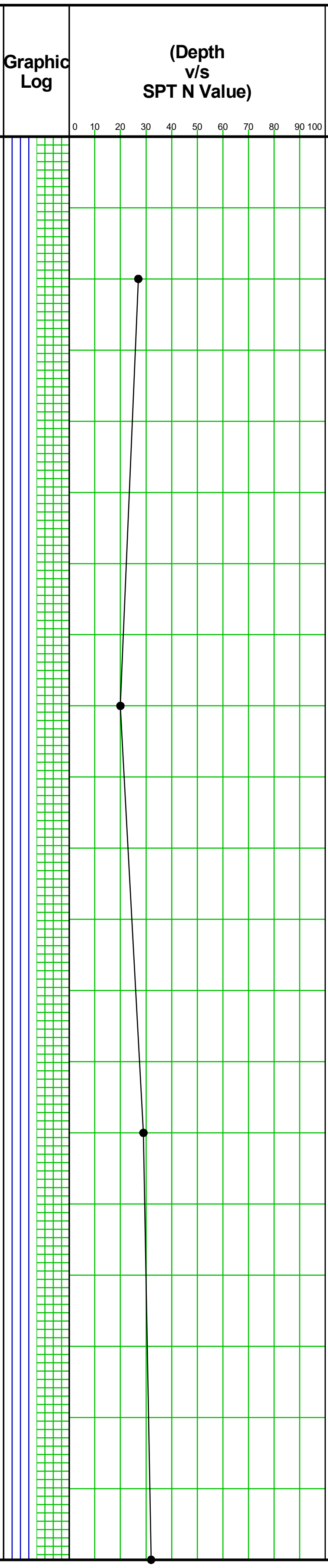


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123223.834 m	*Easting :*696531.197 m
Reduced Level (m):(+)262.678	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*36.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-10-2021	*Date of Completion :*21-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Special Observations
			N1	N2	N3				
0.0		DS					Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL	
0.5									
1.0	1	SPT-1	7	12	15	27			
1.5									
2.0									
2.5	2.5	UDS-1							
3.0									
3.5									
4.0	4	SPT-2	7	9	11	20			
4.5									
5.0									
5.5	5.5	UDS-2							
6.0									
6.5									
7.0	7	SPT-3	9	13	16	29			
7.5									
8.0									
8.5	8.5	UDS-3							
9.0									
9.5									
10.0	10	SPT-4	11	15	17	32			

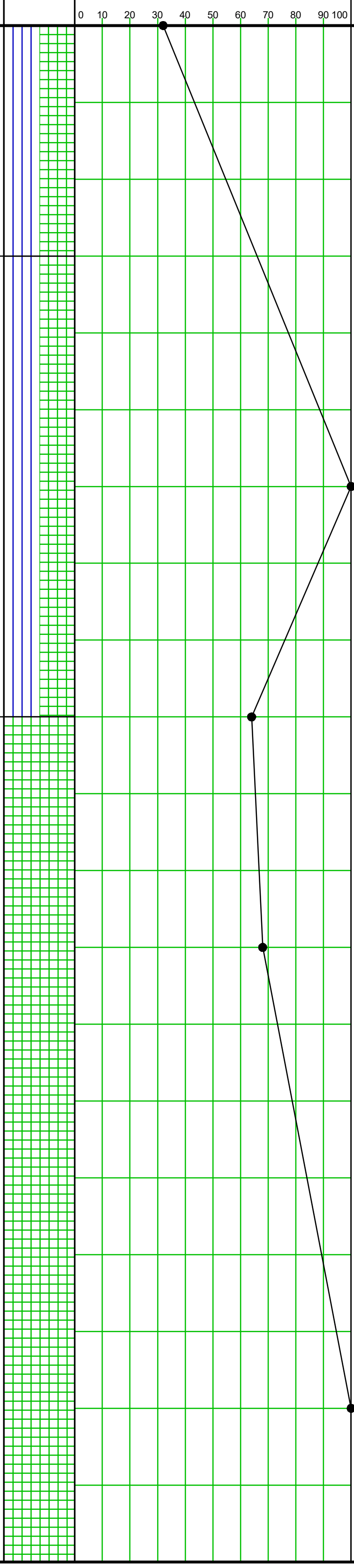


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123223.834 m	*Easting :*696531.197 m
Reduced Level (m):(+)262.678	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*36.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-10-2021	*Date of Completion :*21-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
10.0							Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
10.5											
11.0											
11.5	11.5	UDS-4									
12.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
12.5											
13.0	13	SPT-5	18	52	48	100					
13.5											
14.0											
14.5	14.5	SPT-6	21	29	35	64					
15.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	SPT-7	19	31	37	68					
16.5											
17.0											
17.5	17.5	UDS-5									
18.0											
18.5											
19.0	19	SPT-8	35	57	43 (8cm)	>100					
19.5											
20.0											

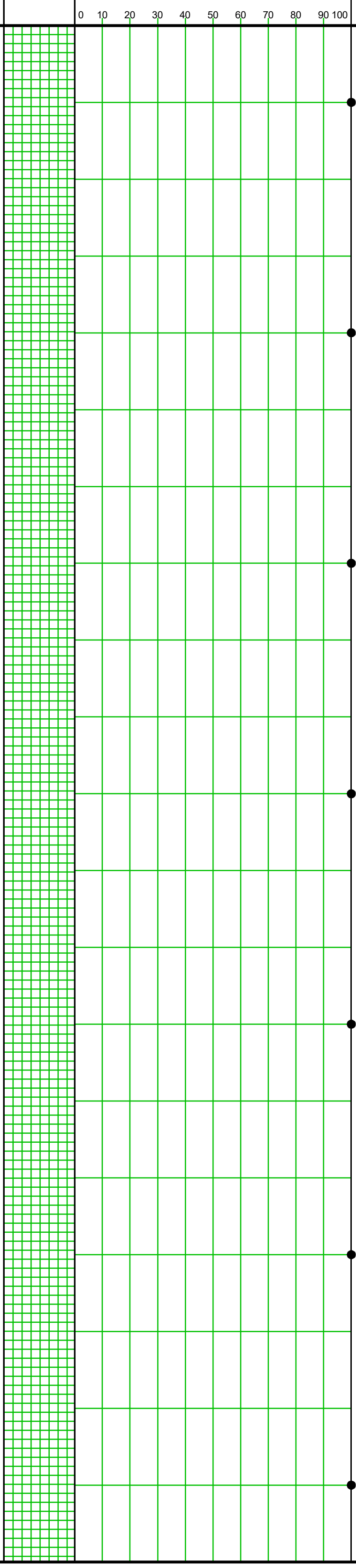


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123223.834 m	*Easting :*696531.197 m
Reduced Level (m):(+)262.678	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*36.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-10-2021	*Date of Completion :*21-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	Blow counts per 15cm N2	Blow counts per 15cm N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
20.5	20.5	SPT-9	38	49	51 (6cm)	>100					
21.0											
21.5											
22.0	22	SPT-10	35	60	40 (9cm)	>100					
22.5											
23.0											
23.5	23.5	SPT-11	41	56	46 (6cm)	>100					
24.0											
24.5											
25.0	25	SPT-12	37	53	47 (8cm)	>100					
25.5											
26.0											
26.5	26.5	SPT-13	40	51	49 (10cm)	>100					
27.0											
27.5											
28.0	28	SPT-14	38	53	47 (8cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-15	41	52	48 (7cm)	>100					
30.0											

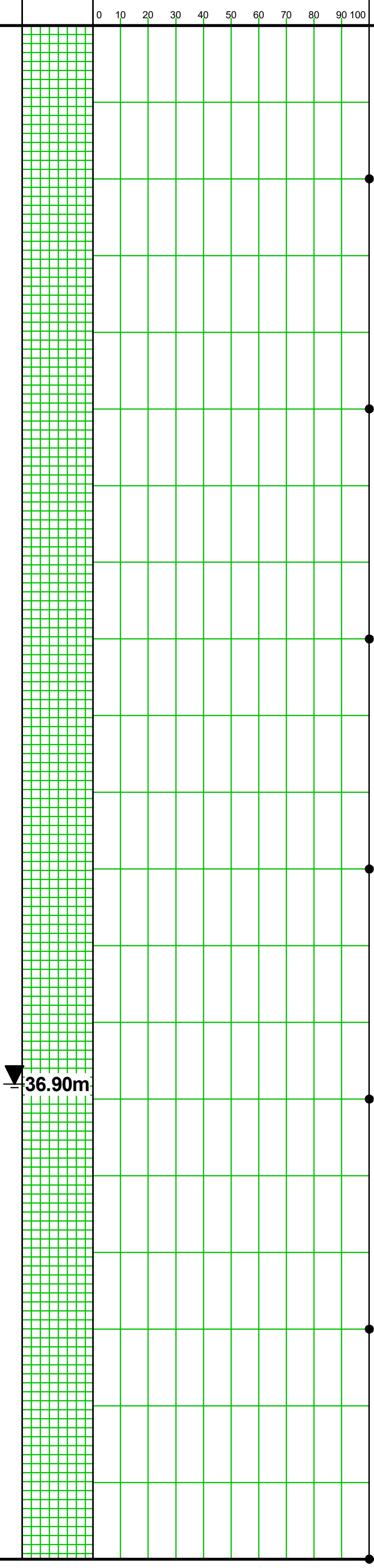


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123223.834 m	*Easting :*696531.197 m
Reduced Level (m):(+)262.678	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*36.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-10-2021	*Date of Completion :*21-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
30.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
30.5											
31.0	31	SPT-16	26	52	48 (10cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-17	34	40	60 (8cm)	>100					
33.0											
33.5											
34.0	34	SPT-18	19	43	57 (15cm)	>100					
34.5											
35.0											
35.5	35.5	SPT-19	23	45	55 (8cm)	>100					
36.0											
36.5											
37.0	37	SPT-20	19	58	42 (5cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-21	100 (10cm)	-	-	>100					
39.0											
39.5											
40.0	40	SPT-22	60 (15cm)	100	-	>100					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.

*Client :*HRIDCL

*BH Location/Chainage :*28+900 km

*Northing :*3123214.311 m

*Easting :*696528.146 m

Reduced Level (m):(+)263.022

*BH. No. :*BH-P1

*BH Termination Depth (m):*50

*Proposed / Existing Structure :*Major Bridge

*Water Table (m):*38.10

Inclination : Vertical

*Boring type :*Rotary

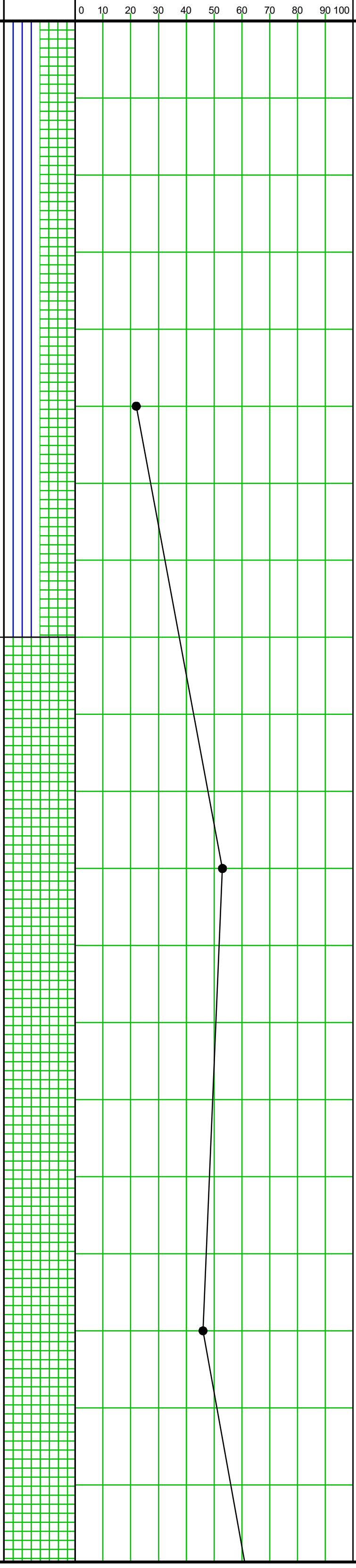
*Dia. of Boring :*150 mm

*Depth of Casing (m) :*Not Used

*Date of Start :*19-10-2021

*Date of Completion :*22-10-2021

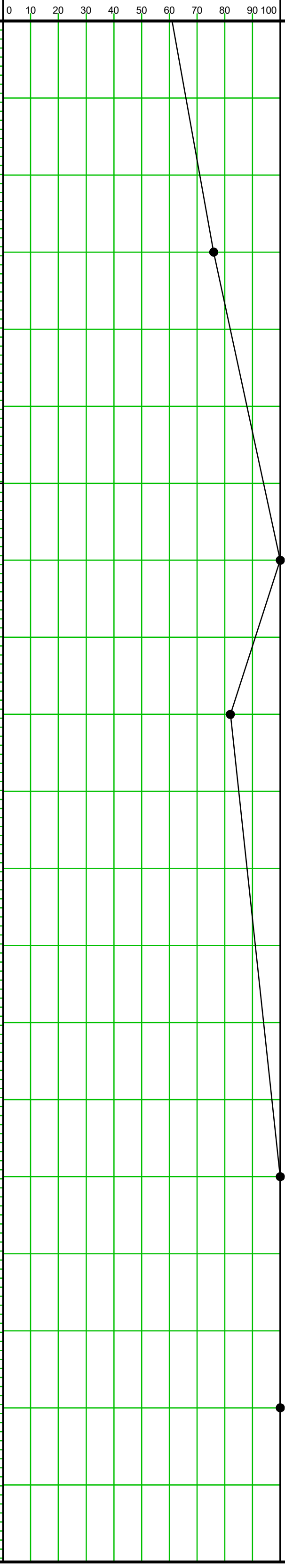
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
0.0		DS					Brown, Medium dense, Sandy silt of low plasticity with gravel	ML-CL			
0.5											
1.0	1	UDS-1									
1.5											
2.0											
2.5	2.5	SPT-1	7	9	13	22					
3.0											
3.5											
4.0	4	UDS-2					Brown, Hard, Silty clay of low plasticity with gravel	CL			
4.5											
5.0											
5.5	5.5	SPT-2	15	24	29	53					
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	12	19	27	46					
9.0											
9.5											
10.0	10	UDS-4									



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123214.311 m	*Easting :*696528.146 m
Reduced Level (m):(+)263.022	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*38.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*19-10-2021	*Date of Completion :*22-10-2021	

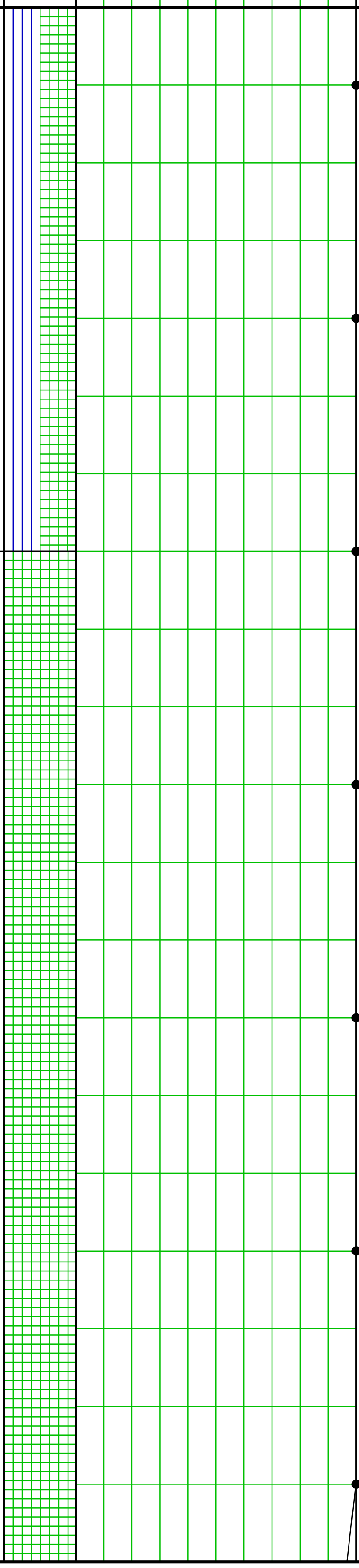
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	23	34	42	76	Brown, Hard, Silty clay of low plasticity with gravel	CL			
12.0											
12.5											
13.0	13	UDS-5									
13.5	13.5	SPT-5	29	45	55 (7cm)	>100					
14.0											
14.5	14.5	SPT-6	24	38	44	82					
15.0											
15.5											
16.0	16	UDS-6									
16.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
17.0											
17.5	17.5	SPT-7	28	47	53 (8cm)	>100					
18.0											
18.5											
19.0	19	SPT-8	32	50	50 (6cm)	>100					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123214.311 m	*Easting :*696528.146 m
Reduced Level (m):(+)263.022	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*38.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*19-10-2021	*Date of Completion :*22-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
20.5	20.5	SPT-9	36	53	47 (7cm)	>100					
21.0											
21.5											
22.0	22	SPT-10	35	100 (13cm)	-	>100					
22.5											
23.0											
23.5	23.5	SPT-11	30	46	54 (10cm)	>100					
24.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
24.5											
25.0	25	SPT-12	25	47	53 (12cm)	>100					
25.5											
26.0											
26.5	26.5	SPT-13	28	48	52 (10cm)	>100					
27.0											
27.5											
28.0	28	SPT-14	34	60	40 (7cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-15	42	56	44 (8cm)	>100					
30.0											



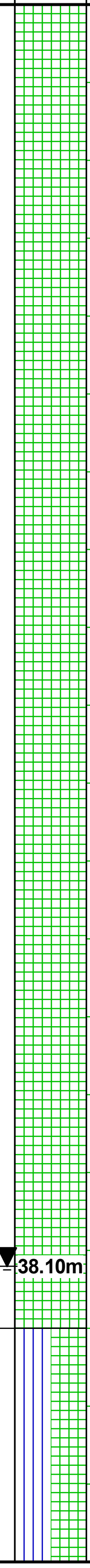
UDS*-UDS not recovered

FIELD BOREHOLE LOG

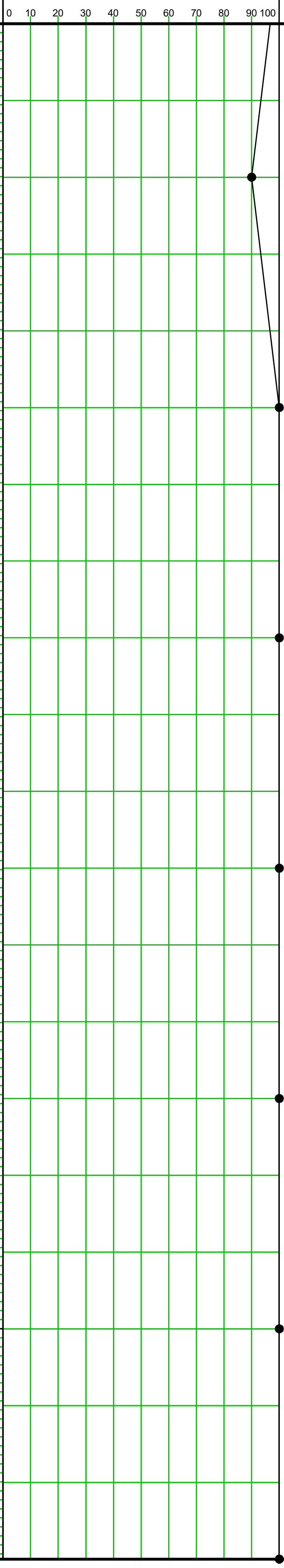
*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123214.311 m	*Easting :*696528.146 m
Reduced Level (m):(+)263.022	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*38.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*19-10-2021	*Date of Completion :*22-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
30.0							Brown, Hard, Silty clay of low plasticity with gravel	CL	
30.5									
31.0	31	SPT-16	19	36	54	90			
31.5									
32.0									
32.5	32.5	SPT-17	38	55	45 (9cm)	>100			
33.0									
33.5									
34.0	34	SPT-18	43	57	43 (7cm)	>100			
34.5									
35.0									
35.5	35.5	SPT-19	35	44	56 (8cm)	>100			
36.0									
36.5									
37.0	37	SPT-20	41	62	38 (8cm)	>100			
37.5									
38.0									
38.5	38.5	SPT-21	100 (15cm)	-	-	>100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	
39.0									
39.5									
40.0	40	SPT-22	46	100 (13cm)	-	>100			

Graphic Log



(Depth v/s SPT N Value)



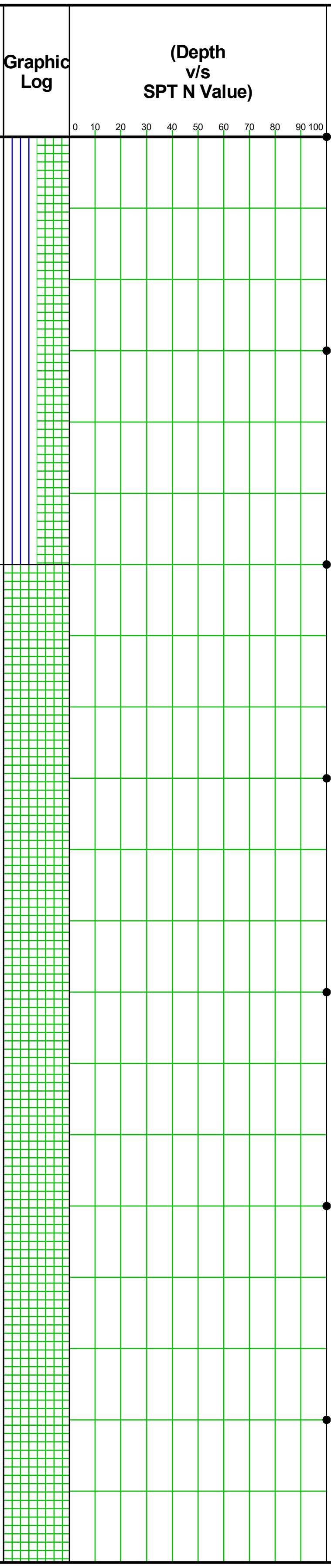
UDS*-UDS not recovered

FIELD BOREHOLE LOG

Project Name : GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :* HRIDCL
BH Location/Chainage : 28+900 km	*Northing :* 3123214.311 m	*Easting :* 696528.146 m
Reduced Level (m): (+)263.022	*BH. No. :* BH-P1	*BH Termination Depth (m):* 50
Proposed / Existing Structure : Major Bridge	*Water Table (m):* 38.10	*Inclination :* Vertical
Boring type : Rotary	*Dia. of Boring :* 150 mm	*Depth of Casing (m) :* Not Used
Date of Start : 19-10-2021	*Date of Completion :* 22-10-2021	

Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**
			N1	**N2**	**N3**			
40.0								
40.5								
41.0								
41.5	41.5	SPT-23	51	100 (12cm)	-	>100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL
42.0								
42.5								
43.0	43	SPT-24	47	53	47 (9cm)	>100		
43.5								
44.0								
44.5	44.5	SPT-25	52	65	35 (8cm)	>100		
45.0								
45.5								
46.0	46	SPT-26	55 (10cm)	100	-	>100		
46.5							Brown, Hard, Silty clay of low plasticity with gravel	CL
47.0								
47.5	47.5	SPT-27	100 (13cm)	-	-	>100		
48.0								
48.5								
49.0	49 49.22	SPT-28 -	80	100 (7cm)	-	>100		
49.5								
50.0								

Graphic Log | **(Depth v/s SPT N Value)** | **Special Observations**

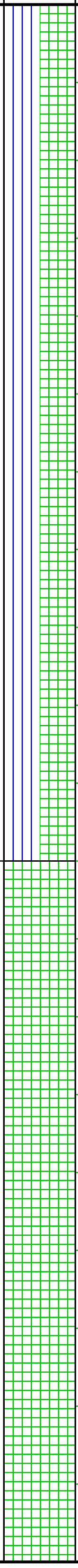


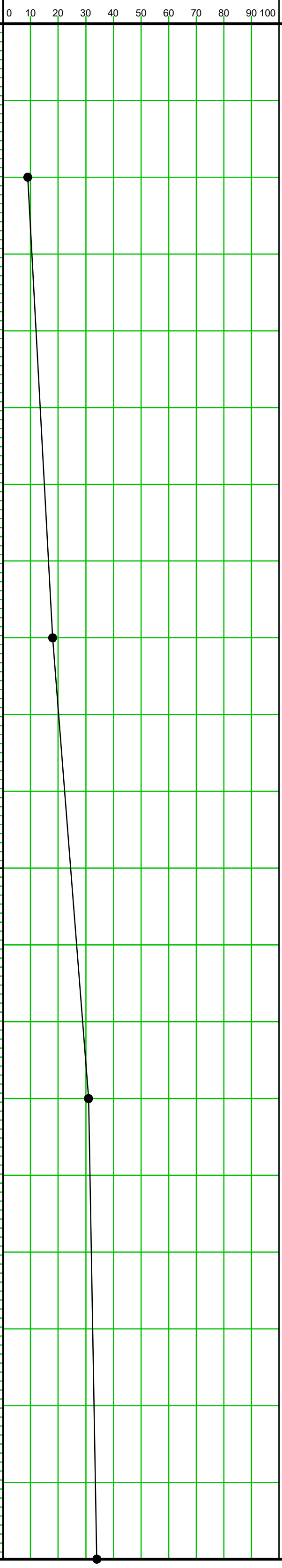
UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+900 km
*Northing :*3123189.55 m
*Easting :*696520.214 m
Reduced Level (m):(+)263.955
*BH. No. :*BH-P2
*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*34.55
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021
*Date of Completion :*18-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
0.0		DS					Brown, Loose to medium dense, Sandy silt of low plasticity	ML-CL			
0.5											
1.0	1	SPT-1	3	4	5	9					
1.5											
2.0											
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	5	7	11	18					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	CL			
6.5											
7.0	7	SPT-3	8	14	17	31					
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	12	16	18	34					

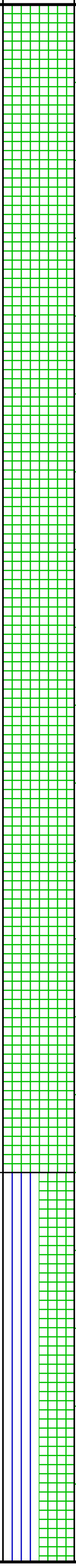
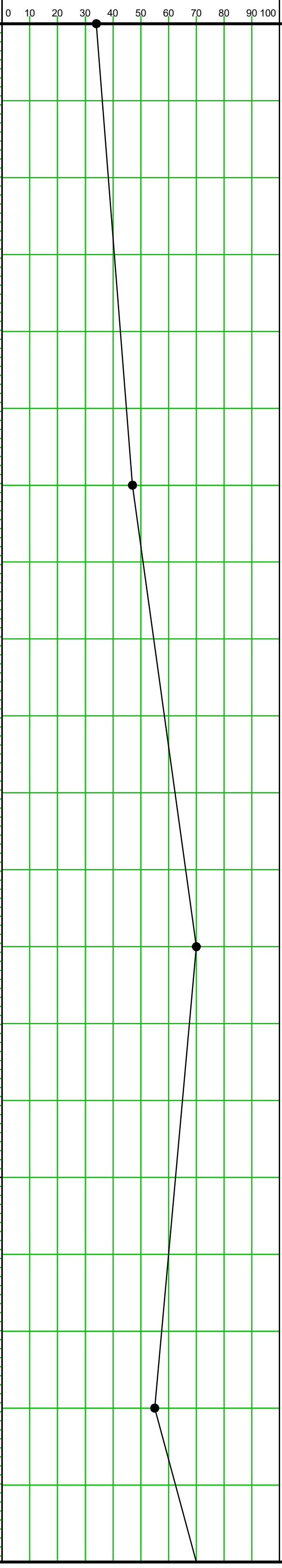




UDS*-UDS not recovered

FIELD BOREHOLE LOG

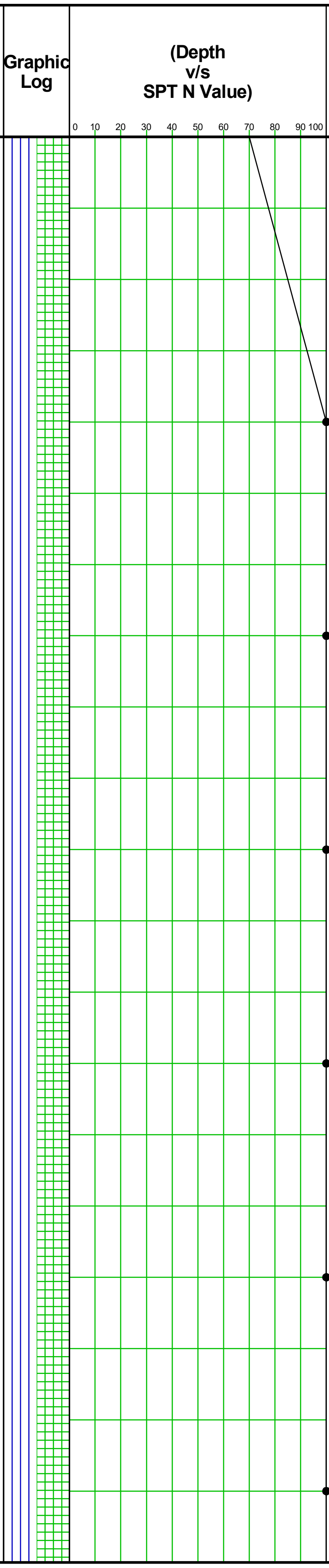
*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123189.55 m	*Easting :*696520.214 m
Reduced Level (m):(+)263.955	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
10.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	CL			
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	14	21	26	47					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0											
15.5											
16.0	16	SPT-6	25	29	41	70					
16.5											
17.0											
17.5	17.5	UDS-6					Brown, Hard, Silty clay of low plasticity with gravel	ML-CL			
18.0											
18.5											
19.0	19	SPT-7	20	23	32	55					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123189.55 m	*Easting :*696520.214 m
Reduced Level (m):(+)263.955	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021	*Date of Completion :*18-10-2021	

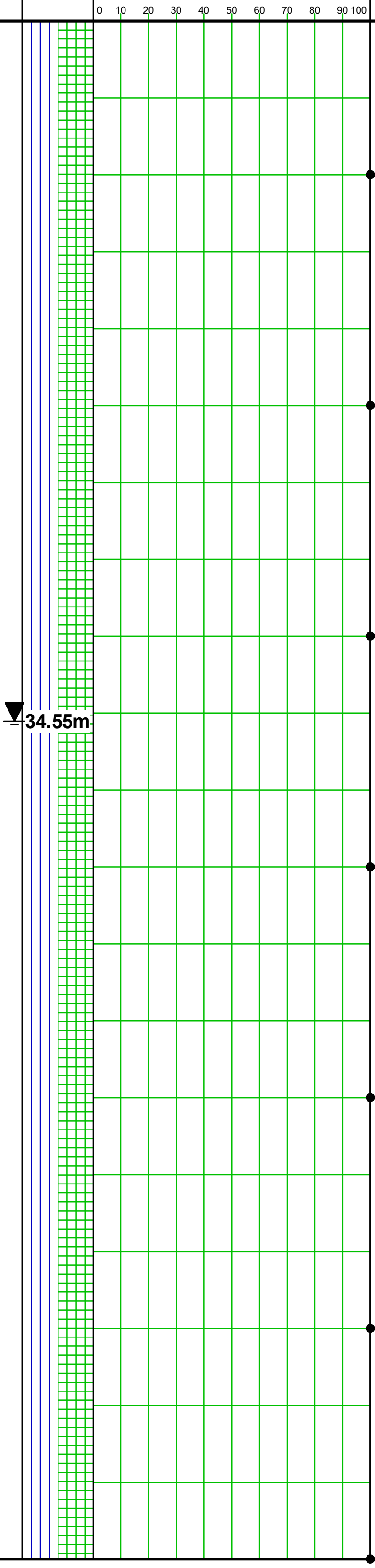
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	58	100 (10cm)	-	>100					
22.5											
23.0											
23.5	23.5	SPT-9	70	100 (15cm)	-	>100					
24.0											
24.5											
25.0	25	SPT-10	34	45	55 (8cm)	>100	Brown, Hard, Silty clay of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	SPT-11	50	82	18 (2cm)	>100					
27.0											
27.5											
28.0	28	SPT-12	25	52	48 (10cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-13	42	100 (15cm)	-	>100					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123189.55 m	*Easting :*696520.214 m
Reduced Level (m):(+)263.955	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
30.0							Brown, Hard, Silty clay of low plasticity with gravel	ML-CL			
30.5											
31.0	31	SPT-14	44	60	40 (7cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-15	26	44	56 (11cm)	>100					
33.0											
33.5											
34.0	34	SPT-16	30	85	15 (2cm)	>100					
34.5											
35.0											
35.5	35.5	SPT-17	32	50	50 (7cm)	>100					
36.0											
36.5											
37.0	37	SPT-18	41	65	35 (8cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-19	47	100 (5cm)	-	>100					
39.0											
39.5											
40.0	40	SPT-20	45	100 (7cm)	-	>100					

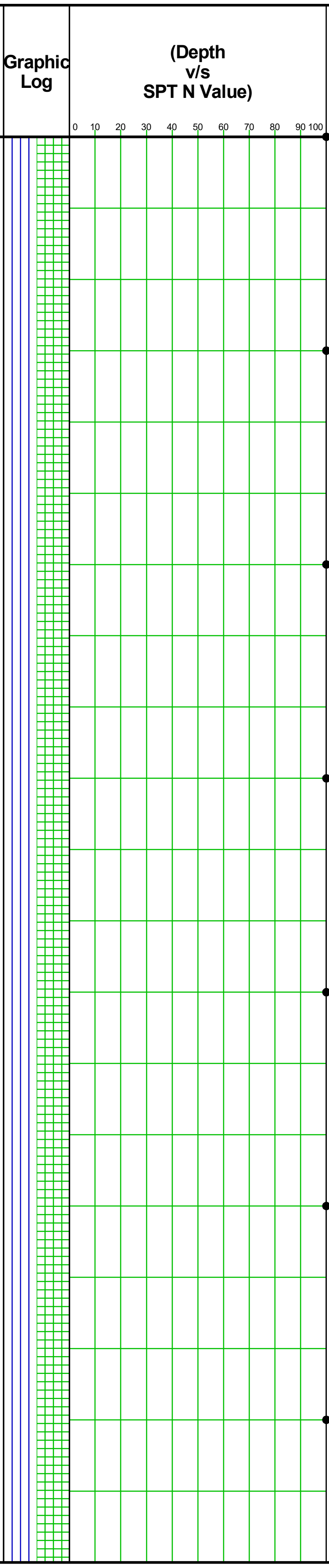


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.
*Client :*HRIDCL
*BH Location/Chainage :*28+900 km
*Northing :*3123189.55 m
*Easting :*696520.214 m
Reduced Level (m):(+)263.955
*BH. No. :*BH-P2
*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge
*Water Table (m):*34.55
Inclination : Vertical
*Boring type :*Rotary
*Dia. of Boring :*150 mm
*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021
*Date of Completion :*18-10-2021

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Special Observations
			N1	N2	N3				
40.0							Brown, Hard, Silty clay of low plasticity with gravel	ML-CL	
40.5									
41.0									
41.5	41.5	SPT-21	52	100 (4cm)	-	>100			
42.0									
42.5									
43.0	43	SPT-22	100 (15cm)	-	-	>100			
43.5									
44.0									
44.5	44.5	SPT-23	80	100 (9cm)	-	>100			
45.0									
45.5									
46.0	46	SPT-24	65	100 (7cm)	-	>100			
46.5									
47.0									
47.5	47.5	SPT-25	100 (14cm)	-	-	>100			
48.0									
48.5									
49.0	49 49.08	SPT-26 -	100 (9cm)	-	-	>100			
49.5									
50.0									

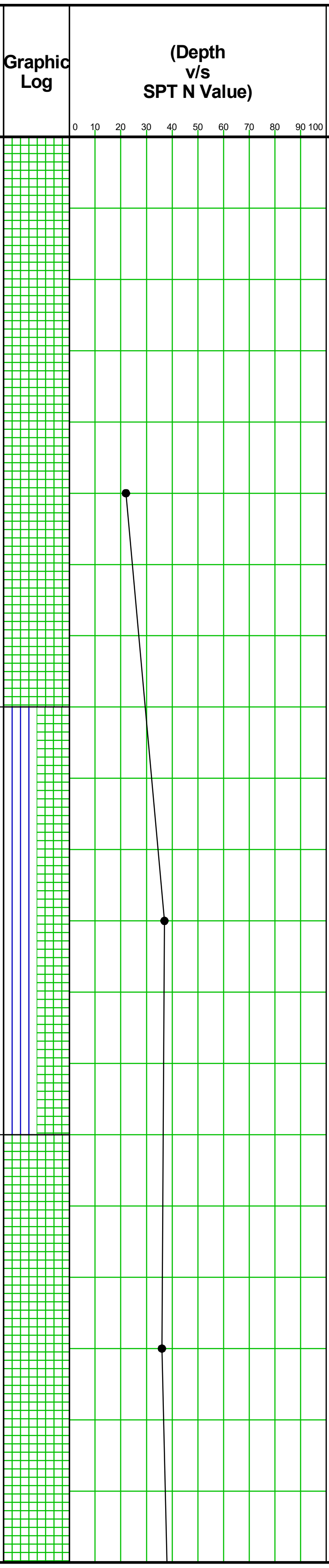


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123180.027 m	*Easting :*696517.163 m
Reduced Level (m):(+)263.847	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
0.0		DS					Brown, Very stiff, Silty clay of low plasticity	CL	
0.5									
1.0	1	UDS-1							
1.5									
2.0									
2.5	2.5	SPT-1	7	9	13	22			
3.0									
3.5									
4.0	4	UDS-2					Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL	
4.5									
5.0									
5.5	5.5	SPT-2	12	16	21	37			
6.0									
6.5									
7.0	7	UDS-3					Brown, Hard, Silty clay of low plasticity with gravel	CL	
7.5									
8.0									
8.5	8.5	SPT-3	9	12	24	36			
9.0									
9.5									
10.0	10	UDS-4							

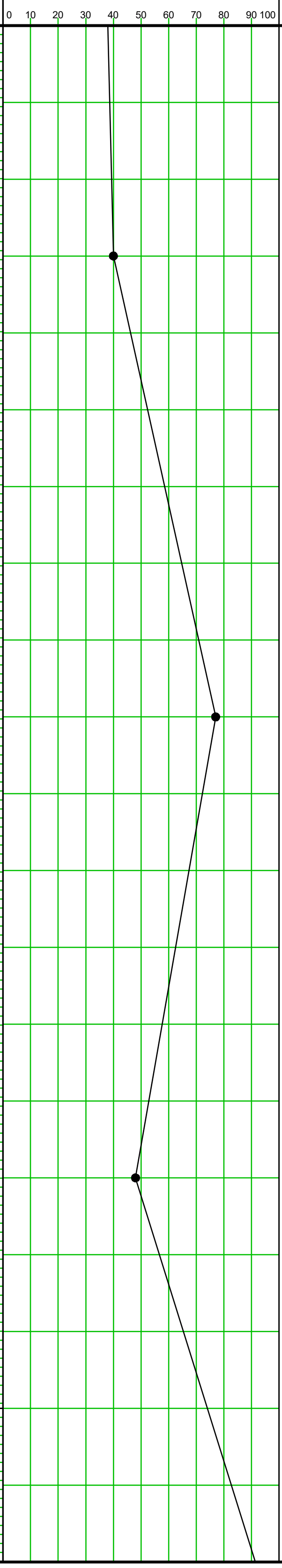


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123180.027 m	*Easting :*696517.163 m
Reduced Level (m):(+)263.847	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm			SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
			N1	N2	N3						
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	14	18	22	40					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	18	35	42	77	Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	16	19	29	48					
18.0											
18.5											
19.0	19	UDS-7									
19.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
20.0											



UDS*-UDS not recovered

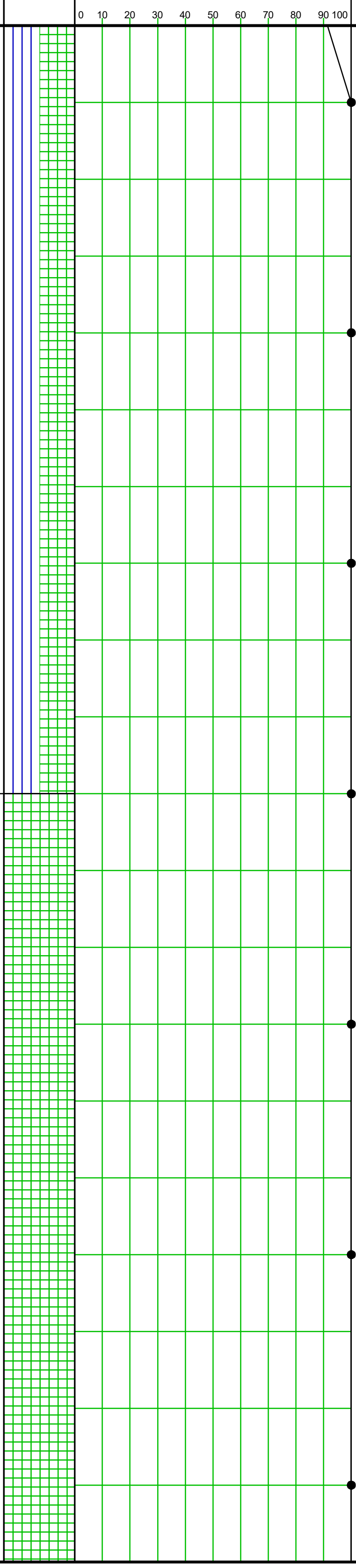
FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123180.027 m	*Easting :*696517.163 m
Reduced Level (m):(+)263.847	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Special Observations
20.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	
20.5	20.5	SPT-7	34	100 (15cm)	-	>100			
21.0									
21.5									
22.0	22	SPT-8	37	100 (10cm)	-	>100			
22.5									
23.0									
23.5	23.5	SPT-9	100 (10cm)	-	-	>100			
24.0									
24.5									
25.0	25	SPT-10	33	75	25 (3cm)	>100			
25.5							Brown, Hard, Silty clay of low plasticity with gravel	CL	
26.0									
26.5	26.5	SPT-11	45	100 (4cm)	-	>100			
27.0									
27.5									
28.0	28	SPT-12	48	52	48 (4cm)	>100			
28.5									
29.0									
29.5	29.5	SPT-13	51	100 (7cm)	-	>100			
30.0									

Graphic Log

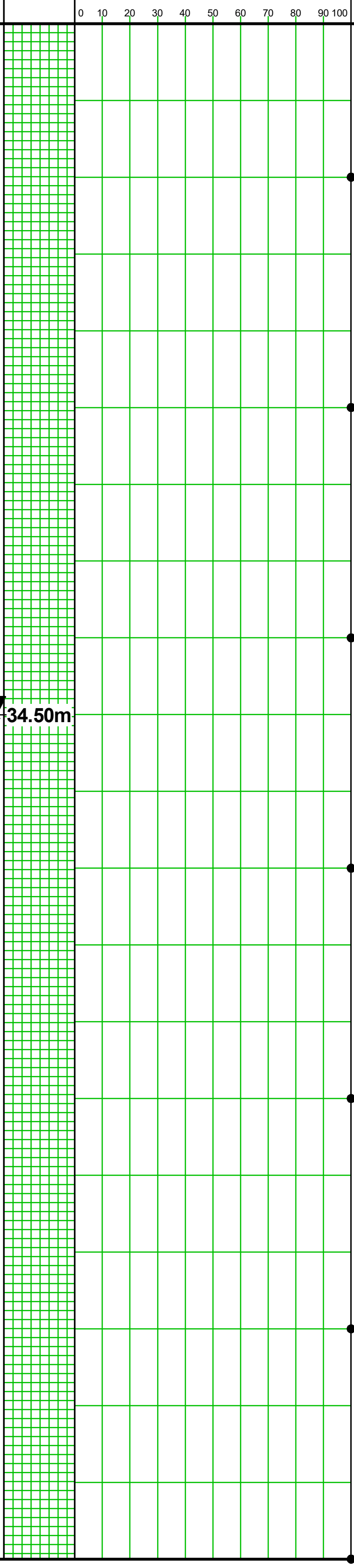
(Depth v/s SPT N Value)



UDS*-UDS not recovered

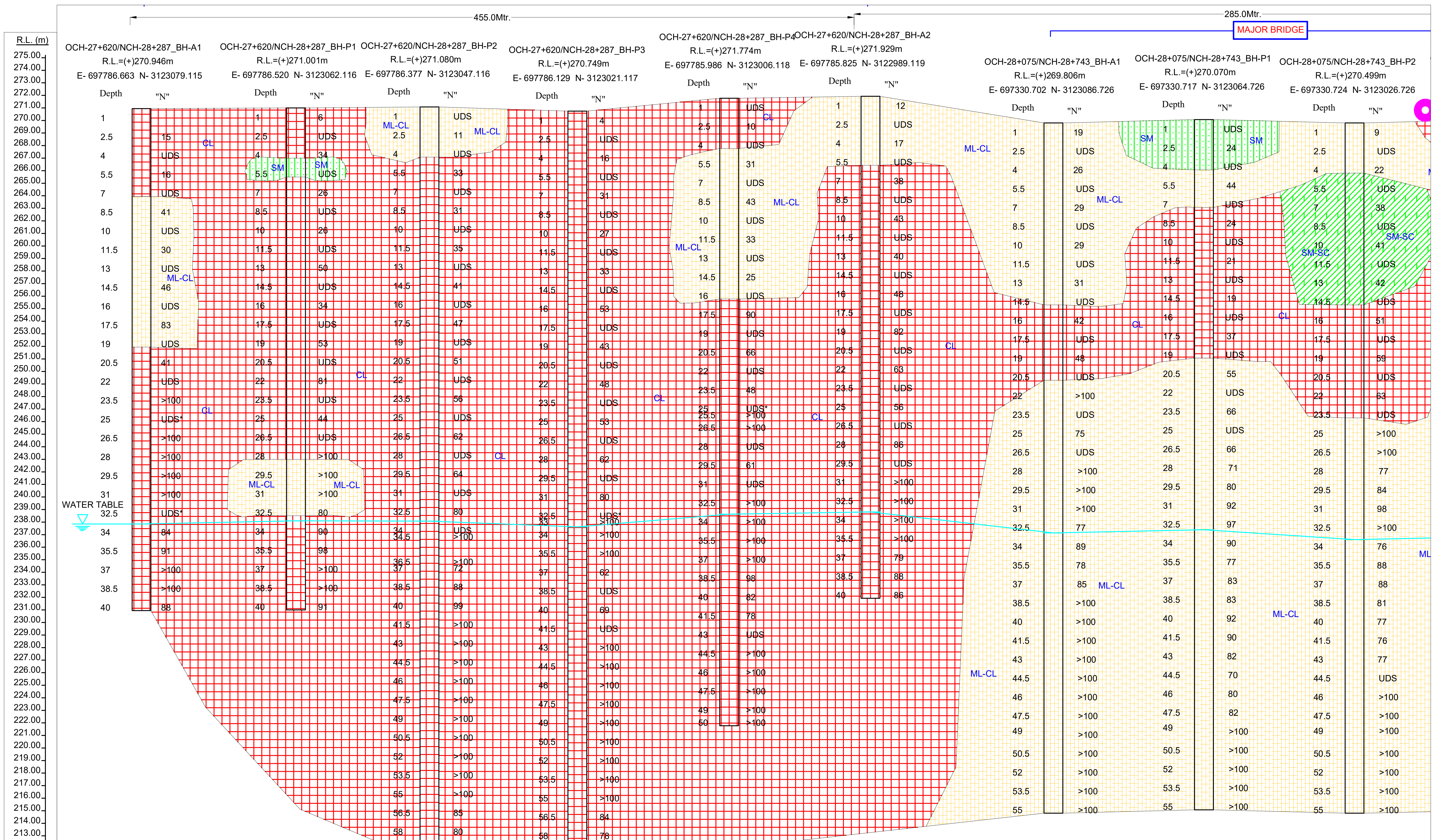
FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123180.027 m	*Easting :*696517.163 m
Reduced Level (m):(+)263.847	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	**In-Situ Sample Depth (m)**	**Sample Type**	**Blow counts per 15cm**			**SPT N Value**	**Strata Description**	**IS Classification**	**Graphic Log**	**(Depth v/s SPT N Value)**	**Special Observations**
			N1	**N2**	**N3**						
30.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
30.5											
31.0	31	SPT-14	41	53 (7cm)	47	>100					
31.5											
32.0											
32.5	32.5	SPT-15	32	47	53 (4cm)	>100					
33.0											
33.5											
34.0	34	SPT-16	45	59	41 (6cm)	>100					
34.5											
35.0											
35.5	35.5	SPT-17	58	100 (5cm)	-	>100					
36.0											
36.5											
37.0	37	SPT-18	35	48	52 (8cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-19	38	55	45 (6cm)	>100					
39.0											
39.5											
40.0	40	SPT-20	33	100 (15cm)	-	>100					

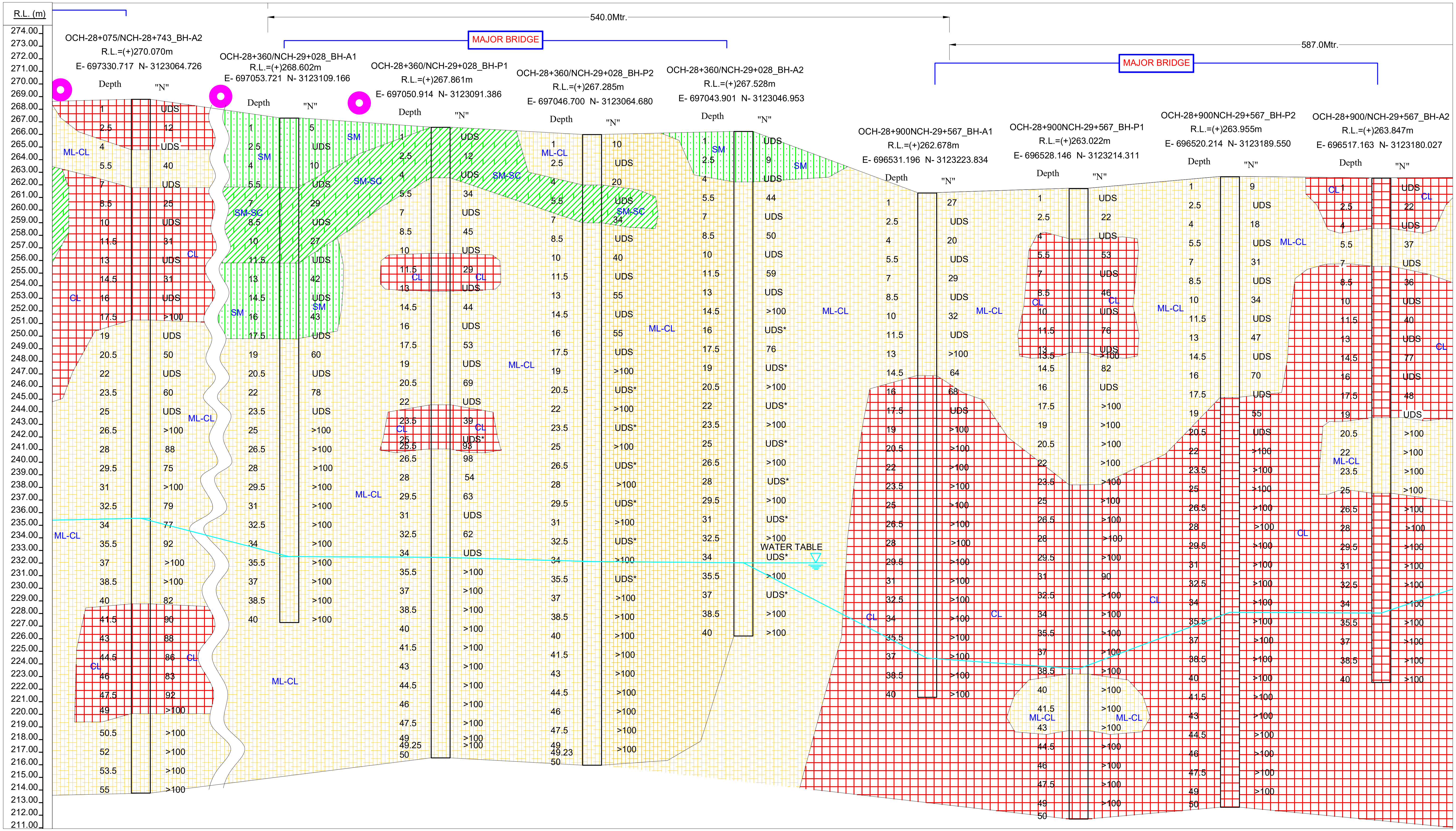
UDS*-UDS not recovered

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



SYMBOL	DESCRIPTION		
	SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line)		
	SM-SC -Clayey Sand (Having fines Less Than 50% and in the hatched zone (4<PI<7)		
	ML-CL -Sandy with clay (Having fines greater than 50% and in the hatched zone (LL<35 & 4<PI<7)		
	CL-Silty Clay of low plasticity (Above A-line, LL<35)		
	CI- Clay of medium plasticity (Above A-line, 35≤LL<50)		
●	BOREHOLE REQUIRED		WATER TABLE
Note:- Fines= Percentage of Silty + Clay A-line=.73(wl-20)		SCALE:- HOR:- 1:2850	SCALE:- VER:- 1:285

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



SYMBOL	DESCRIPTION		
🟩	SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line)		
▨	SM-SC -Clayey Sand (Having fines Less Than 50% and in the hatched zone (4<PI<7)		
🟨	ML-CL -Sandy with clay (Having fines greater than 50% and in the hatched zone (LL<35 & 4<PI<7)		
🟥	CL-Silty Clay of low plasticity (Above A-line, LL<35)		
▧	CI- Clay of medium plasticity (Above A-line, 35≤LL<50)		
●	BOREHOLE REQUIRED	▽	WATER TABLE
Note:- Fines= Percentage of Silty + Clay A-line=.73(wl-20)		SCALE:- HOR:- 1:2850	SCALE:- VER:- 1:285

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APPENDIX – B (LAB TEST RESULTS)

Appendix No.	**ITEMS**
B-1	SOIL CHARACTERISTICS SHEETS
B-2	RESULT OF CHEMICAL ANALYSIS OF SOIL SAMPLES
B-3	RESULT OF CHEMICAL ANALYSIS OF WATER SAMPLES
B-4	GSD CURVES
B-5	SHEAR CURVE
B-6	CONSOLIDATION CURVE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		11-10-2021	to	12-10-2021	27+620 Major Bridge	BH-A1	33.10 m	40.00 m	697786.663 m	3123079.115 m	(+)270.946 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Very stiff, Silty clay of low plasticity	-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		CL	▦	9	52	30	3	4	2	0	30	21	9	-	1.72	13.26	1.52	2.68	UUT	0.53	4	-	-	-	-	-	-	-	-
SPT-1	2.50	15	15		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-		CL	▦	10	54	26	5	3	2	0	31	21	10	-	1.73	13.80	1.52	-	-	-	-	-	-	-	-	-	-	-	-
SPT-2	5.50	16	16		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL	▥	8	47	35	4	3	3	0	28	21	7	-	1.82	13.34	1.61	2.66	DST	0.21	26	-	-	-	-	-	-	-	-
SPT-3	8.50	41	36		-	▥	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		ML-CL	▥	7	51	38	1	1	2	0	26	20	6	-	1.82	13.94	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	11.50	30	23		-	▥	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		ML-CL	▥	7	48	34	3	5	3	0	27	20	7	-	1.83	14.25	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	46	31		-	▥	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL	▦	11	56	19	3	4	7	0	31	20	11	-	1.96	16.22	1.69	2.67	UUT	2.58	4	-	-	-	-	-	-	-	-
SPT-6	17.50	83	83		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL	▦	10	57	21	5	2	5	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	20.50	41	41		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		CL	▦	12	56	18	4	4	6	0	32	21	11	-	2.00	17.84	1.70	2.68	UUT	3.13	4	-	-	-	-	-	-	-	-
SPT-8	23.50	100 (18cm)	100 (18cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	80	80		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	100 (27cm)	100 (27cm)		CL	▦	9	50	28	4	2	7	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		11-10-2021	to	12-10-2021	27+620 Major Bridge	BH-A1	33.10 m	40.00 m	697786.663 m	3123079.115 m	(+)270.946 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-11	28.00	100 (20cm)	100 (20cm)	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	29.50	100 (24cm)	100 (24cm)		CL		11	52	21	3	2	11	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	31.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	32.50	100 (25cm)	100 (25cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	34.00	84	84		CL		12	49	20	3	5	9	2	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	35.50	91	91		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	37.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	38.50	100 (18cm)	100 (18cm)		CL		11	50	23	4	4	8	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	40.00	88	88		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	11-10-2021	to	12-10-2021	27+620 Major Bridge	BH-P1	32.90 m	40.00 m	697786.520 m	3123062.116 m	(+)271.001 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Medium stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	6	6		CL		12	60	19	5	4	0	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		CL		13	63	18	3	2	1	0	34	23	11	-	1.63	12.30	1.45	2.67	UUT	0.23	5	-	-	-	-	-	-	-	-
SPT-2	4.00	34	39	Brown, Dense, Silty sand	SM		0	38	49	9	4	0	0	-	Nil	NP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL		11	68	14	2	3	2	0	31	20	11	-	1.79	13.46	1.58	2.68	UUT	0.88	4	-	-	-	0.695	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	9.44 6.30 5.16 4.57	1.79 1.39 0.92 0.59	0.1260
SPT-3	7.00	26	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		CL		12	66	16	1	2	3	0	32	21	11	-	1.80	14.06	1.58	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	26	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		CL		11	58	18	3	4	6	0	31	20	11	-	1.85	14.70	1.61	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	50	50		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		CL		13	56	20	5	3	3	0	34	23	11	-	1.86	15.26	1.61	2.67	UUT	1.17	5	-	-	-	-	-	-	-	-
SPT-6	16.00	34	34		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		12	55	19	7	2	5	0	33	22	11	-	1.90	16.11	1.64	2.68	UUT	1.75	4	-	-	-	-	-	-	-	-
SPT-7	19.00	53	53		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		10	54	23	5	2	6	0	31	21	10	-	1.97	16.80	1.69	2.68	UUT	2.50	4	-	-	-	-	-	-	-	-
SPT-8	22.00	81	81		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		CL		11	59	22	2	2	4	0	32	21	11	-	1.92	17.67	1.63	2.67	UUT	1.46	5	-	-	-	-	-	-	-	-
SPT-9	25.00	44	44				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-		CL		10	57	21	4	3	4	1	30	20	10	-	1.93	18.10	1.63	-	CUT Total Effective	 0.26 0.21	 22 26	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	**Date of Boring**			**Chainage (km.)/Location**	**B.H. No.**	**Depth of Water Table**	**Termination Depth**	**Cordinates (E,N)**		**R.L.**	**Ref. Code**
		11-10-2021	to	12-10-2021	27+620 Major Bridge	BH-P1	32.90 m	40.00 m	697786.520 m	3123062.116 m	(+)271.001 m	**SR-544_21-22**

Sample Type	**Depth from G.L. (m)**	**Observed SPT Value (N)**	**Corrected SPT Value (N_c)**	**Soil Description**	**IS Classification**	**IS Symbol**	**Grain Size Distribution % wt retained**							**Atterberg Limits %**				**Bulk Density (g/cm^3)**	**Natural Moisture Content (%)**	**Dry Density (g/cm^3)**	**Specific Gravity**	**Shear Strength**			**Free Swell Index (%)**	**Swelling Pressure (kg/cm^2)**	**Permeability (cm/sec)**	**Consolidation Parameters**				
									Sand			**Gravel**																				
							Clay	**Silt**	**Fine**	**Medium**	**Coarse**	**Fine**	**Coarse**	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**	**Shrinkage Limit**					**Type of Test**	**Cohesion C (kg/cm^2)**	**Angle of Friction (φ°)**				**Void Ratio (e_0)**	**Pressure (kg/cm^2)**	**C_v x 10^{-4} (cm^2/Sec)**	**M_v x 10^{-2} (cm^2/Kg)**	**Compression Index (C_c)**
SPT-10	28.00	100 (25cm)	100 (25cm)	Brown, Very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	29.50	100 (23cm)	-		ML-CL		7	49	28	3	5	8	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	31.00	100 (17cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	32.50	80	80	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	58	19	2	1	10	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	34.00	90	90		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	35.50	98	98		CL		12	52	20	4	3	7	2	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	37.00	100 (25cm)	100 (25cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	38.50	100 (23cm)	100 (23cm)		CL		11	53	18	6	4	8	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	40.00	91	91		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	20-11-2021	27+620 Major Bridge	BH-P3	33.13 m	60.00 m	697786.129 m	3123021.117 m	-	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^4 (cm^2/Sec)	M_v x 10^2 (cm^2/Kg)	Compression Index (C_c)
DS-1	0.00	-	-	Brown, Medium stiff to very stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	4	4		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		CL		11	54	28	6	1	0	0	31	21	10	-	1.69	14.05	1.48	2.67	UUT	0.37	5	-	-	-	-	-	-	-	-
SPT-2	4.00	16	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	53	30	5	1	1	0	30	20	10	-	1.84	15.23	1.60	2.68	UUT	1.02	5	-	-	-	-	-	-	-	-
SPT-3	7.00	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		CL		12	53	26	4	2	3	0	33	22	11	-	1.85	15.47	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	27	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		CL		11	48	28	5	3	5	0	31	20	11	-	1.85	15.60	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	33	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		CL		13	47	26	6	1	7	0	34	23	11	-	1.90	15.96	1.64	2.67	UUT	1.66	4	-	-	-	-	-	-	-	-
SPT-6	16.00	53	53		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		12	47	28	4	3	6	0	33	22	11	-	1.90	16.42	1.63	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	19.00	43	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		11	49	24	7	2	7	0	31	20	11	-	1.91	16.23	1.64	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		CL		10	48	30	5	1	6	0	30	20	10	-	1.91	16.74	1.64	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	53	53		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-		CL		12	45	27	6	2	8	0	33	22	11	-	1.94	17.02	1.66	2.68	UUT	1.98	4	-	-	-	-	-	-	-	-
SPT-10	28.00	62	62		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	20-11-2021	27+620 Major Bridge	BH-P3	33.13 m	60.00 m	697786.129 m	3123021.117 m	-	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
UDS-10	29.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL	▦	11	47	24	6	2	10	0	31	20	11	-	1.98	17.25	1.69	2.67	UUT	3.12	4	-	-	-	-	-	-	-	-
SPT-11	31.00	80	80		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	32.50	-	-		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	33.00	100 (20cm)	100 (20cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	34.00	100 (20cm)	100 (20cm)		CL	▦	13	45	23	6	2	11	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	35.50	100 (26cm)	100 (26cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	37.00	62	62		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-11	38.50	-	-		CL	▦	11	46	28	5	1	9	0	31	21	10	-	2.03	21.36	1.67	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	40.00	69	69		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-12	41.50	-	-		CL	▦	12	42	28	6	2	10	0	33	22	11	-	2.05	20.64	1.70	2.68	UUT	3.18	4	-	-	-	-	-	-	-	-
SPT-17	43.00	100 (27cm)	100 (27cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	44.50	100 (23cm)	100 (23cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	46.00	100 (20cm)	100 (20cm)		CL	▦	12	45	25	6	2	10	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	47.50	100 (20cm)	100 (20cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	49.00	100 (22cm)	100 (22cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	50.50	100 (21cm)	100 (21cm)		CL	▦	11	44	26	7	4	8	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	52.00	100 (20cm)	100 (20cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	53.50	>100	-		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	55.00	>100	-		CL	▦	10	42	28	5	3	12	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	56.50	84	84		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	**Date of Boring**			**Chainage (km.)/Location**	**B.H. No.**	**Depth of Water Table**	**Termination Depth**	**Cordinates (E,N)**		**R.L.**	**Ref. Code**
		18-11-2021	to	20-11-2021	27+620 Major Bridge	BH-P3	33.13 m	60.00 m	697786.129 m	3123021.117 m	-	**SR-544_21-22**

Sample Type	**Depth from G.L. (m)**	**Observed SPT Value (N)**	**Corrected SPT Value (N_c)**	**Soil Description**	**IS Classification**	**IS Symbol**	**Grain Size Distribution % wt retained**							**Atterberg Limits %**				**Bulk Density (g/cm^3)**	**Natural Moisture Content (%)**	**Dry Density (g/cm^3)**	**Specific Gravity**	**Shear Strength**			**Free Swell Index (%)**	**Swelling Pressure (kg/cm^2)**	**Permeability (cm/sec)**	**Consolidation Parameters**				
									Sand			**Gravel**																				
							Clay	**Silt**	**Fine**	**Medium**	**Coarse**	**Fine**	**Coarse**	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**	**Shrinkage Limit**					**Type of Test**	**Cohesion C (kg/cm^2)**	**Angle of Friction (φ°)**				**Void Ratio (e_0)**	**Pressure (kg/cm^2)**	**C_v x 10^4 (cm^2/Sec)**	**M_v x 10^2 (cm^2/Kg)**	**Compression Index (C_c)**
SPT-27	58.00	78	78	Brown, Hard, Silty clay of low plasticity with gravel	-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	59.50	97	97		CL	▦	11	47	26	4	3	9	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DS-2	60.00	-	-		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	20-11-2021	27+620 Major Bridge	BH-P4	33.14 m	50.00 m	697785.986 m	3123006.118 m	-	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^4 (cm^2/Sec)	M_v x 10^2 (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		CL		11	50	33	6	0	0	0	31	20	11	-	1.66	12.40	1.48	2.67	UUT	0.37	5	-	-	-	-	-	-	-	-
SPT-1	2.50	10	10		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL		7	44	34	10	2	3	0	27	20	7	-	1.81	13.22	1.60	2.66	DST	0.18	27	-	-	-	-	-	-	-	-
SPT-2	5.50	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		ML-CL		8	45	34	7	1	5	0	28	21	7	-	1.83	13.60	1.61	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	43	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		ML-CL		6	45	35	6	4	4	0	26	20	6	-	1.81	14.02	1.59	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	11.50	33	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		ML-CL		7	46	35	6	3	3	0	26	19	7	-	1.80	14.80	1.57	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	25	17		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		12	40	30	10	1	7	0	33	22	11	-	1.92	15.26	1.67	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	90	90		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL		11	49	26	7	1	6	0	32	21	11	-	1.92	15.40	1.66	2.68	UUT	2.24	4	-	-	-	-	-	-	-	-
SPT-7	20.50	66	66		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		CL		11	49	28	5	3	4	0	31	20	11	-	1.91	16.23	1.64	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	25.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.50	100 (25cm)	100 (25cm)		CL		10	47	27	4	3	9	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	20-11-2021	27+620 Major Bridge	BH-P4	33.14 m	50.00 m	697785.986 m	3123006.118 m	-	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
UDS-9	28.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL	▦	12	48	25	7	1	7	0	32	21	11	-	1.96	18.25	1.66	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	29.50	61	61		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	31.00	-	-		CL	▦	11	43	26	10	0	10	0	31	21	10	-	2.05	20.34	1.70	2.68	UUT	3.15	4	-	-	-	-	-	-	-	-
SPT-12	32.50	100 (28cm)	100 (28cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	34.00	100 (26cm)	100 (26cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	35.50	100 (24cm)	100 (24cm)		CL	▦	12	46	23	6	1	12	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	37.00	100 (30cm)	100 (30cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	38.50	98	98		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	40.00	82	82		CL	▦	13	46	22	5	4	10	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	41.50	78	78		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-11	43.00	-	-		CL	▦	11	47	22	12	0	8	0	30	20	10	-	2.04	20.85	1.69	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	44.50	100 (26cm)	100 (26cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	46.00	100 (23cm)	100 (23cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	47.50	100 (22cm)	100 (22cm)		CL	▦	13	45	23	8	2	9	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	49.00	100 (22cm)	100 (22cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	50.00	100 (19cm)	100 (19cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	**Date of Boring**			**Chainage (km.)/Location**	**B.H. No.**	**Depth of Water Table**	**Termination Depth**	**Cordinates (E,N)**		**R.L.**	**Ref. Code**
		18-11-2021	to	21-11-2021	27+620 Major Bridge	BH-P2	33.00 m	60.00 m	697786.377 m	3123047.116 m	(+)271.080 m	**SR-544_21-22**

Sample Type	**Depth from G.L. (m)**	**Observed SPT Value (N)**	**Corrected SPT Value (N_c)**	**Soil Description**	**IS Classification**	**IS Symbol**	**Grain Size Distribution % wt retained**							**Atterberg Limits %**				**Bulk Density (g/cm^3)**	**Natural Moisture Content (%)**	**Dry Density (g/cm^3)**	**Specific Gravity**	**Shear Strength**			**Free Swell Index (%)**	**Swelling Pressure (kg/cm^2)**	**Permeability (cm/sec)**	**Consolidation Parameters**				
									Sand			**Gravel**																				
							Clay	**Silt**	**Fine**	**Medium**	**Coarse**	**Fine**	**Coarse**	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**	**Shrinkage Limit**					**Type of Test**	**Cohesion C (kg/cm^2)**	**Angle of Friction (φ°)**				**Void Ratio (e_0)**	**Pressure (kg/cm^2)**	**C_v x 10^{-4} (cm^2/Sec)**	**M_v x 10^{-2} (cm^2/Kg)**	**Compression Index (C_c)**
DS	0.00	-	-	Brown, Medium dense, Sandy silt of low plasticity	-	▥	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		ML-CL	▥	9	55	30	5	1	0	0	28	21	7	-	1.69	12.04	1.51	2.66	DST	0.20	24	-	-	-	-	-	-	-	-
SPT-1	2.50	11	14		-	▥	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL	▦	11	52	28	4	2	3	0	32	21	11	-	1.81	13.25	1.60	2.67	UUT	1.12	5	-	-	-	-	-	-	-	-
SPT-2	5.50	33	33		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		CL	▦	12	54	25	3	2	4	0	33	22	11	-	1.82	13.51	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	31	31		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL	▦	11	50	27	6	1	5	0	32	21	11	-	1.83	13.89	1.61	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	11.50	35	35		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL	▦	10	54	26	4	2	4	0	30	20	10	-	1.86	14.29	1.63	2.68	UUT	1.45	4	-	-	-	-	-	-	-	-
SPT-5	14.50	41	41		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL	▦	10	49	30	6	1	4	0	30	20	10	-	1.87	14.90	1.63	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	47	47		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL	▦	13	48	24	7	2	6	0	34	23	11	-	1.90	15.34	1.65	2.67	UUT	1.78	4	-	-	-	-	-	-	-	-
SPT-7	20.50	51	51		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		CL	▦	12	49	23	5	4	7	0	32	21	11	-	1.92	16.42	1.65	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	56	56		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	25.00	-	-		CL	▦	11	51	25	4	3	6	0	31	21	10	-	1.94	17.12	1.66	2.68	UUT	2.02	5	-	-	-	-	-	-	-	-
SPT-9	26.50	62	62		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	28.00	-	-		CL	▦	12	42	30	6	2	8	0	33	22	11	-	1.96	17.88	1.66	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	18-11-2021	to	21-11-2021	27+620 Major Bridge	BH-P2	33.00 m	60.00 m	697786.377 m	3123047.116 m	(+)271.080 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-10	29.50	64	64	Brown, Hard, Silty clay of low plasticity with gravel	-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-11	31.00	-	-		CL	▨	12	48	28	3	2	7	0	32	21	11	-	2.04	20.45	1.69	2.67	UUT	3.15	5	-	-	-	-	-	-	-	-
SPT-11	32.50	80	80		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-12	34.00	-	-		CL	▨	10	50	23	5	1	11	0	31	21	10	-	2.04	20.10	1.70	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	34.50	100 (25cm)	100 (25cm)		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	36.50	100 (22cm)	100 (22cm)		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	37.00	62	62		CL	▨	11	47	26	7	1	8	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	38.50	88	88		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	40.00	99	99		CL	▨	11	41	30	6	2	10	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	41.50	100 (23cm)	100 (23cm)		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	43.00	100 (23cm)	100 (23cm)		CL	▨	13	47	26	6	1	7	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	44.50	100 (20cm)	100 (20cm)		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	46.00	>100	-		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	47.50	100 (24cm)	100 (24cm)		CL	▨	11	49	24	4	3	9	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	49.00	>100	-		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	50.50	100 (22cm)	100 (22cm)		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	52.00	100 (21cm)	100 (21cm)		CL	▨	12	49	26	3	2	8	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	53.50	>100	-		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	55.00	>100	-		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	56.50	85	85		CL	▨	13	45	22	7	2	11	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project		Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	18-11-2021	to	21-11-2021	27+620 Major Bridge	BH-P2	33.00 m	60.00 m	697786.377 m	3123047.116 m	(+)271.080 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-28	58.00	80	80	Brown, Hard, Silty clay of low plasticity with gravel	-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-29	59.50	95	95		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	60.00	-	-		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	18-11-2021	to	19-11-2021	27+620 Major Bridge	BH-A2	33.12 m	40.00 m	697785.825 m	3122989.119 m	-	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^4 (cm^2/Sec)	M_v x 10^2 (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Medium dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	12	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		9	52	32	7	0	0	0	28	21	7	-	1.74	13.26	1.54	2.66	DST	0.20	24	-	-	-	-	-	-	-	-
SPT-2	4.00	17	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		11	46	26	12	1	4	0	32	21	11	-	1.92	18.41	1.62	2.68	UUT	1.36	5	-	-	-	-	-	-	-	-
SPT-3	7.00	38	38		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		CL		12	50	25	6	2	5	0	33	22	11	-	1.93	18.96	1.62	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	43	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		CL		10	50	27	8	0	5	0	30	20	10	-	1.93	19.10	1.62	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	40	40		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		CL		11	45	30	5	3	6	0	31	20	11	-	1.94	19.32	1.63	2.67	UUT	1.59	4	-	-	-	-	-	-	-	-
SPT-6	16.00	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		13	45	28	4	2	8	0	34	23	11	-	2.01	20.11	1.67	2.67	UUT	2.02	5	-	-	-	-	-	-	-	-
SPT-7	19.00	82	82		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		12	47	27	7	1	6	0	33	22	11	-	2.01	20.60	1.67	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	63	63		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		CL		10	43	33	6	1	7	0	30	20	10	-	2.03	20.78	1.68	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	56	56		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-		CL		11	47	28	8	0	6	0	33	22	11	-	2.05	21.05	1.69	2.68	UUT	2.67	4	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	19-11-2021	27+620 Major Bridge	BH-A2	33.12 m	40.00 m	697785.825 m	3122989.119 m	-	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^4 (cm^2/Sec)	M_v x 10^2 (cm^2/Kg)	Compression Index (C_c)
SPT-10	28.00	86	86	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	29.50	-	-		CL		13	46	23	7	1	10	0	34	23	11	-	2.05	20.60	1.70	2.67	UUT	3.17	4	-	-	-	-	-	-	-	-
SPT-11	31.00	100 (25cm)	100 (25cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	32.50	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	34.00	100 (20cm)	100 (20cm)		CL		12	43	25	11	0	9	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	35.50	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	37.00	79	79		CL		11	44	26	9	2	8	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	38.50	88	88		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	40.00	86	86		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		16-10-2021	to	18-10-2021	28+075 Major Bridge	BH-A1	32.67 m	55.00 m	697330.702 m	3123086.726 m	(+)269.806 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	19	30		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL	▨	7	48	26	12	5	2	0	27	20	7	-	1.79	12.17	1.60	2.66	DST	0.22	27	-	-	-	-	-	-	-	-
SPT-2	4.00	26	29		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		ML-CL	▨	8	53	31	3	2	3	0	28	21	7	-	1.79	12.80	1.59	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	7.00	29	27		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL	▨	6	51	23	13	3	4	0	26	20	6	-	1.79	13.24	1.58	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	29	23		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		ML-CL	▨	7	49	26	9	4	5	0	26	19	7	-	1.80	13.76	1.58	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	31	22		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL	▨	10	54	16	11	4	5	0	31	20	11	-	1.88	15.06	1.63	2.67	UUT	1.39	5	-	-	-	-	-	-	-	-
SPT-6	16.00	42	42		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL	▨	12	56	18	4	3	7	0	33	22	11	-	1.88	15.29	1.63	2.68	UUT	1.59	5	-	-	-	-	-	-	-	-
SPT-7	19.00	48	48		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	▨	8	51	27	4	3	5	2	28	21	7	-	1.88	16.23	1.62	2.66	DST	0.21	28	-	-	-	-	-	-	-	-
SPT-8	22.00	68	36		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		ML-CL	▨	6	48	25	9	4	7	1	26	20	6	-	1.88	16.89	1.61	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	75	37		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-		ML-CL	▨	7	45	30	5	3	10	0	27	20	7	-	1.90	17.10	1.62	2.66	DST	0.18	30	-	-	-	-	-	-	-	-
SPT-10	28.00	100 (20cm)	-		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project		Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	16-10-2021	to	18-10-2021	28+075 Major Bridge	BH-A1	32.67 m	55.00 m	697330.702 m	3123086.726 m	(+)269.806 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-11	29.50	80	37	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		8	44	22	10	3	13	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	31.00	100 (25cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	32.50	77	35		ML-CL		6	48	33	6	2	5	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	34.00	89	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	35.50	78	25		ML-CL		7	49	26	8	3	7	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	37.00	85	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	38.50	85	27		ML-CL		7	49	30	3	2	8	1	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	40.00	100 (19cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	41.50	88	28		ML-CL		6	49	25	9	1	10	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	43.00	100 (27cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	44.50	100 (25cm)	-		ML-CL		8	48	29	2	1	12	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	46.00	100 (28cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	47.50	100 (23cm)	-		ML-CL		7	49	30	3	2	8	1	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	50.50	100 (28cm)	-		ML-CL		6	55	27	1	0	11	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	52.00	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	53.50	100 (23cm)	-		ML-CL		7	47	30	3	1	12	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	55.00	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		11-10-2021	to	15-10-2021	28+075 Major Bridge	BH-P1	32.68 m	55.00 m	697330.717 m	3123064.726 m	(+)270.070 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Medium dense, Silty sand	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM		0	25	69	2	1	3	0	-	Nil	NP	-	1.77	10.34	1.60	2.62	DST	0.00	30	-	-	-	-	-	-	-	-
SPT-1	2.50	24	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		7	48	32	6	3	4	0	28	21	7	-	1.83	12.19	1.63	2.66	DST	0.22	26	-	-	-	-	-	-	-	-
SPT-2	5.50	44	44		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-	Brown, Very stiff to hard, Silty clay of low plasticity	CL		12	57	20	4	3	3	1	33	22	11	-	1.79	14.30	1.57	2.68	UUT	0.82	5	-	-	-	0.705	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	7.05 6.30 5.15 4.23	2.02 1.44 0.97 0.59	0.126
SPT-3	8.50	24	24		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		10	57	23	2	5	3	0	31	20	11	-	1.79	15.24	1.55	2.67	UUT	0.70	4	-	-	-	-	-	-	-	-
SPT-4	11.50	21	21		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		12	53	23	5	4	2	1	34	23	11	-	1.80	15.90	1.55	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	19	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		11	58	21	4	1	5	0	32	21	11	-	1.87	16.43	1.61	2.68	UUT	1.26	5	-	-	-	-	-	-	-	-
SPT-6	17.50	37	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		6	48	28	6	4	7	1	26	20	6	-	1.84	15.10	1.60	2.66	DST	0.21	27	-	-	-	-	-	-	-	-
SPT-7	20.50	55	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		ML-CL		8	51	30	3	2	6	0	28	21	7	-	1.86	15.76	1.61	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	66	34		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	25.00	-	-		ML-CL		7	48	29	5	4	5	2	27	20	7	-	1.87	16.43	1.61	2.66	DST	0.22	29	-	-	-	-	-	-	-	-
SPT-9	26.50	66	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		11-10-2021	to	15-10-2021	28+075 Major Bridge	BH-P1	32.68 m	55.00 m	697330.717 m	3123064.726 m	(+)270.070 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-10	28.00	71	33	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		6	54	27	3	2	7	1	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	29.50	80	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	31.00	92	42		ML-CL		7	52	30	2	3	6	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	32.50	97	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	34.00	90	28		ML-CL		7	50	25	3	5	9	1	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	35.50	77	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	37.00	83	27		ML-CL		8	51	27	3	2	7	2	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	38.50	83	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	40.00	92	29		ML-CL		7	51	25	3	3	11	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	41.50	90	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	43.00	82	26		ML-CL		7	49	28	5	2	9	0	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	44.50	70	24		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	46.00	80	26		ML-CL		8	48	26	4	5	8	1	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	47.50	82	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.00	100 (25cm)	-		ML-CL		6	53	26	6	2	7	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	50.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	52.00	100 (20cm)	-		ML-CL		7	46	27	7	3	8	2	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	53.50	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	55.00	100 (18cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	11-10-2021	to	14-10-2021	28+075 Major Bridge	BH-P2	33.20 m	55.00 m	697330.724 m	3123026.726 m	(+)270.499 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Loose, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	9	14		ML-CL		6	51	25	13	4	1	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		7	52	29	8	3	1	0	27	20	7	-	1.69	11.63	1.51	2.66	DST	0.20	24	-	-	-	-	-	-	-	-
SPT-2	4.00	22	25	Brown, Medium dense to dense, Silty sand with clay & gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		SM-SC		5	41	34	14	3	3	0	26	21	5	-	1.80	12.10	1.61	2.65	DST	0.11	29	-	-	-	-	-	-	-	-
SPT-3	7.00	38	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		SM-SC		4	40	41	8	3	4	0	25	20	5	-	1.81	12.36	1.61	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	41	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		SM-SC		5	38	38	11	2	4	2	25	20	5	-	1.81	12.89	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	42	30		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	50	19	11	5	5	0	31	21	10	-	1.89	15.11	1.64	2.68	UUT	1.69	5	-	-	-	-	-	-	-	-
SPT-6	16.00	51	51		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		12	52	20	7	3	4	2	33	22	11	-	1.92	15.80	1.66	2.67	UUT	1.95	4	-	-	-	-	-	-	-	-
SPT-7	19.00	59	59		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		11	52	25	4	2	6	0	32	21	11	-	1.93	16.24	1.66	2.67	CUT Total Effective	0.23 0.20	24 27	-	-	-	-	-	-	-	-
SPT-8	22.00	63	63		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		8	45	25	13	3	6	0	28	21	7	-	1.92	16.30	1.65	2.66	DST	0.21	29	-	-	-	-	-	-	-	-
SPT-9	25.00	100 (24cm)	-				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	100 (24cm)	-		ML-CL		7	45	26	10	3	9	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	11-10-2021	to	14-10-2021	28+075 Major Bridge	BH-P2	33.20 m	55.00 m	697330.724 m	3123026.726 m	(+)270.499 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-11	28.00	77	35	Brown, Very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	29.50	84	39		ML-CL		7	47	24	13	1	8	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	31.00	98	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	32.50	>100	-		ML-CL		6	48	20	17	1	7	1	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	34.00	76	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	35.50	88	28		ML-CL		6	47	24	11	2	10	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	37.00	88	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	38.50	81	26		ML-CL		8	49	30	4	3	6	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	40.00	77	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	41.50	76	25		ML-CL		7	47	27	8	5	4	2	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	43.00	77	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	44.50	-	-		ML-CL		6	49	24	11	3	7	0	26	20	6	-	1.96	18.00	1.66	2.66	DST	0.18	31	-	-	-	-	-	-	-	-
SPT-22	46.00	100 (26cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	47.50	100 (22cm)	-		ML-CL		6	47	28	7	2	10	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.00	100 (18cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	50.50	100 (21cm)	-		ML-CL		7	44	30	3	5	9	2	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	52.00	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	53.50	100 (19cm)	-		ML-CL		7	45	20	13	4	11	0	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	55.00	100 (27cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		16-10-2021	to	18-10-2021	28+075 Major Bridge	BH-A2	33.21 m	55.00 m	697330.724 m	3123004.726 m	(+)270.616 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm³)	Natural Moisture Content (%)	Dry Density (g/cm³)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm²)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm²)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm²)	C_v x 10^{-4} (cm²/Sec)	M_v x 10^{-2} (cm²/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		CL		12	59	16	10	2	1	0	34	21	13	-	1.69	12.64	1.50	2.67	UUT	0.44	4	-	-	-	0.780	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	9.39 8.23 5.96 4.78	2.28 1.85 1.24 0.72	0.159
SPT-1	2.50	12	12		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		8	46	31	11	2	2	0	28	21	7	-	1.82	12.36	1.62	2.66	DST	0.18	27	-	-	-	-	-	-	-	-
SPT-2	5.50	40	41		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-	Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL		10	62	15	7	4	2	0	34	22	12	-	1.80	14.16	1.58	2.68	UUT	0.85	5	-	-	-	-	-	-	-	-
SPT-3	8.50	25	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		12	49	21	4	9	5	0	33	22	11	-	1.84	14.80	1.60	2.67	UUT	1.06	5	-	-	-	-	-	-	-	-
SPT-4	11.50	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		11	58	15	7	5	4	0	32	21	11	-	1.84	15.04	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		11	53	20	6	3	7	0	31	20	11	-	1.84	15.26	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	>100	-	Brown, Very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		ML-CL		7	45	31	8	2	7	0	27	20	7	-	1.86	16.11	1.60	2.66	DST	0.20	28	-	-	-	-	-	-	-	-
SPT-7	20.50	50	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		ML-CL		8	49	29	3	0	9	2	28	21	7	-	1.86	16.30	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	60	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	25.00	-	-		ML-CL		7	49	19	12	3	10	0	28	21	7	-	1.89	16.74	1.62	2.66	DST	0.22	29	-	-	-	-	-	-	-	-
SPT-9	26.50	100 (29cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	28.00	88	40		ML-CL		6	54	22	6	4	8	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	**Date of Boring**			**Chainage (km.)/Location**	**B.H. No.**	**Depth of Water Table**	**Termination Depth**	**Cordinates (E,N)**		**R.L.**	**Ref. Code**
		16-10-2021	to	18-10-2021	28+075 Major Bridge	BH-A2	33.21 m	55.00 m	697330.724 m	3123004.726 m	(+)270.616 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-11	29.50	75	35	Brown, Very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	31.00	100 (19cm)	-		ML-CL		7	48	25	8	2	9	1	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	32.50	79	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	34.00	77	25		ML-CL		6	49	29	4	3	7	2	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	35.50	92	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	37.00	100 (22cm)	-		ML-CL		7	45	24	10	2	12	0	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	38.50	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	40.00	82	82	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	50	18	9	5	8	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	41.50	90	90		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	43.00	88	88		CL		12	52	16	7	2	11	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	44.50	86	86		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	46.00	83	83		CL		11	55	17	4	1	10	2	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	47.50	92	92		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.00	100 (25cm)	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	45	24	10	1	13	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	50.50	100 (24cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	52.00	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	53.50	100 (23cm)	-		ML-CL		6	48	28	6	2	9	1	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	55.00	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	13-10-2021	to	14-10-2021	28+360 Major Bridge	BH-A1	34.78 m	40.00 m	697053.722 m	3123109.166 m	(+)268.602 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Loose, Silty sand	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	5	8		SM		0	32	62	5	1	0	0	-	Nil	NP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		SM		0	25	68	6	1	0	0	-	Nil	NP	-	1.62	10.36	1.47	2.62	DST	0.00	28	-	-	-	-	-	-	-	-
SPT-2	4.00	10	11		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Medium dense, Silty sand with clay	SM-SC		4	36	53	4	1	2	0	25	20	5	-	1.73	11.20	1.56	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	7.00	29	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		SM-SC		5	29	55	6	2	3	0	25	20	5	-	1.75	11.49	1.57	2.63	DST	0.10	27	-	-	-	-	-	-	-	-
SPT-4	10.00	27	22		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-	Brown, Dense, Silty sand with gravel	SM		0	21	60	11	3	5	0	-	Nil	NP	-	1.80	12.40	1.60	2.62	DST	0.00	31	-	-	-	-	-	-	-	-
SPT-5	13.00	42	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		SM		0	32	55	6	1	6	0	-	Nil	NP	-	1.80	12.77	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	16.00	43	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	46	28	11	2	6	0	27	20	7	-	1.84	14.16	1.61	2.66	DST	0.18	28	-	-	-	-	-	-	-	-
SPT-7	19.00	60	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		ML-CL		6	47	24	10	6	5	2	26	20	6	-	1.86	14.80	1.62	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	78	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		ML-CL		7	46	22	13	4	7	1	28	21	7	-	1.92	15.64	1.66	2.66	DST	0.19	30	-	-	-	-	-	-	-	-
SPT-9	25.00	100 (28cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	101 (24cm)	-		ML-CL		7	51	25	7	1	9	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project		Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	13-10-2021	to	14-10-2021	28+360 Major Bridge	BH-A1	34.78 m	40.00 m	697053.722 m	3123109.166 m	(+)268.602 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-11	28.00	100 (21cm)	-	Brown, Very dense, Sandy silt of low plasticity with gravel	-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	29.50	100 (23cm)	-		ML-CL	▨	8	47	26	6	2	11	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	31.00	100 (22cm)	-		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	32.50	100 (23cm)	-		ML-CL	▨	7	44	25	13	1	10	0	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	34.00	100 (21cm)	-		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	35.50	100 (22cm)	-		ML-CL	▨	6	52	27	5	2	8	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	37.00	100 (20cm)	-		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	38.50	100 (23cm)	-		ML-CL	▨	7	47	26	7	2	11	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	40.00	100 (28cm)	-		-	▨	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	13-10-2021	to	15-10-2021	28+360 Major Bridge	BH-P1	34.10 m	50.00 m	697050.915 m	3123091.386 m	(+)267.861 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Medium dense, Silty sand with clay	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM-SC		5	30	44	14	7	0	0	25	20	5	-	1.69	11.03	1.52	2.63	DST	0.11	26	-	-	-	-	-	-	-	-
SPT-1	2.50	12	15		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		6	53	28	4	4	5	0	27	21	6	-	1.82	12.74	1.61	2.66	DST	0.21	26	-	-	-	-	-	-	-	-
SPT-2	5.50	34	34		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		ML-CL		7	56	26	3	2	6	0	27	20	7	-	1.83	13.10	1.62	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	45	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-	Brown, Very stiff, Silty clay of low plasticity with gravel	CL		11	50	18	10	7	4	0	32	21	11	-	1.84	14.79	1.60	2.67	UUT	2.93	5	-	-	-	-	-	-	-	-
SPT-4	11.50	29	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL		6	49	26	12	3	4	0	26	20	6	-	1.83	14.60	1.60	2.66	DST	0.20	27	-	-	-	-	-	-	-	-
SPT-5	14.50	44	30		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		ML-CL		7	46	25	13	3	5	1	27	20	7	-	1.84	15.03	1.60	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	53	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		ML-CL		7	44	27	11	4	7	0	28	21	7	-	1.87	15.41	1.62	2.66	DST	0.22	28	-	-	-	-	-	-	-	-
SPT-7	20.50	69	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		9	57	19	6	5	4	0	30	20	10	-	1.89	16.74	1.62	2.68	CUT Total Effective	 0.21 0.18	 24 26	-	-	-	-	-	-	-	-
SPT-8	23.50	39	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	25.00	-	-				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	13-10-2021	to	15-10-2021	28+360 Major Bridge	BH-P1	34.10 m	50.00 m	697050.915 m	3123091.386 m	(+)267.861 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-9	25.50	93	45	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	49	26	7	3	8	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	98	46		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	28.00	54	25		ML-CL		8	46	21	12	7	6	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	29.50	63	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	31.00	-	-		ML-CL		7	46	28	9	4	5	1	26	19	7	-	1.88	17.68	1.60	2.66	DST	0.18	29	-	-	-	-	-	-	-	-
SPT-13	32.50	62	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	34.00	-	-		ML-CL		6	48	25	7	8	6	0	27	21	6	-	1.95	18.10	1.65	2.65	DST	0.19	31	-	-	-	-	-	-	-	-
SPT-14	35.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	37.00	100 (20cm)	-		ML-CL		8	51	23	4	3	10	1	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	38.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	40.00	100 (21cm)	-		ML-CL		7	46	27	7	5	8	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	41.50	100 (20cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	43.00	100 (20cm)	-		ML-CL		6	50	25	6	2	9	2	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	44.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	46.00	100 (22cm)	-		ML-CL		7	45	30	4	5	7	2	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	47.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	49.00	100 (21cm)	-		ML-CL		8	44	27	7	3	10	1	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.25	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	12-10-2021	to	14-10-2021	28+360 Major Bridge	BH-P2	33.85 m	50.00 m	697046.700 m	3123064.680 m	(+)267.285 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Loose, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	10	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		7	48	34	7	3	1	0	28	21	7	-	1.70	11.67	1.52	2.66	DST	0.20	23	-	-	-	-	-	-	-	-
SPT-2	4.00	20	23	Brown, Medium dense, Silty sand with clay	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		SM-SC		5	34	43	12	4	2	0	25	20	5	-	1.74	11.26	1.56	2.65	DST	0.09	27	-	-	-	-	-	-	-	-
SPT-3	7.00	34	32	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		7	55	28	2	4	4	0	27	20	7	-	1.81	13.27	1.60	2.66	DST	0.18	27	-	-	-	-	-	-	-	-
SPT-4	10.00	40	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		ML-CL		6	53	27	5	3	6	0	26	20	6	-	1.85	14.36	1.62	2.65	DST	0.18	28	-	-	-	-	-	-	-	-
SPT-5	13.00	55	40		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		ML-CL		7	49	30	6	2	5	1	27	20	7	-	1.85	14.89	1.61	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	16.00	55	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		ML-CL		6	49	30	4	3	8	0	26	20	6	-	1.91	15.74	1.65	2.66	DST	0.19	30	-	-	-	-	-	-	-	-
SPT-7	19.00	100 (20cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	20.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	100 (20cm)	-		ML-CL		7	46	30	6	1	10	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	23.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	100 (19cm)	-		ML-CL		8	50	26	7	2	7	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	26.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		12-10-2021	to	14-10-2021	28+360 Major Bridge	BH-P2	33.85 m	50.00 m	697046.700 m	3123064.680 m	(+)267.285 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-10	28.00	100	46	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL		8	47	28	7	2	8	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	29.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	31.00	100 (19cm)	-		ML-CL		7	50	24	6	3	10	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	32.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	34.00	100 (21cm)	-		ML-CL		6	52	29	5	1	7	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	35.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	37.00	100 (20cm)	-		ML-CL		7	50	22	8	4	9	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	38.50	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	40.00	100 (20cm)	-		ML-CL		8	48	24	10	2	8	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	41.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	43.00	100 (24cm)	-		ML-CL		7	47	26	11	1	7	1	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	44.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	46.00	>100	-		ML-CL		7	45	25	9	4	9	1	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	47.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	49.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	49.23	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	12-10-2021	to	13-10-2021	28+360 Major Bridge	BH-A2	34.20 m	40.00 m	697043.901 m	3123046.953 m	(+)267.528 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm³)	Natural Moisture Content (%)	Dry Density (g/cm³)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm²)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm²)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm²)	C_v x 10^{-4} (cm²/Sec)	M_v x 10^{-2} (cm²/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Loose, Silty sand	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM		0	32	56	11	1	0	0	-	Nil	NP	-	1.66	10.43	1.50	2.62	DST	0.00	28	-	-	-	-	-	-	-	-
SPT-1	2.50	9	12		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL		7	50	30	5	4	4	0	27	20	7	-	1.83	12.40	1.63	2.66	DST	0.20	27	-	-	-	-	-	-	-	-
SPT-2	5.50	44	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		ML-CL		6	46	31	8	3	6	0	27	21	6	-	1.84	13.04	1.63	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	50	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		ML-CL		7	48	28	6	4	5	2	26	19	7	-	1.85	13.78	1.63	2.66	DST	0.18	28	-	-	-	-	-	-	-	-
SPT-4	11.50	59	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		ML-CL		6	47	23	11	5	8	0	26	20	6	-	1.89	14.76	1.65	2.65	DST	0.18	30	-	-	-	-	-	-	-	-
SPT-5	14.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	16.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	76	47		ML-CL		7	50	22	9	6	6	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	19.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	20.50	>100	-		ML-CL		8	49	28	4	3	7	1	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	22.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	100 (21cm)	-		ML-CL		7	46	26	9	5	5	2	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	25.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	26.50	100 (20cm)	-		ML-CL		8	44	16	14	8	10	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		12-10-2021	to	13-10-2021	28+360 Major Bridge	BH-A2	34.20 m	40.00 m	697043.901 m	3123046.953 m	(+)267.528 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
UDS*	28.00	-	-	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	29.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	31.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	32.50	100 (19cm)	-		ML-CL		7	47	20	10	7	9	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	34.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	35.50	100 (25cm)	-		ML-CL		6	47	19	13	4	8	3	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	37.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	38.50	100 (18cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	40.00	100 (25cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	18-10-2021	to	21-10-2021	28+900 Major Bridge	BH-A1	36.90 m	40.00 m	696531.197 m	3123223.834 m	(+)262.678 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	27	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		6	48	32	10	2	2	0	26	20	6	-	1.76	12.10	1.57	2.66	DST	0.21	26	-	-	-	-	-	-	-	-
SPT-2	4.00	20	22		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		ML-CL		7	44	27	14	5	3	0	27	20	7	-	1.78	12.78	1.58	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	7.00	29	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		7	45	30	9	4	5	0	26	19	7	-	1.79	13.04	1.58	2.66	DST	0.18	27	-	-	-	-	-	-	-	-
SPT-4	10.00	32	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		6	50	28	5	3	8	0	27	21	6	-	1.88	13.90	1.65	2.66	DST	0.20	29	-	-	-	-	-	-	-	-
SPT-5	13.00	100 (30cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	14.50	64	64	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	55	19	6	6	4	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	16.00	68	68		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	17.50	-	-		CL		12	60	15	4	3	6	0	33	22	11	-	1.96	15.47	1.70	2.68	UUT	3.16	5	-	-	-	-	-	-	-	-
SPT-8	19.00	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	20.50	100 (21cm)	100 (21cm)		CL		11	56	16	3	2	11	1	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	22.00	100 (24cm)	100 (24cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	23.50	102 (21cm)	102 (21cm)		CL		12	49	19	7	3	8	2	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	25.00	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	26.50	100 (25cm)	100 (25cm)		CL		10	53	20	3	2	12	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	28.00	100 (21cm)	100 (21cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	**Date of Boring**			**Chainage (km.)/Location**	**B.H. No.**	**Depth of Water Table**	**Termination Depth**	**Cordinates (E,N)**		**R.L.**	**Ref. Code**
		18-10-2021	to	21-10-2021	28+900 Major Bridge	BH-A1	36.90 m	40.00 m	696531.197 m	3123223.834 m	(+)262.678 m	**SR-544_21-22**

Sample Type	**Depth from G.L. (m)**	**Observed SPT Value (N)**	**Corrected SPT Value (N_c)**	**Soil Description**	**IS Classification**	**IS Symbol**	**Grain Size Distribution % wt retained**							**Atterberg Limits %**				**Bulk Density (g/cm^3)**	**Natural Moisture Content (%)**	**Dry Density (g/cm^3)**	**Specific Gravity**	**Shear Strength**			**Free Swell Index (%)**	**Swelling Pressure (kg/cm^2)**	**Permeability (cm/sec)**	**Consolidation Parameters**				
									Sand			**Gravel**																				
							Clay	**Silt**	**Fine**	**Medium**	**Coarse**	**Fine**	**Coarse**	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**	**Shrinkage Limit**					**Type of Test**	**Cohesion C (kg/cm^2)**	**Angle of Friction (φ°)**				**Void Ratio (e_0)**	**Pressure (kg/cm^2)**	**C_v x 10^{-4} (cm^2/Sec)**	**M_v x 10^{-2} (cm^2/Kg)**	**Compression Index (C_c)**
SPT-15	29.50	100 (22cm)	100 (22cm)	Brown, Hard, Silty clay of low plasticity with gravel	CL	▦	13	52	17	5	3	9	1	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	31.00	100 (25cm)	100 (25cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	32.50	100 (23cm)	100 (23cm)		CL	▦	11	56	14	7	1	11	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	34.00	100 (30cm)	100 (30cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	35.50	100 (23cm)	100 (23cm)		CL	▦	10	48	20	6	4	9	3	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	37.00	100 (20cm)	100 (20cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	38.50	>100	-		CL	▦	10	53	19	4	1	13	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	40.00	>100	-		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring	Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)	R.L.	Ref. Code
		19-10-2021 to 22-10-2021	28+900 Major Bridge	BH-P1	38.10 m	50.00 m	696528.146 m 3123214.311 m	(+)263.022 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-		-	‖▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-	Brown, Medium dense, Sandy silt of low plasticity with gravel	ML-CL	‖▦	7	54	26	6	3	4	0	28	21	7	-	1.77	12.10	1.58	2.66	DST	0.20	26	-	-	-	-	-	-	-	-
SPT-1	2.50	22	28		-	‖▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL	▦	12	55	20	4	3	5	1	33	22	11	-	1.87	14.10	1.64	2.67	UUT	1.75	5	-	-	-	-	-	-	-	-
SPT-2	5.50	53	53		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		CL	▦	11	55	17	8	2	7	0	32	21	11	-	1.87	14.85	1.63	2.68	UUT	1.52	5	-	-	-	-	-	-	-	-
SPT-3	8.50	46	46		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL	▦	11	50	23	4	3	9	0	31	20	11	-	1.93	15.04	1.68	2.68	UUT	2.43	4	-	-	-	-	-	-	-	-
SPT-4	11.50	76	76		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	‖▦	7	46	27	8	2	10	0	27	20	7	-	1.90	14.87	1.65	2.66	DST	0.19	30	-	-	-	-	-	-	-	-
SPT-5	13.50	100 (22cm)	-		-	‖▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	14.50	82	55		-	‖▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		ML-CL	‖▦	8	45	28	3	4	12	0	28	21	7	-	1.91	15.11	1.66	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	17.50	100 (23cm)	-		-	‖▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	19.00	100 (21cm)	-		-	‖▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	20.50	100 (22cm)	-		ML-CL	‖▦	7	47	30	2	3	9	2	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	22.00	>100	-		-	‖▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	23.50	100 (25cm)	100 (25cm)	Brown, Hard, Silty clay of low plasticity with gravel	CL	▦	11	49	20	6	3	9	2	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	25.00	100 (27cm)	100 (27cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	26.50	100 (25cm)	100 (25cm)		CL	▦	12	48	18	9	1	12	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	**Date of Boring**			**Chainage (km.)/Location**	**B.H. No.**	**Depth of Water Table**	**Termination Depth**	**Cordinates (E,N)**		**R.L.**	**Ref. Code**
		19-10-2021	to	22-10-2021	28+900 Major Bridge	BH-P1	38.10 m	50.00 m	696528.146 m	3123214.311 m	(+)263.022 m	**SR-544_21-22**

Sample Type	**Depth from G.L. (m)**	**Observed SPT Value (N)**	**Corrected SPT Value (N_c)**	**Soil Description**	**IS Classification**	**IS Symbol**	**Grain Size Distribution % wt retained**							**Atterberg Limits %**				**Bulk Density (g/cm^3)**	**Natural Moisture Content (%)**	**Dry Density (g/cm^3)**	**Specific Gravity**	**Shear Strength**			**Free Swell Index (%)**	**Swelling Pressure (kg/cm^2)**	**Permeability (cm/sec)**	**Consolidation Parameters**				
									Sand			**Gravel**																				
							Clay	**Silt**	**Fine**	**Medium**	**Coarse**	**Fine**	**Coarse**	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**	**Shrinkage Limit**					**Type of Test**	**Cohesion C (kg/cm^2)**	**Angle of Friction (φ°)**				**Void Ratio (e_0)**	**Pressure (kg/cm^2)**	**C_v x 10^{-4} (cm^2/Sec)**	**M_v x 10^{-2} (cm^2/Kg)**	**Compression Index (C_c)**
SPT-14	28.00	100 (22cm)	100 (22cm)	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	29.50	100 (23cm)	100 (23cm)		CL		13	48	21	3	4	11	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	31.00	90	90		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	32.50	100 (22cm)	100 (22cm)		CL		12	51	18	5	3	7	4	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	34.00	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	35.50	100 (23cm)	100 (23cm)		CL		11	46	22	4	5	12	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	37.00	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	38.50	>100	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	48	30	2	1	12	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	40.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	41.50	>100	-		ML-CL		6	48	29	4	2	10	1	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	43.00	100 (24cm)	100 (24cm)	Brown, Hard, Silty clay of low plasticity with gravel	CL		11	54	22	5	1	7	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	44.50	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	46.00	>100	-		CL		11	55	17	4	3	9	1	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	47.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	49.00	>100	-		CL		12	48	15	8	4	13	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	49.22	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		15-10-2021	to	18-10-2021	28+900 Major Bridge	BH-P2	34.55 m	50.00 m	696520.214 m	3123189.550 m	(+)263.955 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Loose to medium dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	9	14		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		6	46	34	13	1	0	0	26	20	6	-	1.70	12.10	1.52	2.66	DST	0.20	25	-	-	-	-	-	-	-	-
SPT-2	4.00	18	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL		7	48	28	10	2	5	0	27	20	7	-	1.79	12.76	1.59	2.66	DST	0.19	26	-	-	-	-	-	-	-	-
SPT-3	7.00	31	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		8	47	30	6	2	4	3	28	21	7	-	1.80	13.02	1.59	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	34	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		ML-CL		7	53	26	3	5	6	0	27	20	7	-	1.83	13.46	1.61	2.66	DST	0.20	27	-	-	-	-	-	-	-	-
SPT-5	13.00	47	34		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		ML-CL		6	46	30	6	4	7	1	27	21	6	-	1.86	14.28	1.63	2.66	DST	0.19	28	-	-	-	-	-	-	-	-
SPT-6	16.00	70	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		12	57	13	10	1	7	0	33	22	11	-	1.92	16.34	1.65	2.68	UUT	1.82	5	-	-	-	-	-	-	-	-
SPT-7	19.00	55	55		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		13	53	16	5	1	12	0	34	23	11	-	1.99	17.20	1.70	2.67	UUT	3.14	5	-	-	-	0.575	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	9.58 8.53 7.59 6.17	1.15 0.84 0.52 0.36	0.073
SPT-8	22.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	23.50	>100	-		CL		10	51	18	8	2	10	1	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	25.00	100 (23cm)	100 (23cm)				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	26.50	100 (17cm)	100 (17cm)		CL		11	41	21	11	5	11	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	15-10-2021	to	18-10-2021	28+900 Major Bridge	BH-P2	34.55 m	50.00 m	696520.214 m	3123189.550 m	(+)263.955 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-12	28.00	100 (25cm)	100 (25cm)	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	29.50	>100	-		CL		12	50	23	2	1	9	3	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	31.00	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	32.50	100 (26cm)	100 (26cm)		CL		13	50	20	3	2	10	2	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	34.00	100 (17cm)	100 (17cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	35.50	100 (22cm)	100 (22cm)		CL		11	53	17	2	3	14	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	37.00	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	38.50	>100	-		CL		12	50	16	7	4	11	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	40.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	41.50	>100	-		CL		10	51	20	3	5	9	2	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	43.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	44.50	>100	-		CL		11	47	19	10	3	7	3	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	46.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	47.50	>100	-		CL		12	47	22	4	3	10	2	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	49.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	49.08	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		16-10-2021	to	18-10-2021	28+900 Major Bridge	BH-A2	34.50 m	40.00 m	696517.163 m	3123180.027 m	(+)263.847 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained						Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																			
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
DS	0.00	-	-	Brown, Very stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		CL		10	58	16	11	2	3	0	31	21	10	-	1.77	13.16	1.56	2.67	UUT	0.75	4	-	-	-	-	-	-	-	-
SPT-1	2.50	22	22		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		7	51	28	6	3	5	0	27	20	7	-	1.81	12.48	1.61	2.66	DST	0.20	26	-	-	-	-	-	-	-	-
SPT-2	5.50	37	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		11	57	21	4	3	4	0	32	21	11	-	1.84	14.19	1.61	2.67	UUT	1.23	5	-	-	-	-	-	-	-	-
SPT-3	8.50	36	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		12	58	20	2	2	5	1	33	22	11	-	1.87	15.26	1.62	2.68	UUT	1.35	5	-	-	-	-	-	-	-	-
SPT-4	11.50	40	40		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		13	58	17	3	1	8	0	34	23	11	-	1.90	15.90	1.64	2.67	UUT	1.66	5	-	-	-	0.630	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	10.07 8.47 6.84 5.82	1.48 1.06 0.63 0.45	0.093
SPT-5	14.50	77	77		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		12	53	20	6	4	5	0	32	21	11	-	1.91	16.34	1.64	2.67	CUT Total Effective	0.30 0.23	24 27	-	-	-	-	-	-	-	-
SPT-6	17.50	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	46	24	10	1	12	0	28	21	7	-	1.93	17.00	1.65	2.66	DST	0.18	30	-	-	-	-	-	-	-	-
SPT-7	20.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	>100	-		ML-CL		6	46	29	6	2	9	2	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	23.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	25.00	>100	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	57	20	4	1	8	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	26.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEGTH
CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	16-10-2021	to	18-10-2021	28+900 Major Bridge	BH-A2	34.50 m	40.00 m	696517.163 m	3123180.027 m	(+)263.847 m	**SR-544_21-22**

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
									Sand			Gravel																				
							Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
SPT-12	28.00	100 (19cm)	100 (19cm)	Brown, Hard, Silty clay of low plasticity with gravel	CL	▦	13	54	19	2	1	11	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	29.50	>100	-		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	31.00	100 (22cm)	100 (22cm)		CL	▦	12	50	20	3	2	13	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	32.50	100 (19cm)	100 (19cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	34.00	100 (21cm)	100 (21cm)		CL	▦	11	49	19	7	3	11	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	35.50	>100	-		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	37.00	100 (23cm)	100 (23cm)		CL	▦	12	49	17	3	5	10	4	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	38.50	100 (21cm)	100 (21cm)		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	40.00	>100	-		-	▦	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEGTH
CEG TEST HOUSE

RESULT OF CHEMICAL ANALYSIS OF SOIL SAMPLES

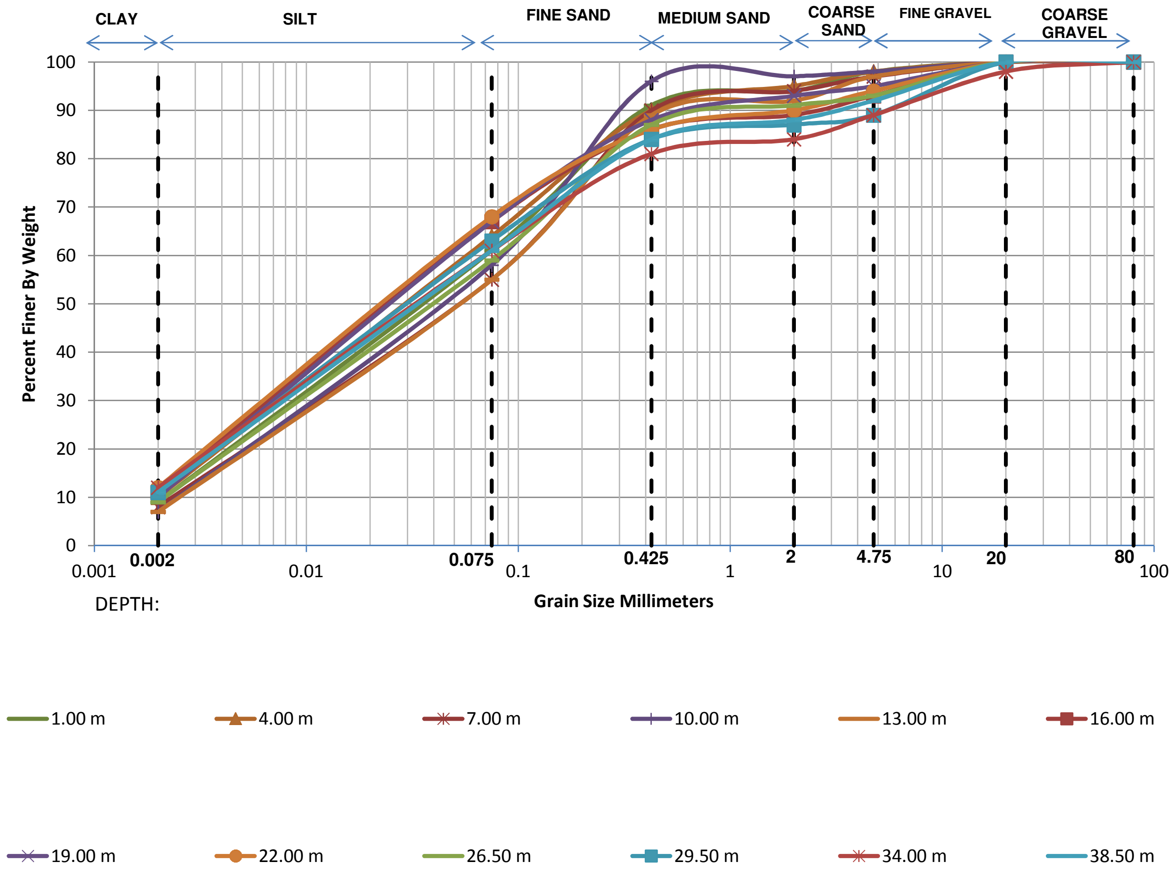
Sr. No	Chainage Old (km)	Chainage New (km)	BH No.	Depth of collected sample (m)	pH	Chlorides (Cl^-)		Sulphate (SO_3^{2-})	
						(mg/kg)	(%)	(mg/kg)	(%)
1.	27+620	28+287	BH-A1	19.00	7.93	78.34	0.0078	30.71	0.0031
2.			BH-P1	2.50	7.40	48.78	0.0049	25.81	0.0026
3.	28+075	28+743	BH-A1	2.50	7.00	57.13	0.0057	30.91	0.0031
4.			BH-P1	25.00	8.01	61.08	0.0061	21.95	0.0022
5.	28+360	29+028	BH-A1	1.00	6.85	47.45	0.0047	28.27	0.0028
6.			BH-P1	34.00	8.61	57.04	0.0057	34.12	0.0034
7.	28+900	27+567	BH-A1	17.5	7.95	63.25	0.0063	34.74	0.0035
8.			BH-P2	14.5	8.11	52.26	0.0052	31.04	0.0031

RESULT OF CHEMICAL ANALYSIS OF WATER SAMPLE

Sr. No	Chainage Old (km)	Chainage New (km)	BH No.	pH	Chlorides (Cl^-)	Sulphate (SO_3^{2-})
					(mg/l)	(mg/l)
1.	27+620	28+287	BH-A1	7.86	696.25	412.17
2.	28+075	28+743	BH-A1	7.94	526.14	346.28
3.	28+360	29+028	BH-P1	7.86	491.25	274.26
4.	28+900	29+567	BH-A1	7.63	484.16	304.18

GRAIN SIZE DISTRIBUTION CURVES

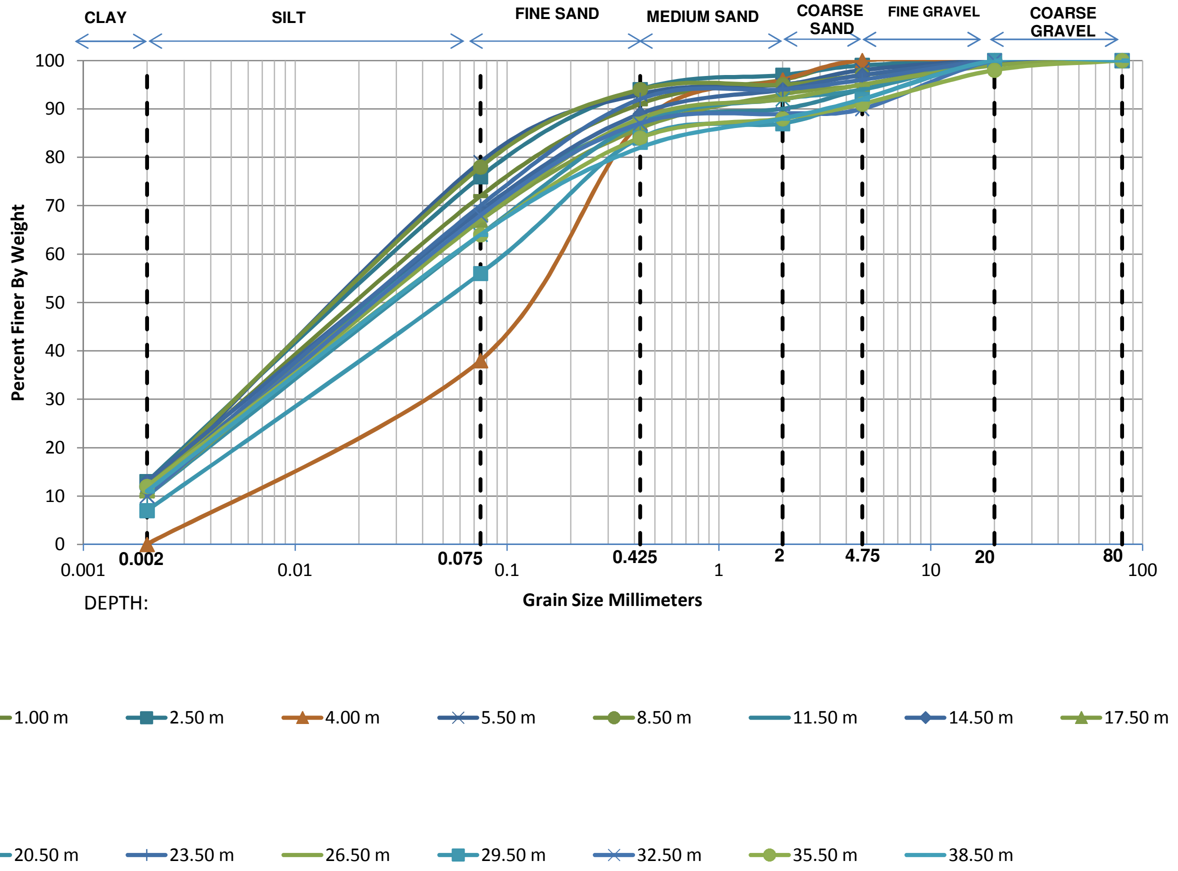
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	9.00	52.00	30.00	3.00	4.00	2.00	0.00	0.0024	0.0183	0.0725	30.19	1.92
4.00 m	10.00	54.00	26.00	5.00	3.00	2.00	0.00	0.0020	0.0159	0.0655	32.76	1.94
7.00 m	8.00	47.00	35.00	4.00	3.00	3.00	0.00	0.0030	0.0230	0.0923	31.23	1.93
10.00 m	7.00	51.00	38.00	1.00	1.00	2.00	0.00	0.0036	0.0223	0.0804	22.45	1.73
13.00 m	7.00	48.00	34.00	3.00	5.00	3.00	0.00	0.0036	0.0240	0.0925	25.52	1.72
16.00 m	11.00	56.00	19.00	3.00	4.00	7.00	0.00	-	0.0138	0.0591	-	-
19.00 m	10.00	57.00	21.00	5.00	2.00	5.00	0.00	0.0020	0.0147	0.0594	29.71	1.83
22.00 m	12.00	56.00	18.00	4.00	4.00	6.00	0.00	-	0.0126	0.0569	-	-
26.50 m	9.00	50.00	28.00	4.00	2.00	7.00	0.00	0.0024	0.0192	0.0779	32.38	1.96
29.50 m	11.00	52.00	21.00	3.00	2.00	11.00	0.00	-	0.0152	0.0675	-	-
34.00 m	12.00	49.00	20.00	3.00	5.00	9.00	2.00	-	0.0150	0.0723	-	-
38.50 m	11.00	50.00	23.00	4.00	4.00	8.00	0.00	-	0.0160	0.0724	-	-

GRAIN SIZE DISTRIBUTION CURVES

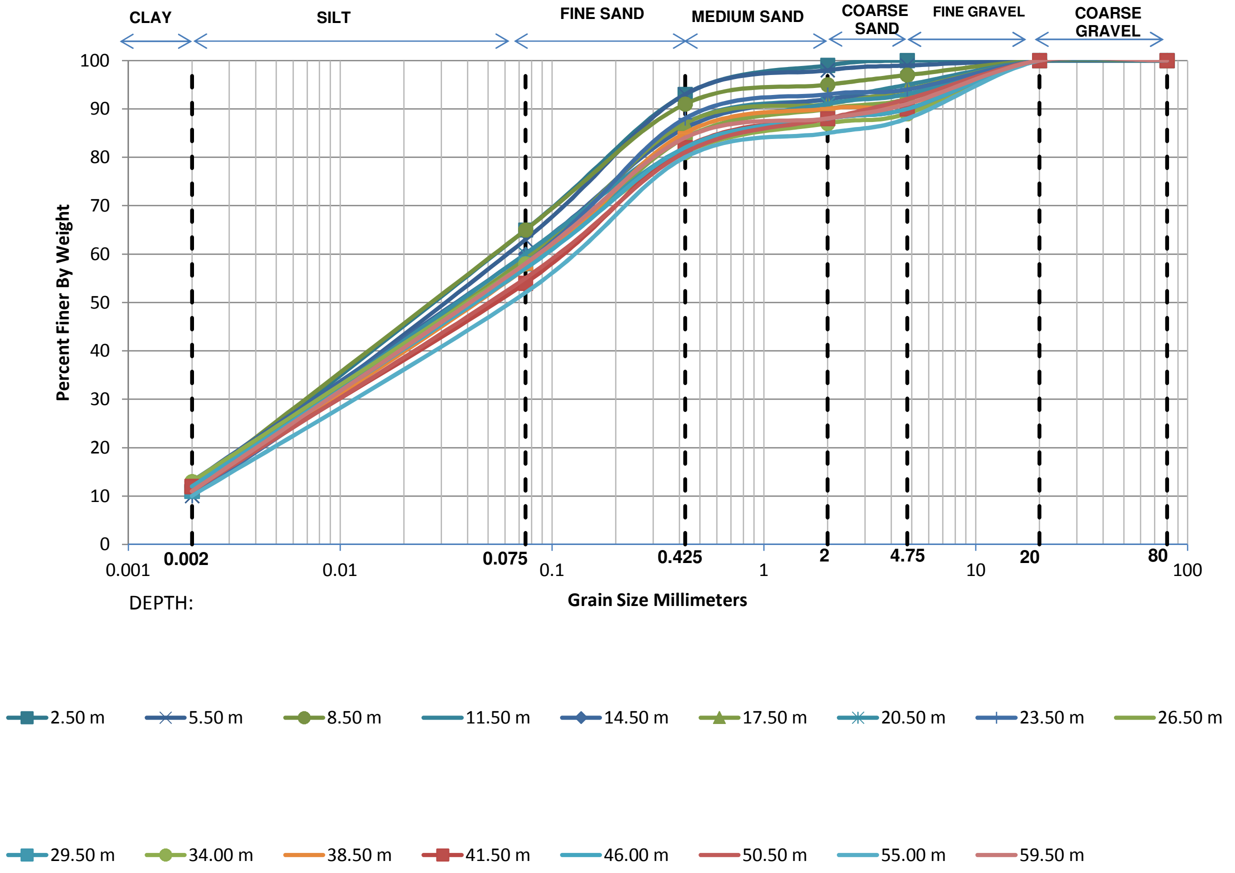
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-P1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	12.00	60.00	19.00	5.00	4.00	0.00	0.00	-	0.0117	0.0504	-	-
2.50 m	13.00	63.00	18.00	3.00	2.00	1.00	0.00	-	0.0102	0.0446	-	-
4.00 m	0.00	38.00	49.00	9.00	4.00	0.00	0.00	0.0086	0.0516	0.1688	19.55	1.82
5.50 m	11.00	68.00	14.00	2.00	3.00	2.00	0.00	-	0.0111	0.0420	-	-
8.50 m	12.00	66.00	16.00	1.00	2.00	3.00	0.00	-	0.0106	0.0427	-	-
11.50 m	11.00	58.00	18.00	3.00	4.00	6.00	0.00	-	0.0132	0.0555	-	-
14.50 m	13.00	56.00	20.00	5.00	3.00	3.00	0.00	-	0.0116	0.0549	-	-
17.50 m	12.00	55.00	19.00	7.00	2.00	5.00	0.00	-	0.0129	0.0588	-	-
20.50 m	10.00	54.00	23.00	5.00	2.00	6.00	0.00	0.0020	0.0158	0.0654	32.72	1.91
23.50 m	11.00	59.00	22.00	2.00	2.00	4.00	0.00	-	0.0131	0.0540	-	-
26.50 m	10.00	57.00	21.00	4.00	3.00	4.00	1.00	0.0020	0.0147	0.0594	29.71	1.83
29.50 m	7.00	49.00	28.00	3.00	5.00	8.00	0.00	0.0036	0.0230	0.0903	25.10	1.63
32.50 m	10.00	58.00	19.00	2.00	1.00	10.00	0.00	0.0020	0.0144	0.0575	28.77	1.79
35.50 m	12.00	52.00	20.00	4.00	3.00	7.00	2.00	-	0.0139	0.0650	-	-
38.50 m	11.00	53.00	18.00	6.00	4.00	8.00	0.00	-	0.0147	0.0651	-	-

GRAIN SIZE DISTRIBUTION CURVES

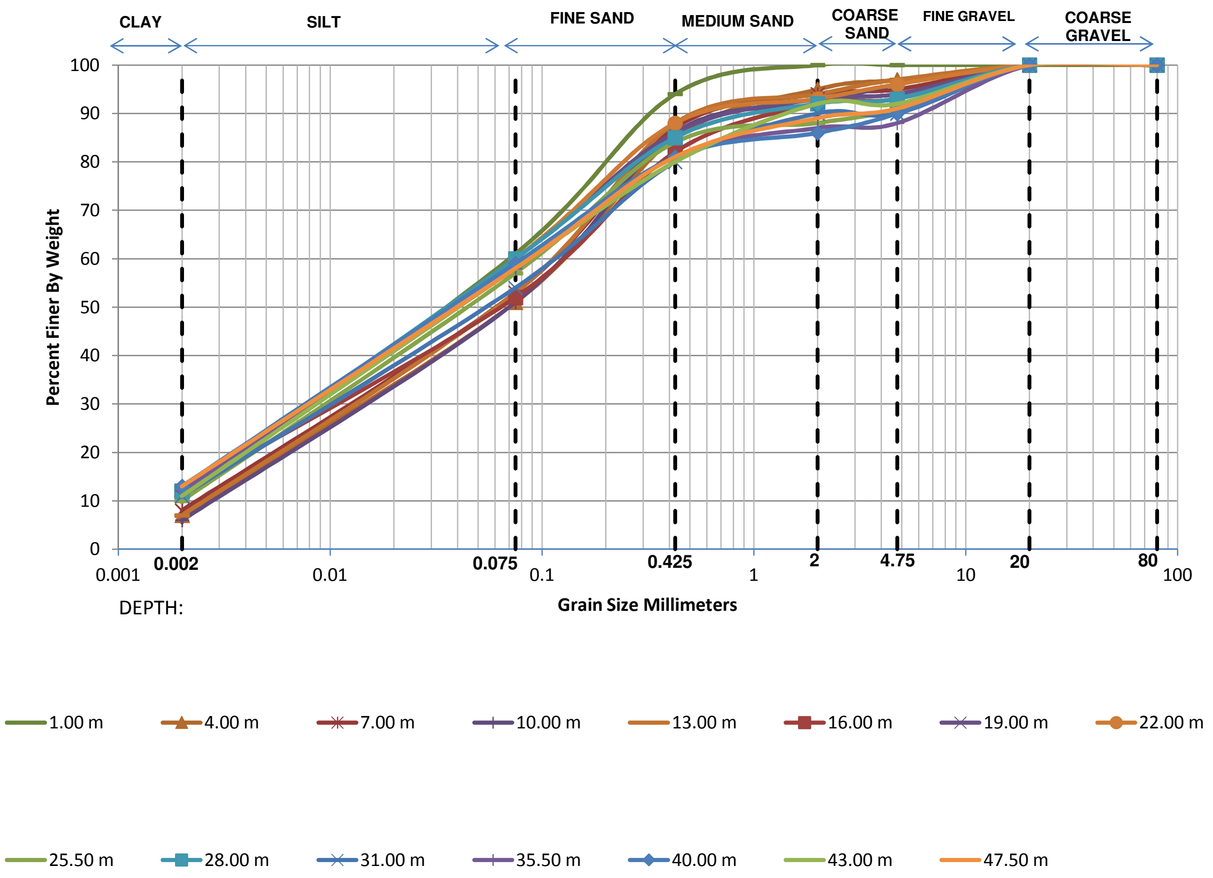
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-P3



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	11.00	54.00	28.00	6.00	1.00	0.00	0.00	-	0.0147	0.0633	-	-
5.50 m	10.00	53.00	30.00	5.00	1.00	1.00	0.00	0.0020	0.0165	0.0678	33.90	2.00
8.50 m	12.00	53.00	26.00	4.00	2.00	3.00	0.00	-	0.0138	0.0631	-	-
11.50 m	11.00	48.00	28.00	5.00	3.00	5.00	0.00	-	0.0172	0.0780	-	-
14.50 m	13.00	47.00	26.00	6.00	1.00	7.00	0.00	-	0.0148	0.0750	-	-
17.50 m	12.00	47.00	28.00	4.00	3.00	6.00	0.00	-	0.0162	0.0780	-	-
20.50 m	11.00	49.00	24.00	7.00	2.00	7.00	0.00	-	0.0165	0.0750	-	-
23.50 m	10.00	48.00	30.00	5.00	1.00	6.00	0.00	0.0020	0.0188	0.0813	40.67	2.17
26.50 m	12.00	45.00	27.00	6.00	2.00	8.00	0.00	-	0.0172	0.0865	-	-
29.50 m	11.00	47.00	24.00	6.00	2.00	10.00	0.00	-	0.0175	0.0824	-	-
34.00 m	13.00	45.00	23.00	6.00	2.00	11.00	0.00	-	0.0155	0.0828	-	-
38.50 m	11.00	46.00	28.00	5.00	1.00	9.00	0.00	-	0.0182	0.0860	-	-
41.50 m	12.00	42.00	28.00	6.00	2.00	10.00	0.00	-	0.0191	0.1035	-	-
46.00 m	12.00	45.00	25.00	6.00	2.00	10.00	0.00	-	0.0171	0.0872	-	-
50.50 m	11.00	44.00	26.00	7.00	4.00	8.00	0.00	-	0.0193	0.0988	-	-
55.00 m	10.00	42.00	28.00	5.00	3.00	12.00	0.00	0.0020	0.0226	0.1176	58.79	2.18
59.50 m	11.00	47.00	26.00	4.00	3.00	9.00	0.00	-	0.0176	0.0819	-	-

GRAIN SIZE DISTRIBUTION CURVES

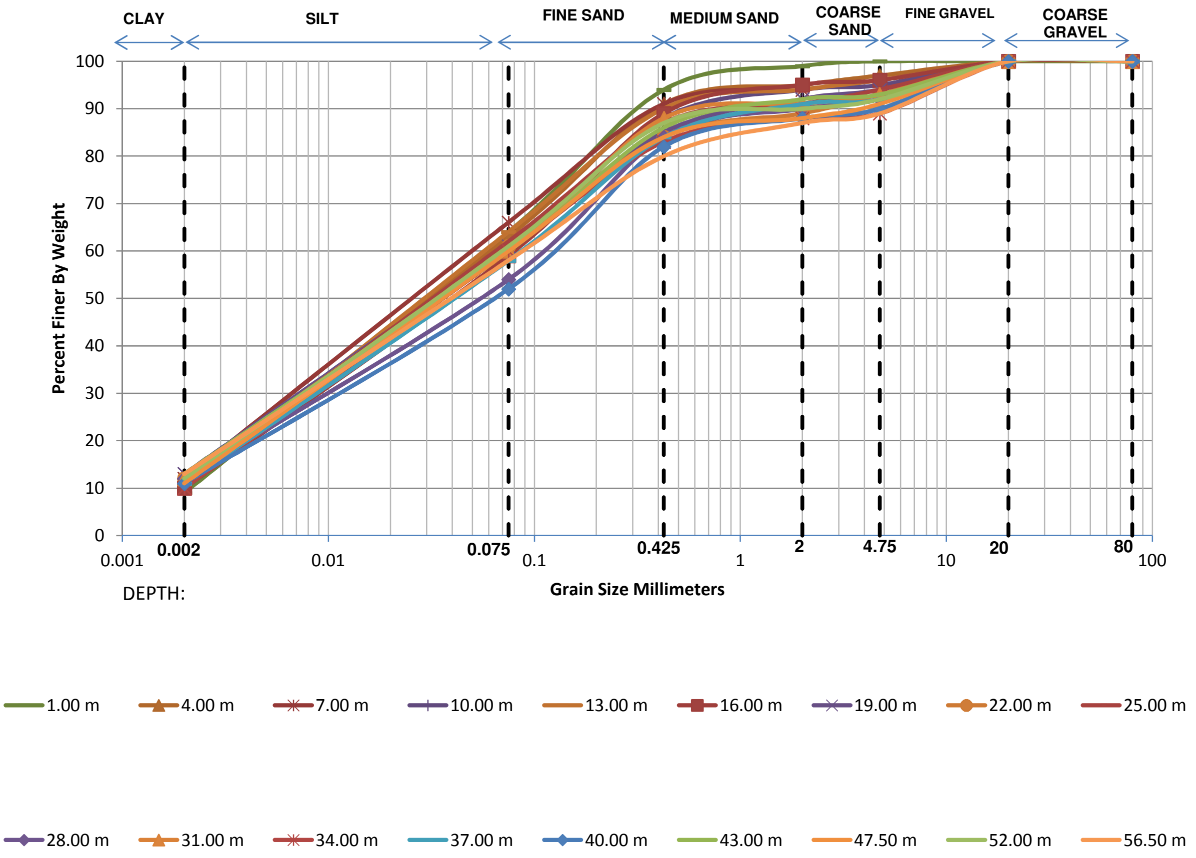
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-P4



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	11.00	50.00	33.00	6.00	0.00	0.00	0.00	-	0.0165	0.0725	-	-
4.00 m	7.00	44.00	34.00	10.00	2.00	3.00	0.00	0.0037	0.0271	0.1156	31.28	1.72
7.00 m	8.00	45.00	34.00	7.00	1.00	5.00	0.00	0.0030	0.0244	0.1032	34.73	1.93
10.00 m	6.00	45.00	35.00	6.00	4.00	4.00	0.00	0.0046	0.0284	0.1133	24.84	1.56
13.00 m	7.00	46.00	35.00	6.00	3.00	3.00	0.00	0.0037	0.0255	0.1021	27.90	1.75
16.00 m	12.00	40.00	30.00	10.00	1.00	7.00	0.00	-	0.0206	0.1160	-	-
19.00 m	11.00	49.00	26.00	7.00	1.00	6.00	0.00	-	0.0166	0.0750	-	-
22.00 m	11.00	49.00	28.00	5.00	3.00	4.00	0.00	-	0.0167	0.0750	-	-
25.50 m	10.00	47.00	27.00	4.00	3.00	9.00	0.00	0.0020	0.0192	0.0861	43.07	2.14
28.00 m	12.00	48.00	25.00	7.00	1.00	7.00	0.00	-	0.0156	0.0750	-	-
31.00 m	11.00	43.00	26.00	10.00	0.00	10.00	0.00	-	0.0200	0.1066	-	-
35.50 m	12.00	46.00	23.00	6.00	1.00	12.00	0.00	-	0.0165	0.0827	-	-
40.00 m	13.00	46.00	22.00	5.00	4.00	10.00	0.00	-	0.0150	0.0784	-	-
43.00 m	11.00	47.00	22.00	12.00	0.00	8.00	0.00	-	0.0174	0.0831	-	-
47.50 m	13.00	45.00	23.00	8.00	2.00	9.00	0.00	-	0.0155	0.0829	-	-

GRAIN SIZE DISTRIBUTION CURVES

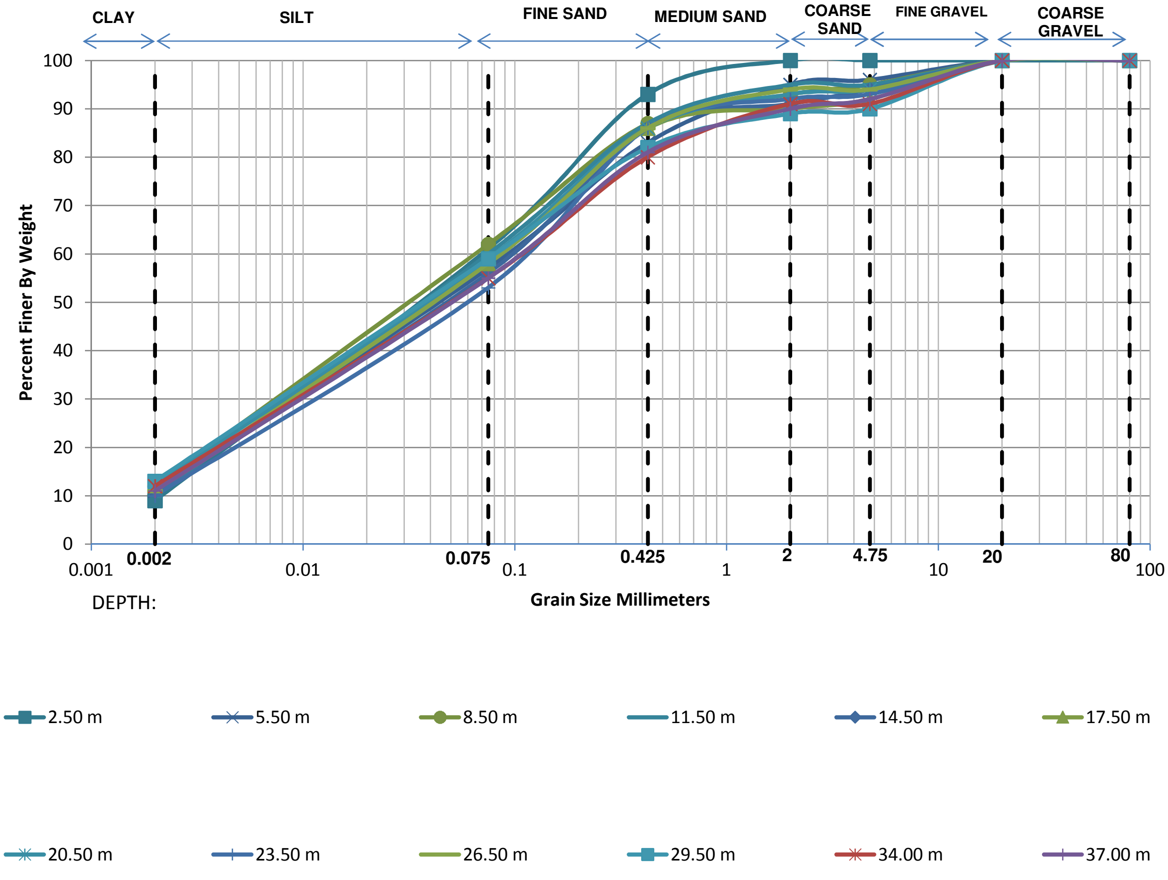
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-P2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	9.00	55.00	30.00	5.00	1.00	0.00	0.00	0.0024	0.0170	0.0658	27.46	1.84
4.00 m	11.00	52.00	28.00	4.00	2.00	3.00	0.00	-	0.0155	0.0676	-	-
7.00 m	12.00	54.00	25.00	3.00	2.00	4.00	0.00	-	0.0134	0.0610	-	-
10.00 m	11.00	50.00	27.00	6.00	1.00	5.00	0.00	-	0.0162	0.0724	-	-
13.00 m	10.00	54.00	26.00	4.00	2.00	4.00	0.00	0.0020	0.0159	0.0655	32.76	1.94
16.00 m	10.00	49.00	30.00	6.00	1.00	4.00	0.00	0.0020	0.0183	0.0779	38.94	2.14
19.00 m	13.00	48.00	24.00	7.00	2.00	6.00	0.00	-	0.0143	0.0723	-	-
22.00 m	12.00	49.00	23.00	5.00	4.00	7.00	0.00	-	0.0151	0.0723	-	-
25.00 m	11.00	51.00	25.00	4.00	3.00	6.00	0.00	-	0.0157	0.0699	-	-
28.00 m	12.00	42.00	30.00	6.00	2.00	8.00	0.00	-	0.0192	0.1016	-	-
31.00 m	12.00	48.00	28.00	3.00	2.00	7.00	0.00	-	0.0158	0.0750	-	-
34.00 m	10.00	50.00	23.00	5.00	1.00	11.00	0.00	0.0020	0.0174	0.0750	37.50	2.03
37.00 m	11.00	47.00	26.00	7.00	1.00	8.00	0.00	-	0.0176	0.0820	-	-
40.00 m	11.00	41.00	30.00	6.00	2.00	10.00	0.00	-	0.0217	0.1147	-	-
43.00 m	13.00	47.00	26.00	6.00	1.00	7.00	0.00	-	0.0148	0.0750	-	-
47.50 m	11.00	49.00	24.00	4.00	3.00	9.00	0.00	-	0.0165	0.0750	-	-
52.00 m	12.00	49.00	26.00	3.00	2.00	8.00	0.00	-	0.0153	0.0723	-	-
56.50 m	13.00	45.00	22.00	7.00	2.00	11.00	0.00	-	0.0155	0.0831	-	-

GRAIN SIZE DISTRIBUTION CURVES

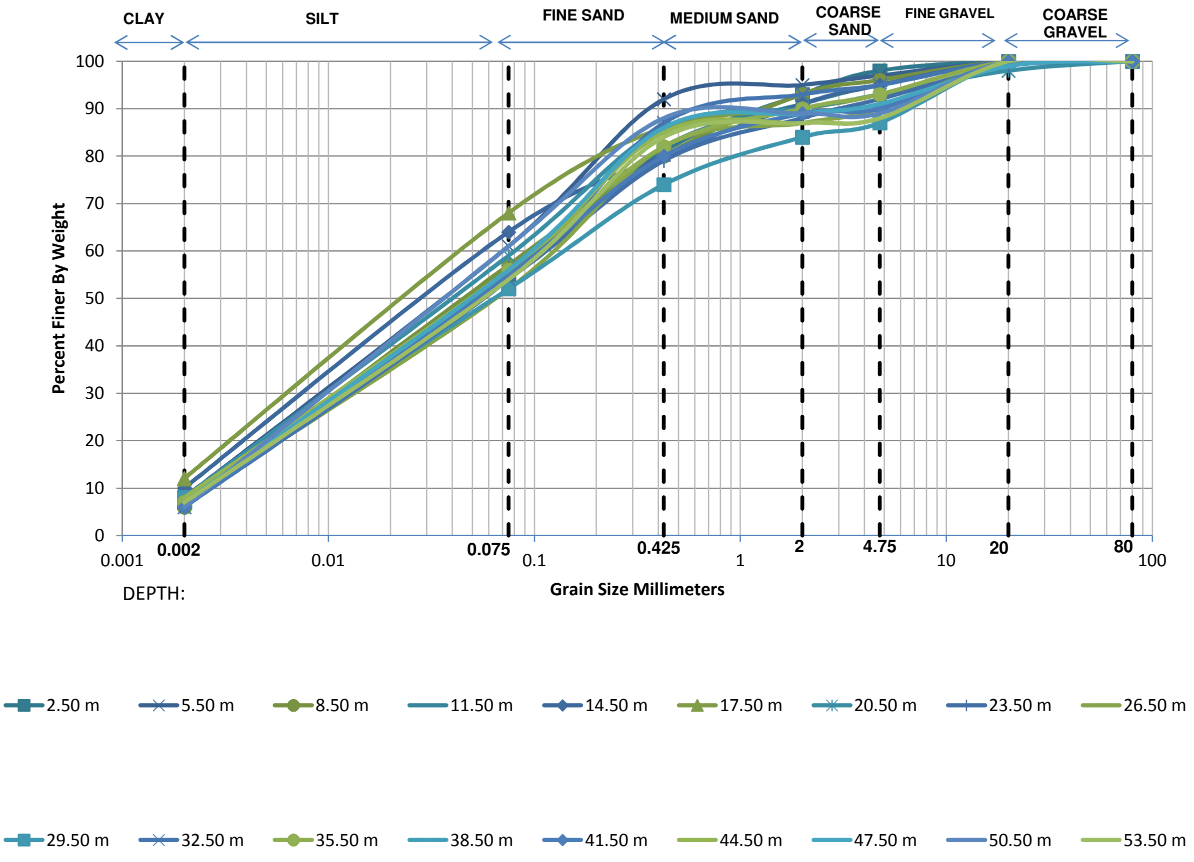
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	9.00	52.00	32.00	7.00	0.00	0.00	0.00	0.0024	0.0184	0.0725	30.20	1.94
5.50 m	11.00	46.00	26.00	12.00	1.00	4.00	0.00	-	0.0181	0.0871	-	-
8.50 m	12.00	50.00	25.00	6.00	2.00	5.00	0.00	-	0.0148	0.0698	-	-
11.50 m	10.00	50.00	27.00	8.00	0.00	5.00	0.00	0.0020	0.0176	0.0750	37.50	2.07
14.50 m	11.00	45.00	30.00	5.00	3.00	6.00	0.00	-	0.0189	0.0902	-	-
17.50 m	13.00	45.00	28.00	4.00	2.00	8.00	0.00	-	0.0158	0.0818	-	-
20.50 m	12.00	47.00	27.00	7.00	1.00	6.00	0.00	-	0.0162	0.0781	-	-
23.50 m	10.00	43.00	33.00	6.00	1.00	7.00	0.00	0.0020	0.0222	0.1044	52.22	2.35
26.50 m	11.00	47.00	28.00	8.00	0.00	6.00	0.00	-	0.0177	0.0817	-	-
29.50 m	13.00	46.00	23.00	7.00	1.00	10.00	0.00	-	0.0151	0.0784	-	-
34.00 m	12.00	43.00	25.00	11.00	0.00	9.00	0.00	-	0.0182	0.1007	-	-
37.00 m	11.00	44.00	26.00	9.00	2.00	8.00	0.00	-	0.0193	0.0991	-	-

GRAIN SIZE DISTRIBUTION CURVES

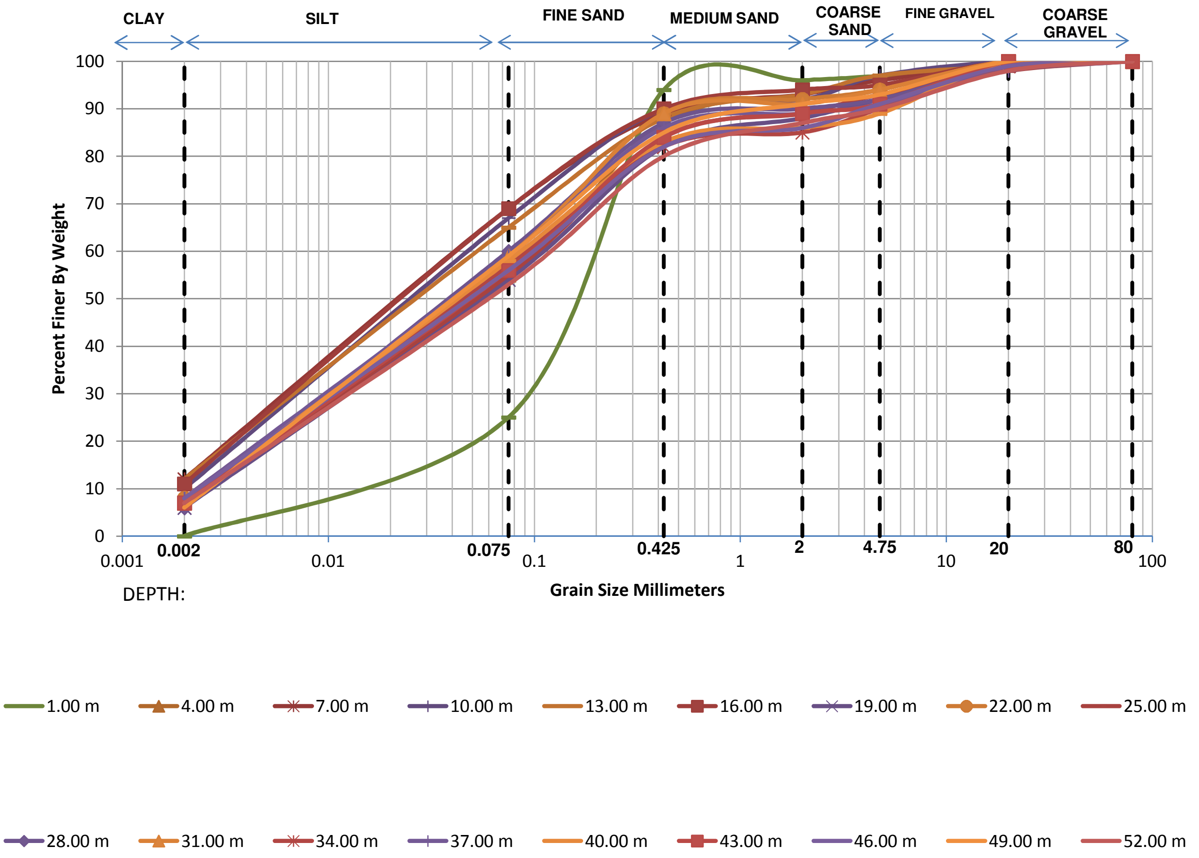
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+075 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	7.00	48.00	26.00	12.00	5.00	2.00	0.00	0.0036	0.0235	0.0988	27.39	1.55
5.50 m	8.00	53.00	31.00	3.00	2.00	3.00	0.00	0.0029	0.0194	0.0726	24.94	1.78
8.50 m	6.00	51.00	23.00	13.00	3.00	4.00	0.00	0.0044	0.0233	0.0880	20.21	1.41
11.50 m	7.00	49.00	26.00	9.00	4.00	5.00	0.00	0.0036	0.0229	0.0920	25.60	1.59
14.50 m	10.00	54.00	16.00	11.00	4.00	5.00	0.00	0.0020	0.0155	0.0652	32.61	1.84
17.50 m	12.00	56.00	18.00	4.00	3.00	7.00	0.00	-	0.0126	0.0569	-	-
20.50 m	8.00	51.00	27.00	4.00	3.00	5.00	2.00	0.0029	0.0201	0.0779	26.68	1.78
23.50 m	6.00	48.00	25.00	9.00	4.00	7.00	1.00	0.0044	0.0253	0.1069	24.11	1.35
26.50 m	7.00	45.00	30.00	5.00	3.00	10.00	0.00	0.0037	0.0260	0.1134	30.93	1.63
29.50 m	8.00	44.00	22.00	10.00	3.00	13.00	0.00	0.0030	0.0244	0.1364	45.93	1.47
32.50 m	6.00	48.00	33.00	6.00	2.00	5.00	0.00	0.0045	0.0258	0.0980	21.96	1.52
35.50 m	7.00	49.00	26.00	8.00	3.00	7.00	0.00	0.0036	0.0229	0.0919	25.57	1.59
38.50 m	7.00	49.00	30.00	3.00	2.00	8.00	1.00	0.0036	0.0231	0.0894	24.84	1.66
41.50 m	6.00	49.00	25.00	9.00	1.00	10.00	0.00	0.0044	0.0246	0.0993	22.51	1.39
44.50 m	8.00	48.00	29.00	2.00	1.00	12.00	0.00	0.0029	0.0220	0.0899	30.54	1.82
47.50 m	7.00	49.00	30.00	3.00	2.00	8.00	1.00	0.0036	0.0231	0.0894	24.84	1.66
50.50 m	6.00	55.00	27.00	1.00	0.00	11.00	0.00	0.0043	0.0214	0.0726	16.95	1.47
53.50 m	7.00	47.00	30.00	3.00	1.00	12.00	0.00	0.0036	0.0245	0.1000	27.54	1.65

GRAIN SIZE DISTRIBUTION CURVES

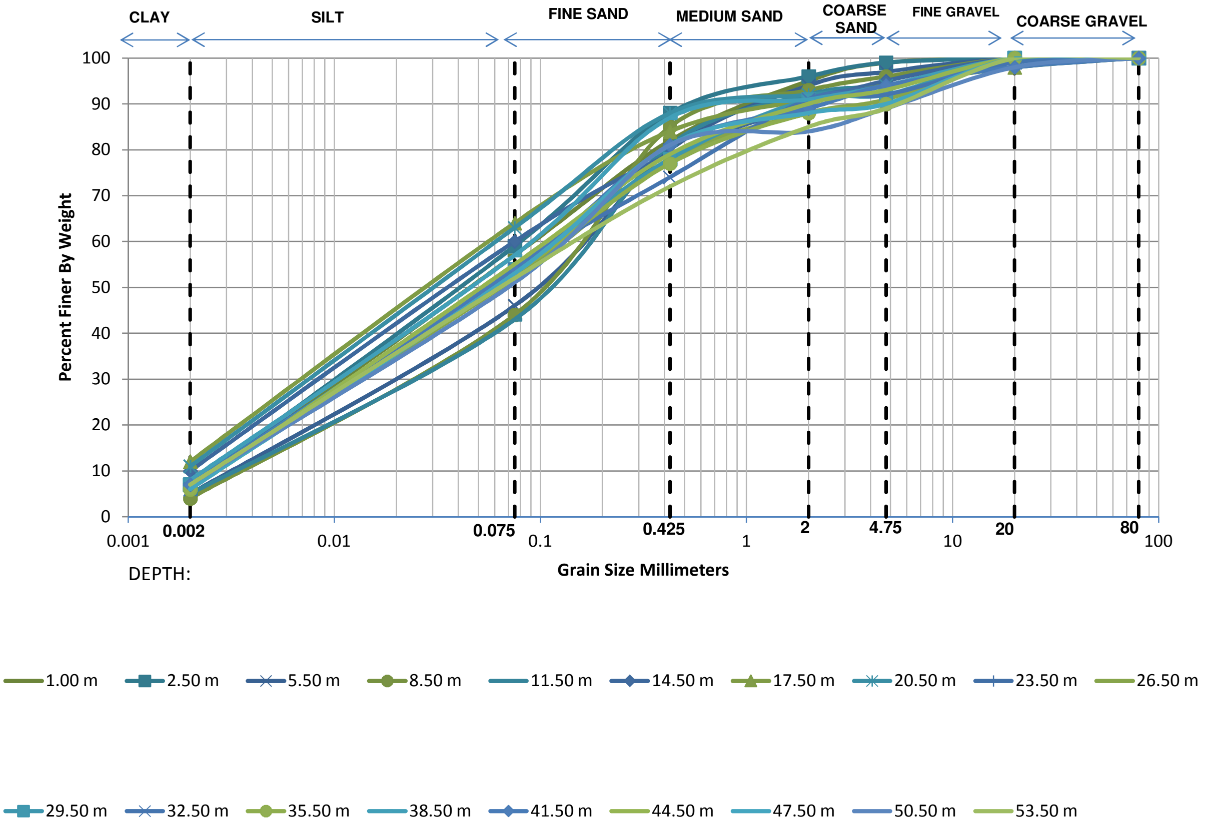
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+075 Major Bridge
B.H. No.	BH-P1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	0.00	25.00	69.00	2.00	1.00	3.00	0.00	0.0188	0.0928	0.1971	10.48	2.32
4.00 m	7.00	48.00	32.00	6.00	3.00	4.00	0.00	0.0036	0.0239	0.0936	25.87	1.68
7.00 m	12.00	57.00	20.00	4.00	3.00	3.00	1.00	-	0.0124	0.0552	-	-
10.00 m	10.00	57.00	23.00	2.00	5.00	3.00	0.00	0.0020	0.0148	0.0595	29.75	1.84
13.00 m	12.00	53.00	23.00	5.00	4.00	2.00	1.00	-	0.0137	0.0629	-	-
16.00 m	11.00	58.00	21.00	4.00	1.00	5.00	0.00	-	0.0133	0.0556	-	-
19.00 m	6.00	48.00	28.00	6.00	4.00	7.00	1.00	0.0044	0.0255	0.1023	23.00	1.43
22.00 m	8.00	51.00	30.00	3.00	2.00	6.00	0.00	0.0029	0.0203	0.0778	26.62	1.81
25.00 m	7.00	48.00	29.00	5.00	4.00	5.00	2.00	0.0036	0.0237	0.0953	26.37	1.63
28.00 m	6.00	54.00	27.00	3.00	2.00	7.00	1.00	0.0043	0.0219	0.0750	17.42	1.48
31.00 m	7.00	52.00	30.00	2.00	3.00	6.00	0.00	0.0036	0.0214	0.0777	21.86	1.65
34.00 m	7.00	50.00	25.00	3.00	5.00	9.00	1.00	0.0036	0.0222	0.0864	24.16	1.60
37.00 m	8.00	51.00	27.00	3.00	2.00	7.00	2.00	0.0029	0.0201	0.0779	26.68	1.79
40.00 m	7.00	51.00	25.00	3.00	3.00	11.00	0.00	0.0036	0.0217	0.0817	22.95	1.61
43.00 m	7.00	49.00	28.00	5.00	2.00	9.00	0.00	0.0036	0.0230	0.0904	25.15	1.63
46.00 m	8.00	48.00	26.00	4.00	5.00	8.00	1.00	0.0029	0.0218	0.0916	31.15	1.76
49.00 m	6.00	53.00	26.00	6.00	2.00	7.00	0.00	0.0043	0.0223	0.0779	18.02	1.48
52.00 m	7.00	46.00	27.00	7.00	3.00	8.00	2.00	0.0036	0.0250	0.1113	30.55	1.54

GRAIN SIZE DISTRIBUTION CURVES

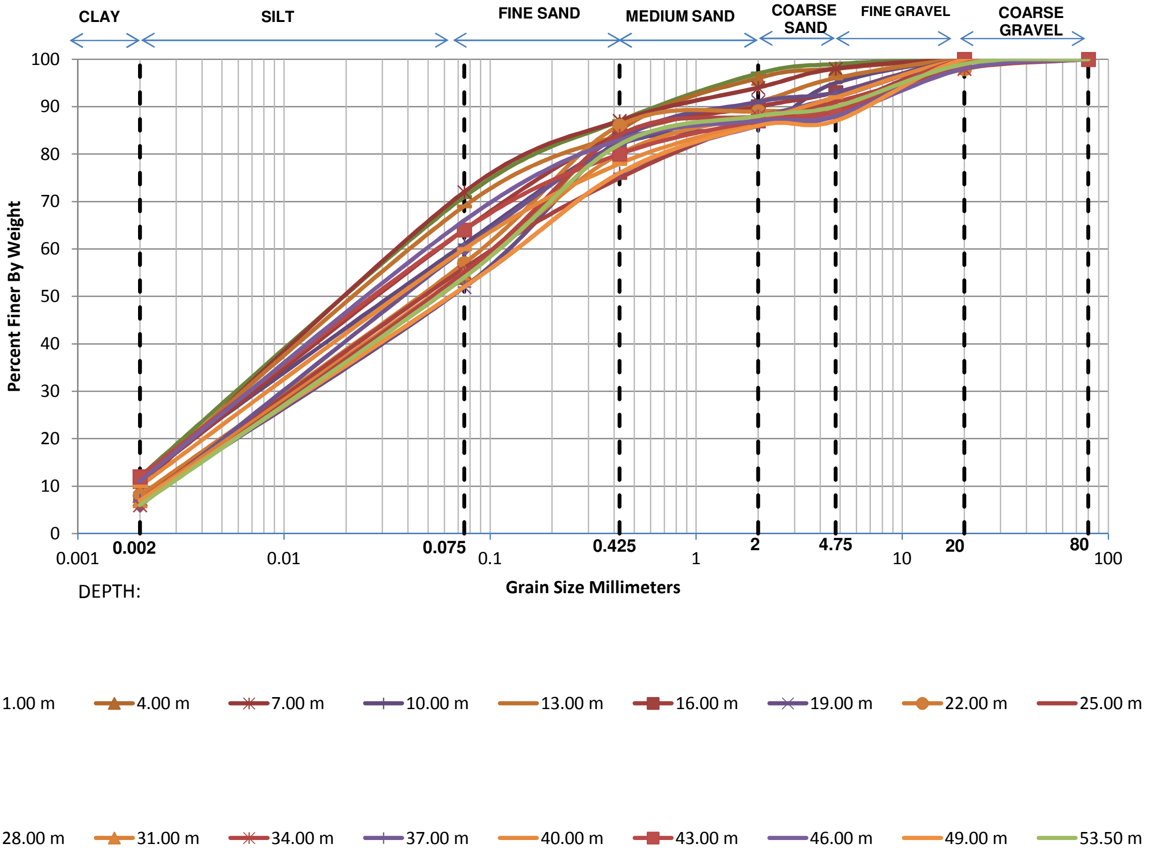
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+075 Major Bridge
B.H. No.	BH-P2



Depth	**Grain Size Distribution % wt retained**							**D10**	**D30**	**D60**	**Cu**	**Cc**
	Clay	**Silt**	**Sand**			**Gravel**						
			Fine	**Medium**	**Coarse**	**Fine**	**Coarse**					
1.00 m	6.00	51.00	25.00	13.00	4.00	1.00	0.00	0.0044	0.0234	0.0870	19.94	1.44
2.50 m	7.00	52.00	29.00	8.00	3.00	1.00	0.00	0.0036	0.0213	0.0778	21.88	1.65
5.50 m	5.00	41.00	34.00	14.00	3.00	3.00	0.00	0.0059	0.0348	0.1549	26.32	1.32
8.50 m	4.00	40.00	41.00	8.00	3.00	4.00	0.00	0.0075	0.0391	0.1489	19.75	1.37
11.50 m	5.00	38.00	38.00	11.00	2.00	4.00	2.00	0.0061	0.0393	0.1662	27.08	1.51
14.50 m	10.00	50.00	19.00	11.00	5.00	5.00	0.00	0.0020	0.0172	0.0750	37.50	1.98
17.50 m	12.00	52.00	20.00	7.00	3.00	4.00	2.00	-	0.0139	0.0650	-	-
20.50 m	11.00	52.00	25.00	4.00	2.00	6.00	0.00	-	0.0153	0.0676	-	-
23.50 m	8.00	45.00	25.00	13.00	3.00	6.00	0.00	0.0030	0.0238	0.1171	39.50	1.63
26.50 m	7.00	45.00	26.00	10.00	3.00	9.00	0.00	0.0037	0.0257	0.1229	33.57	1.47
29.50 m	7.00	47.00	24.00	13.00	1.00	8.00	0.00	0.0036	0.0241	0.1099	30.35	1.46
32.50 m	6.00	48.00	20.00	17.00	1.00	7.00	1.00	0.0044	0.0250	0.1217	27.55	1.16
35.50 m	6.00	47.00	24.00	11.00	2.00	10.00	0.00	0.0045	0.0260	0.1185	26.58	1.28
38.50 m	8.00	49.00	30.00	4.00	3.00	6.00	0.00	0.0029	0.0214	0.0851	28.99	1.83
41.50 m	7.00	47.00	27.00	8.00	5.00	4.00	2.00	0.0036	0.0243	0.1040	28.69	1.56
44.50 m	6.00	49.00	24.00	11.00	3.00	7.00	0.00	0.0044	0.0246	0.1009	22.89	1.36
47.50 m	6.00	47.00	28.00	7.00	2.00	10.00	0.00	0.0045	0.0262	0.1095	24.47	1.41
50.50 m	7.00	44.00	30.00	3.00	5.00	9.00	2.00	0.0037	0.0269	0.1203	32.61	1.63
53.50 m	7.00	45.00	20.00	13.00	4.00	11.00	0.00	0.0036	0.0253	0.1480	40.61	1.19

GRAIN SIZE DISTRIBUTION CURVES

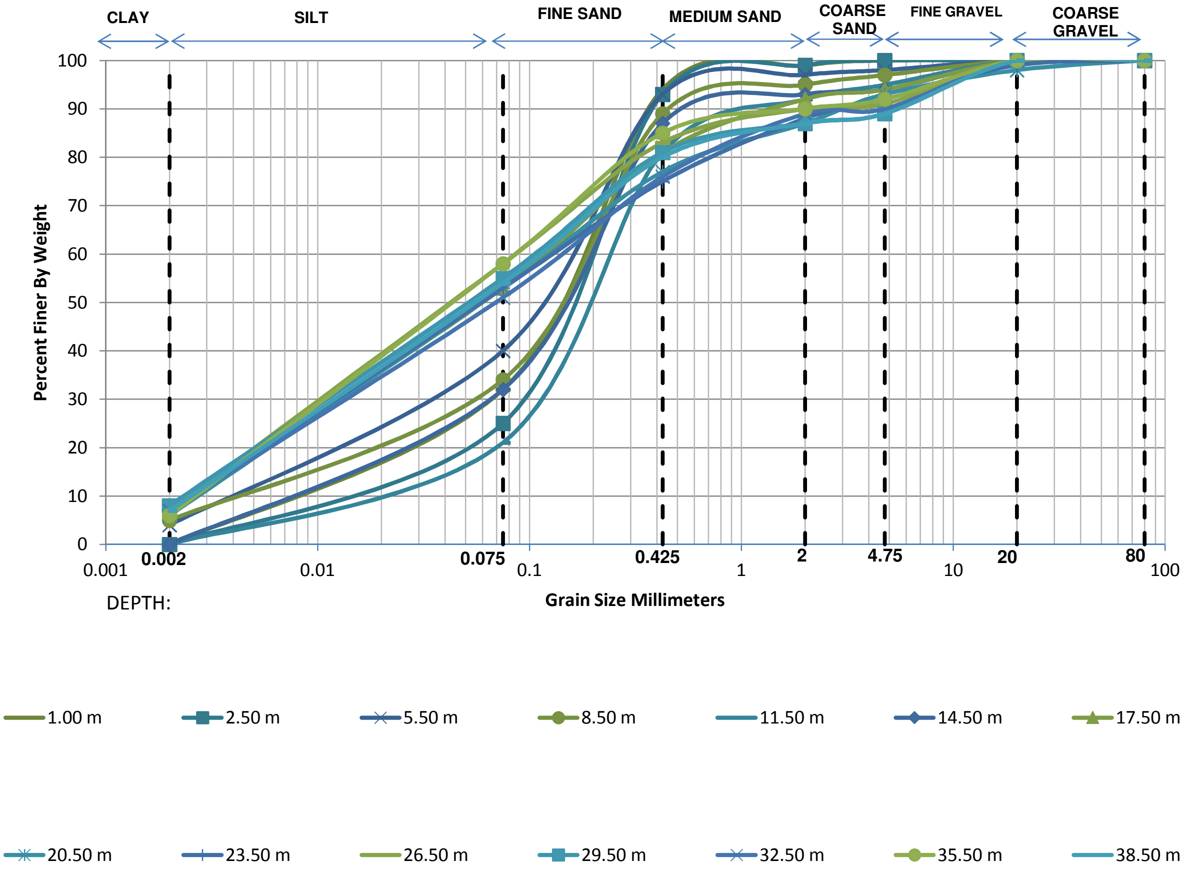
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+075 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	12.00	59.00	16.00	10.00	2.00	1.00	0.00	-	0.0119	0.0518	-	-
4.00 m	8.00	46.00	31.00	11.00	2.00	2.00	0.00	0.0030	0.0234	0.1005	33.95	1.84
7.00 m	10.00	62.00	15.00	7.00	4.00	2.00	0.00	0.0020	0.0132	0.0510	25.50	1.72
10.00 m	12.00	49.00	21.00	4.00	9.00	5.00	0.00	-	0.0150	0.0723	-	-
13.00 m	11.00	58.00	15.00	7.00	5.00	4.00	0.00	-	0.0131	0.0553	-	-
16.00 m	11.00	53.00	20.00	6.00	3.00	7.00	0.00	-	0.0148	0.0652	-	-
19.00 m	7.00	45.00	31.00	8.00	2.00	7.00	0.00	0.0037	0.0261	0.1127	30.70	1.65
22.00 m	8.00	49.00	29.00	3.00	0.00	9.00	2.00	0.0029	0.0214	0.0853	29.06	1.82
25.00 m	7.00	49.00	19.00	12.00	3.00	10.00	0.00	0.0036	0.0225	0.1004	28.05	1.40
28.00 m	6.00	54.00	22.00	6.00	4.00	8.00	0.00	0.0043	0.0216	0.0750	17.47	1.45
31.00 m	7.00	48.00	25.00	8.00	2.00	9.00	1.00	0.0036	0.0235	0.0993	27.53	1.54
34.00 m	6.00	49.00	29.00	4.00	3.00	7.00	2.00	0.0044	0.0249	0.0950	21.48	1.47
37.00 m	7.00	45.00	24.00	10.00	2.00	12.00	0.00	0.0037	0.0256	0.1287	35.20	1.39
40.00 m	10.00	50.00	18.00	9.00	5.00	8.00	0.00	0.0020	0.0172	0.0750	37.50	1.97
43.00 m	12.00	52.00	16.00	7.00	2.00	11.00	0.00	-	0.0137	0.0649	-	-
46.00 m	11.00	55.00	17.00	4.00	1.00	10.00	2.00	-	0.0140	0.0609	-	-
49.00 m	7.00	45.00	24.00	10.00	1.00	13.00	0.00	0.0037	0.0256	0.1287	35.20	1.39
53.50 m	6.00	48.00	28.00	6.00	2.00	9.00	1.00	0.0044	0.0255	0.1023	23.00	1.43

GRAIN SIZE DISTRIBUTION CURVES

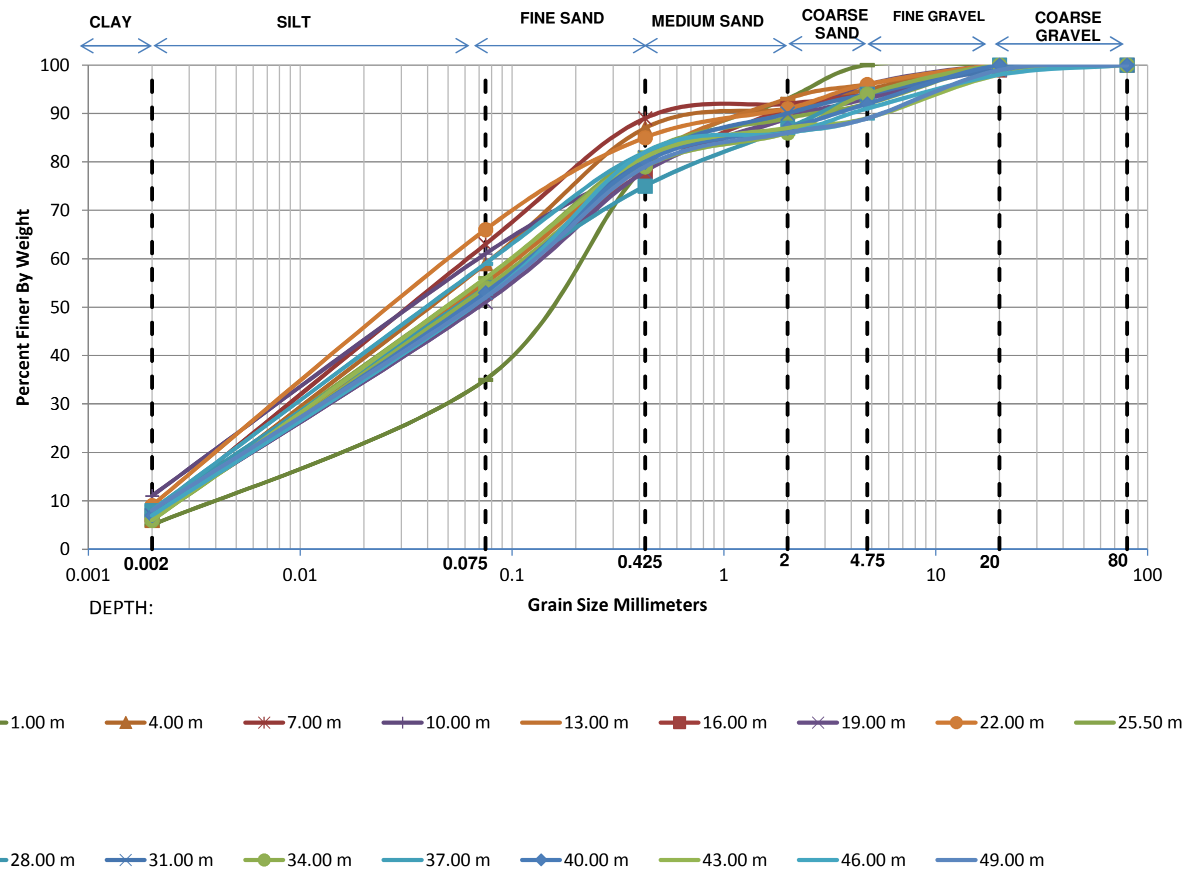
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+360 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	0.00	32.00	62.00	5.00	1.00	0.00	0.00	0.0120	0.0685	0.1751	14.65	2.24
2.50 m	0.00	25.00	68.00	6.00	1.00	0.00	0.00	0.0188	0.0930	0.2002	10.67	2.30
5.50 m	4.00	36.00	53.00	4.00	1.00	2.00	0.00	0.0082	0.0467	0.1499	18.36	1.78
8.50 m	5.00	29.00	55.00	6.00	2.00	3.00	0.00	0.0076	0.0608	0.1812	24.00	2.70
11.50 m	0.00	21.00	60.00	11.00	3.00	5.00	0.00	0.0250	0.1117	0.2477	9.90	2.01
14.50 m	0.00	32.00	55.00	6.00	1.00	6.00	0.00	0.0117	0.0683	0.1905	16.26	2.09
17.50 m	7.00	46.00	28.00	11.00	2.00	6.00	0.00	0.0036	0.0251	0.1106	30.34	1.56
20.50 m	6.00	47.00	24.00	10.00	6.00	5.00	2.00	0.0045	0.0260	0.1182	26.51	1.28
23.50 m	7.00	46.00	22.00	13.00	4.00	7.00	1.00	0.0036	0.0247	0.1254	34.53	1.34
26.50 m	7.00	51.00	25.00	7.00	1.00	9.00	0.00	0.0036	0.0217	0.0819	22.98	1.61
29.50 m	8.00	47.00	26.00	6.00	2.00	11.00	0.00	0.0029	0.0224	0.0980	33.26	1.74
32.50 m	7.00	44.00	25.00	13.00	1.00	10.00	0.00	0.0037	0.0265	0.1373	37.35	1.39
35.50 m	6.00	52.00	27.00	5.00	2.00	8.00	0.00	0.0043	0.0229	0.0814	18.73	1.49
38.50 m	7.00	47.00	26.00	7.00	2.00	11.00	0.00	0.0036	0.0242	0.1051	29.01	1.54

GRAIN SIZE DISTRIBUTION CURVES

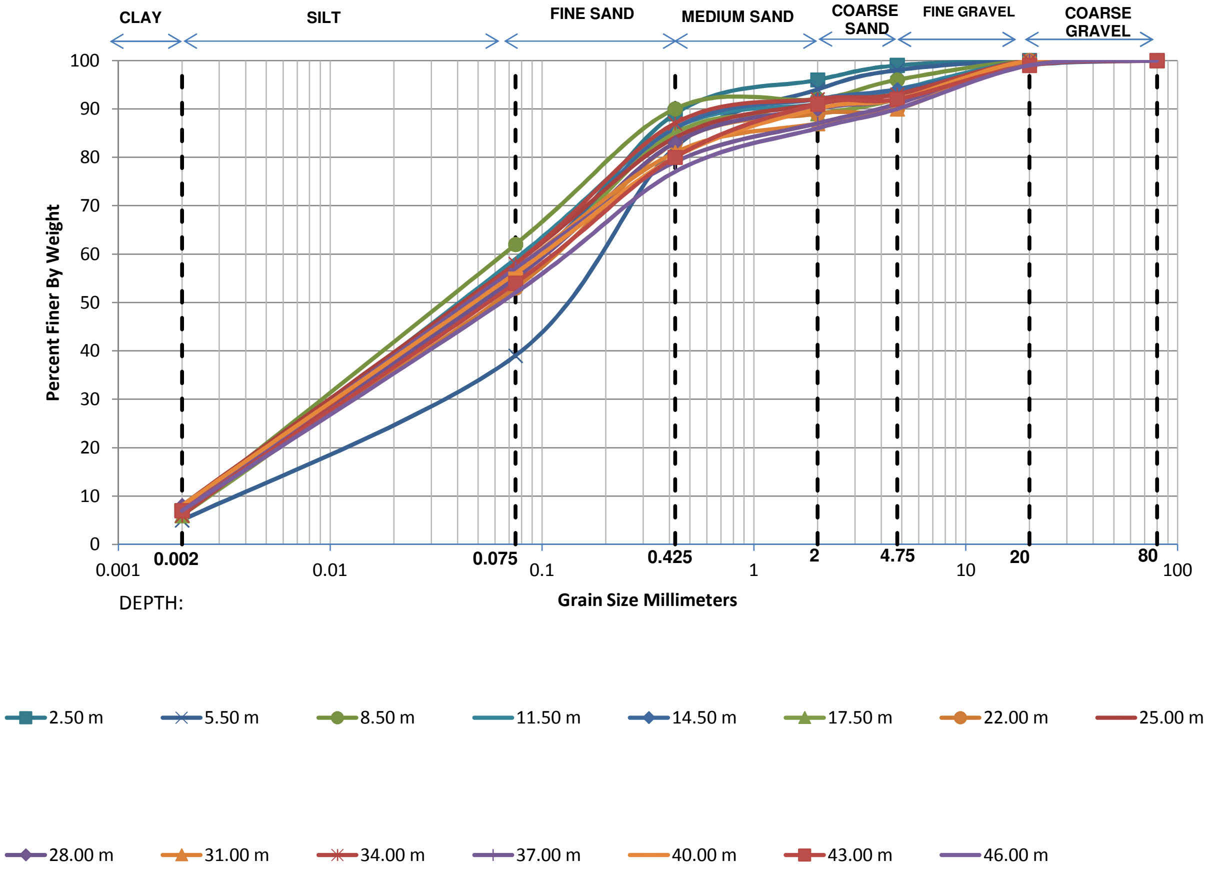
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+360 Major Bridge
B.H. No.	BH-P1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	5.00	30.00	44.00	14.00	7.00	0.00	0.00	0.0072	0.0571	0.2118	29.40	2.14
4.00 m	6.00	53.00	28.00	4.00	4.00	5.00	0.00	0.0043	0.0225	0.0778	17.97	1.50
7.00 m	7.00	56.00	26.00	3.00	2.00	6.00	0.00	0.0035	0.0193	0.0681	19.43	1.57
10.00 m	11.00	50.00	18.00	10.00	7.00	4.00	0.00	-	0.0158	0.0723	-	-
13.00 m	6.00	49.00	26.00	12.00	3.00	4.00	0.00	0.0044	0.0247	0.0986	22.35	1.40
16.00 m	7.00	46.00	25.00	13.00	3.00	5.00	1.00	0.0036	0.0249	0.1169	32.12	1.46
19.00 m	7.00	44.00	27.00	11.00	4.00	7.00	0.00	0.0037	0.0267	0.1300	35.31	1.49
22.00 m	9.00	57.00	19.00	6.00	5.00	4.00	0.00	0.0024	0.0159	0.0615	25.70	1.72
25.50 m	7.00	49.00	26.00	7.00	3.00	8.00	0.00	0.0036	0.0229	0.0918	25.54	1.59
28.00 m	8.00	46.00	21.00	12.00	7.00	6.00	0.00	0.0030	0.0228	0.1170	39.66	1.50
31.00 m	7.00	46.00	28.00	9.00	4.00	5.00	1.00	0.0036	0.0251	0.1102	30.22	1.57
34.00 m	6.00	48.00	25.00	7.00	8.00	6.00	0.00	0.0044	0.0253	0.1065	24.00	1.36
37.00 m	8.00	51.00	23.00	4.00	3.00	10.00	1.00	0.0029	0.0199	0.0781	26.78	1.75
40.00 m	7.00	46.00	27.00	7.00	5.00	8.00	0.00	0.0036	0.0250	0.1113	30.55	1.54
43.00 m	6.00	50.00	25.00	6.00	2.00	9.00	2.00	0.0044	0.0240	0.0922	21.02	1.42
46.00 m	7.00	45.00	30.00	4.00	5.00	7.00	2.00	0.0037	0.0260	0.1132	30.86	1.63
49.00 m	8.00	44.00	27.00	7.00	3.00	10.00	1.00	0.0030	0.0247	0.1197	40.24	1.71

GRAIN SIZE DISTRIBUTION CURVES

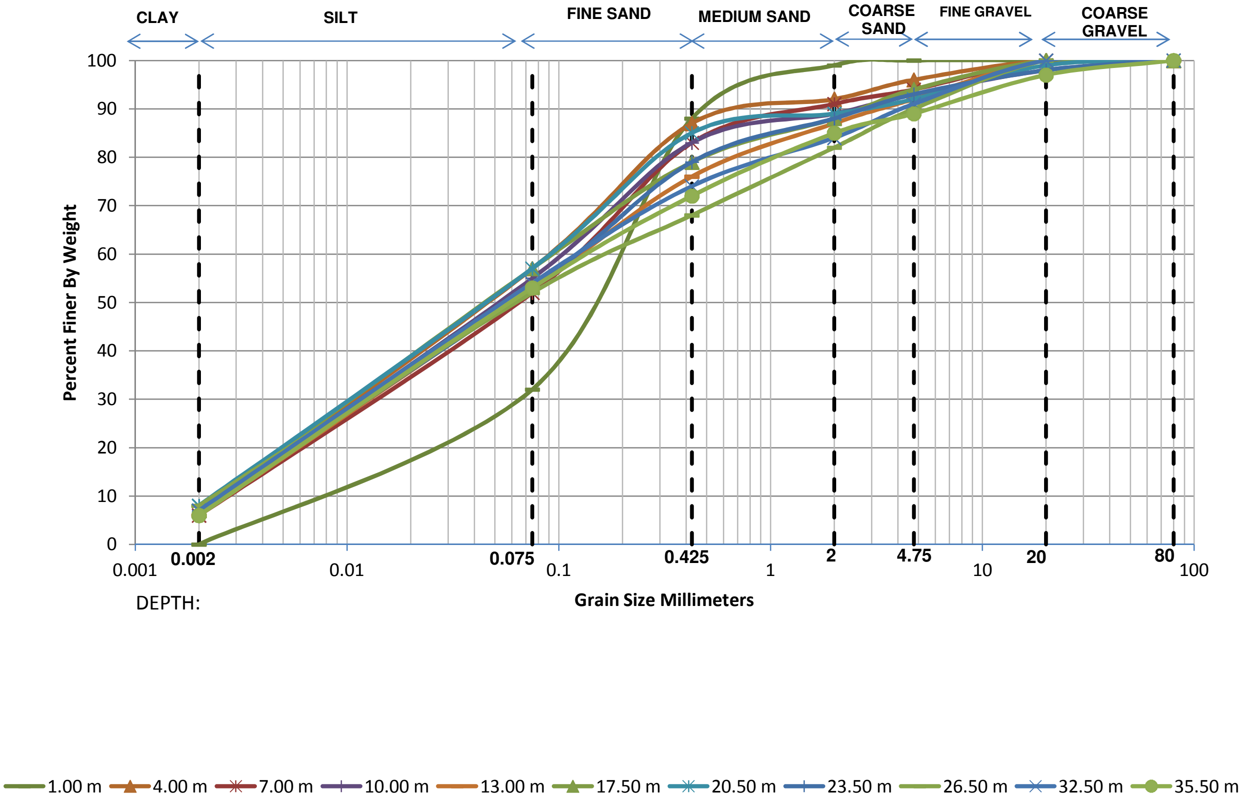
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+360 Major Bridge
B.H. No.	BH-P2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	7.00	48.00	34.00	7.00	3.00	1.00	0.00	0.0036	0.0240	0.0928	25.61	1.72
5.50 m	5.00	34.00	43.00	12.00	4.00	2.00	0.00	0.0066	0.0470	0.1821	27.62	1.84
8.50 m	7.00	55.00	28.00	2.00	4.00	4.00	0.00	0.0035	0.0199	0.0703	19.98	1.59
11.50 m	6.00	53.00	27.00	5.00	3.00	6.00	0.00	0.0043	0.0224	0.0778	17.99	1.49
14.50 m	7.00	49.00	30.00	6.00	2.00	5.00	1.00	0.0036	0.0231	0.0896	24.90	1.66
17.50 m	6.00	49.00	30.00	4.00	3.00	8.00	0.00	0.0044	0.0249	0.0944	21.32	1.49
22.00 m	7.00	46.00	30.00	6.00	1.00	10.00	0.00	0.0036	0.0252	0.1068	29.26	1.63
25.00 m	8.00	50.00	26.00	7.00	2.00	7.00	0.00	0.0029	0.0206	0.0818	27.95	1.78
28.00 m	8.00	47.00	28.00	7.00	2.00	8.00	0.00	0.0029	0.0226	0.0964	32.70	1.79
31.00 m	7.00	50.00	24.00	6.00	3.00	10.00	0.00	0.0036	0.0222	0.0871	24.36	1.58
34.00 m	6.00	52.00	29.00	5.00	1.00	7.00	0.00	0.0044	0.0230	0.0811	18.65	1.50
37.00 m	7.00	50.00	22.00	8.00	4.00	9.00	0.00	0.0036	0.0221	0.0883	24.74	1.54
40.00 m	8.00	48.00	24.00	10.00	2.00	8.00	0.00	0.0029	0.0217	0.0937	31.90	1.71
43.00 m	7.00	47.00	26.00	11.00	1.00	7.00	1.00	0.0036	0.0242	0.1060	29.25	1.53
46.00 m	7.00	45.00	25.00	9.00	4.00	9.00	1.00	0.0037	0.0257	0.1252	34.24	1.44

GRAIN SIZE DISTRIBUTION CURVES

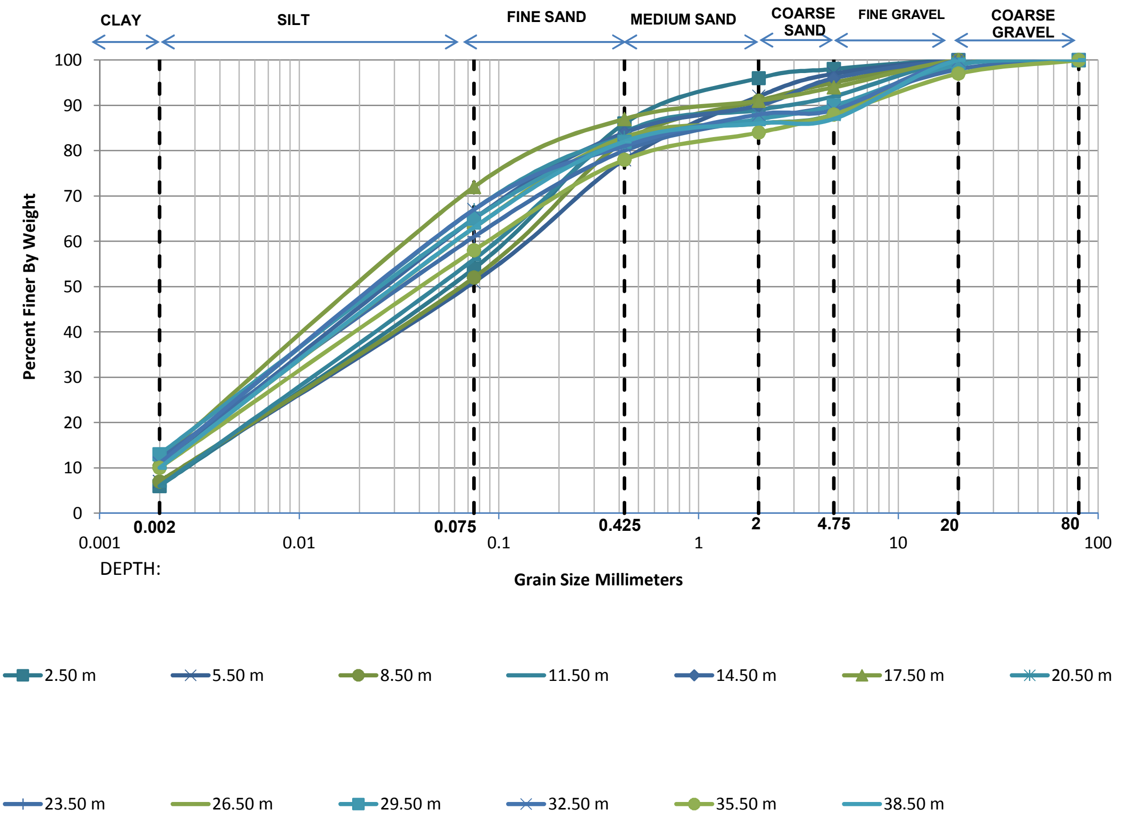
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+360 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	0.00	32.00	56.00	11.00	1.00	0.00	0.00	0.0118	0.0683	0.1896	16.13	2.09
4.00 m	7.00	50.00	30.00	5.00	4.00	4.00	0.00	0.0036	0.0225	0.0850	23.72	1.66
7.00 m	6.00	46.00	31.00	8.00	3.00	6.00	0.00	0.0045	0.0272	0.1124	24.91	1.46
10.00 m	7.00	48.00	28.00	6.00	4.00	5.00	2.00	0.0036	0.0237	0.0961	26.62	1.61
13.00 m	6.00	47.00	23.00	11.00	5.00	8.00	0.00	0.0045	0.0259	0.1213	27.22	1.24
17.50 m	7.00	50.00	22.00	9.00	6.00	6.00	0.00	0.0036	0.0221	0.0884	24.76	1.54
20.50 m	8.00	49.00	28.00	4.00	3.00	7.00	1.00	0.0029	0.0213	0.0856	29.17	1.81
23.50 m	7.00	46.00	26.00	9.00	5.00	5.00	2.00	0.0036	0.0250	0.1136	31.21	1.51
26.50 m	8.00	44.00	16.00	14.00	8.00	10.00	0.00	0.0030	0.0239	0.1829	61.73	1.06
32.50 m	7.00	47.00	20.00	10.00	7.00	9.00	0.00	0.0036	0.0238	0.1193	33.03	1.32
35.50 m	6.00	47.00	19.00	13.00	4.00	8.00	3.00	0.0044	0.0256	0.1384	31.17	1.07

GRAIN SIZE DISTRIBUTION CURVES

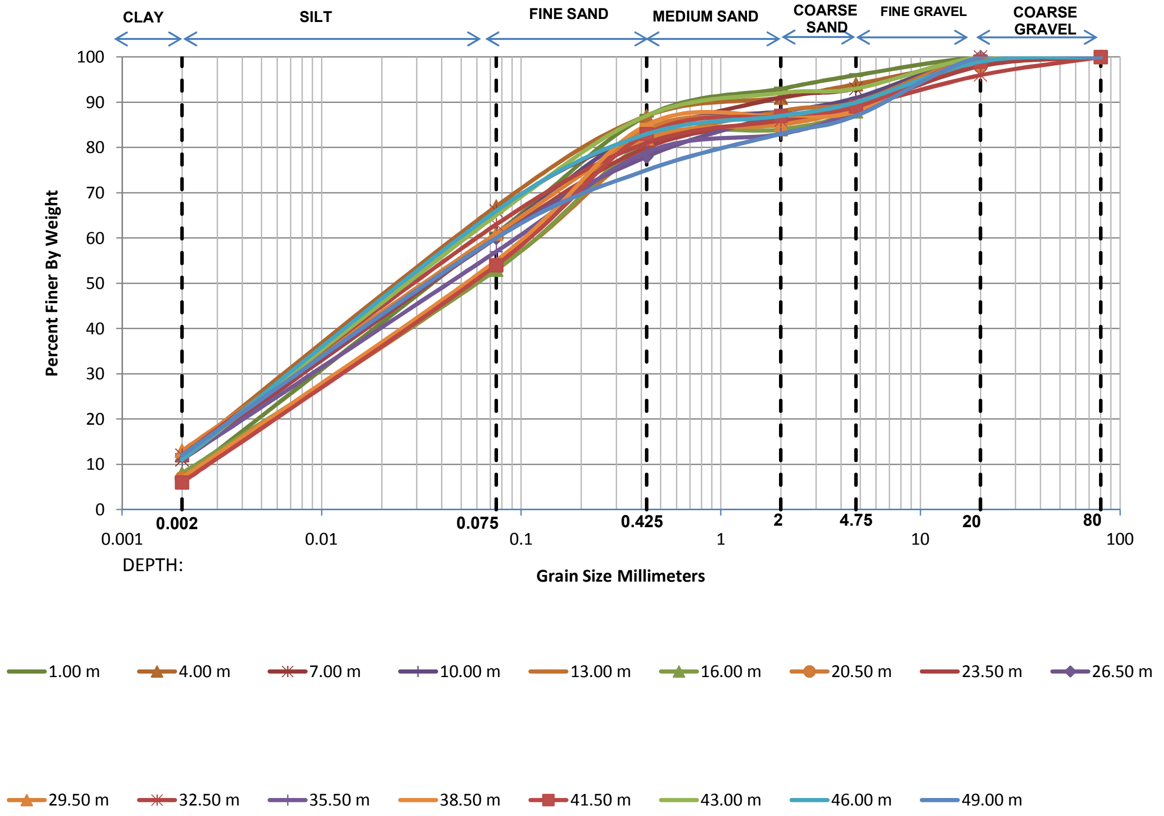
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+900 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	6.00	48.00	32.00	10.00	2.00	2.00	0.00	0.0045	0.0258	0.0992	22.25	1.50
5.50 m	7.00	44.00	27.00	14.00	5.00	3.00	0.00	0.0037	0.0267	0.1310	35.59	1.47
8.50 m	7.00	45.00	30.00	9.00	4.00	5.00	0.00	0.0037	0.0260	0.1144	31.19	1.61
11.50 m	6.00	50.00	28.00	5.00	3.00	8.00	0.00	0.0044	0.0242	0.0903	20.55	1.47
14.50 m	10.00	55.00	19.00	6.00	6.00	4.00	0.00	0.0020	0.0153	0.0632	31.61	1.85
17.50 m	12.00	60.00	15.00	4.00	3.00	6.00	0.00	-	0.0116	0.0502	-	-
20.50 m	11.00	56.00	16.00	3.00	2.00	11.00	1.00	-	0.0137	0.0589	-	-
23.50 m	12.00	49.00	19.00	7.00	3.00	8.00	2.00	-	0.0149	0.0723	-	-
26.50 m	10.00	53.00	20.00	3.00	2.00	12.00	0.00	0.0020	0.0160	0.0676	33.78	1.91
29.50 m	13.00	52.00	17.00	5.00	3.00	9.00	1.00	-	0.0126	0.0625	-	-
32.50 m	11.00	56.00	14.00	7.00	1.00	11.00	0.00	-	0.0136	0.0588	-	-
35.50 m	10.00	48.00	20.00	6.00	4.00	9.00	3.00	0.0020	0.0183	0.0834	41.71	2.00
38.50 m	10.00	53.00	19.00	4.00	1.00	13.00	0.00	0.0020	0.0160	0.0675	33.77	1.90

GRAIN SIZE DISTRIBUTION CURVES

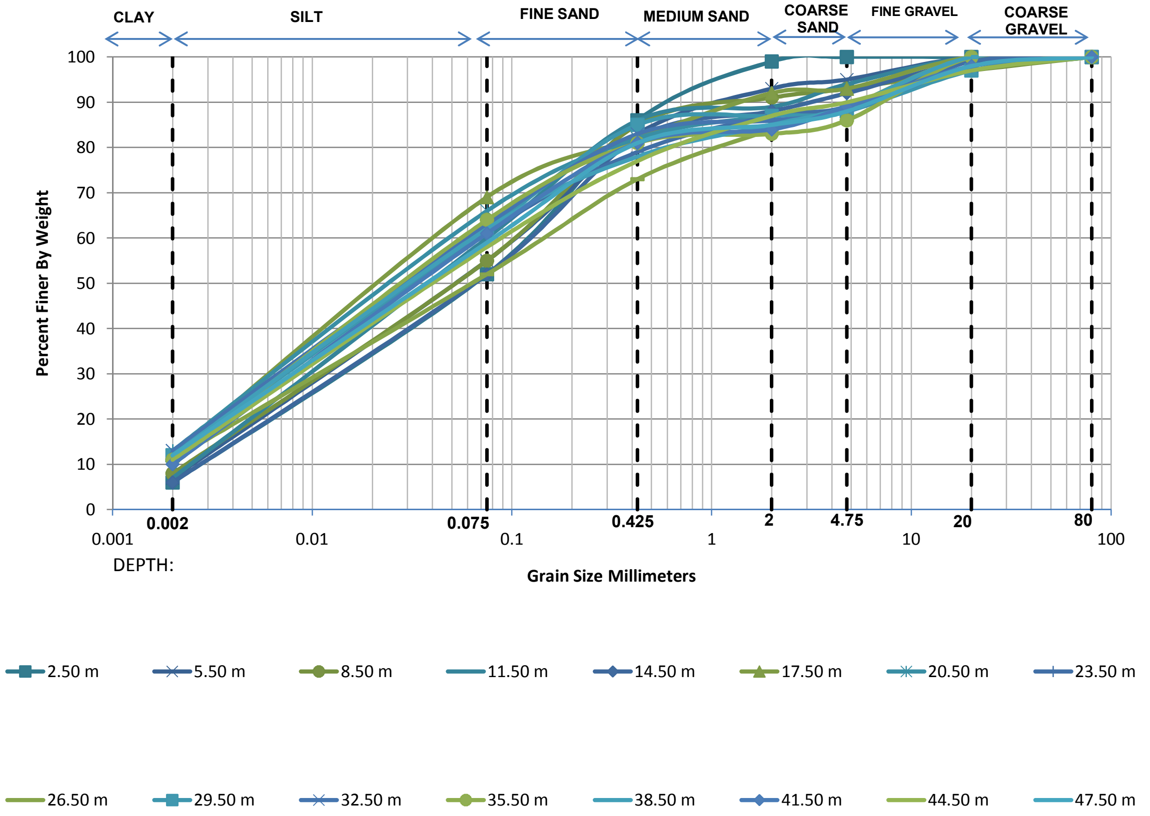
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+900 Major Bridge
B.H. No.	BH-P1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	7.00	54.00	26.00	6.00	3.00	4.00	0.00	0.0035	0.0202	0.0726	20.58	1.60
4.00 m	12.00	55.00	20.00	4.00	3.00	5.00	1.00	-	0.0130	0.0588	-	-
7.00 m	11.00	55.00	17.00	8.00	2.00	7.00	0.00	-	0.0140	0.0609	-	-
10.00 m	11.00	50.00	23.00	4.00	3.00	9.00	0.00	-	0.0160	0.0724	-	-
13.00 m	7.00	46.00	27.00	8.00	2.00	10.00	0.00	0.0036	0.0250	0.1115	30.62	1.54
16.00 m	8.00	45.00	28.00	3.00	4.00	12.00	0.00	0.0030	0.0240	0.1089	36.72	1.78
20.50 m	7.00	47.00	30.00	2.00	3.00	9.00	2.00	0.0036	0.0245	0.0999	27.49	1.65
23.50 m	11.00	49.00	20.00	6.00	3.00	9.00	2.00	-	0.0163	0.0750	-	-
26.50 m	12.00	48.00	18.00	9.00	1.00	12.00	0.00	-	0.0153	0.0750	-	-
29.50 m	13.00	48.00	21.00	3.00	4.00	11.00	0.00	-	0.0141	0.0722	-	-
32.50 m	12.00	51.00	18.00	5.00	3.00	7.00	4.00	-	0.0142	0.0672	-	-
35.50 m	11.00	46.00	22.00	4.00	5.00	12.00	0.00	-	0.0179	0.0884	-	-
38.50 m	7.00	48.00	30.00	2.00	1.00	12.00	0.00	0.0036	0.0238	0.0943	26.08	1.66
41.50 m	6.00	48.00	29.00	4.00	2.00	10.00	1.00	0.0044	0.0256	0.1009	22.68	1.46
43.00 m	11.00	54.00	22.00	5.00	1.00	7.00	0.00	-	0.0145	0.0631	-	-
46.00 m	11.00	55.00	17.00	4.00	3.00	9.00	1.00	-	0.0140	0.0609	-	-
49.00 m	12.00	48.00	15.00	8.00	4.00	13.00	0.00	-	0.0152	0.0750	-	-

GRAIN SIZE DISTRIBUTION CURVES

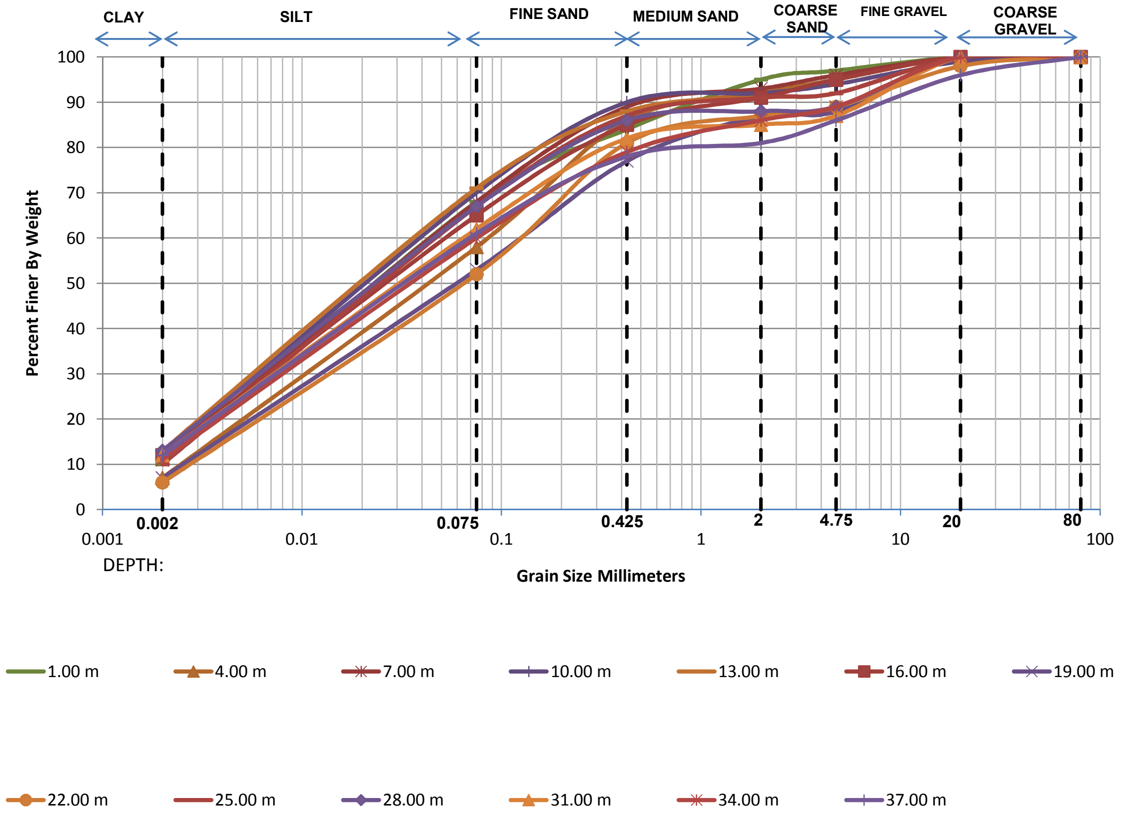
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+900 Major Bridge
B.H. No.	BH-P2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	6.00	46.00	34.00	13.00	1.00	0.00	0.00	0.0045	0.0274	0.1096	24.22	1.52
5.50 m	7.00	48.00	28.00	10.00	2.00	5.00	0.00	0.0036	0.0237	0.0967	26.76	1.60
8.50 m	8.00	47.00	30.00	6.00	2.00	4.00	3.00	0.0030	0.0227	0.0949	32.16	1.83
11.50 m	7.00	53.00	26.00	3.00	5.00	6.00	0.00	0.0035	0.0207	0.0750	21.20	1.61
14.50 m	6.00	46.00	30.00	6.00	4.00	7.00	1.00	0.0045	0.0272	0.1135	25.16	1.44
17.50 m	12.00	57.00	13.00	10.00	1.00	7.00	0.00	-	0.0122	0.0549	-	-
20.50 m	13.00	53.00	16.00	5.00	1.00	12.00	0.00	-	0.0123	0.0603	-	-
23.50 m	10.00	51.00	18.00	8.00	2.00	10.00	1.00	0.0020	0.0168	0.0724	36.18	1.94
26.50 m	11.00	41.00	21.00	11.00	5.00	11.00	0.00	-	0.0211	0.1422	-	-
29.50 m	12.00	50.00	23.00	2.00	1.00	9.00	3.00	-	0.0147	0.0698	-	-
32.50 m	13.00	50.00	20.00	3.00	2.00	10.00	2.00	-	0.0134	0.0671	-	-
35.50 m	11.00	53.00	17.00	2.00	3.00	14.00	0.00	-	0.0146	0.0651	-	-
38.50 m	12.00	50.00	16.00	7.00	4.00	11.00	0.00	-	0.0144	0.0696	-	-
41.50 m	10.00	51.00	20.00	3.00	5.00	9.00	2.00	0.0020	0.0169	0.0724	36.19	1.96
44.50 m	11.00	47.00	19.00	10.00	3.00	7.00	3.00	-	0.0172	0.0842	-	-
47.50 m	12.00	47.00	22.00	4.00	3.00	10.00	2.00	-	0.0159	0.0784	-	-

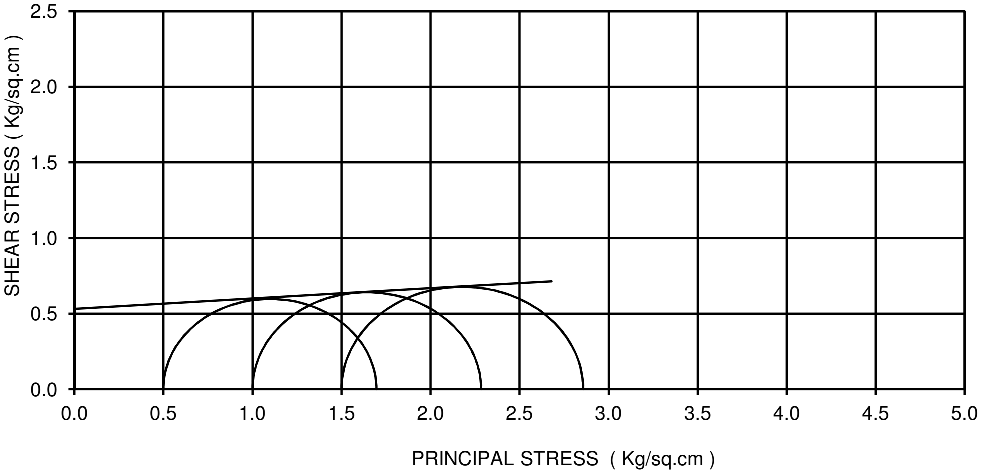
GRAIN SIZE DISTRIBUTION CURVES

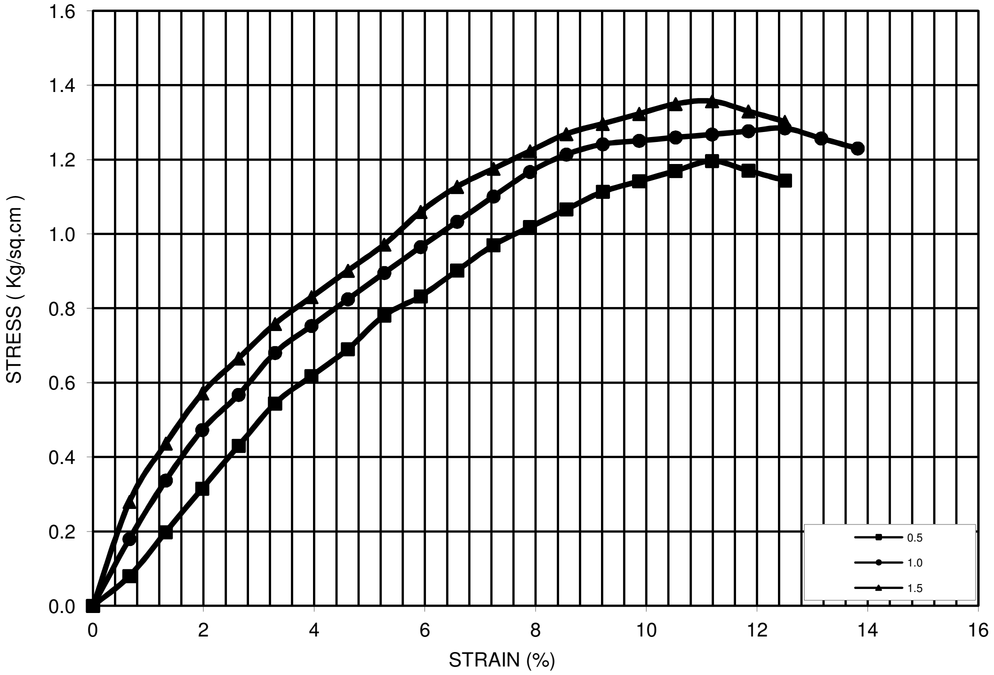
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+900 Major Bridge
B.H. No.	BH-A2



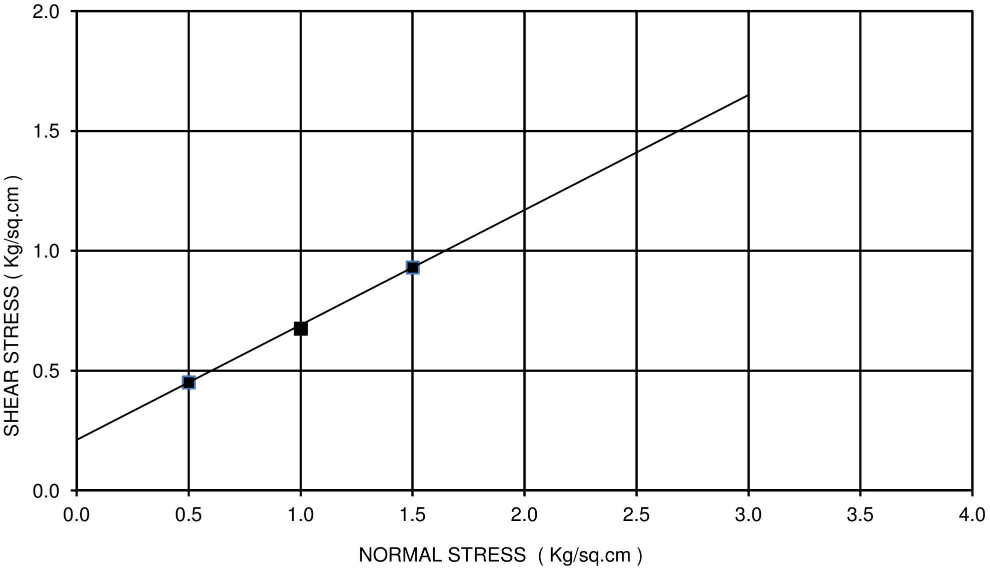
Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	10.00	58.00	16.00	11.00	2.00	3.00	0.00	0.0020	0.0143	0.0574	28.70	1.77
4.00 m	7.00	51.00	28.00	6.00	3.00	5.00	0.00	0.0036	0.0218	0.0814	22.81	1.64
7.00 m	11.00	57.00	21.00	4.00	3.00	4.00	0.00	-	0.0136	0.0573	-	-
10.00 m	12.00	58.00	20.00	2.00	2.00	5.00	1.00	-	0.0122	0.0536	-	-
13.00 m	13.00	58.00	17.00	3.00	1.00	8.00	0.00	-	0.0111	0.0514	-	-
16.00 m	12.00	53.00	20.00	6.00	4.00	5.00	0.00	-	0.0136	0.0628	-	-
19.00 m	7.00	46.00	24.00	10.00	1.00	12.00	0.00	0.0036	0.0248	0.1184	32.56	1.43
22.00 m	6.00	46.00	29.00	6.00	2.00	9.00	2.00	0.0045	0.0271	0.1151	25.54	1.42
25.00 m	10.00	57.00	20.00	4.00	1.00	8.00	0.00	0.0020	0.0147	0.0594	29.69	1.82
28.00 m	13.00	54.00	19.00	2.00	1.00	11.00	0.00	-	0.0121	0.0585	-	-
31.00 m	12.00	50.00	20.00	3.00	2.00	13.00	0.00	-	0.0146	0.0697	-	-
34.00 m	11.00	49.00	19.00	7.00	3.00	11.00	0.00	-	0.0163	0.0750	-	-
37.00 m	12.00	49.00	17.00	3.00	5.00	10.00	4.00	-	0.0149	0.0722	-	-

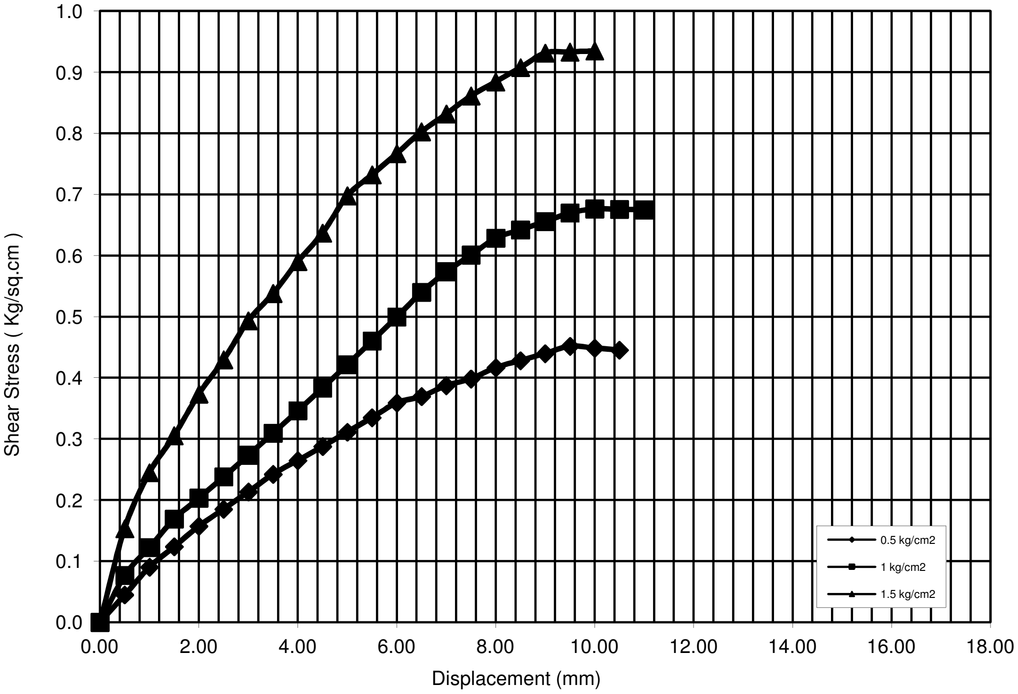
BORE HOLE NO: BH-A-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.53 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT



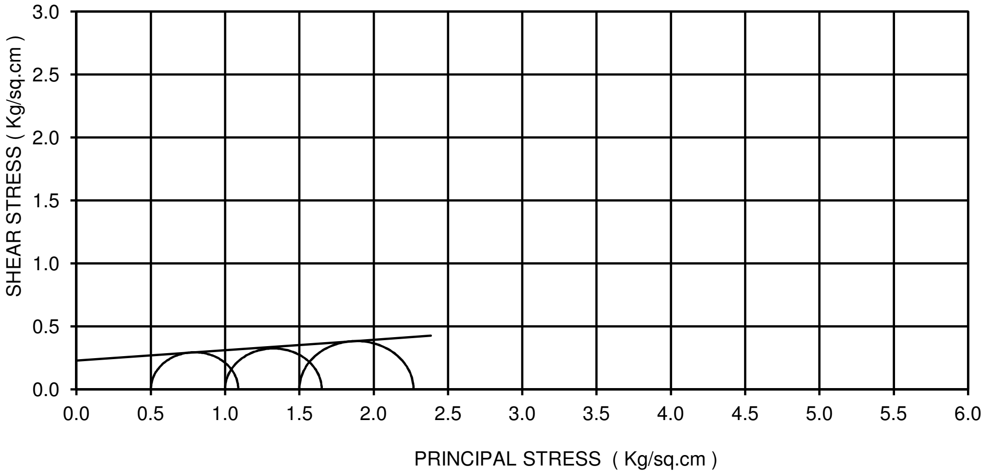


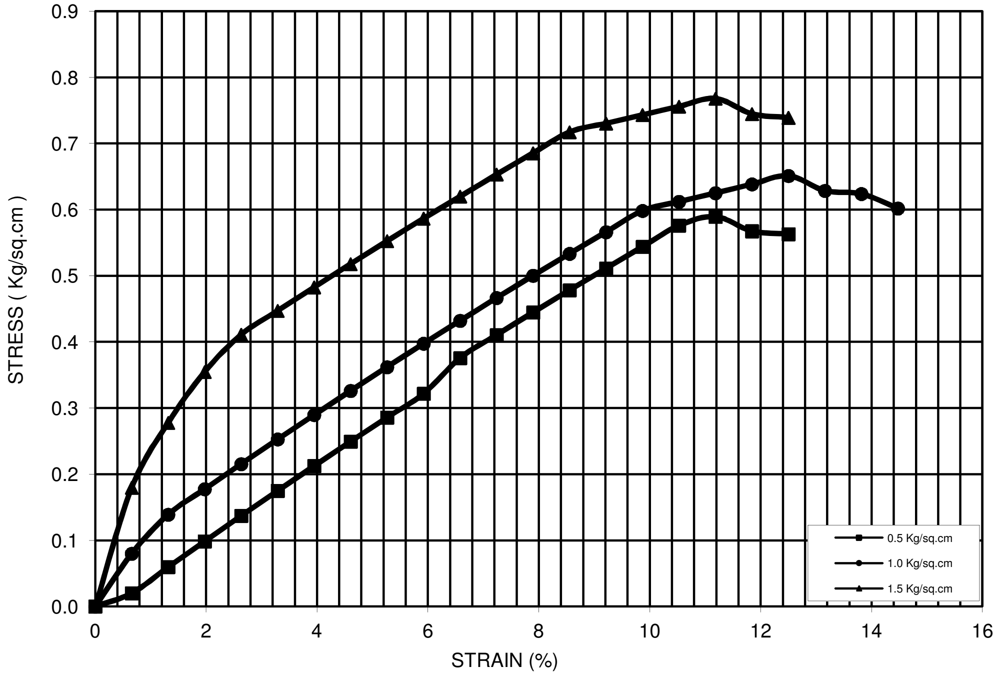
BORE HOLE NO: BH-A-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-3
DEPTH: 7.00 m
COHESION(C)= 0.21 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



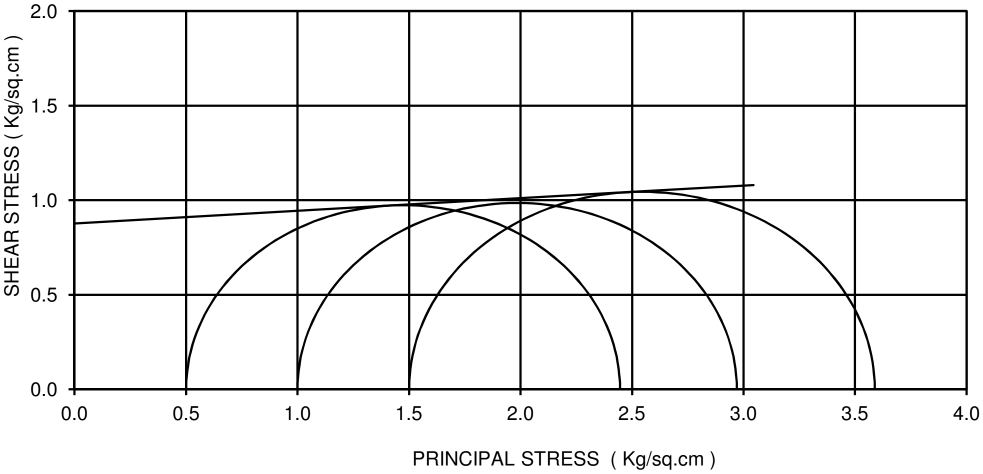


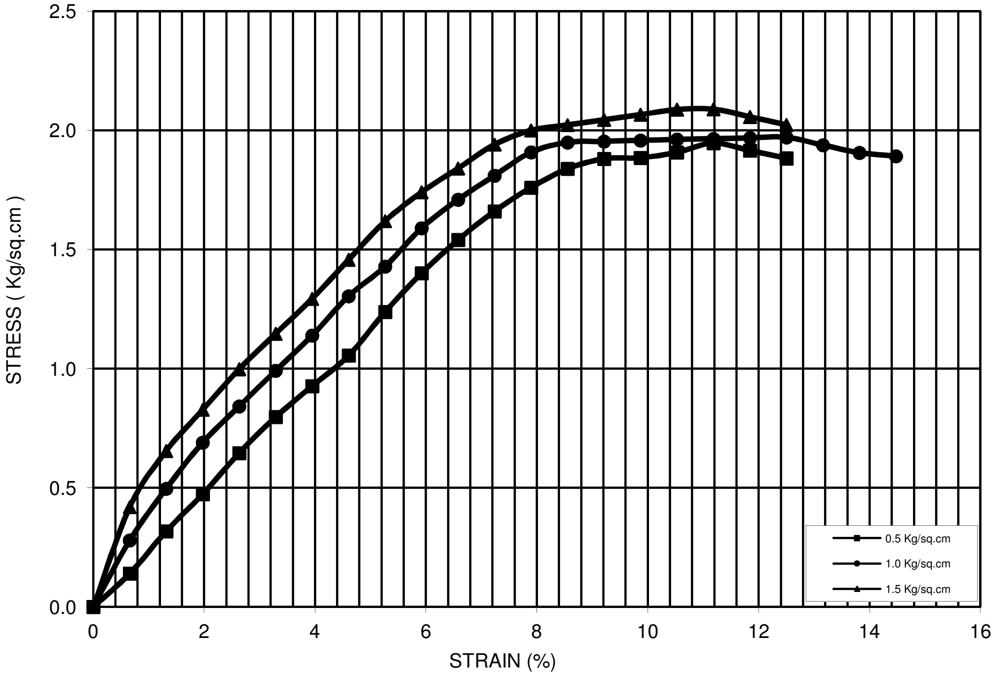
BORE HOLE NO: BH-P-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.23 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



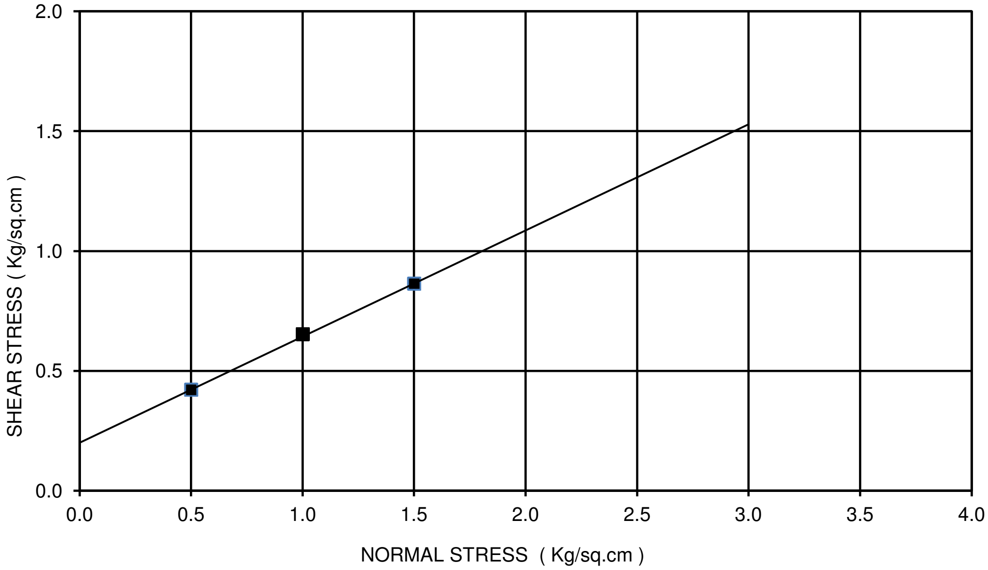


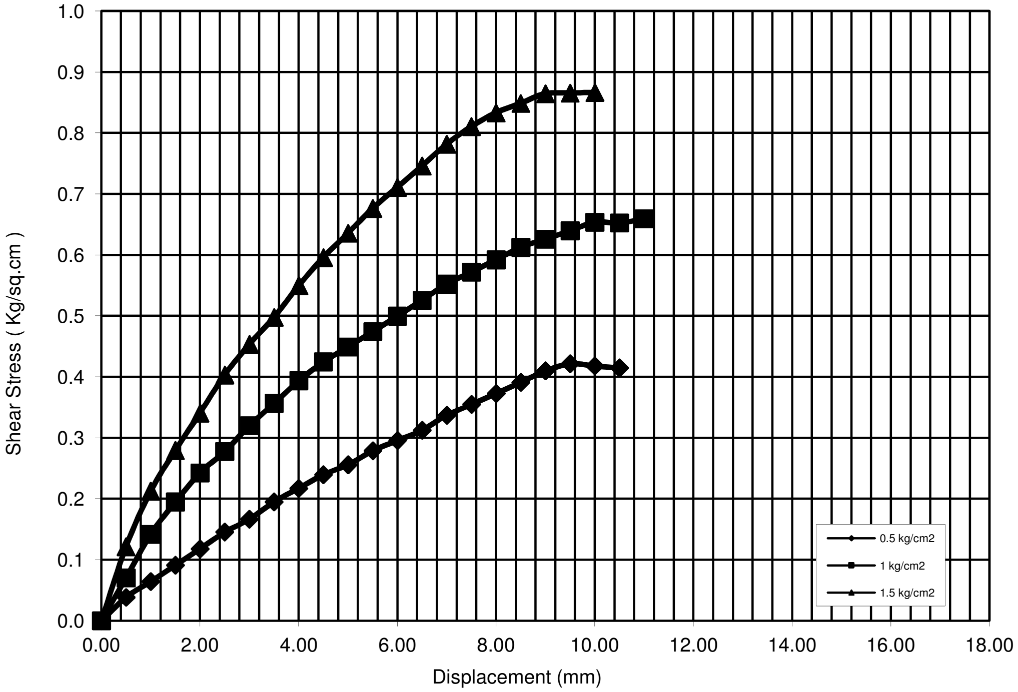
BORE HOLE NO: BH-P-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 0.88 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT



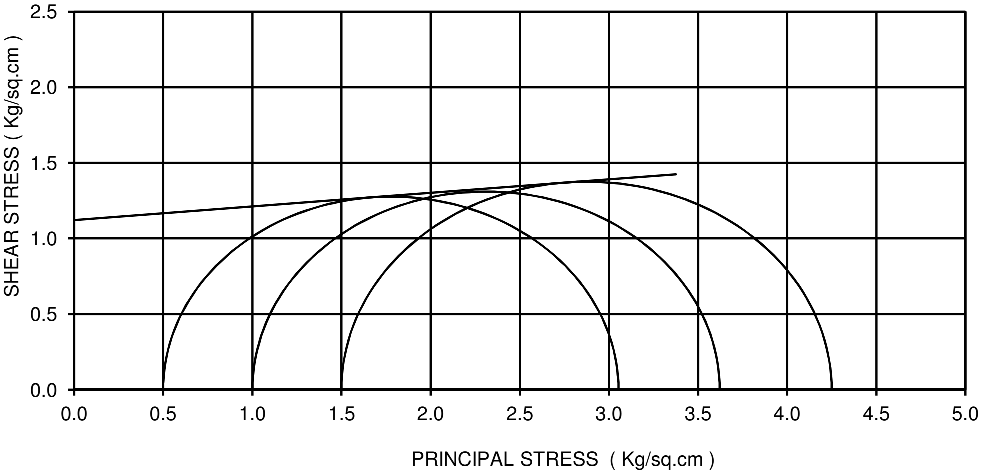


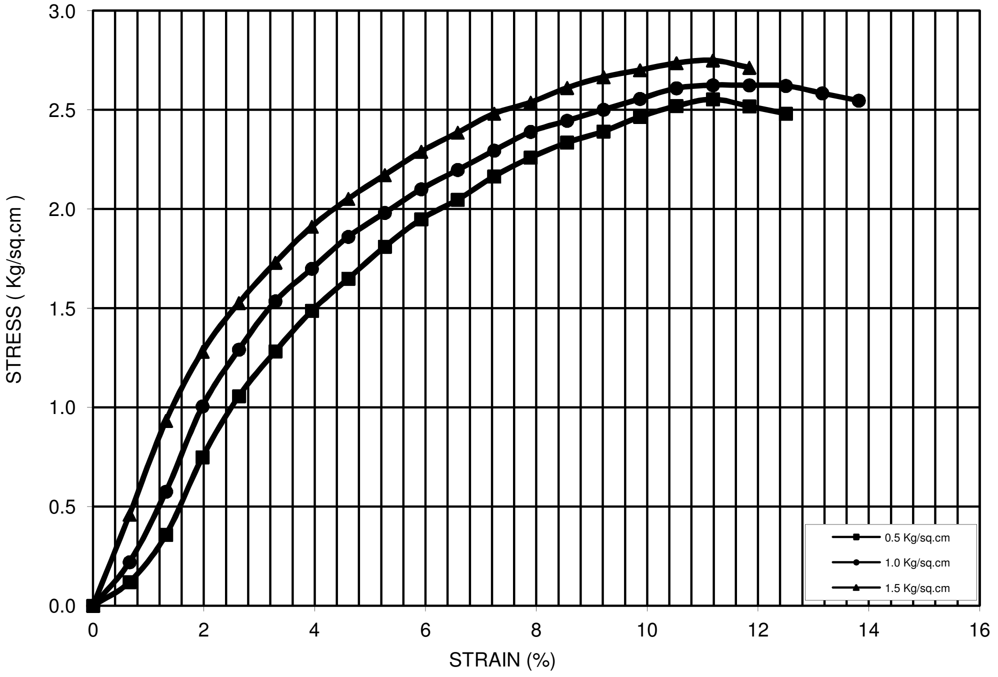
BORE HOLE NO: BH-P-2
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



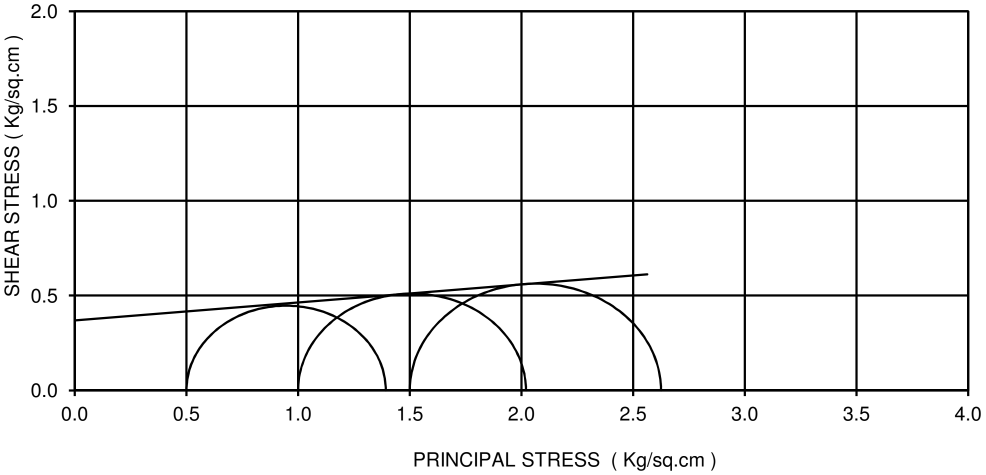


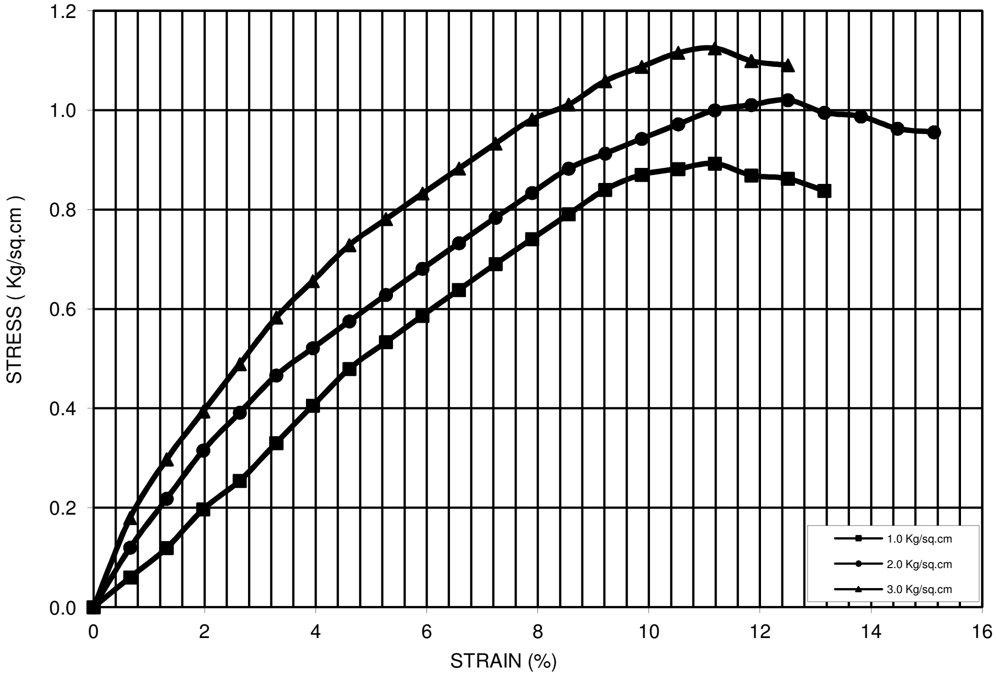
BORE HOLE NO: BH-P-2
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-2
DEPTH: 4.00m
COHESION(C)= 1.12 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



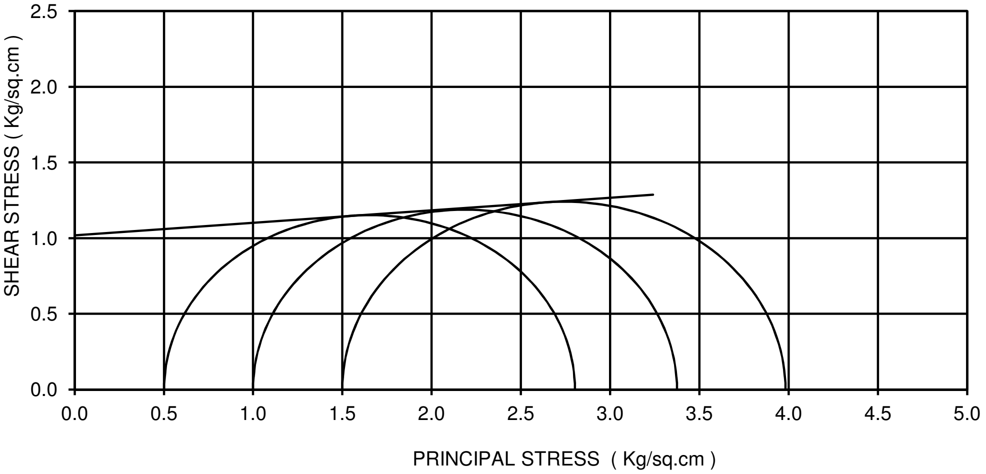


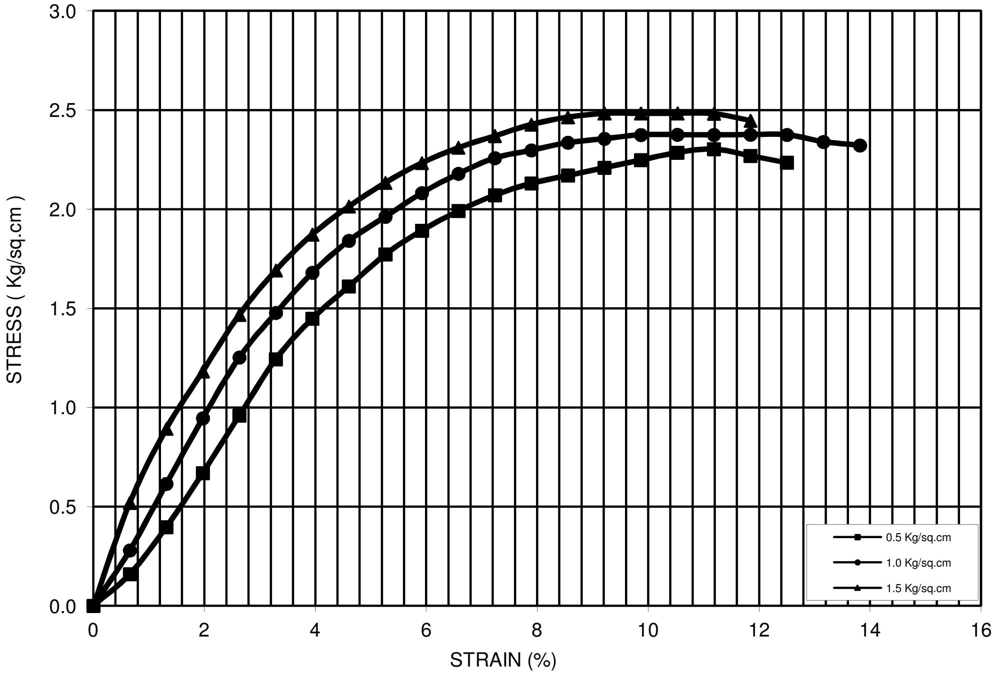
BORE HOLE NO: BH-P-3
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.37 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



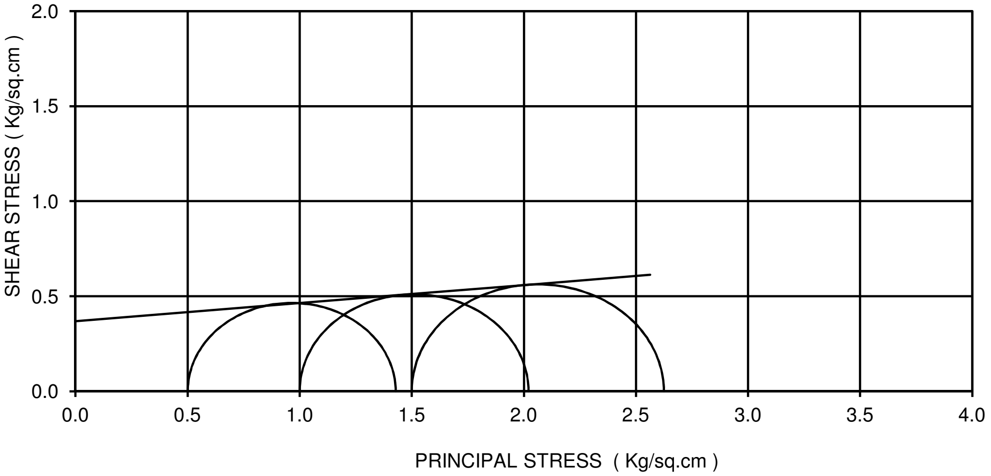


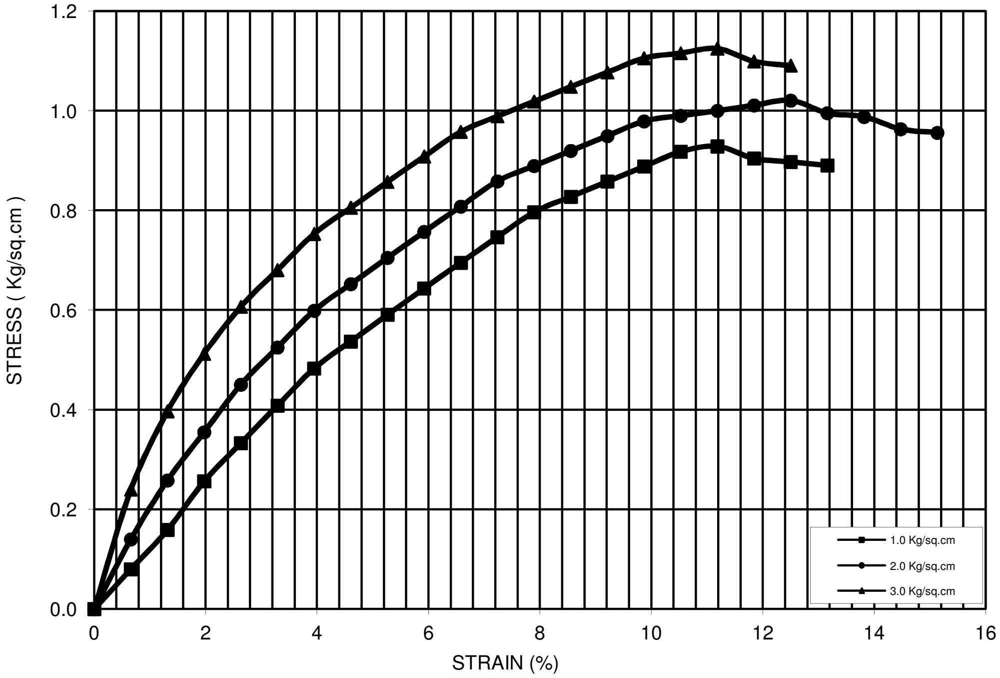
BORE HOLE NO: BH-P-3
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 1.02 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



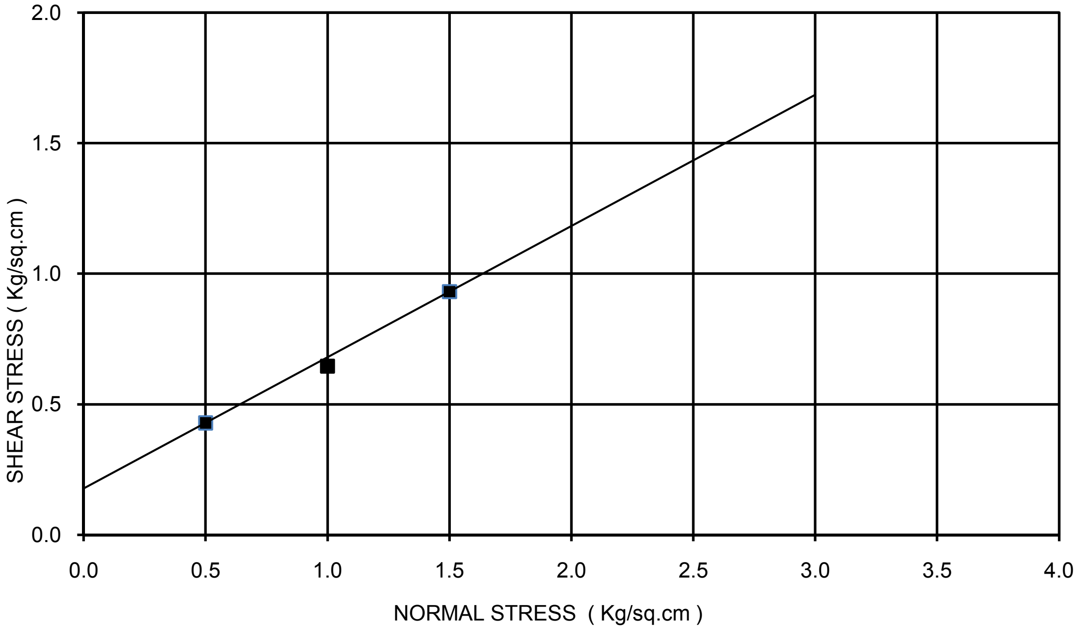


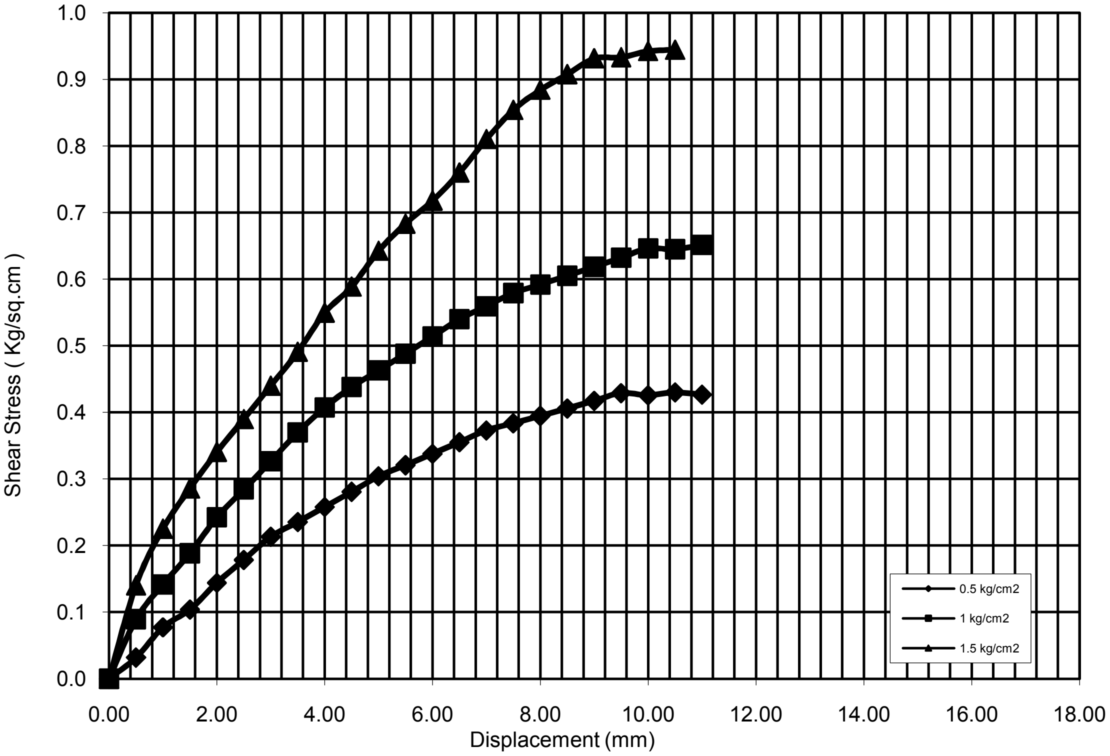
BORE HOLE NO: BH-P-4
Chainage:- 27+620 km
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.37 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



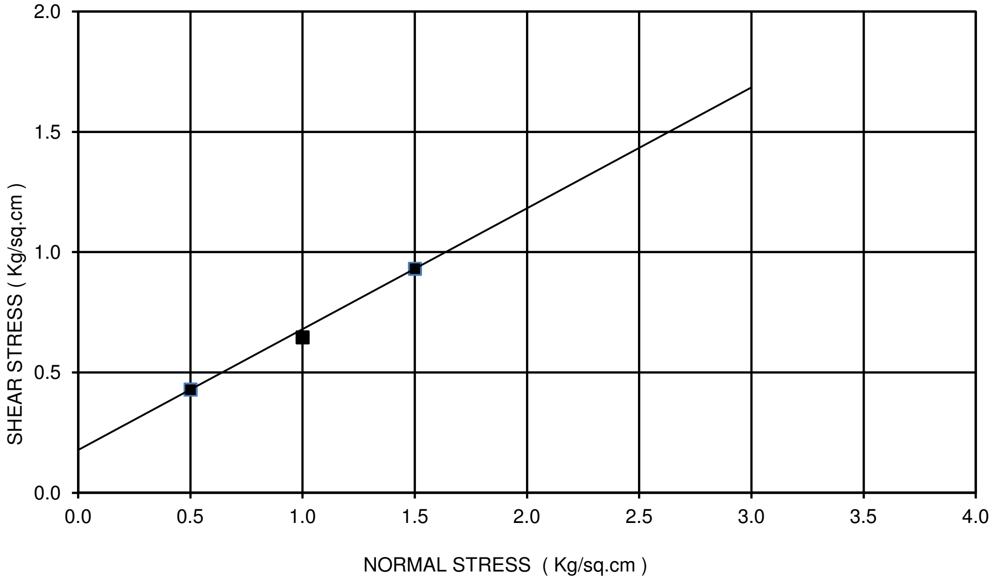


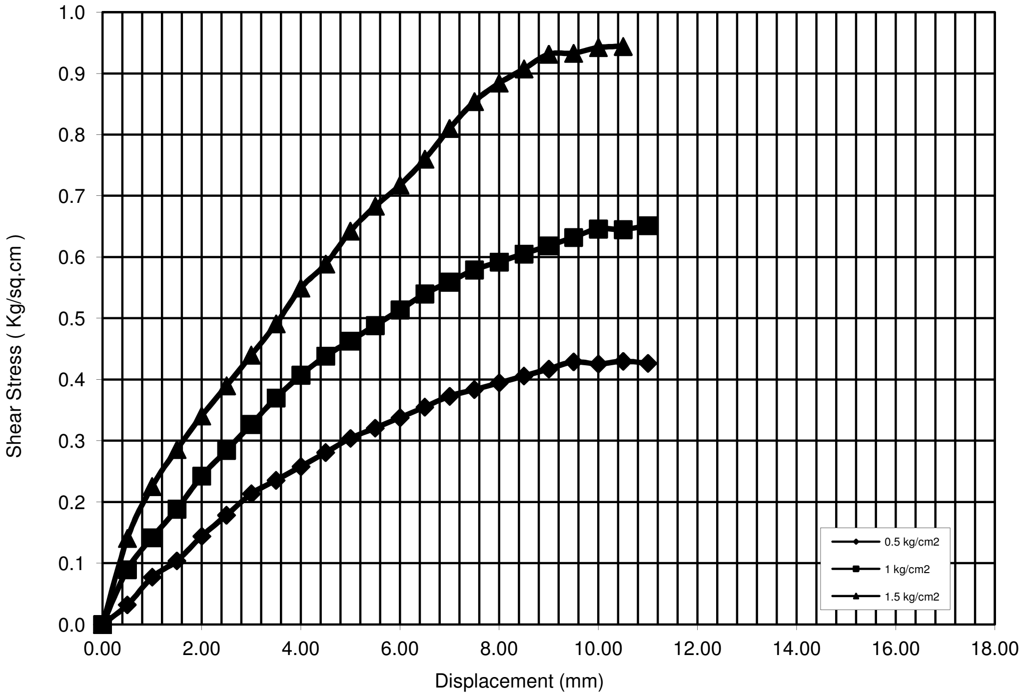
BORE HOLE NO: BH-P4
Chainage:- 27+620
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.09 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



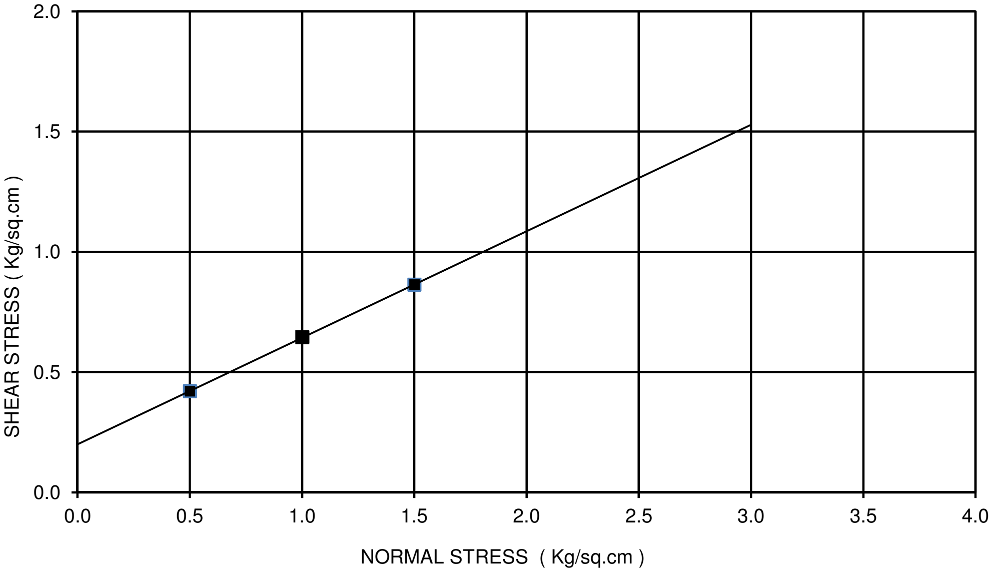


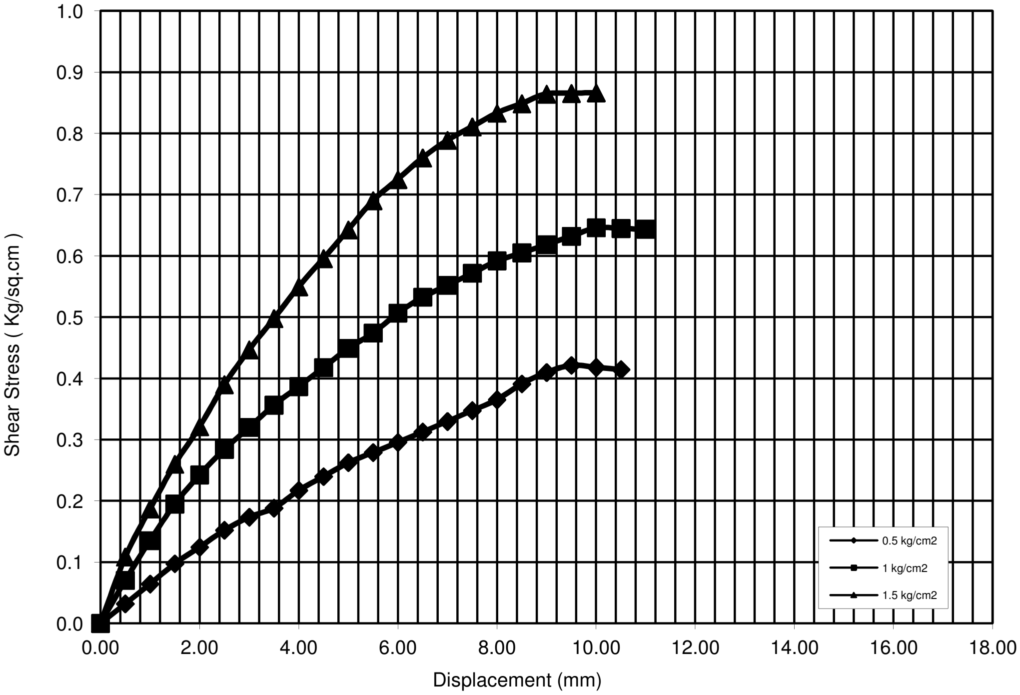
BORE HOLE NO: BH-A2
Chainage:- 27+620 km
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.09 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



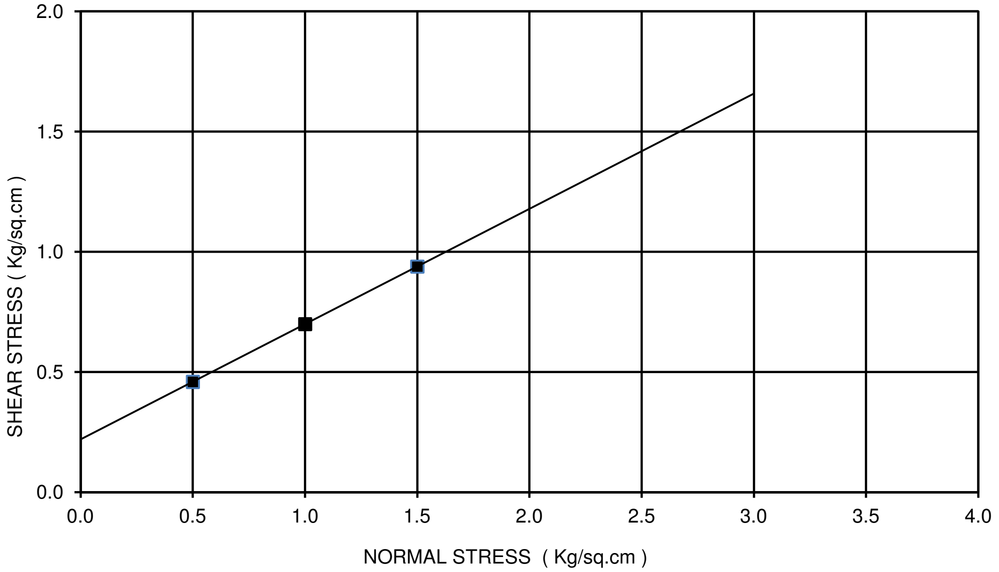


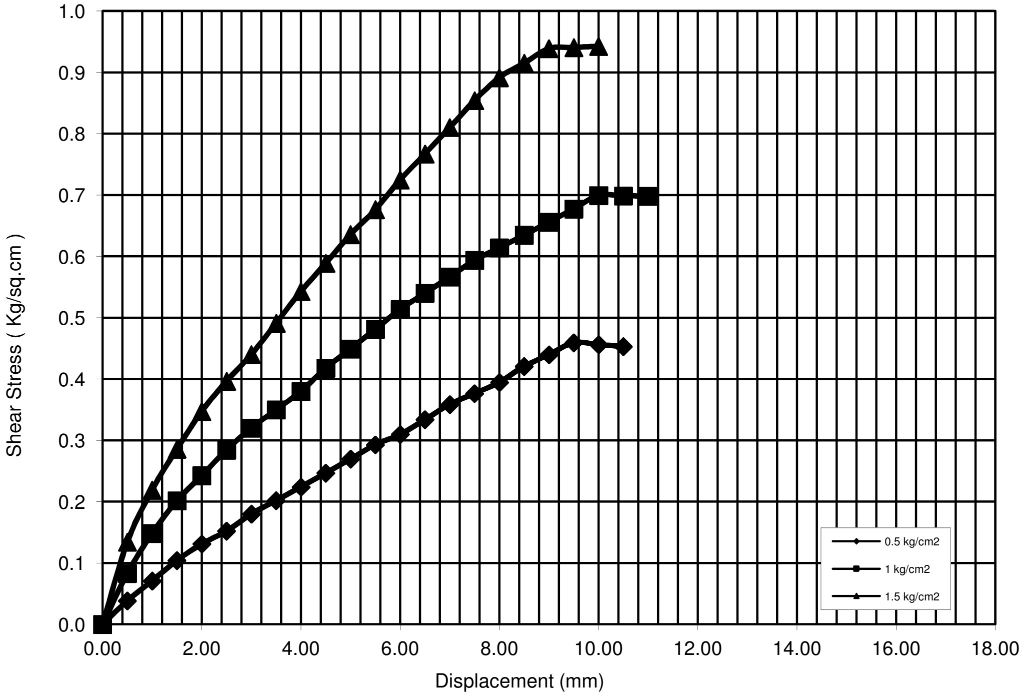
BORE HOLE NO: BH-A2
Chainage:- 27+620 km
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



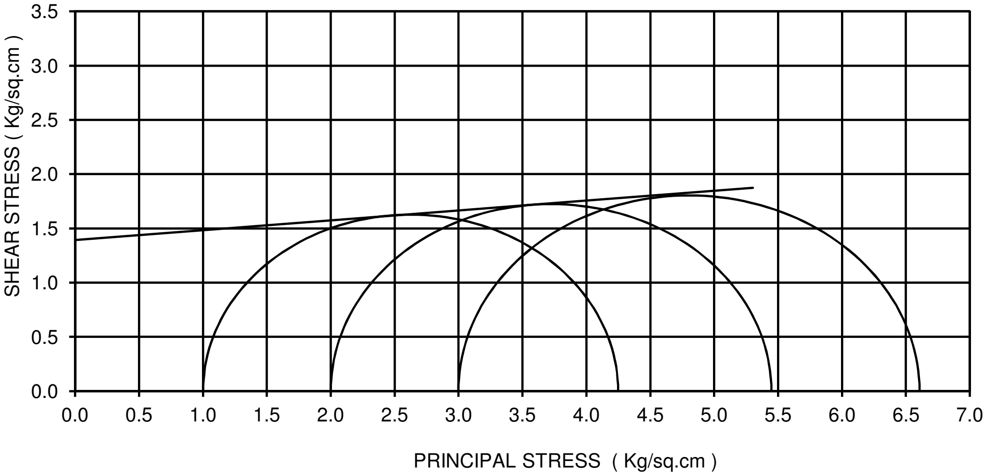


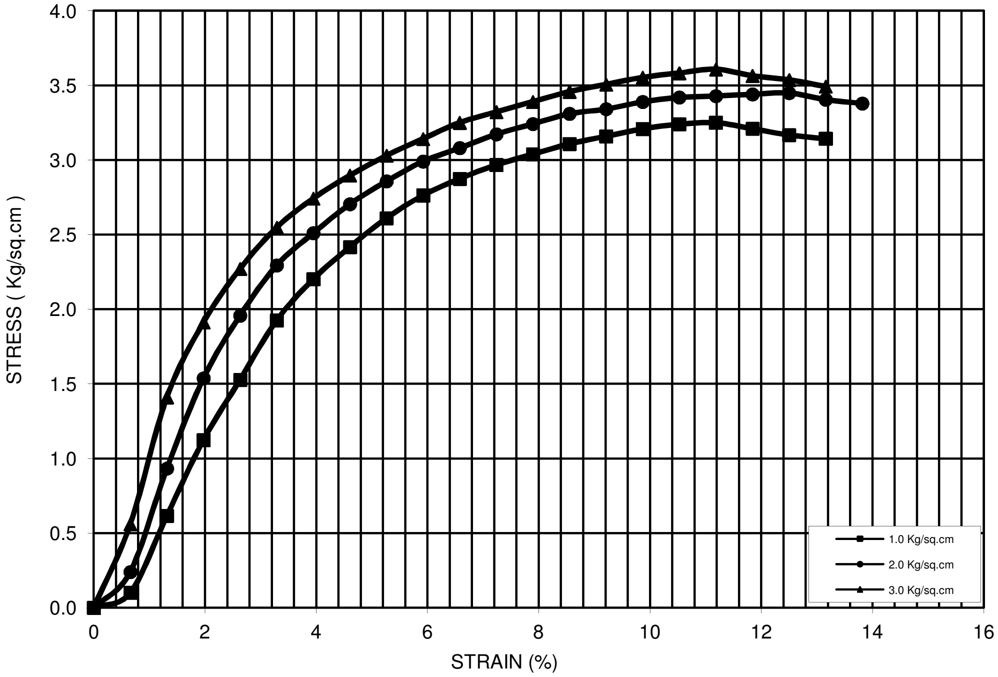
BORE HOLE NO: BH-A1
Chainage:- 28+075 km
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.22 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



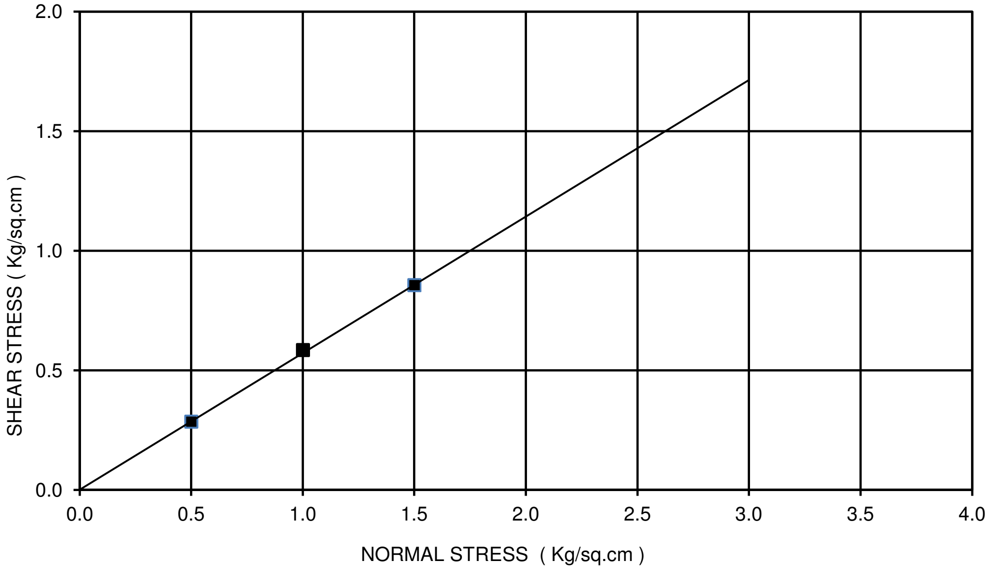


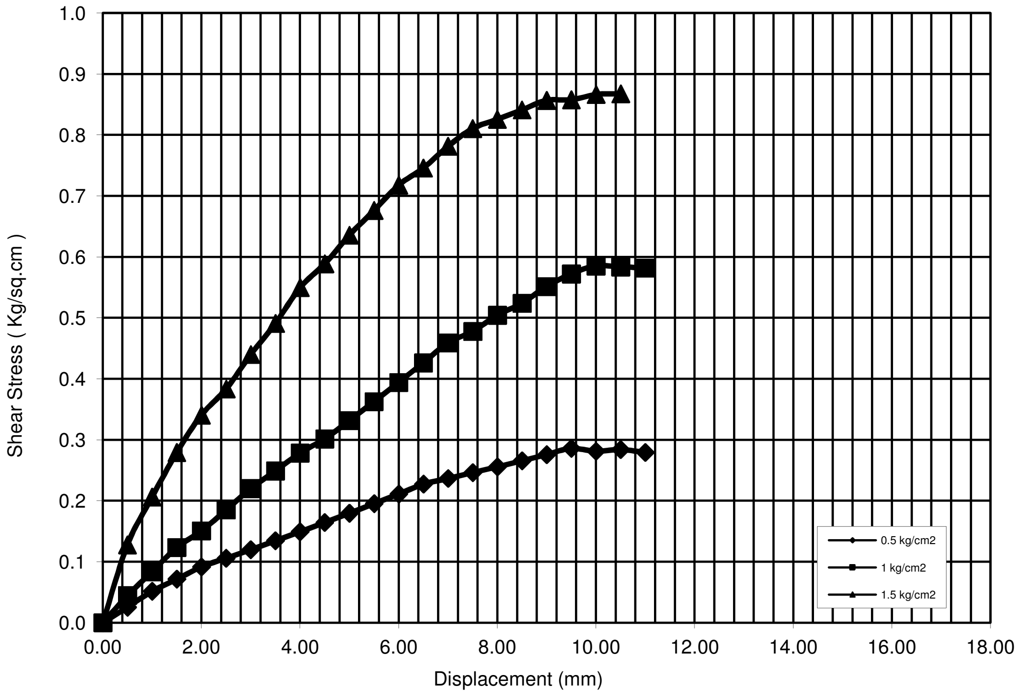
BORE HOLE NO: BH-A1
Chainage:- 28+075 km
SAMPLE NO.: UDS-5
DEPTH: 14.50m
COHESION(C)= 1.39 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



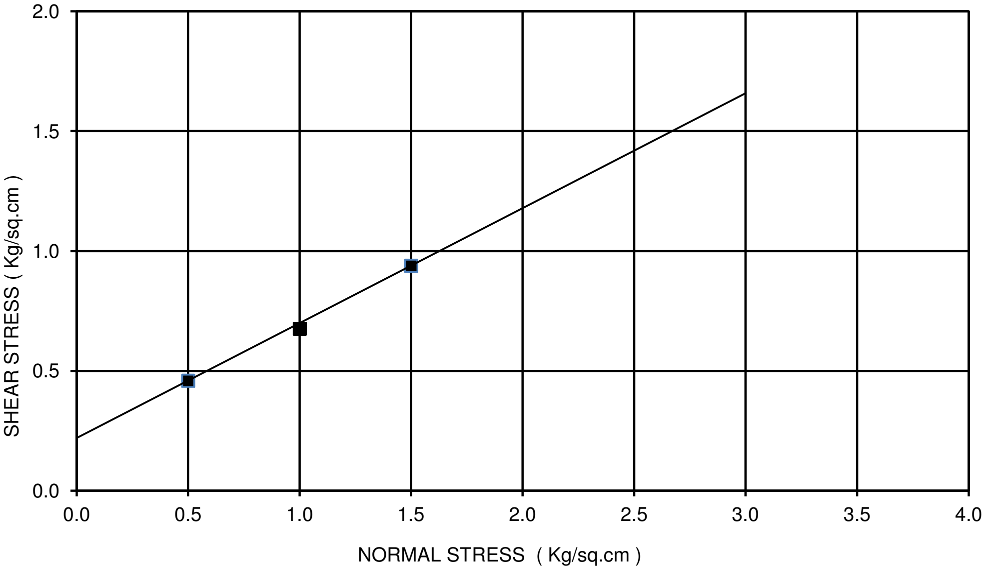


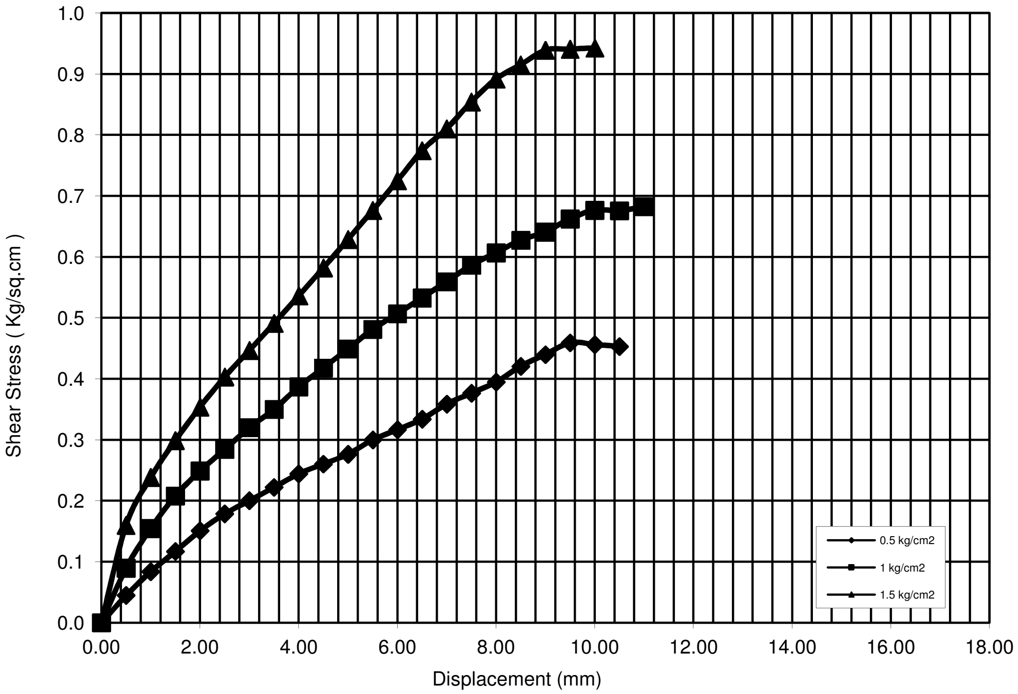
BORE HOLE NO: BH-P1
CHAINAGE : 28+075 KM
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.00 kg/sq.cm
ANGLE OF FRICTION(Phi): 30 deg
TYPE OF THE TEST: DST



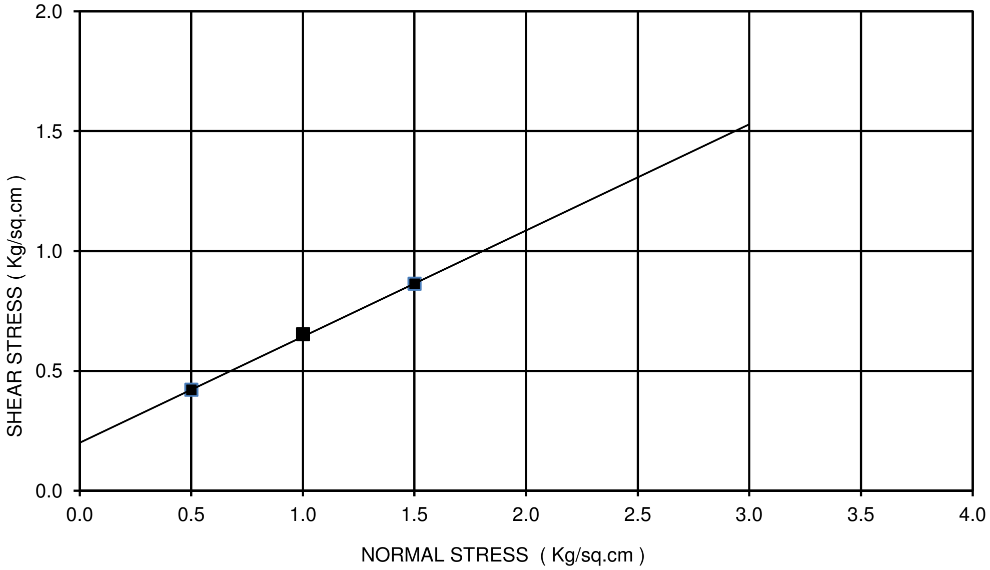


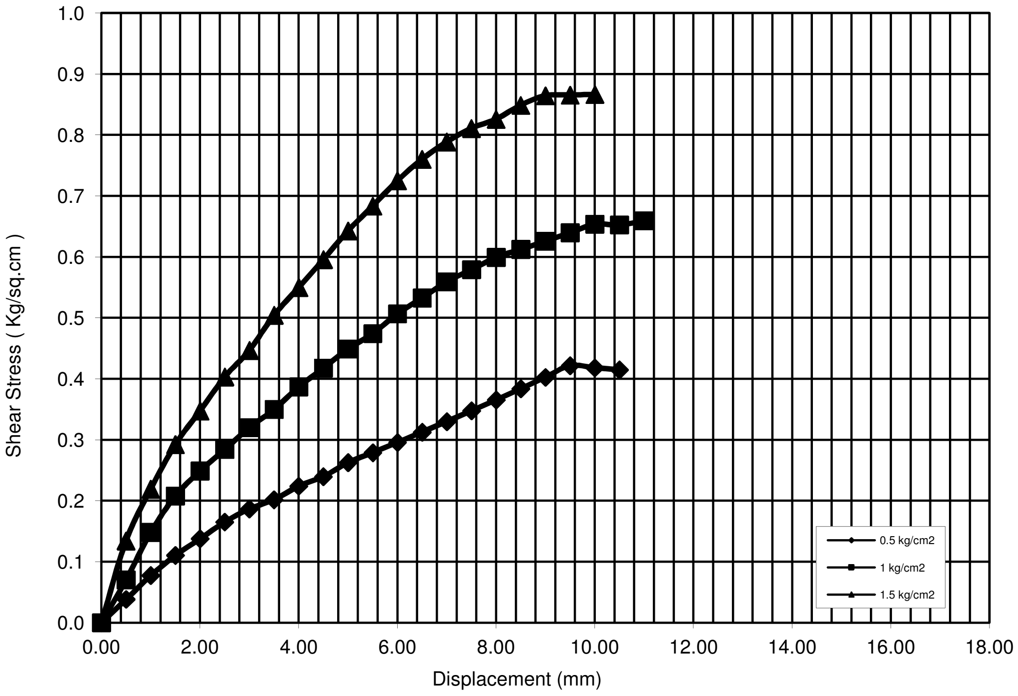
BORE HOLE NO: BH-P1
CHAINAGE : 28+075 KM
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.22 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



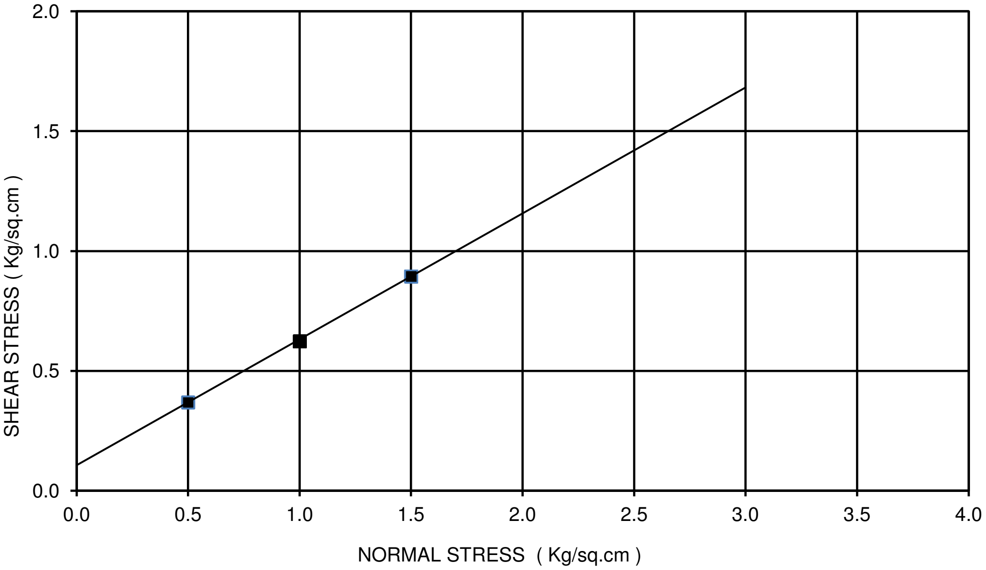


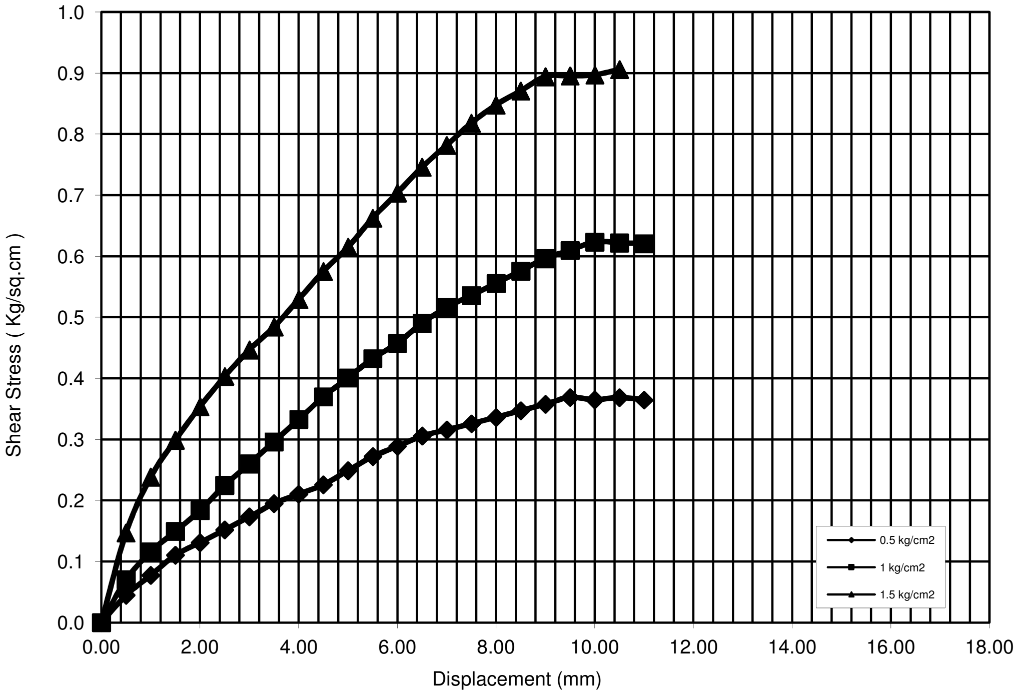
BORE HOLE NO: BH-P2
CHAINAGE : 28+075 KM
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



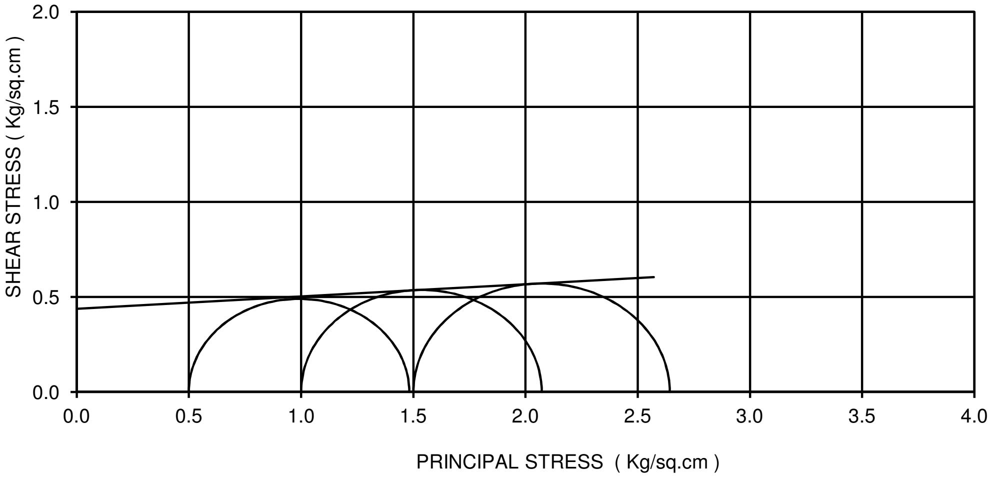


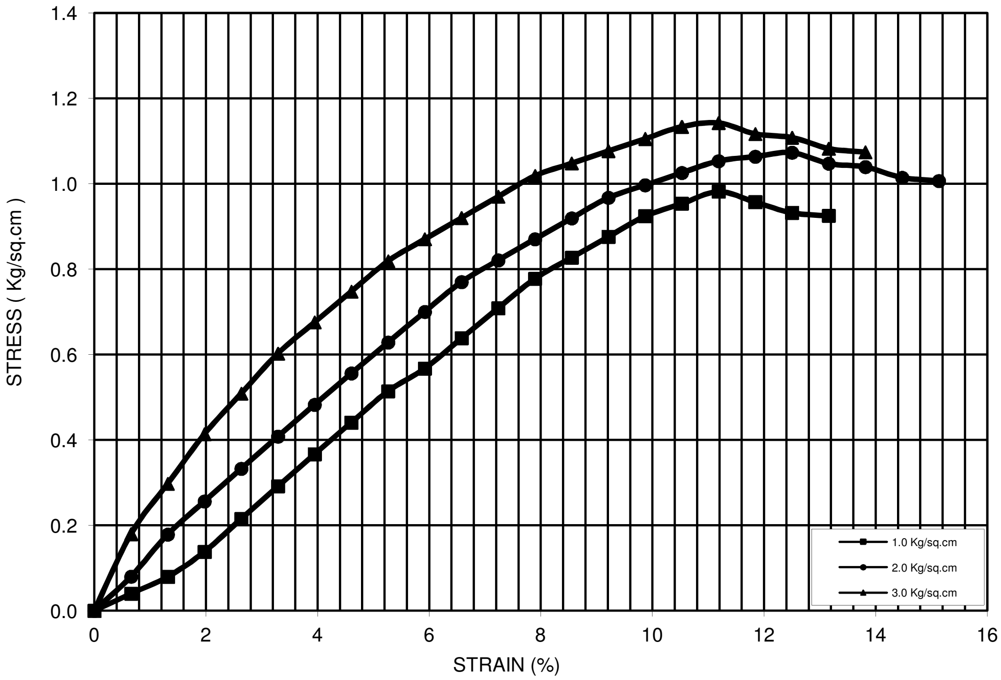
BORE HOLE NO: BH-P2
CHAINAGE : 28+075 km
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.11 kg/sq.cm
ANGLE OF FRICTION(Phi): 28 deg
TYPE OF THE TEST: DST



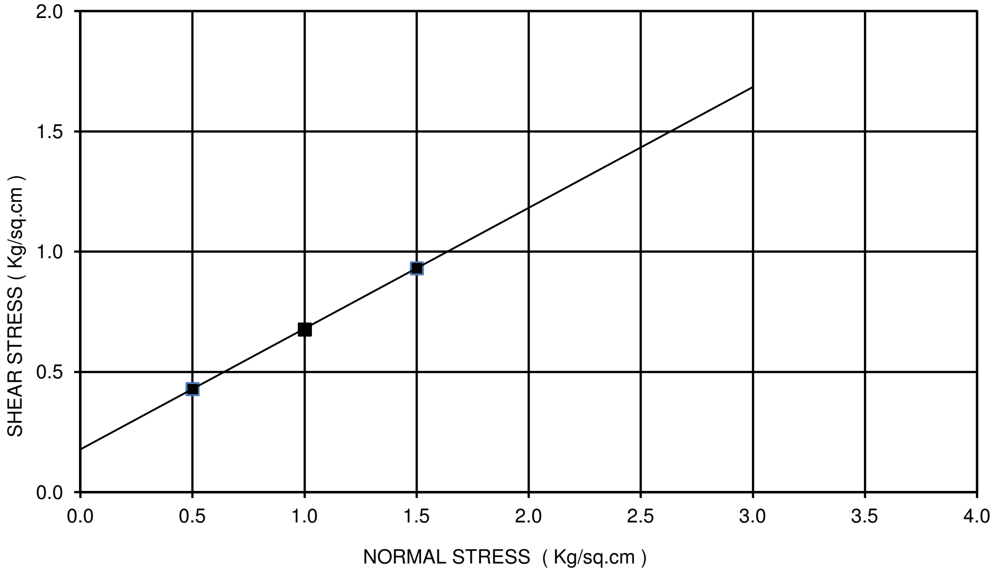


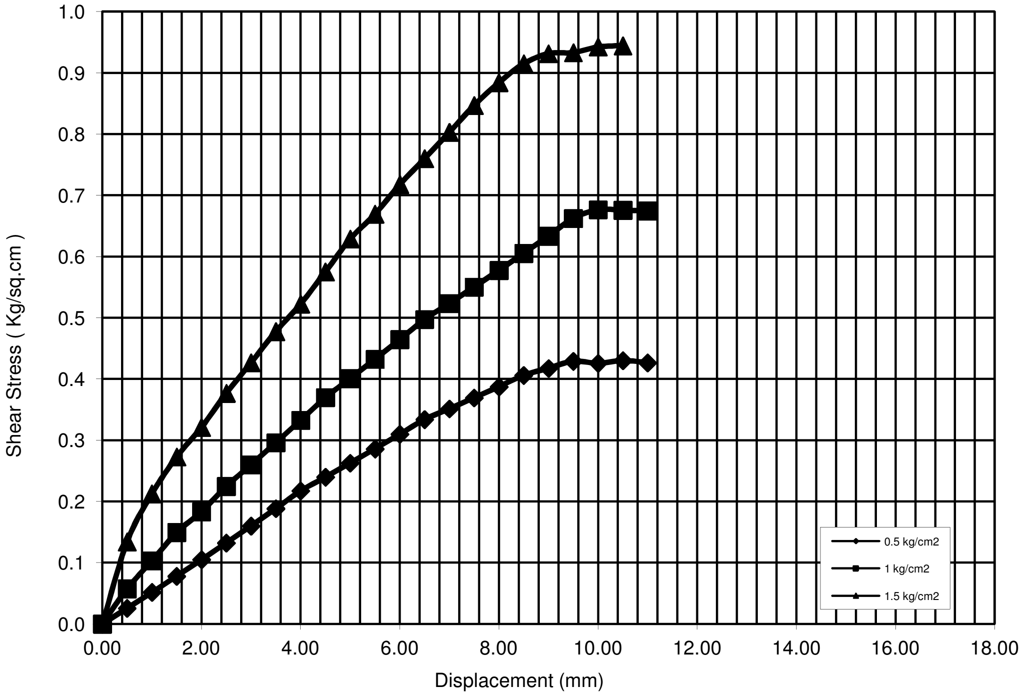
BORE HOLE NO: BH-A2
CHAINAGE : 28+075 km
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.44 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT



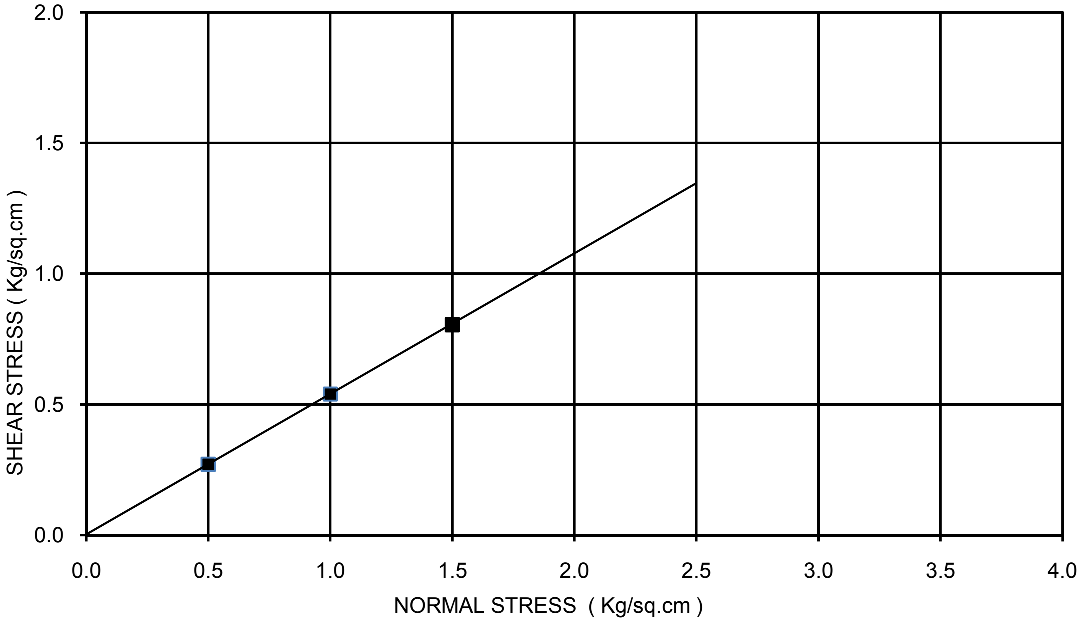


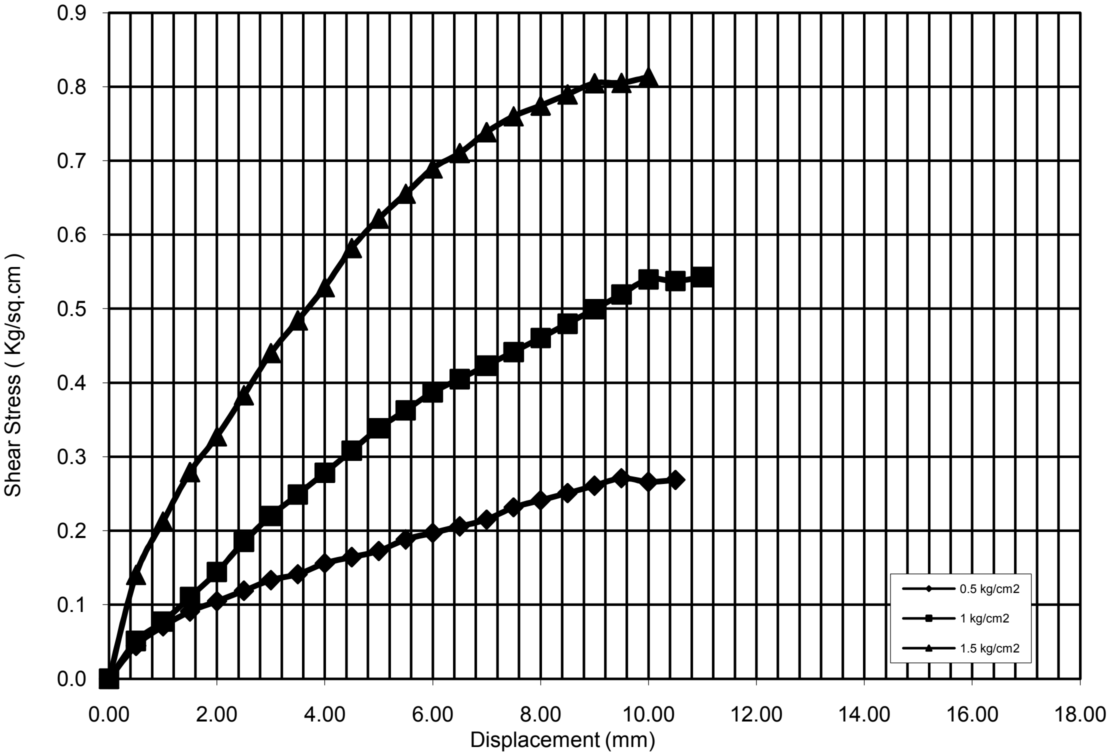
BORE HOLE NO: BH-A2
CHAINAGE : 28+075 km
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.18 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



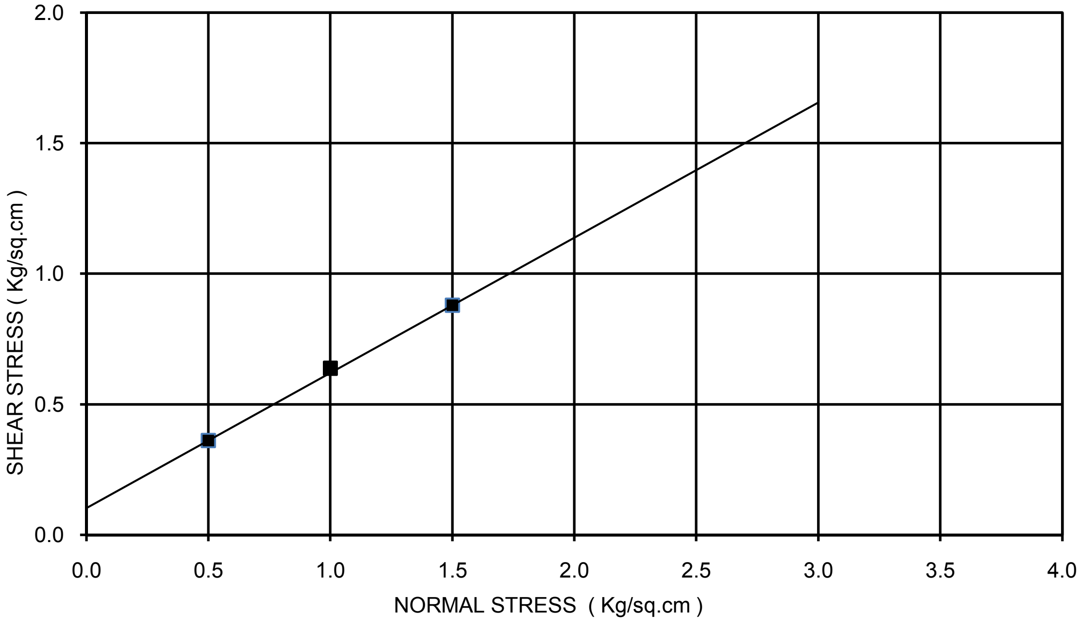


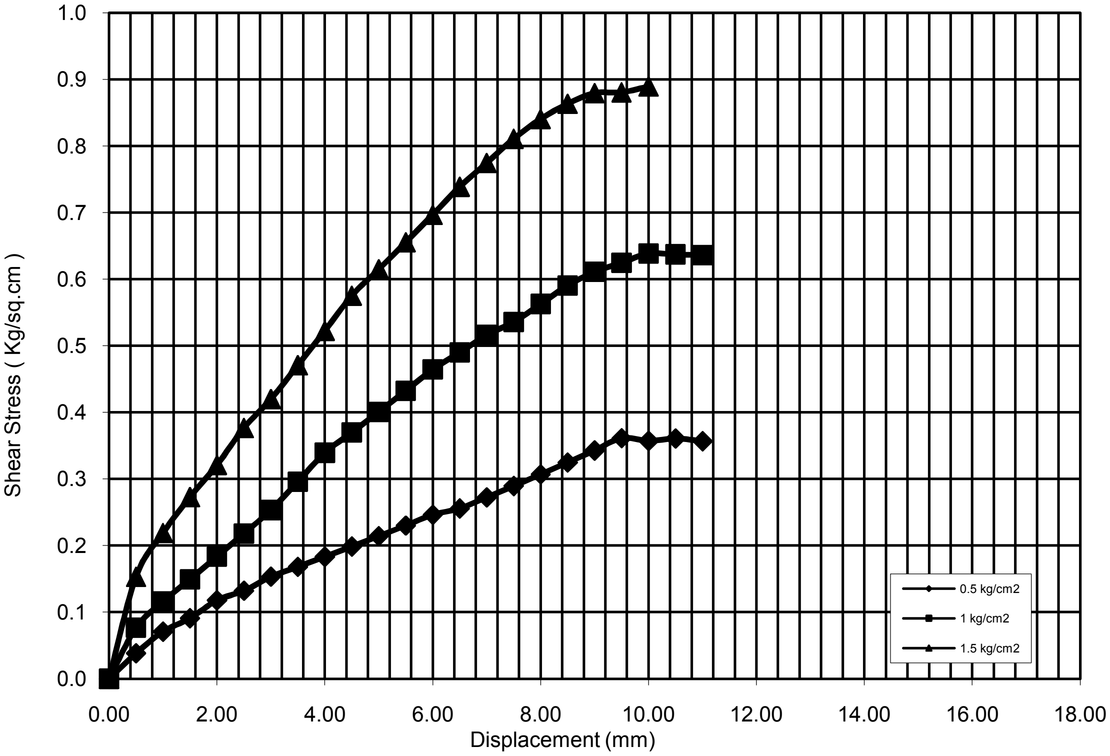
BORE HOLE NO: BH-A1
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 2.5 m
COHESION(C)= 0.00 kg/sq.cm
ANGLE OF FRICTION(Phi): 28 deg
TYPE OF THE TEST: DST



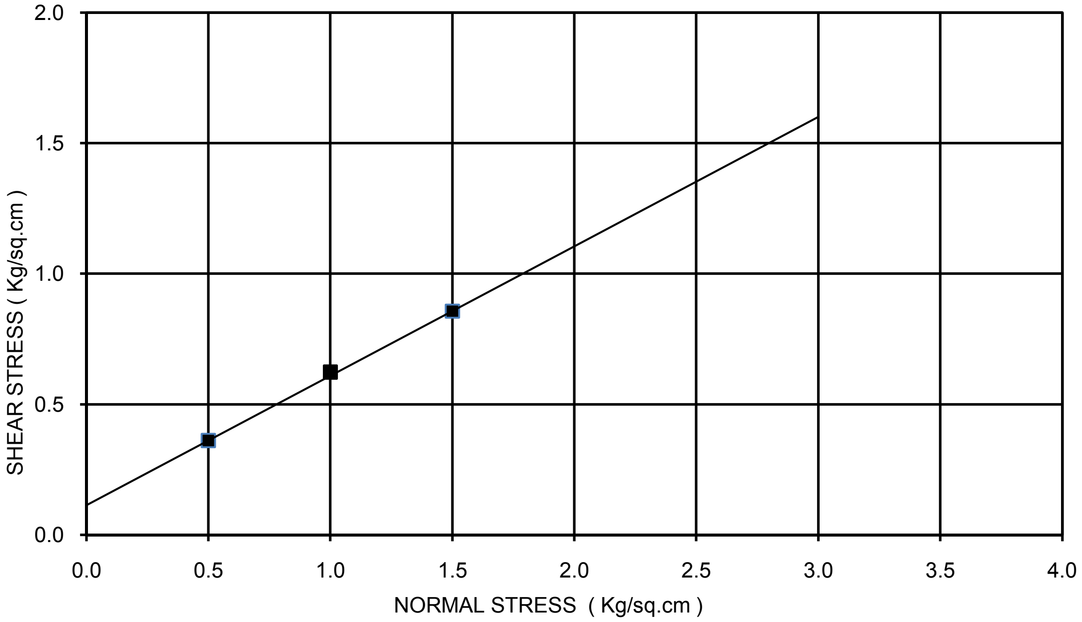


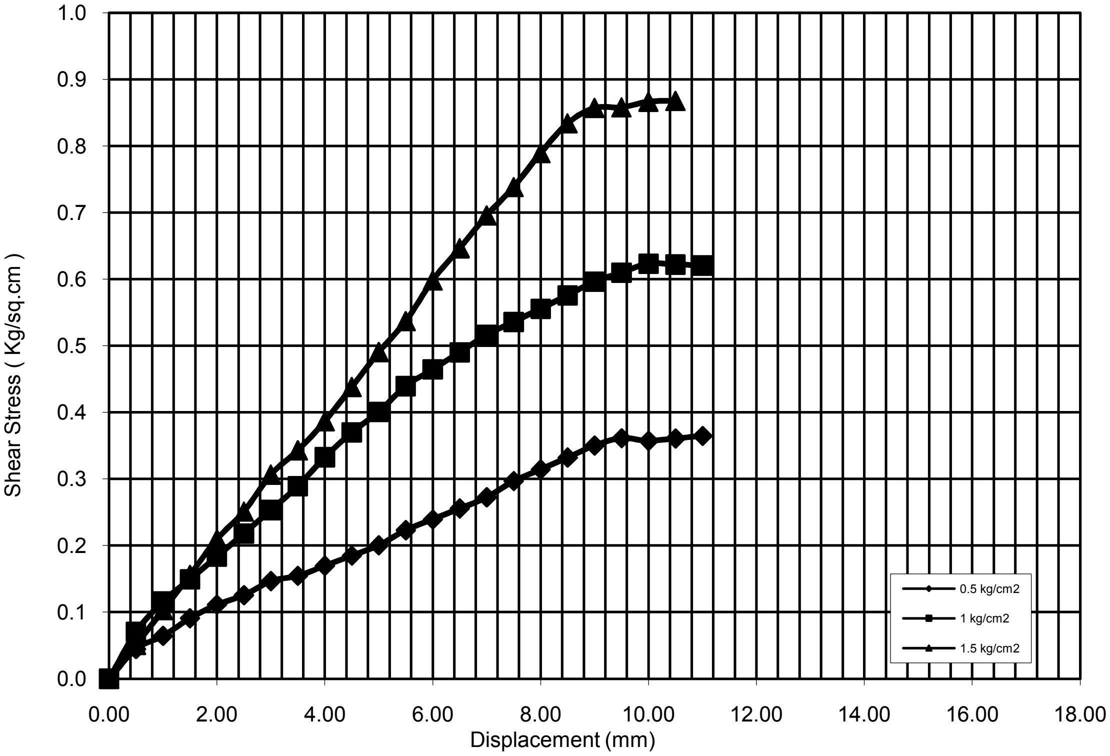
BORE HOLE NO: BH-A1
Chainage:- 28+360
SAMPLE NO.: UDS-3
DEPTH: 8.50 m
COHESION(C)= 0.10 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



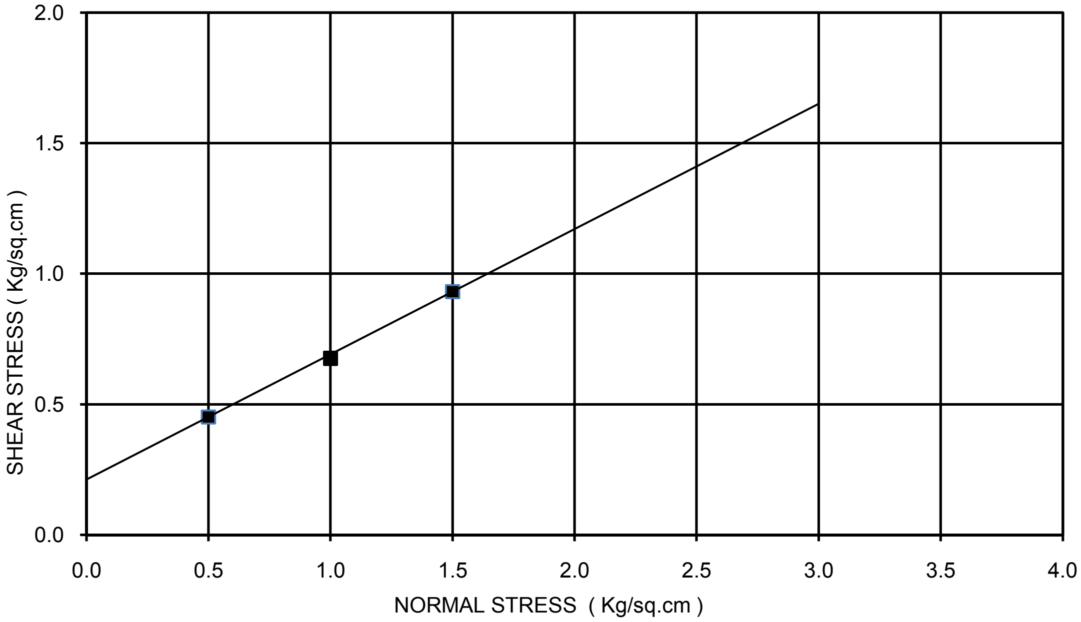


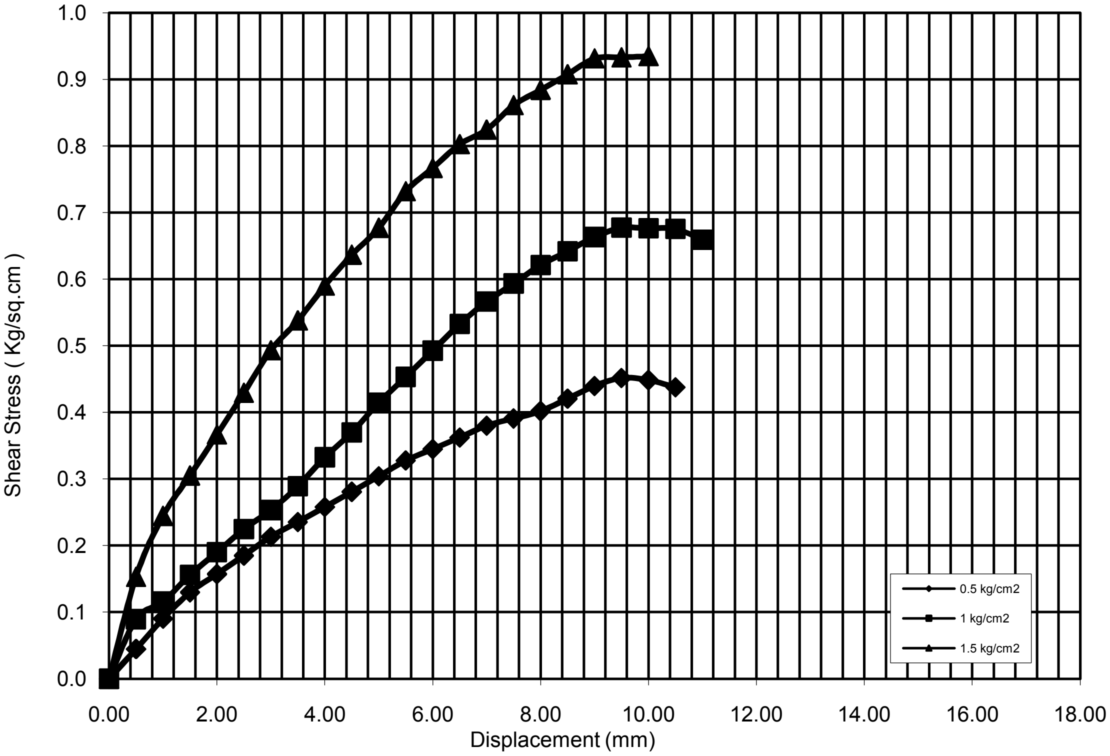
BORE HOLE NO: BH-P1
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.11 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



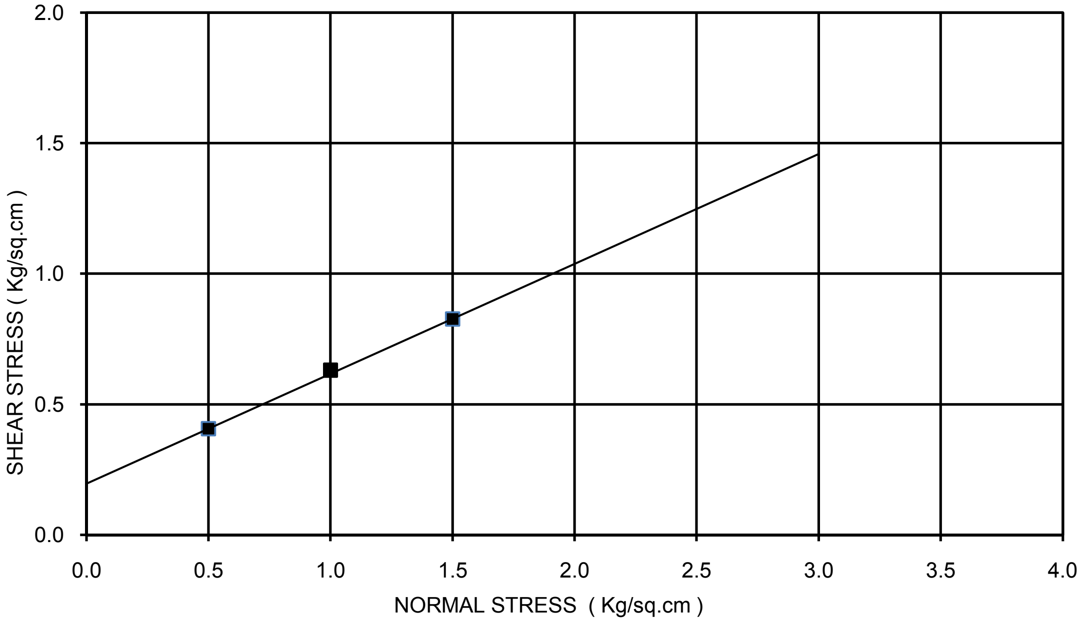


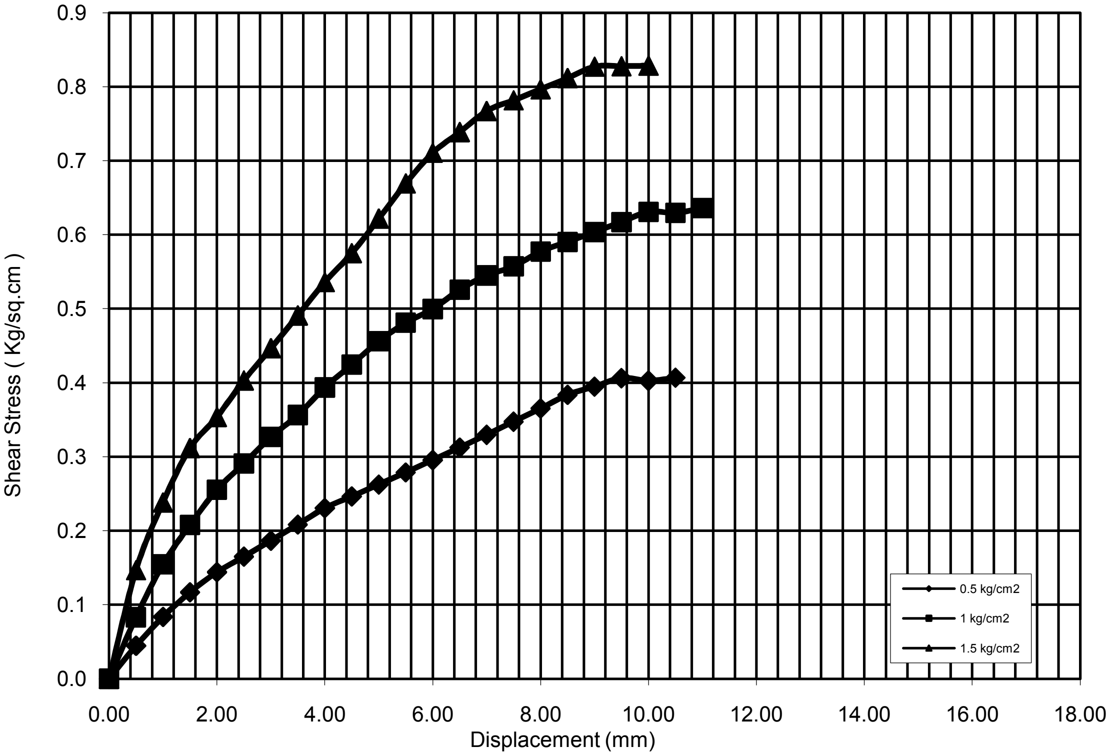
BORE HOLE NO: BH-P1
Chainage:- 28+360
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.21 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST





BORE HOLE NO: BH-P2
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 23 deg
TYPE OF THE TEST: DST





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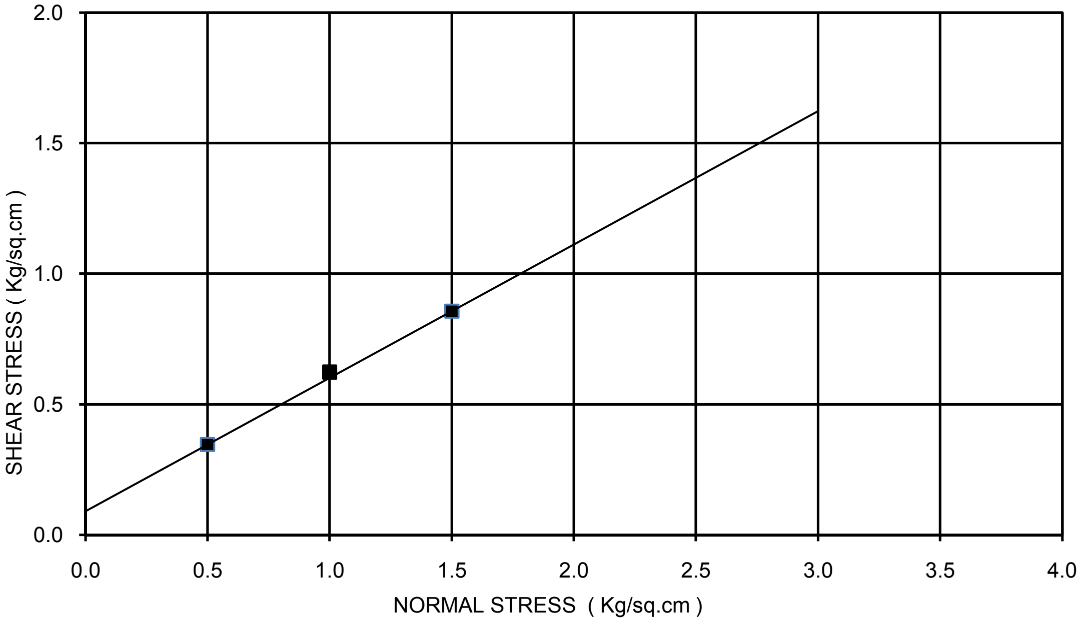
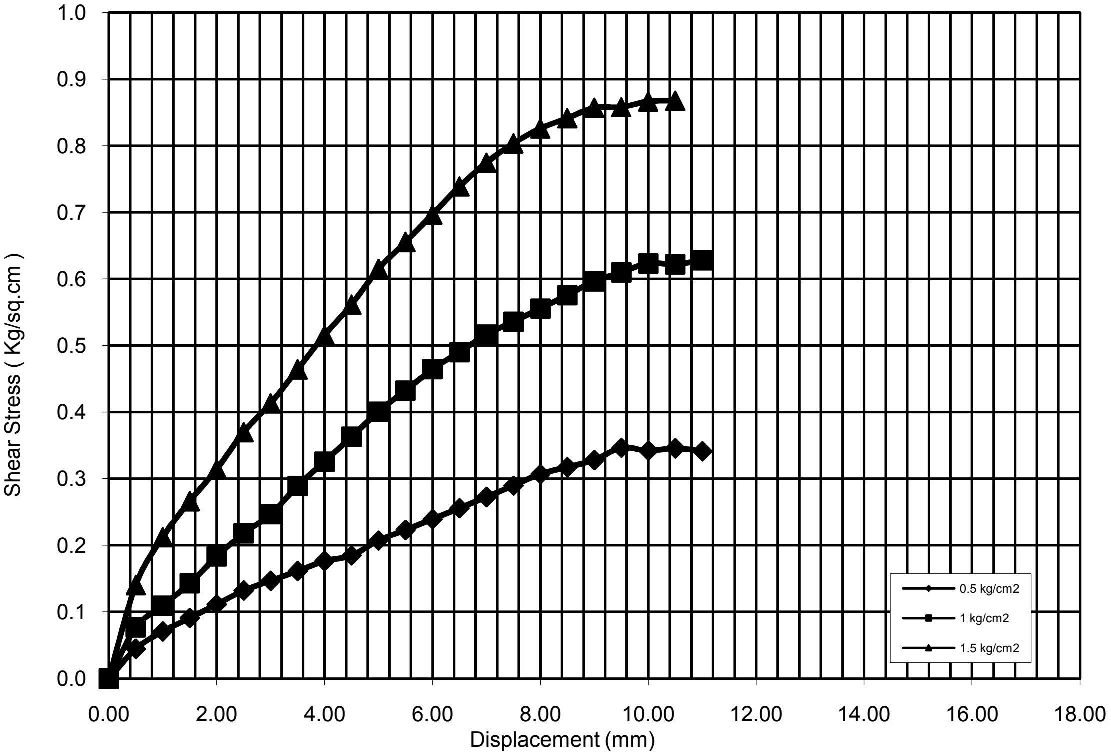
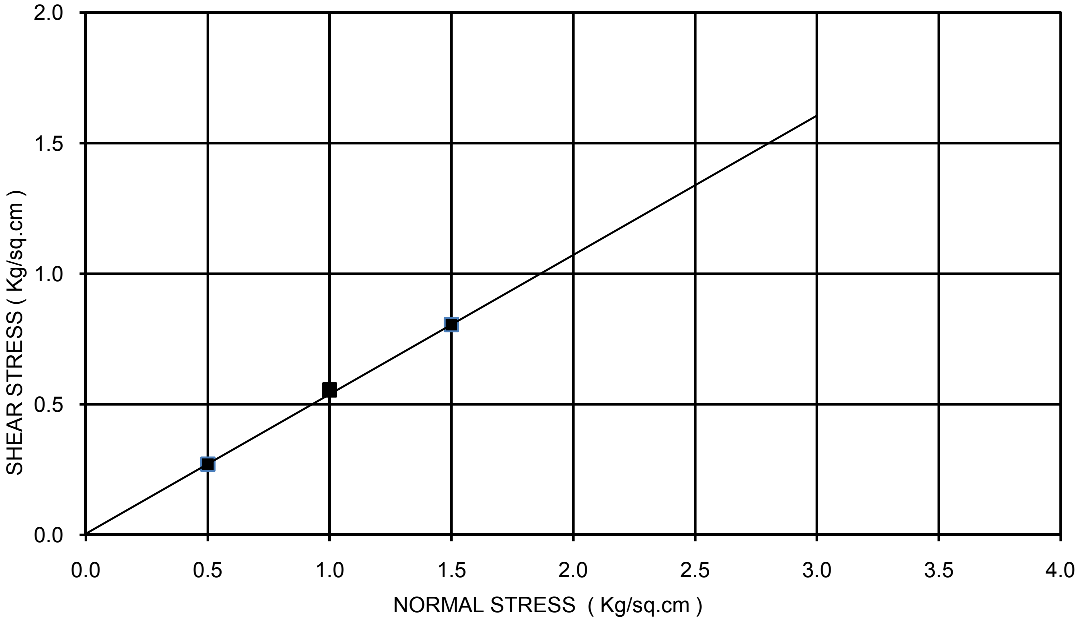
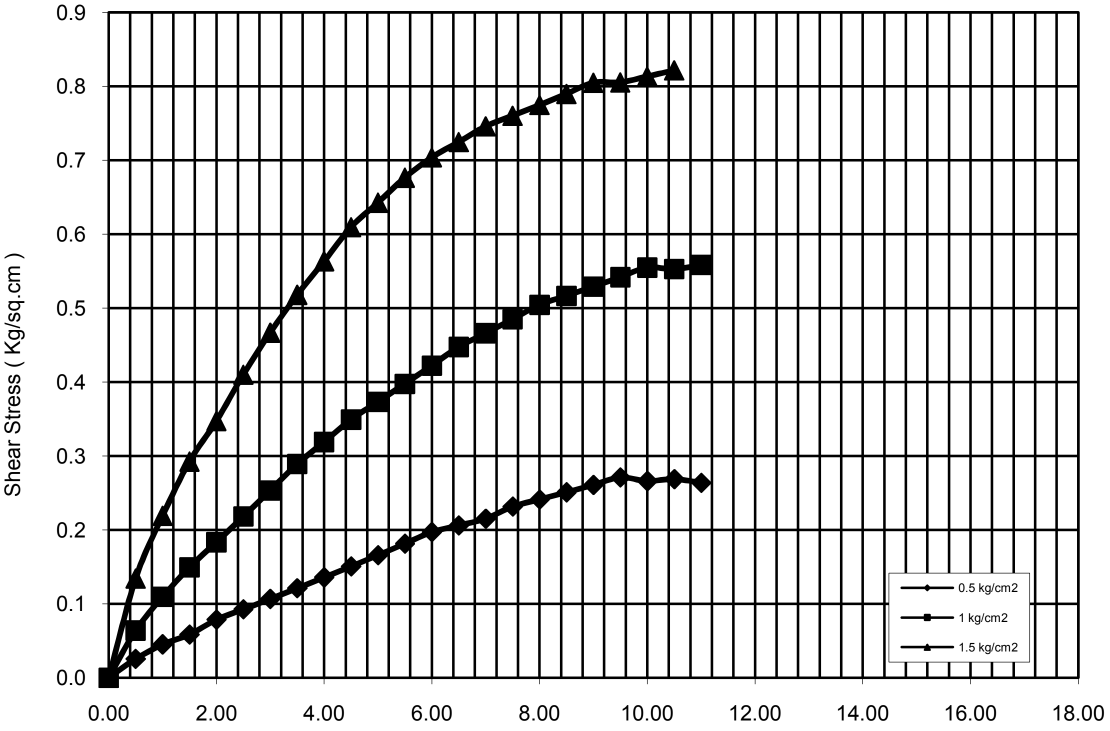
BORE HOLE NO: BH-P2
Chainage:- 28+360
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 0.09 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



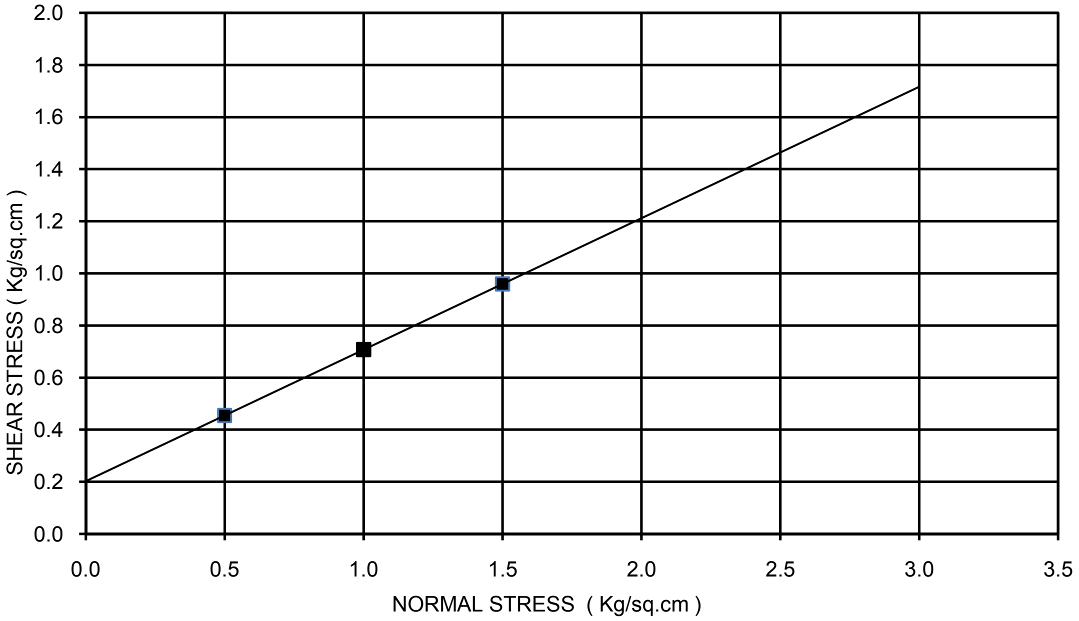


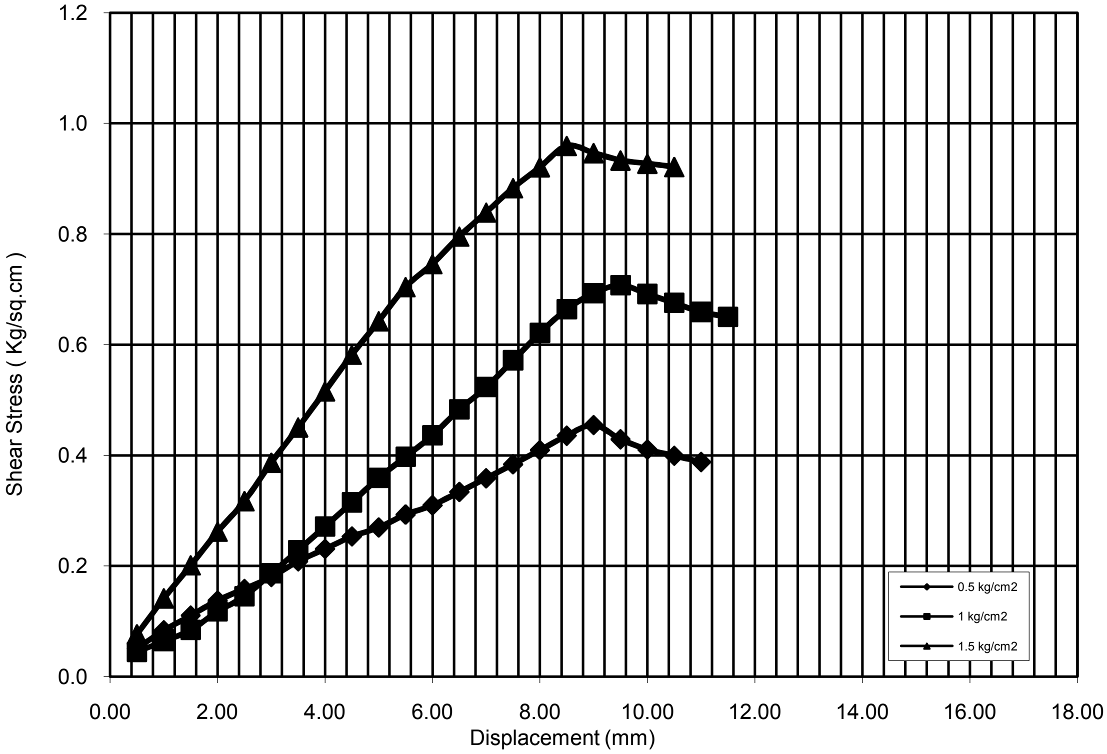
BORE HOLE NO: BH-A2
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.00 kg/sq.cm
ANGLE OF FRICTION(Phi): 28 deg
TYPE OF THE TEST: DST



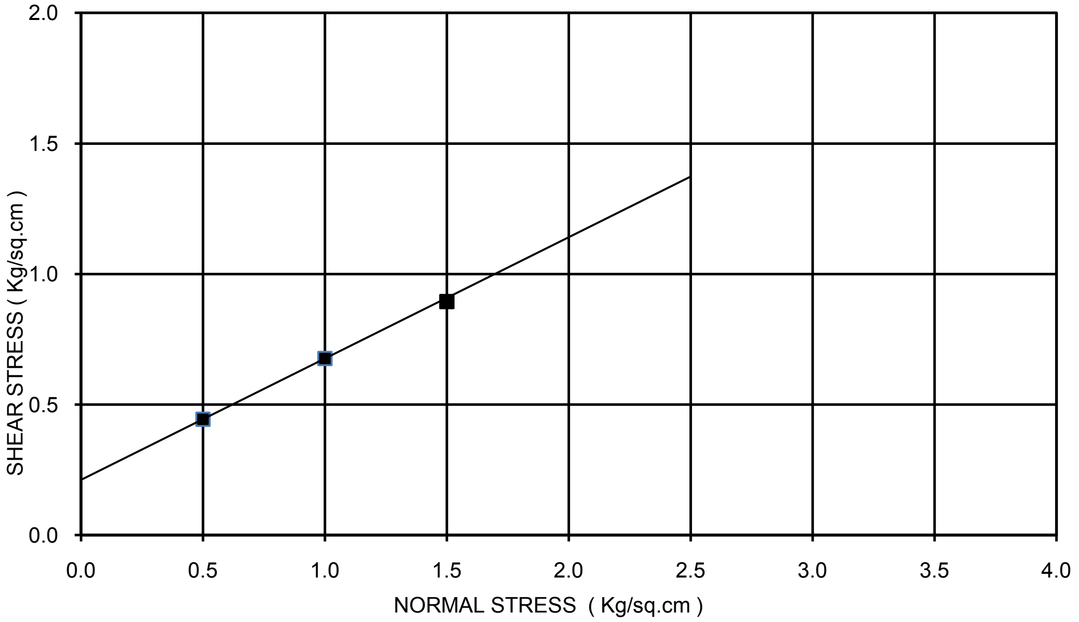


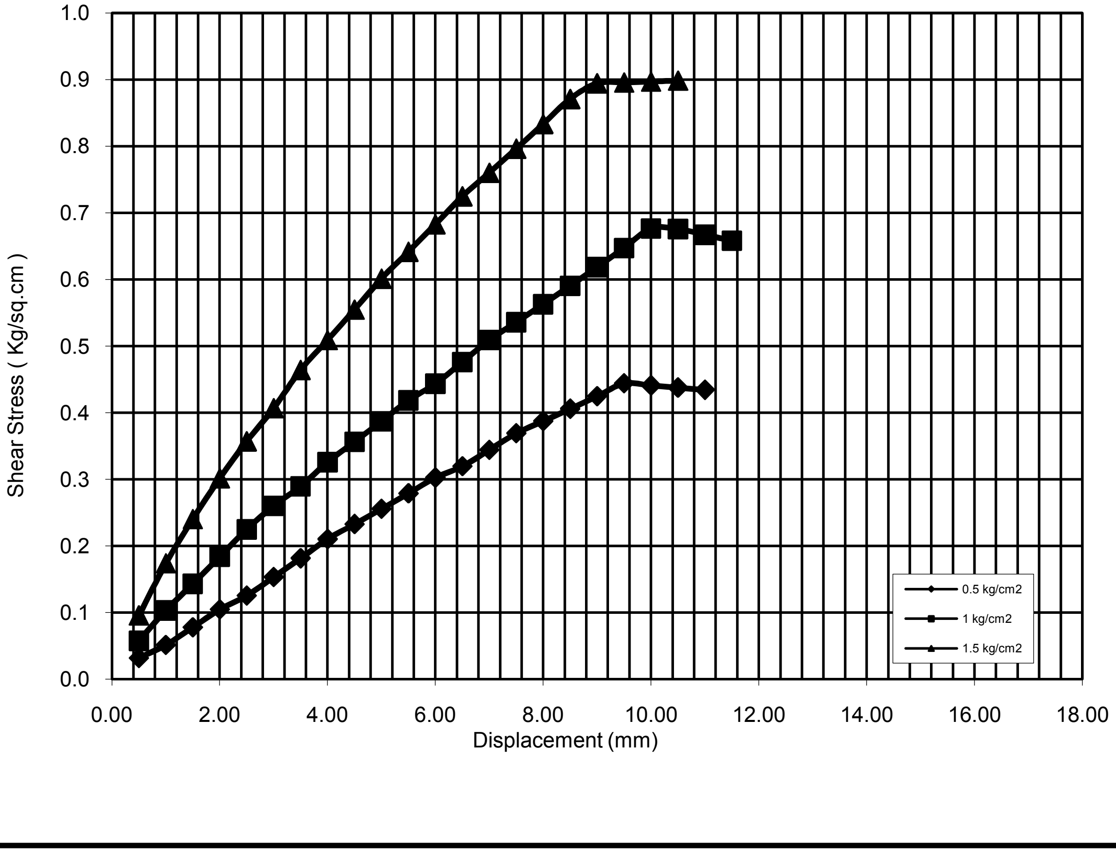
BORE HOLE NO: BH-A2
CHAINAGE : - 28+360
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.2 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



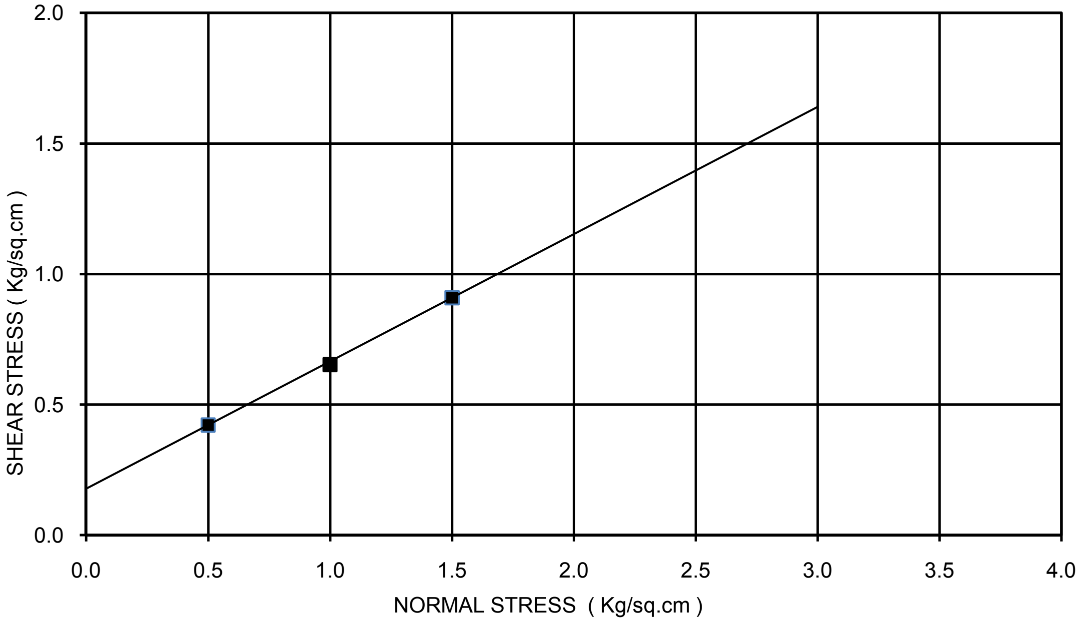


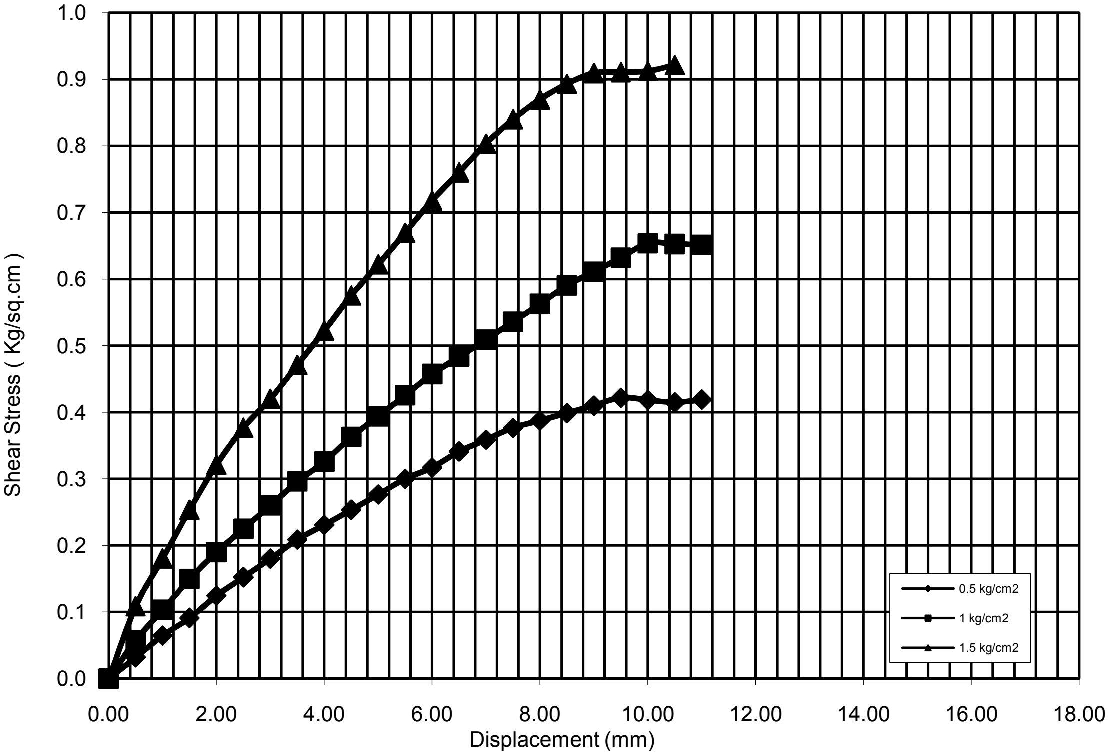
BORE HOLE NO: BH-A1
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.21 kg/sq.cm
ANGLE OF FRICTION(Phi): 25 deg
TYPE OF THE TEST: DST



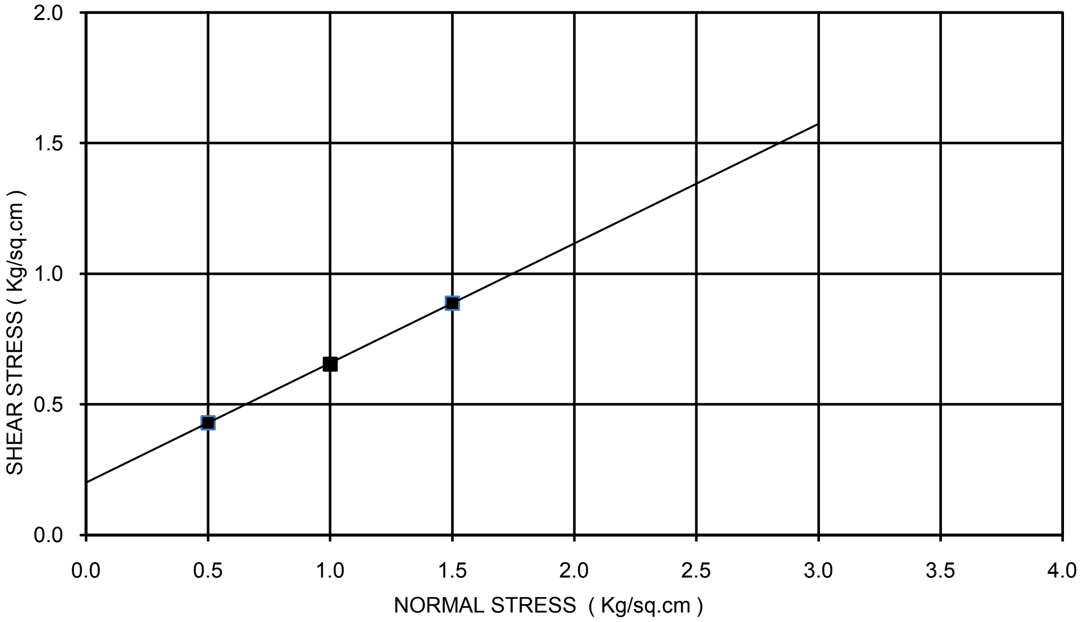


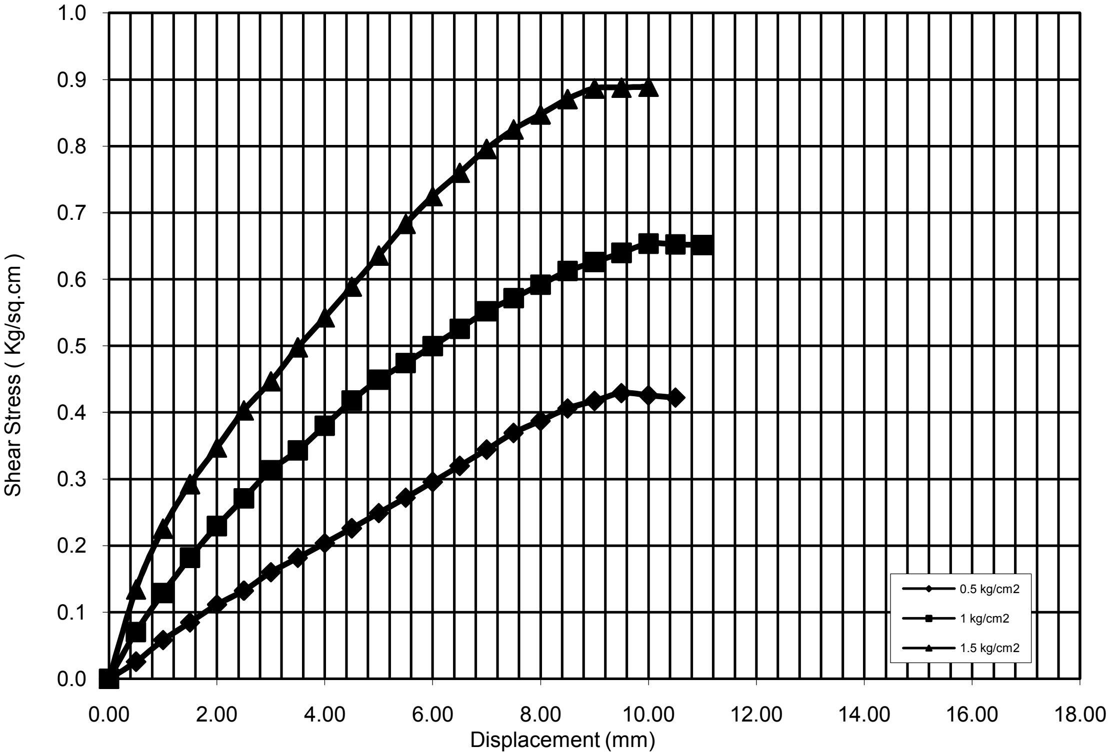
BORE HOLE NO: BH-A1
Chainage: 28+900
SAMPLE NO.: UDS-3
DEPTH: 8.50 m
COHESION(C)= 0.18 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



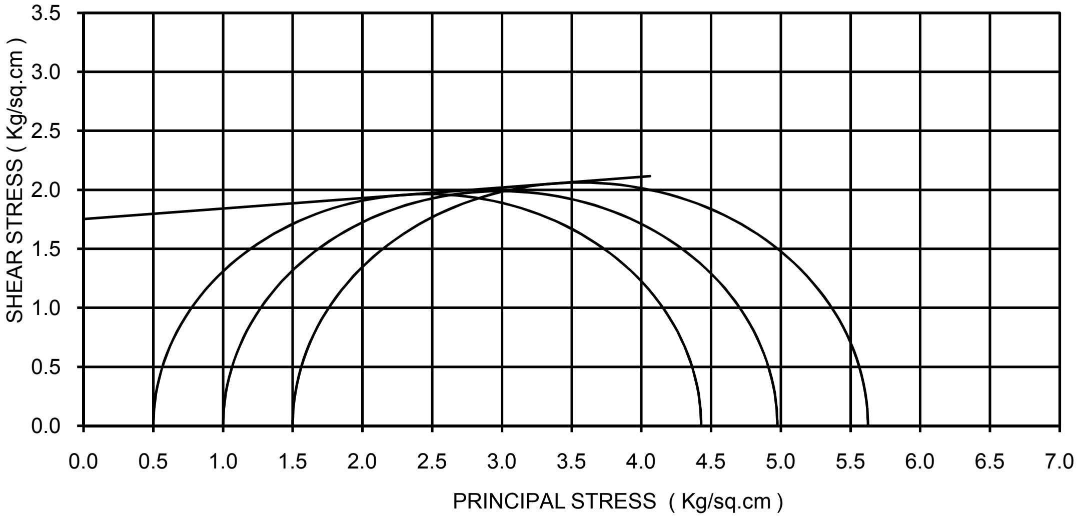


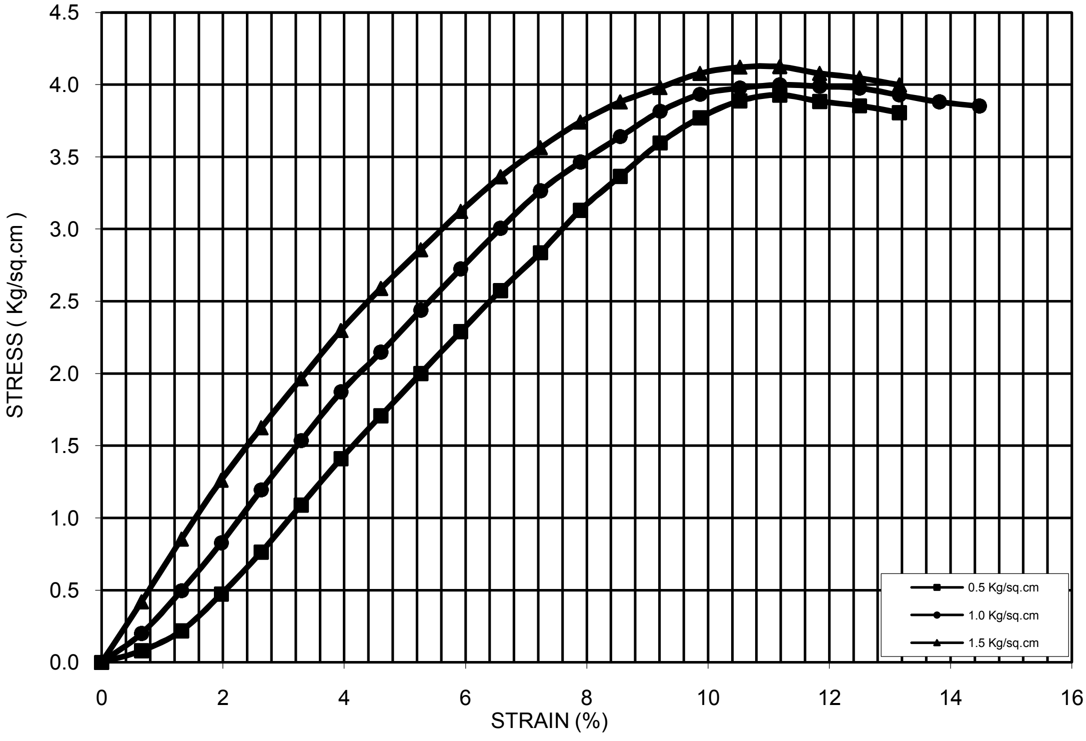
BORE HOLE NO: BH-P1
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 25 deg
TYPE OF THE TEST: DST



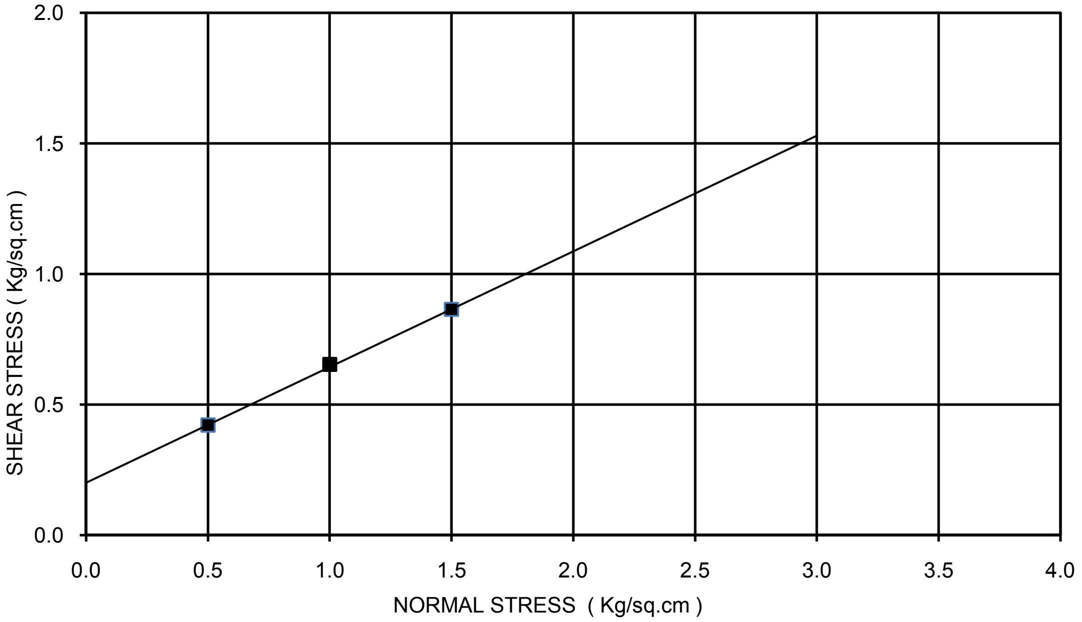


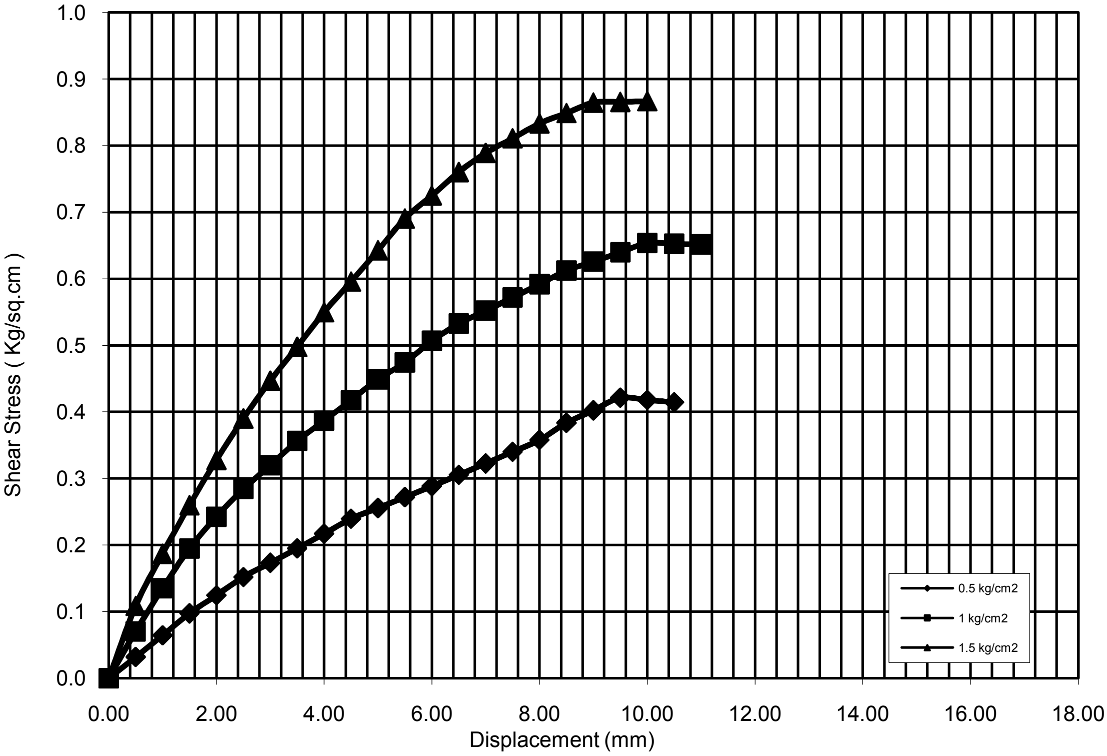
BORE HOLE NO: BH-P1
Chainage: 28+900
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 1.75 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT





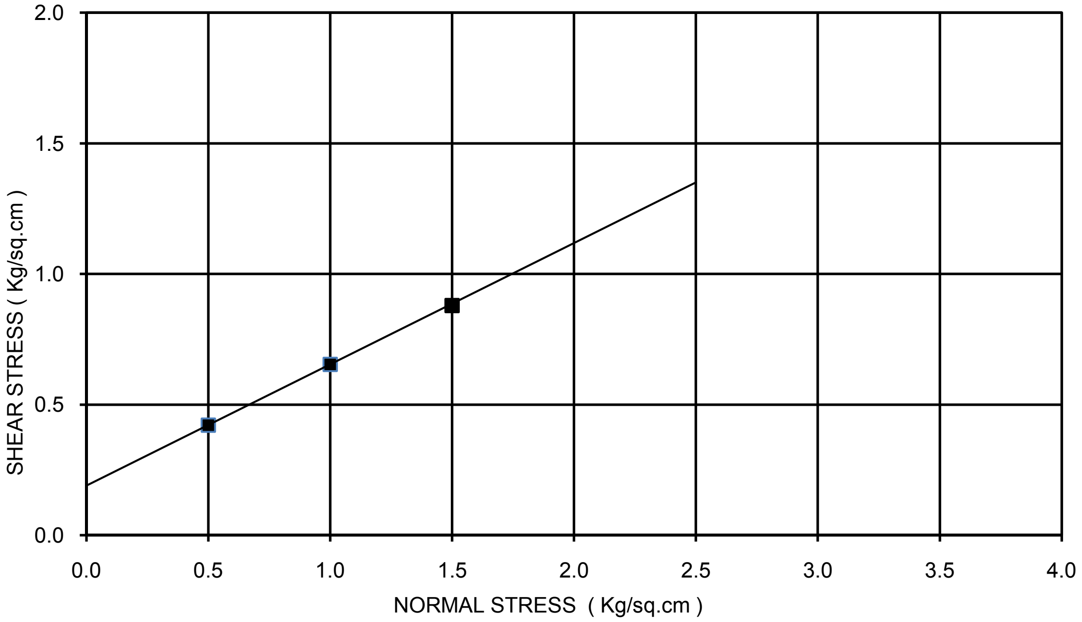
BORE HOLE NO: BH-P2
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST

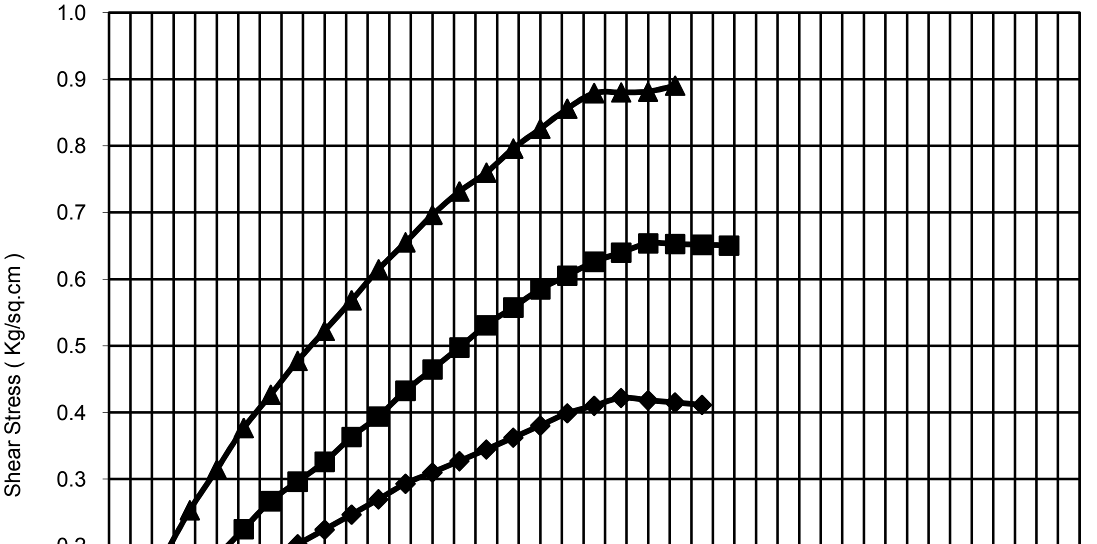




CEG Test House and Research Centre Pvt. Ltd.

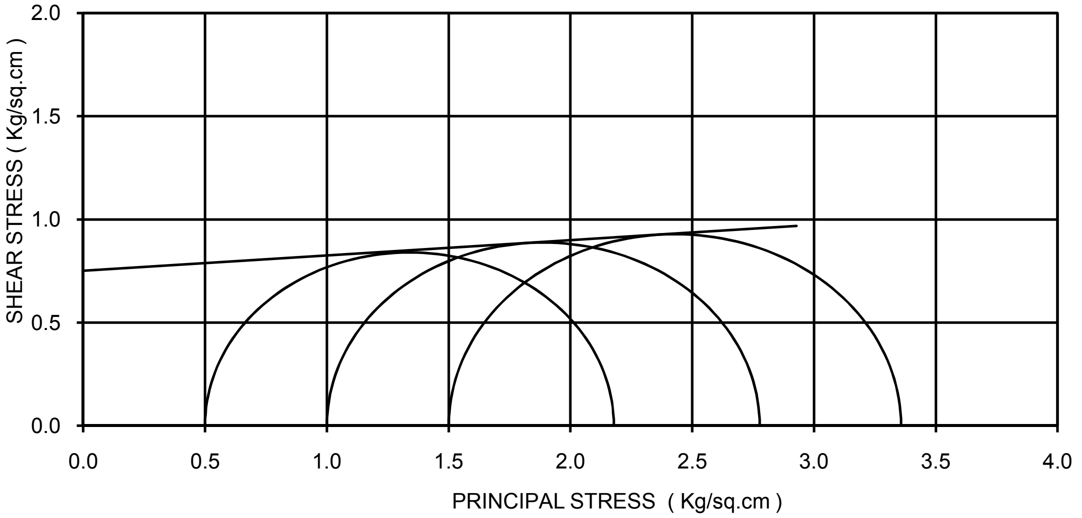
BORE HOLE NO: BH-P2
Chainage: 28+900
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 0.19 kg/sq.cm
ANGLE OF FRICTION(Phi): 25 deg
TYPE OF THE TEST: DST

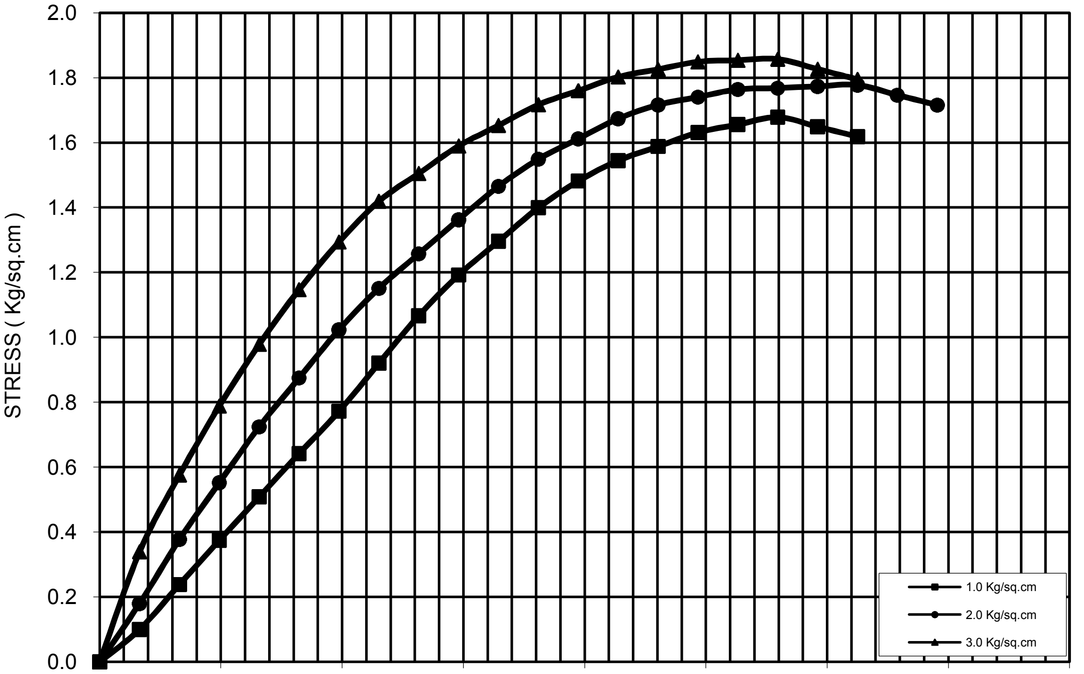




CEG Test House and Research Centre Pvt. Ltd.

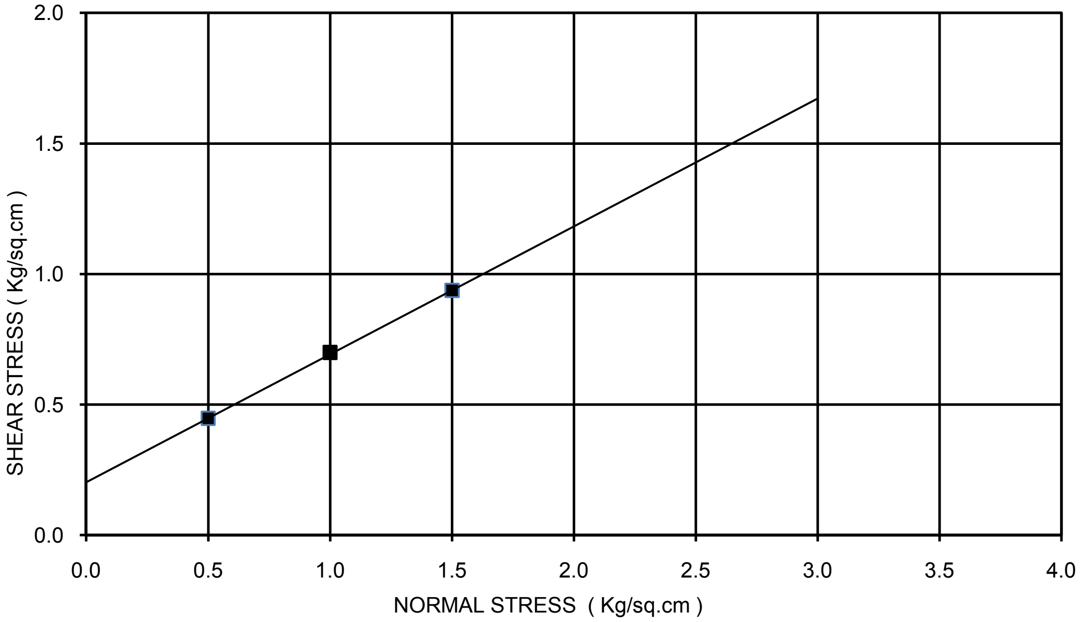
BORE HOLE NO: BH-A2
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.75 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT

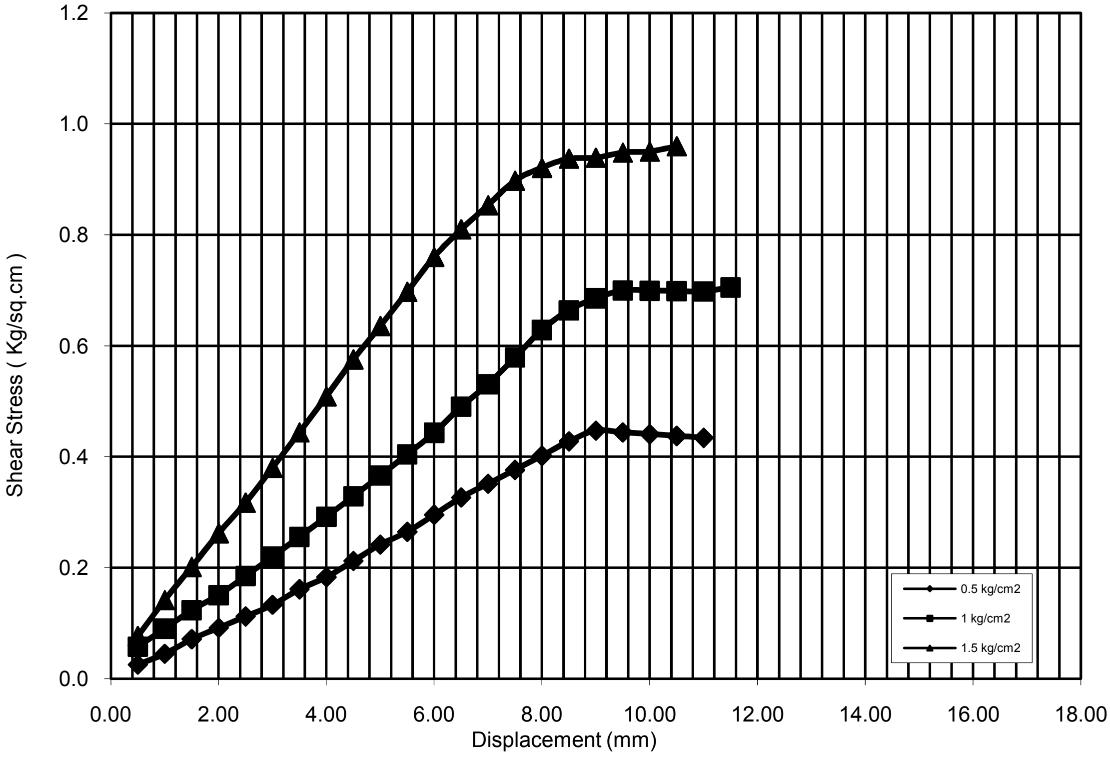


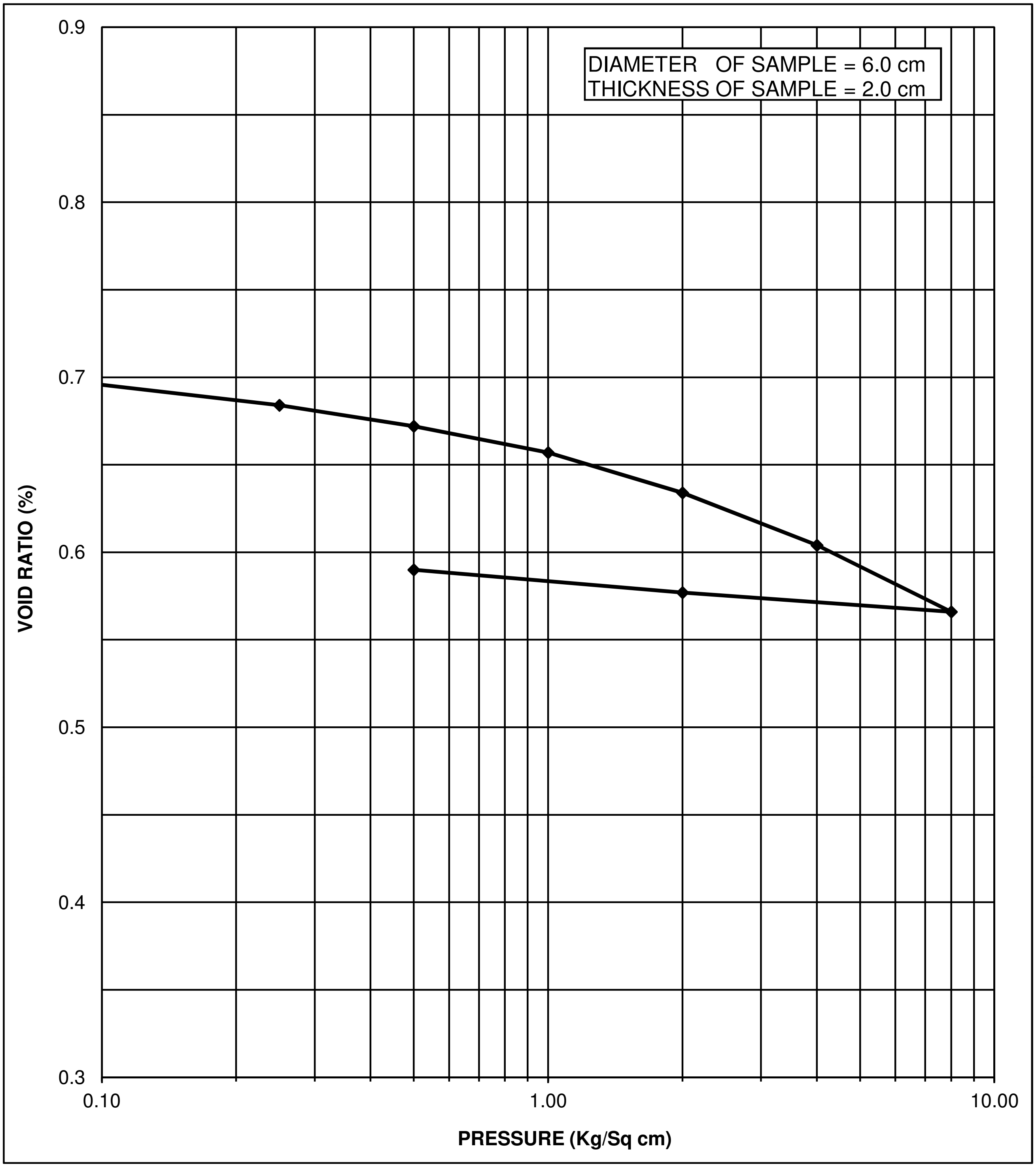


CEG Test House and Research Centre Pvt. Ltd.

BORE HOLE NO: BH-A2
Chainage: 28+900
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST







CHAINAGE : 27+620

BORE HOLE NO. = BH-P1

SAMPLE NO. = UDS-2

DEPTH = 5.50 M

TYPE OF SOIL = CL

INITIAL WATER CONTENT = 13.46 %

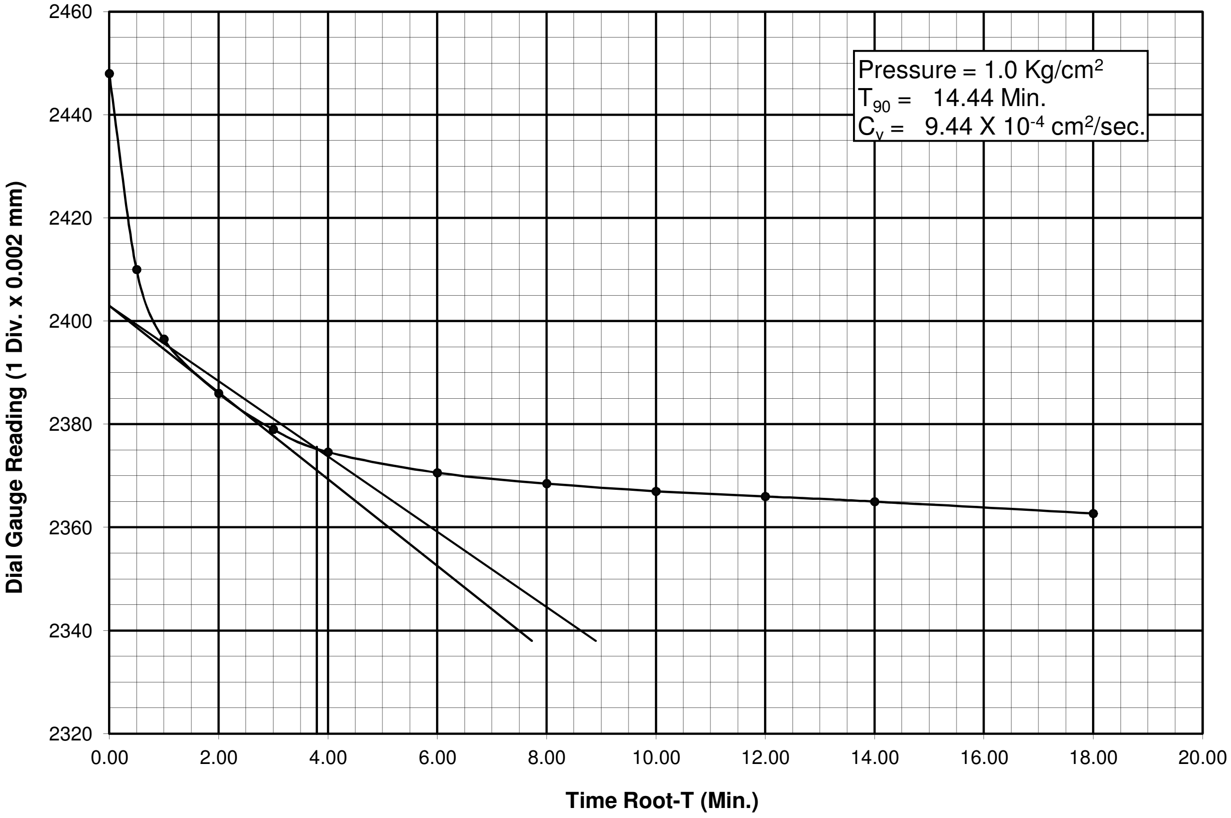
DRY DENSITY = 1.58 gm/cm^3

VOID RATIO (e_o) = 0.695

COMPRESSION INDEX (C_c) = 0.126

FIGURE NO. PRESSURE Vs VOID RATIO CURVE (e-log p)

CHAINAGE: = 27+620
BORE HOLE NO. = BH-P1
SAMPLE NO. = UDS-3
DEPTH = 7.50 M


Pressure = 1.0 Kg/cm^2
T_{90} = 14.44 Min.
C_v = 9.44 X 10^{-4} cm^2/sec.

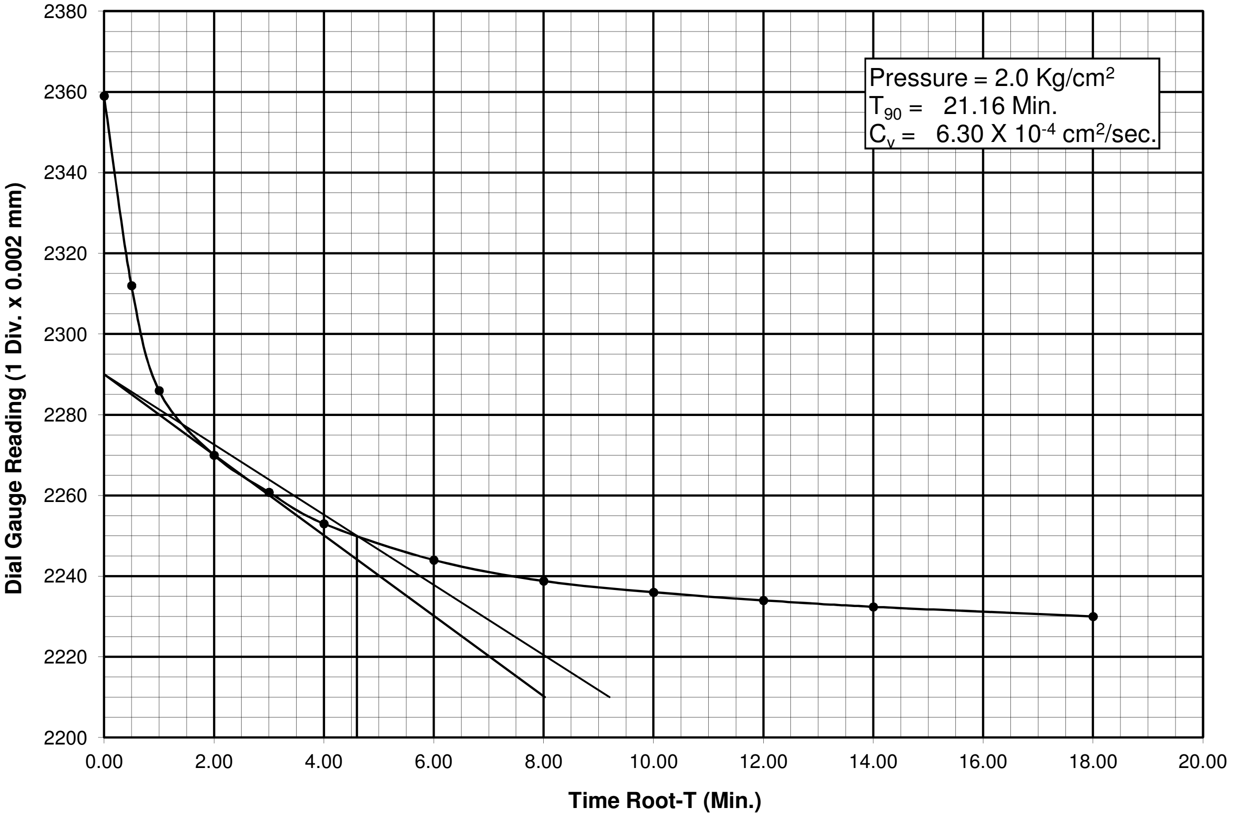
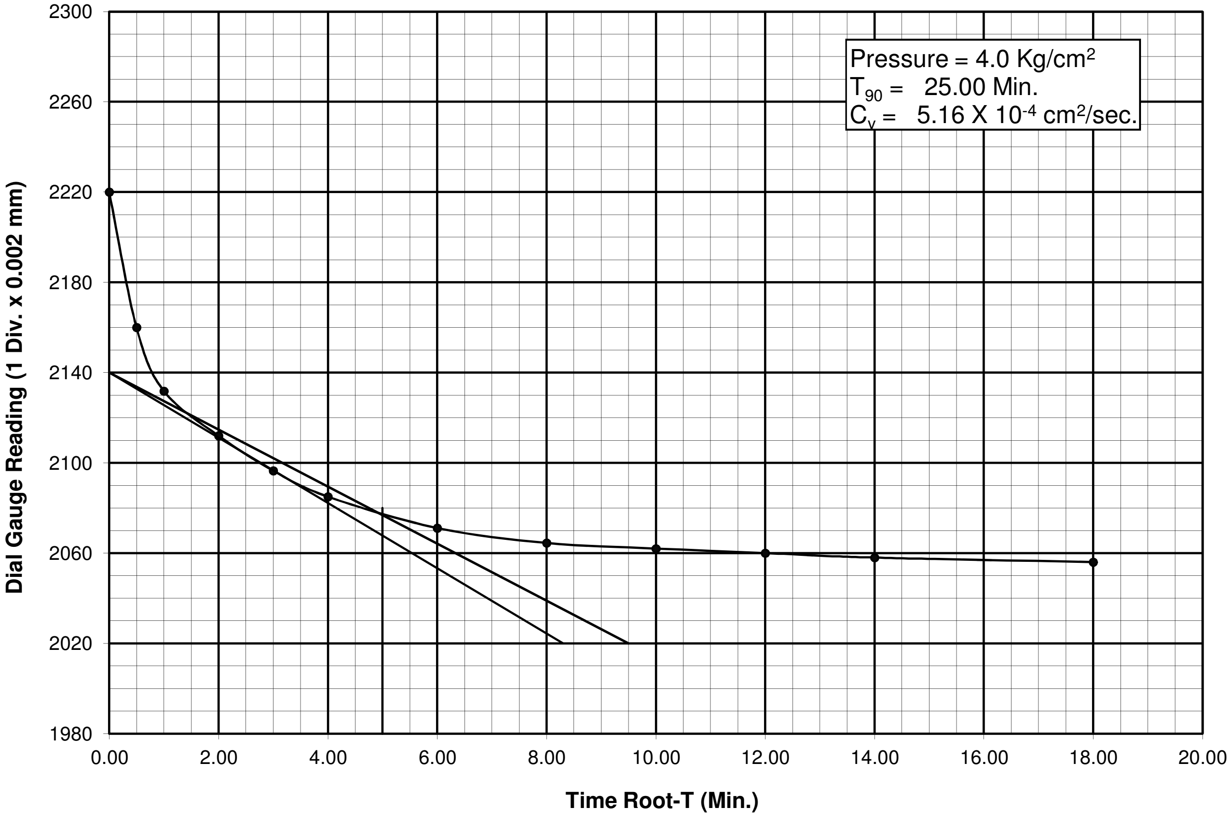

Pressure = 2.0 Kg/cm^2
T_{90} = 21.16 Min.
C_v = 6.30 X 10^{-4} cm^2/sec.

Figure No. -

CHAINAGE: = 27+620
BORE HOLE NO. = BH-P1
SAMPLE NO. = UDS-3
DEPTH = 7.50 M



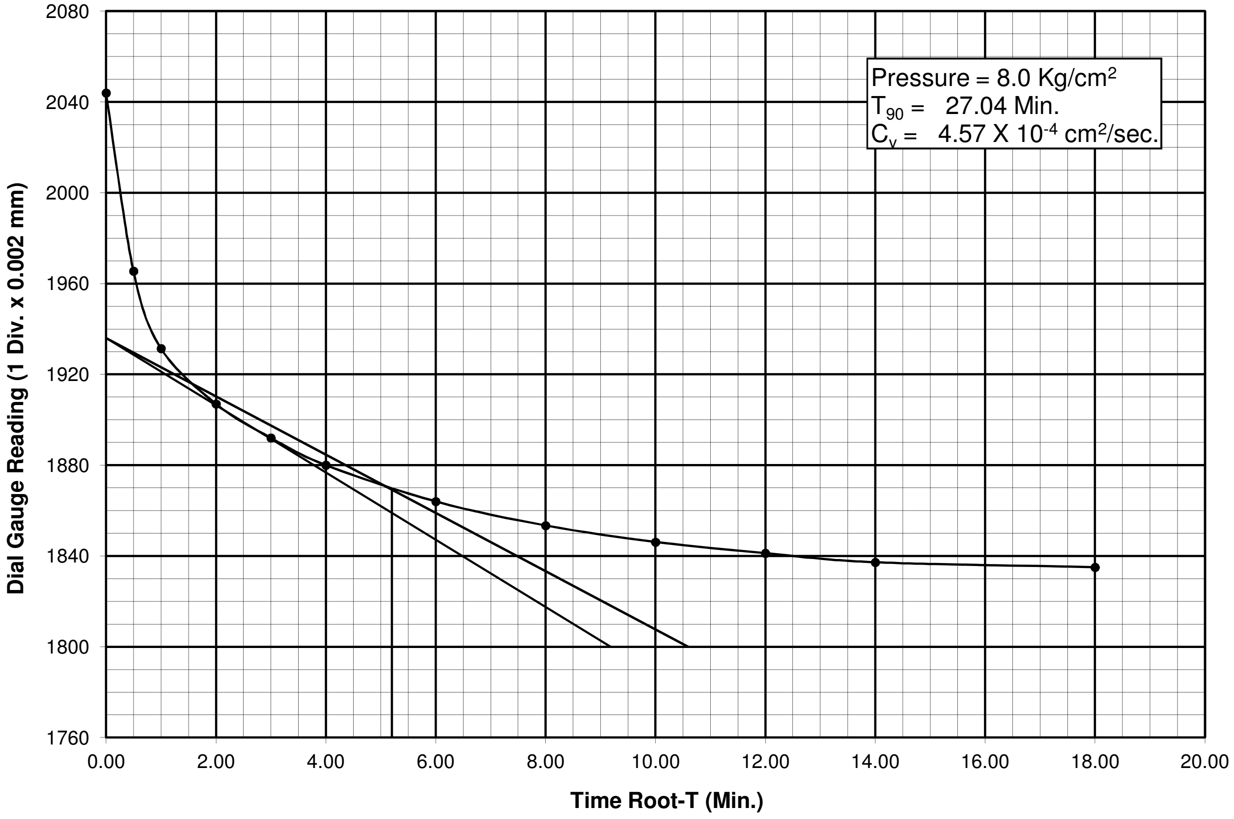
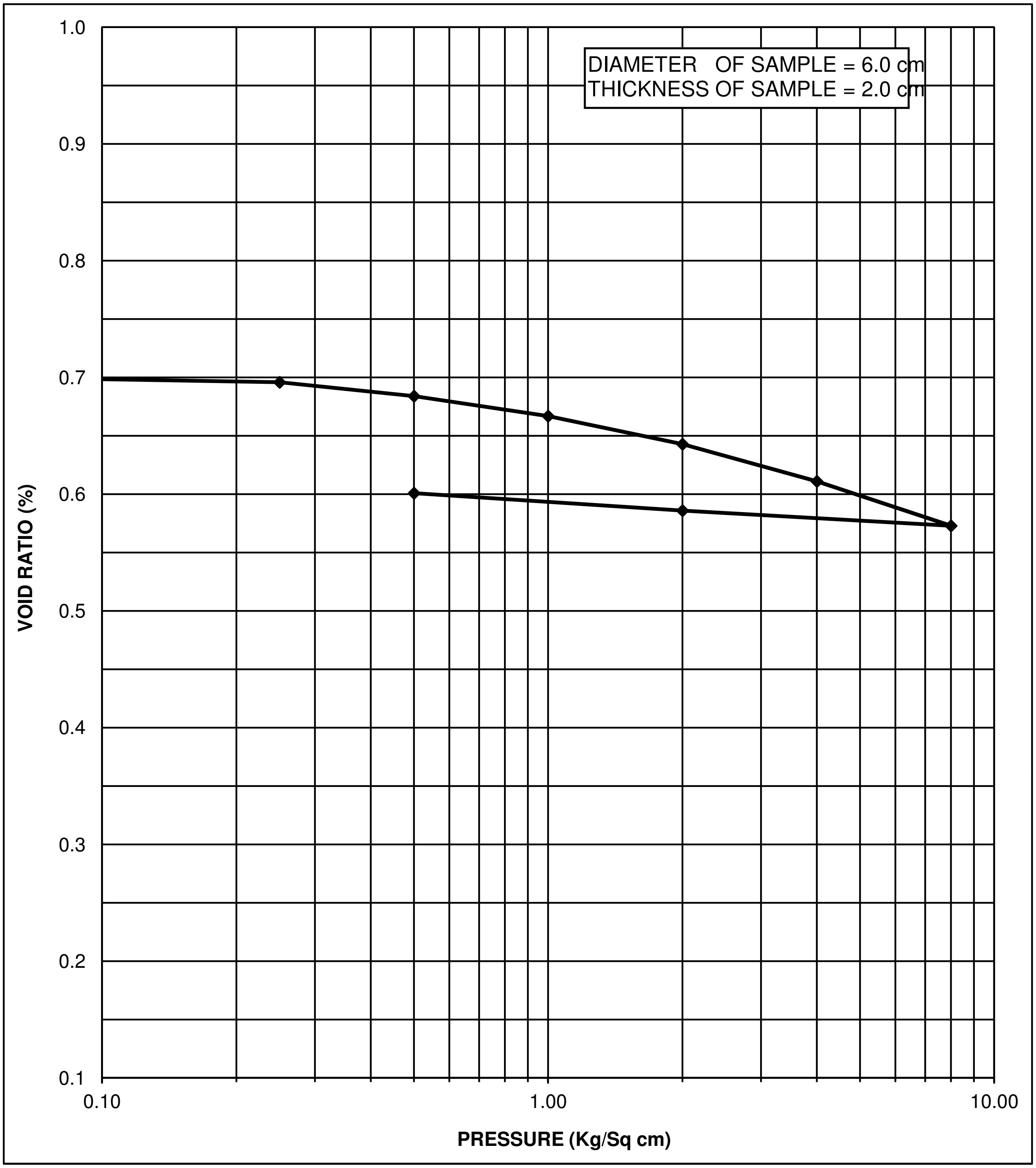


Figure No. -



CHAINAGE = 28+075

BORE HOLE NO. = BH-P1

SAMPLE NO. = UDS-3

DEPTH = 7.00 M

TYPE OF SOIL = CL

INITIAL WATER CONTENT = 14.30 %

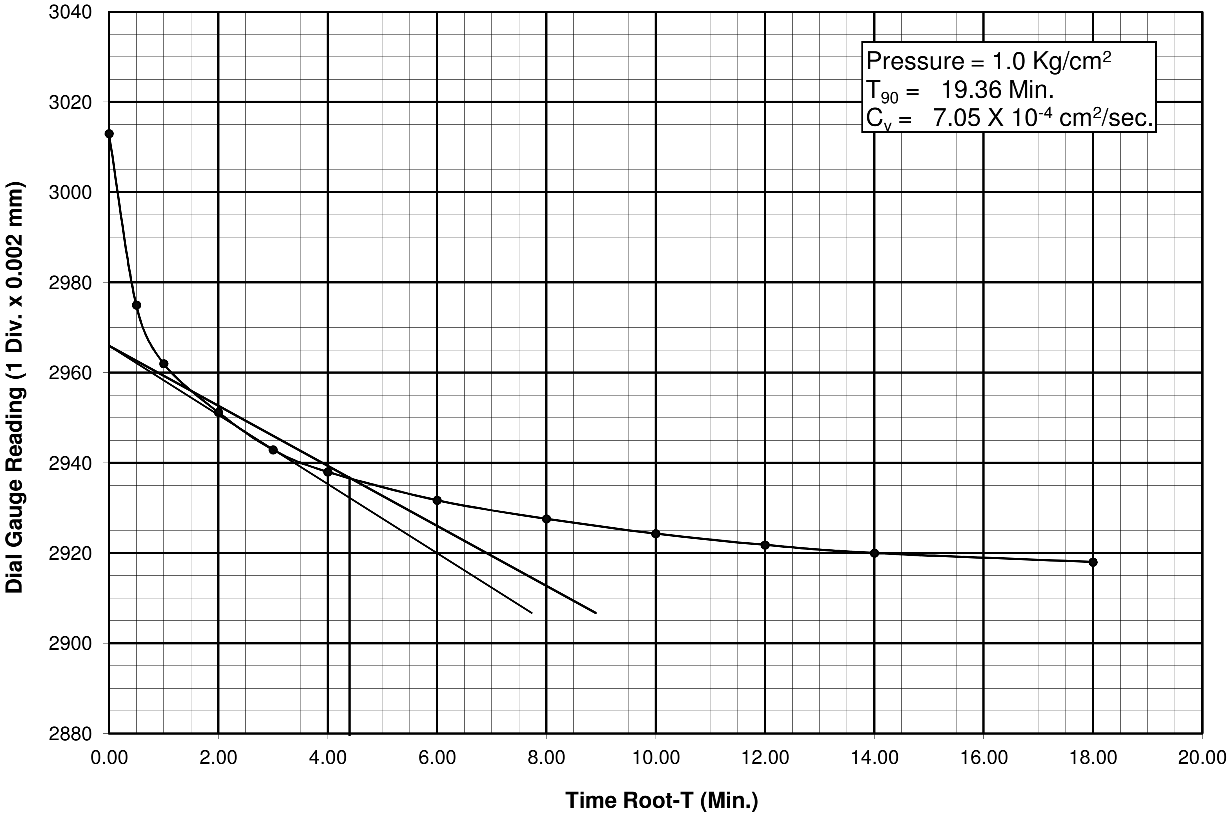
DRY DENSITY = 1.57 gm/cm^3

VOID RATIO (e_o) = 0.705

COMPRESSION INDEX (C_c) = 0.126

FIGURE NO. PRESSURE Vs VOID RATIO CURVE (e-log p)

CHAINAGE = 28+075
BORE HOLE NO. = BH-P1
SAMPLE NO. = UDS-3
DEPTH = 7.00 M



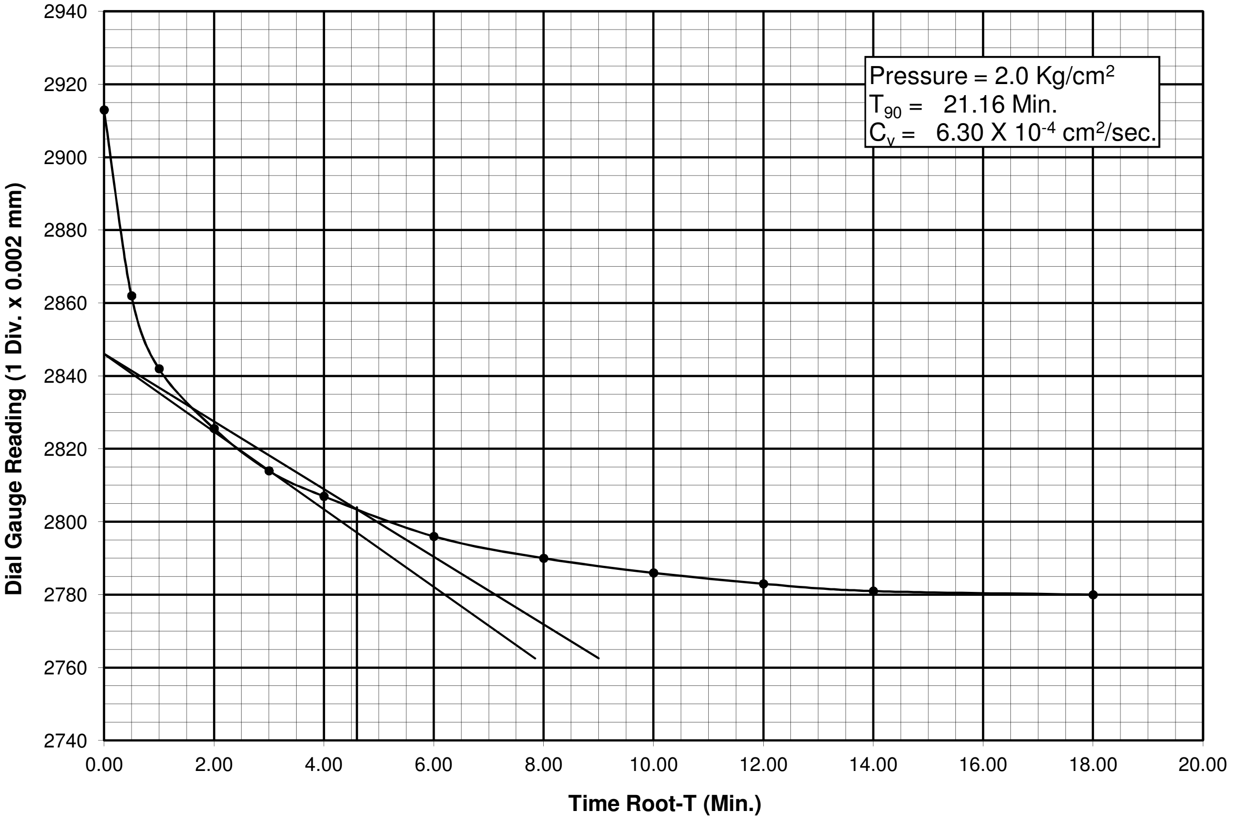
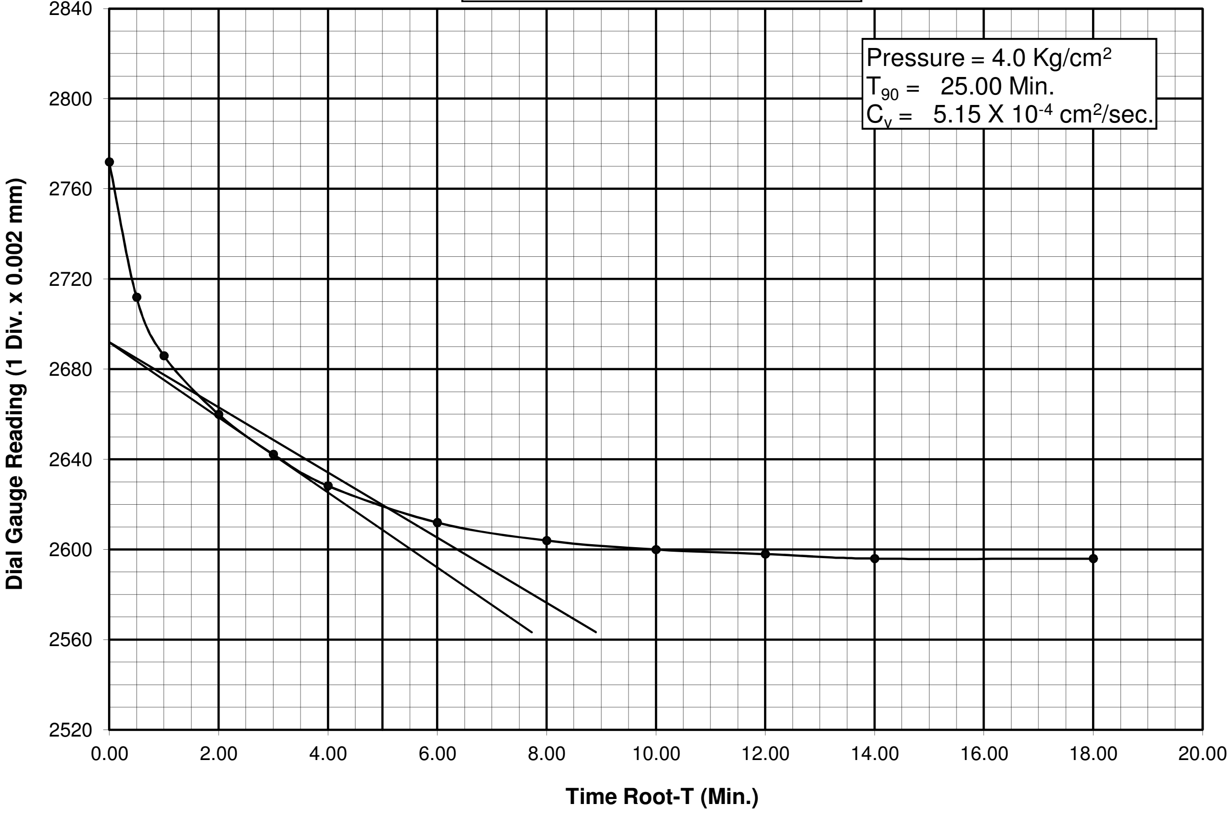


Figure No. -

CHAINAGE = 28+075
BORE HOLE NO. = BH-P1
SAMPLE NO. = UDS-3
DEPTH = 7.00 M



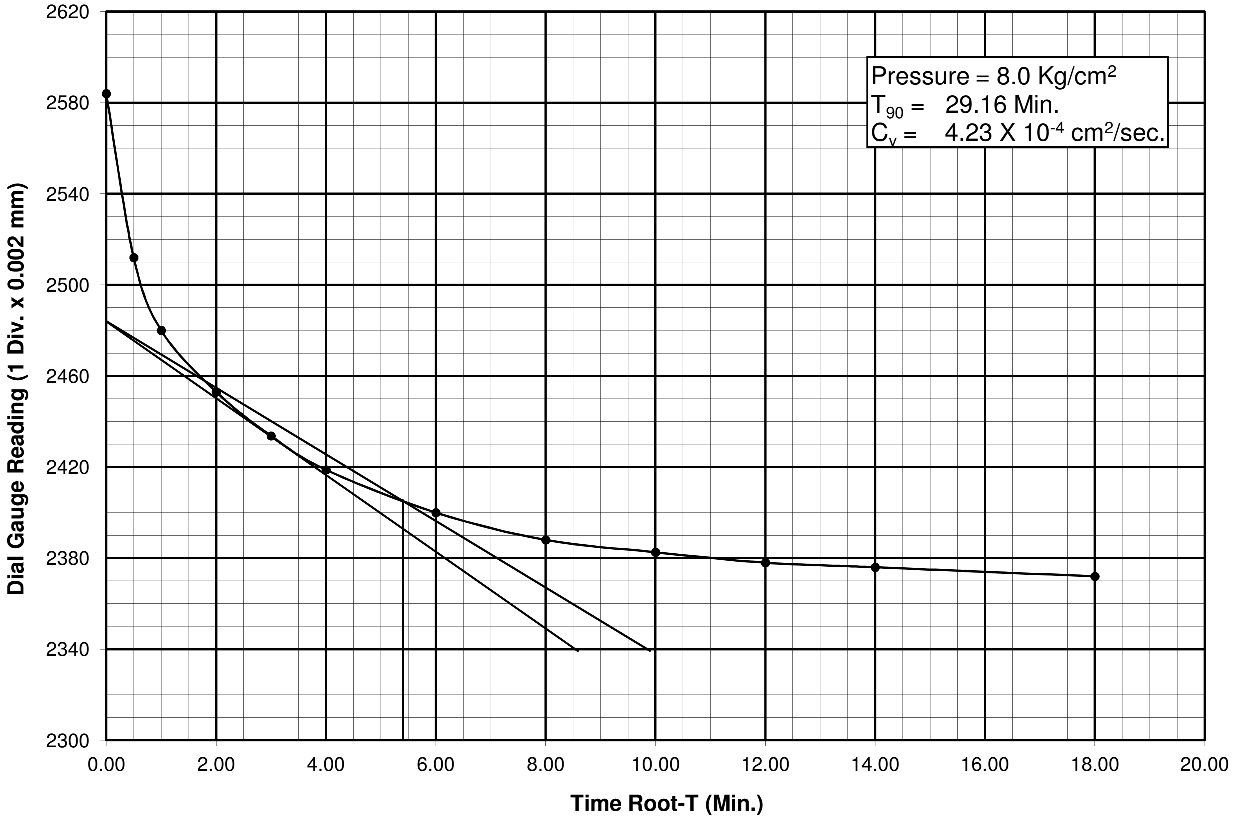
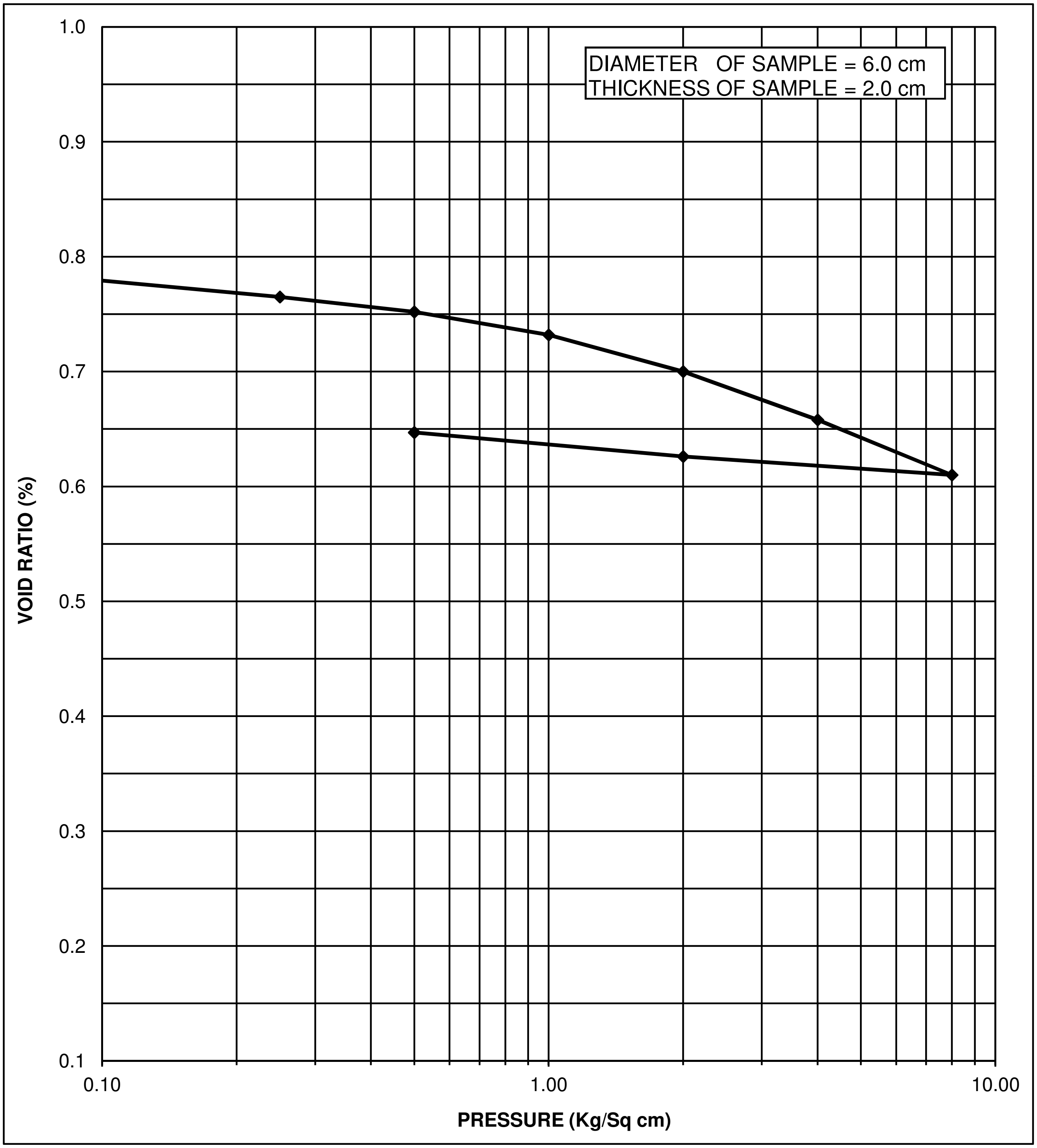


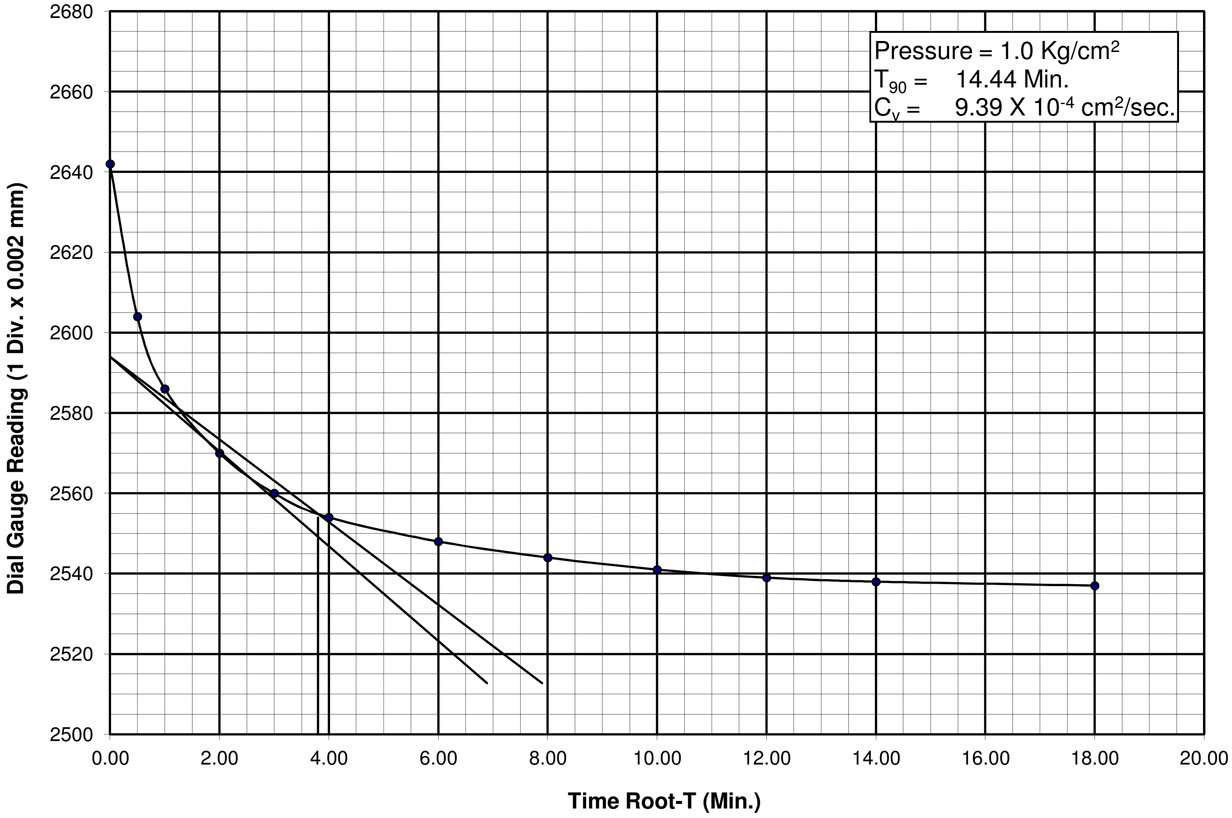
Figure No. -



CHAINAGE = 28+075	INITIAL WATER CONTENT = 12.64 %
BORE HOLE NO. = BH-A2	DRY DENSITY = 1.50 gm/cm^3
SAMPLE NO. = UDS-1	VOID RATIO (e_o) = 0.780
DEPTH = 1.00 M	COMPRESSION INDEX (C_c) = 0.159
TYPE OF SOIL = CL	

FIGURE NO. PRESSURE Vs VOID RATIO CURVE (e-log p)

CHAINAGE	=	28+075
BORE HOLE NO.	=	BH-A2
SAMPLE NO.	=	UDS-2
DEPTH	=	4.50 M



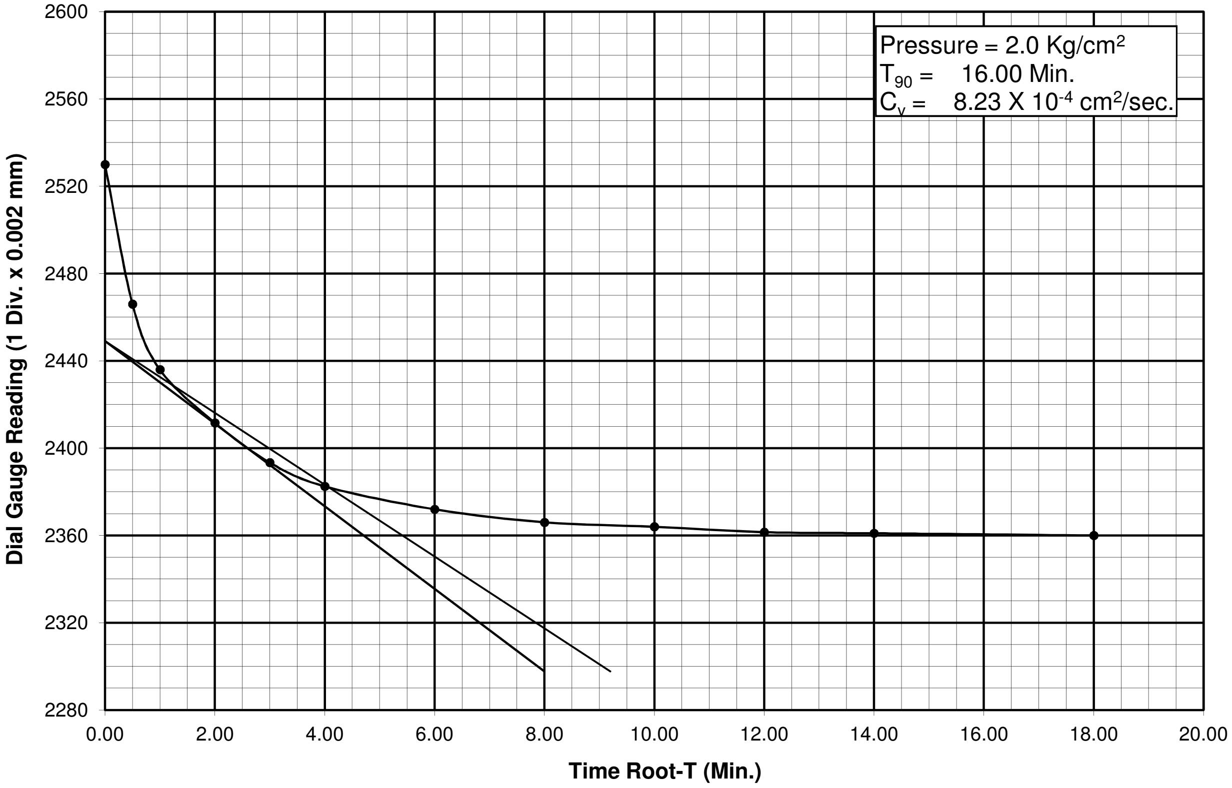
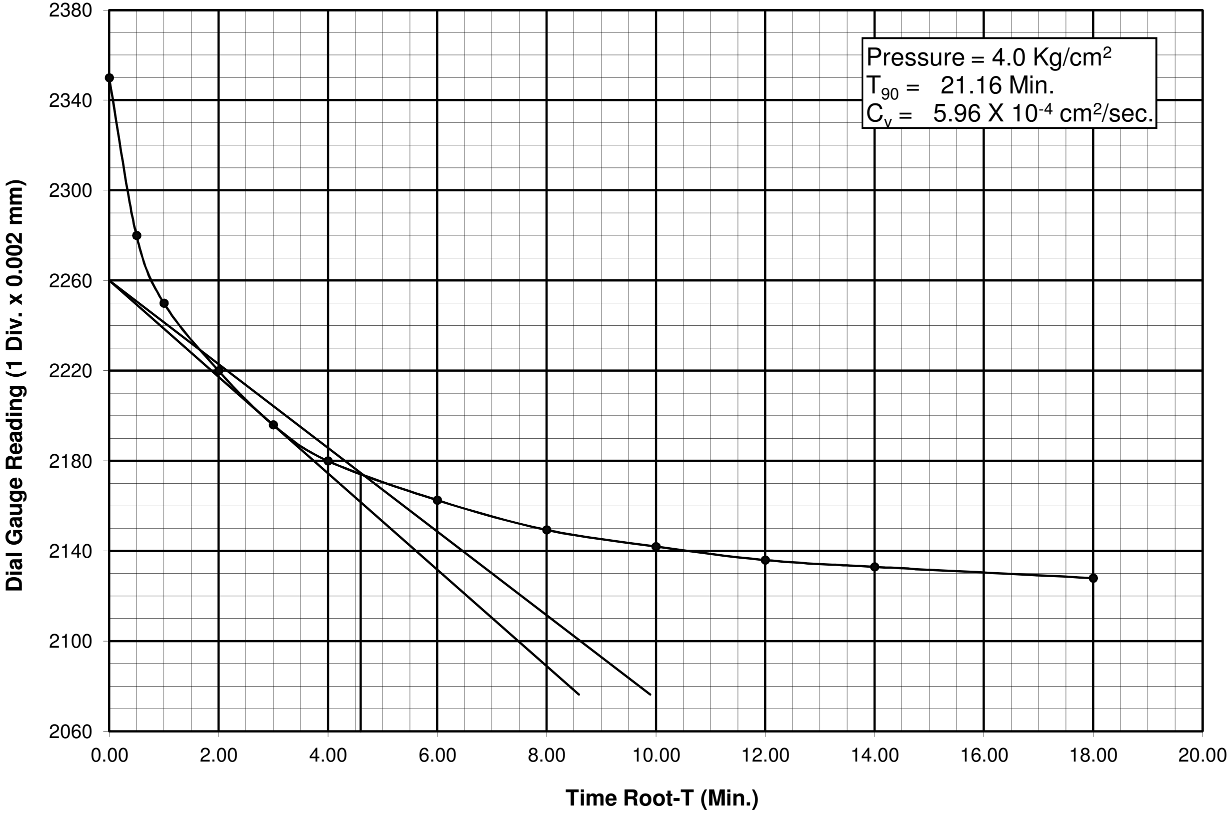


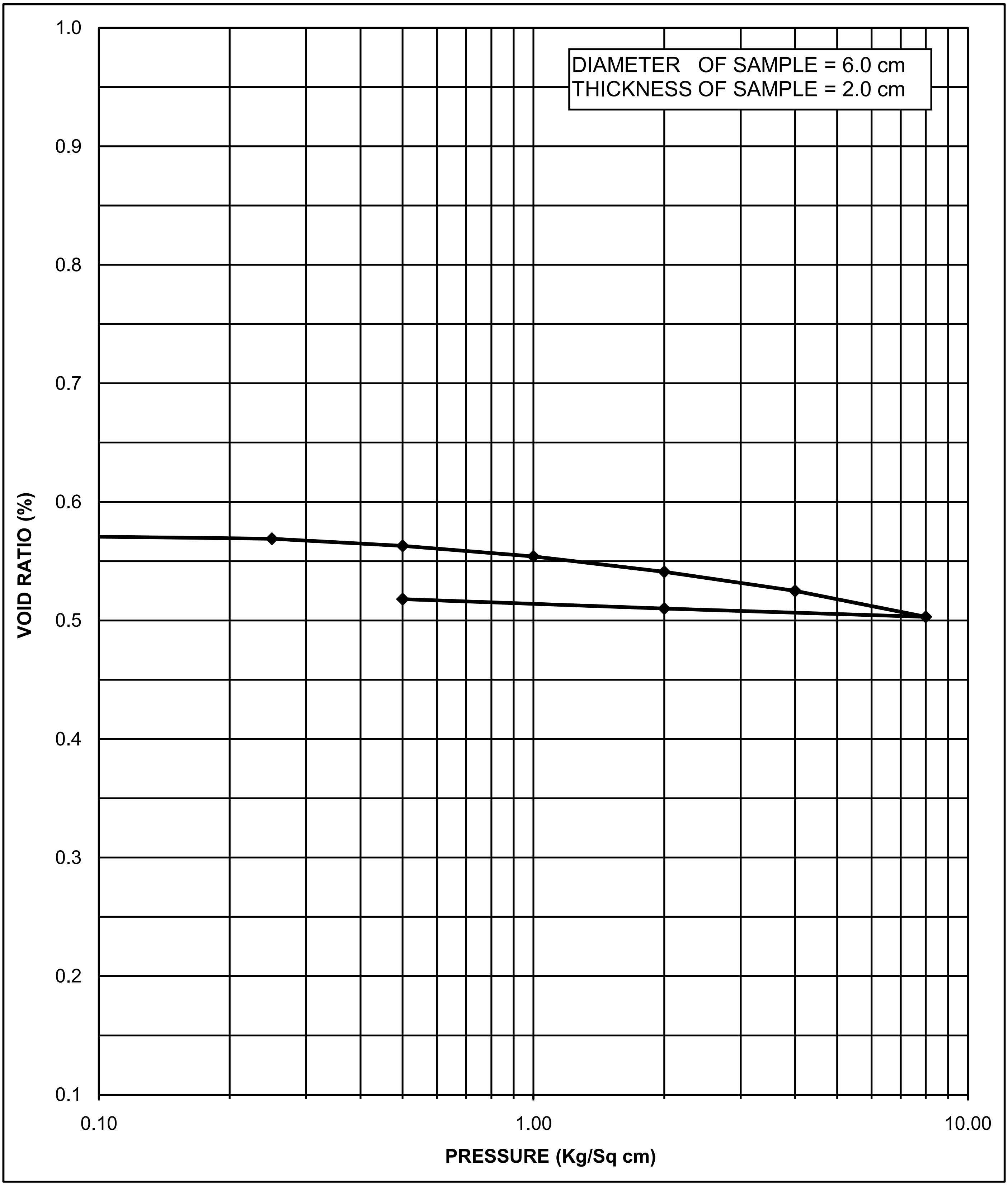
Figure No. -

CHAINAGE = 28+075
BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-2
DEPTH = 4.50 M


Pressure = 4.0 Kg/cm^2
T_{90} = 21.16 Min.
C_v = 5.96 X 10^{-4} cm^2/sec.


Pressure = 8.0 Kg/cm^2
T_{90} = 25.00 Min.
C_v = 4.78 X 10^{-4} cm^2/sec.

Figure No. -



BORE HOLE NO. = BH-P2

SAMPLE NO. = UDS-7

DEPTH = 20.50 M

TYPY OF SOIL = CL

INITIAL WATER CONTENT = 17.20 %

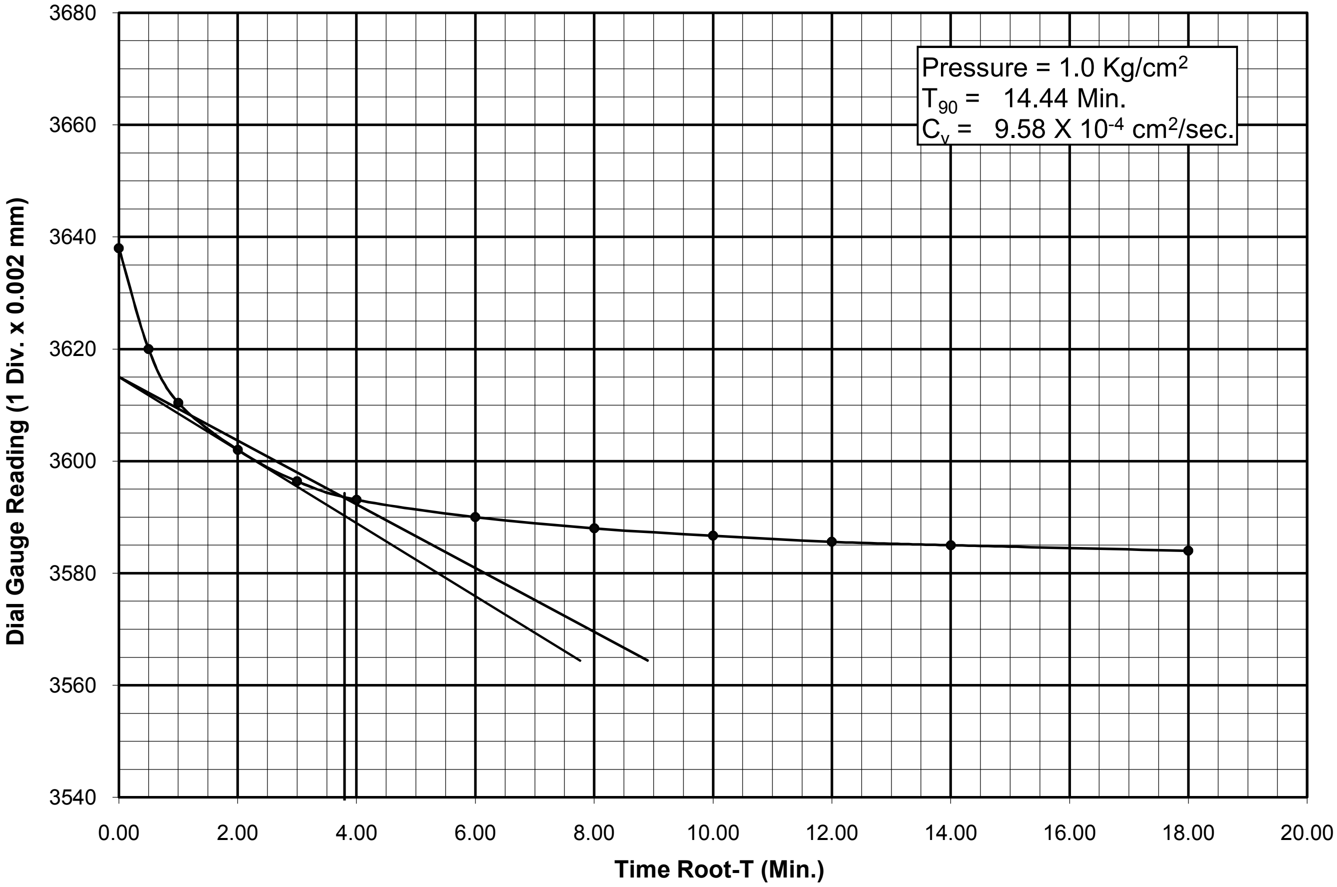
DRY DENSITY = 1.70 gm/cm^3

VOID RATIO (e_o) = 0.575

COMPRESIVE INDEX (C_c) = 0.073

FIGURE NO.   PRESSURE Vs VOID RATIO CURVE (e-log p)

BORE HOLE NO. = BH-P2
SAMPLE NO. = UDS-7
DEPTH = 20.50 M


Pressure = 1.0 Kg/cm^2
T_{90} = 14.44 Min.
C_v = 9.58 X 10^{-4} cm^2/sec.

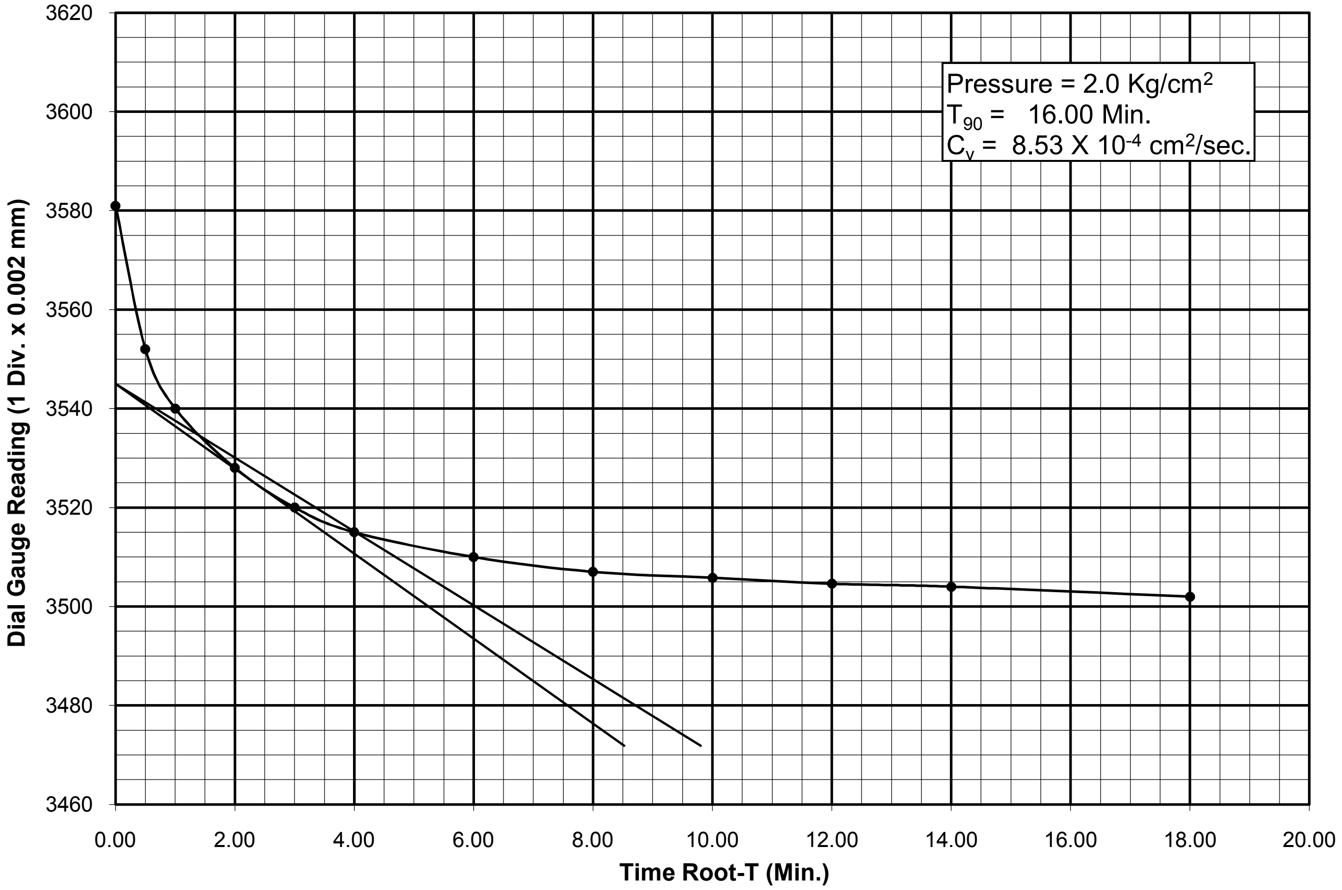
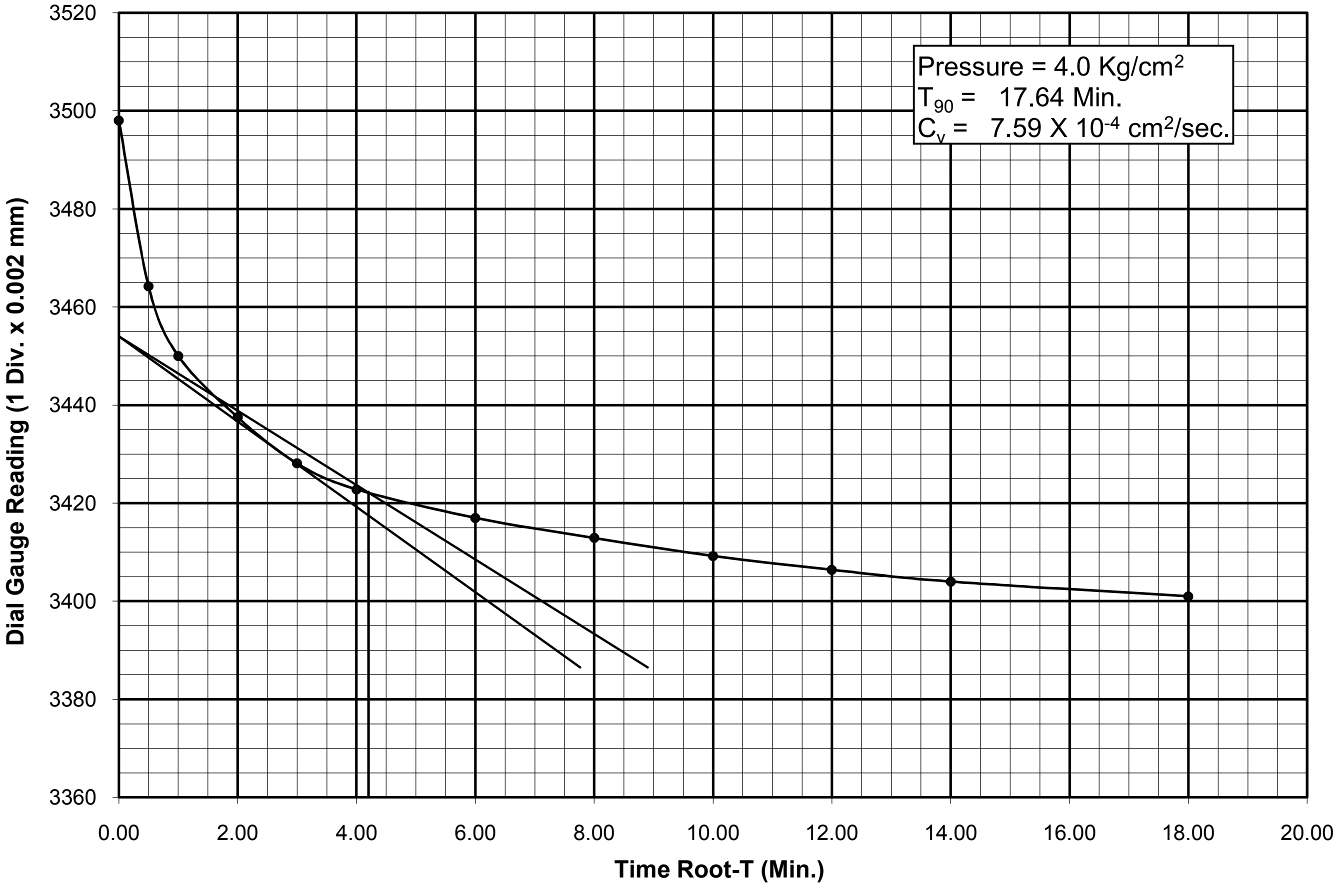

Pressure = 2.0 Kg/cm^2
T_{90} = 16.00 Min.
C_v = 8.53 X 10^{-4} cm^2/sec.

Figure No. -

BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-7
DEPTH = 20.50 M


Pressure = 4.0 Kg/cm^2
T_{90} = 17.64 Min.
C_v = 7.59 X 10^{-4} cm^2/sec.

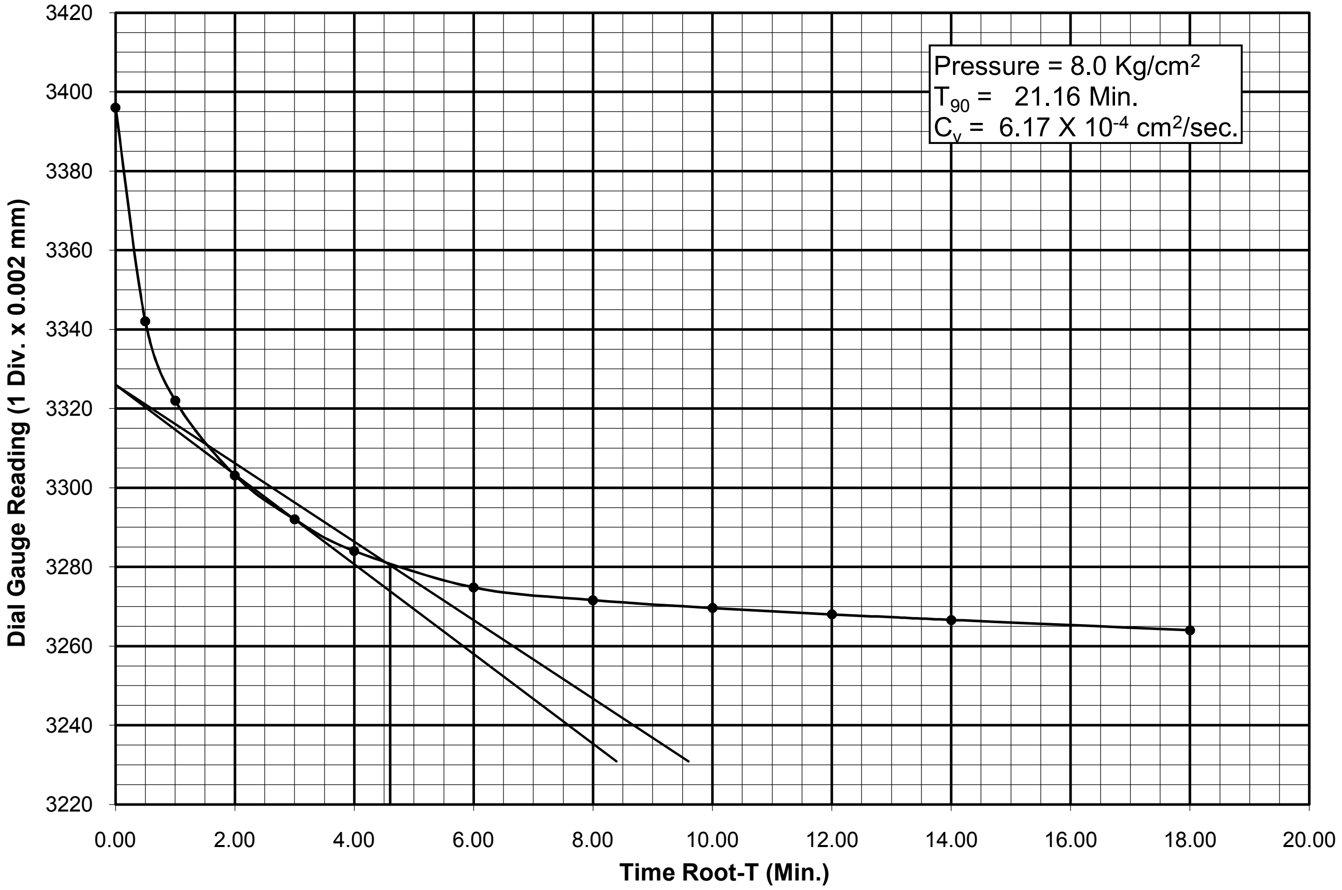
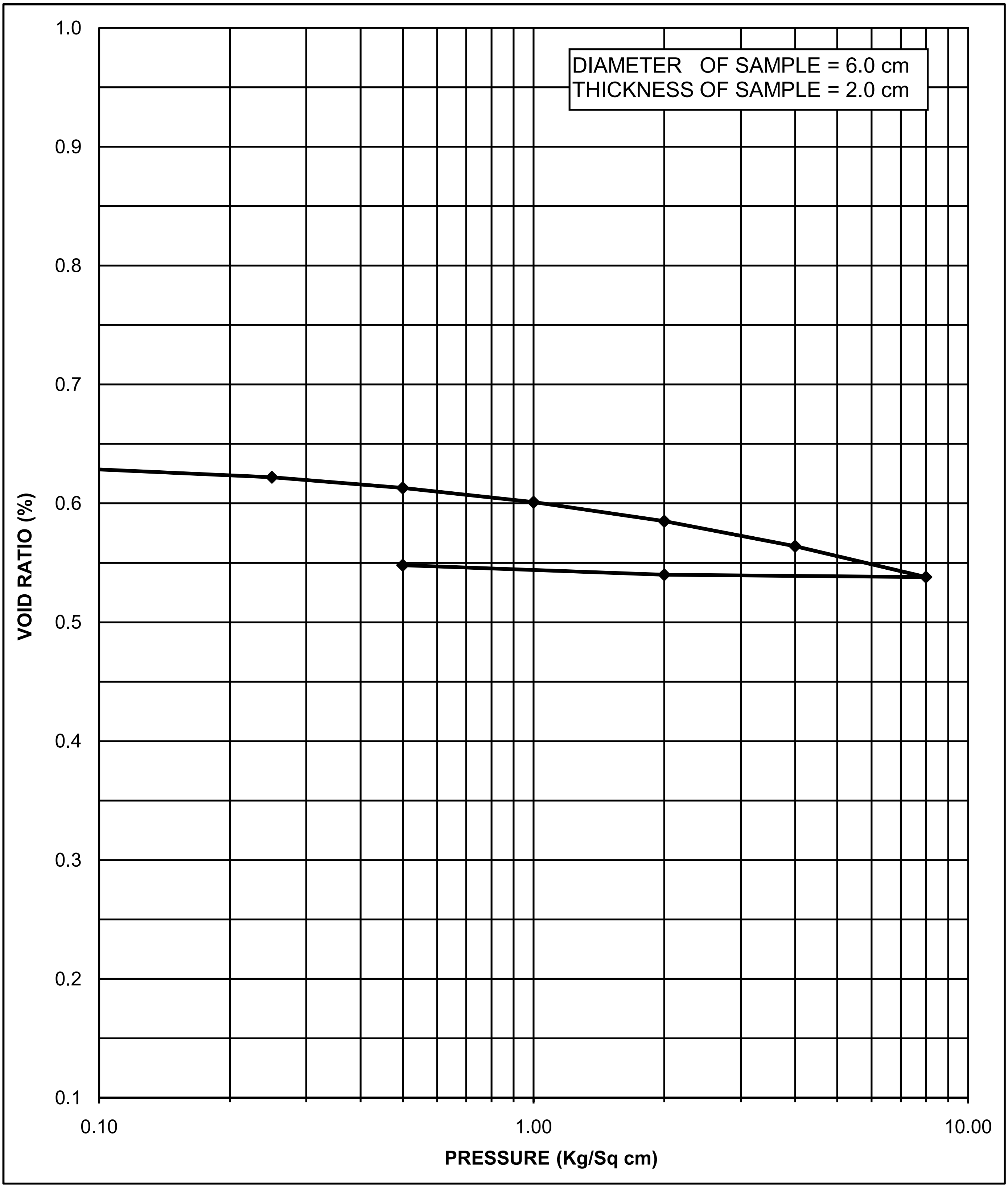

Pressure = 8.0 Kg/cm^2
T_{90} = 21.16 Min.
C_v = 6.17 X 10^{-4} cm^2/sec.

Figure No. -



BORE HOLE NO. = BH-A2

SAMPLE NO. = UDS-5

DEPTH = 13.00 M

TYPE OF SOIL = CL

INITIAL WATER CONTENT = 15.90 %

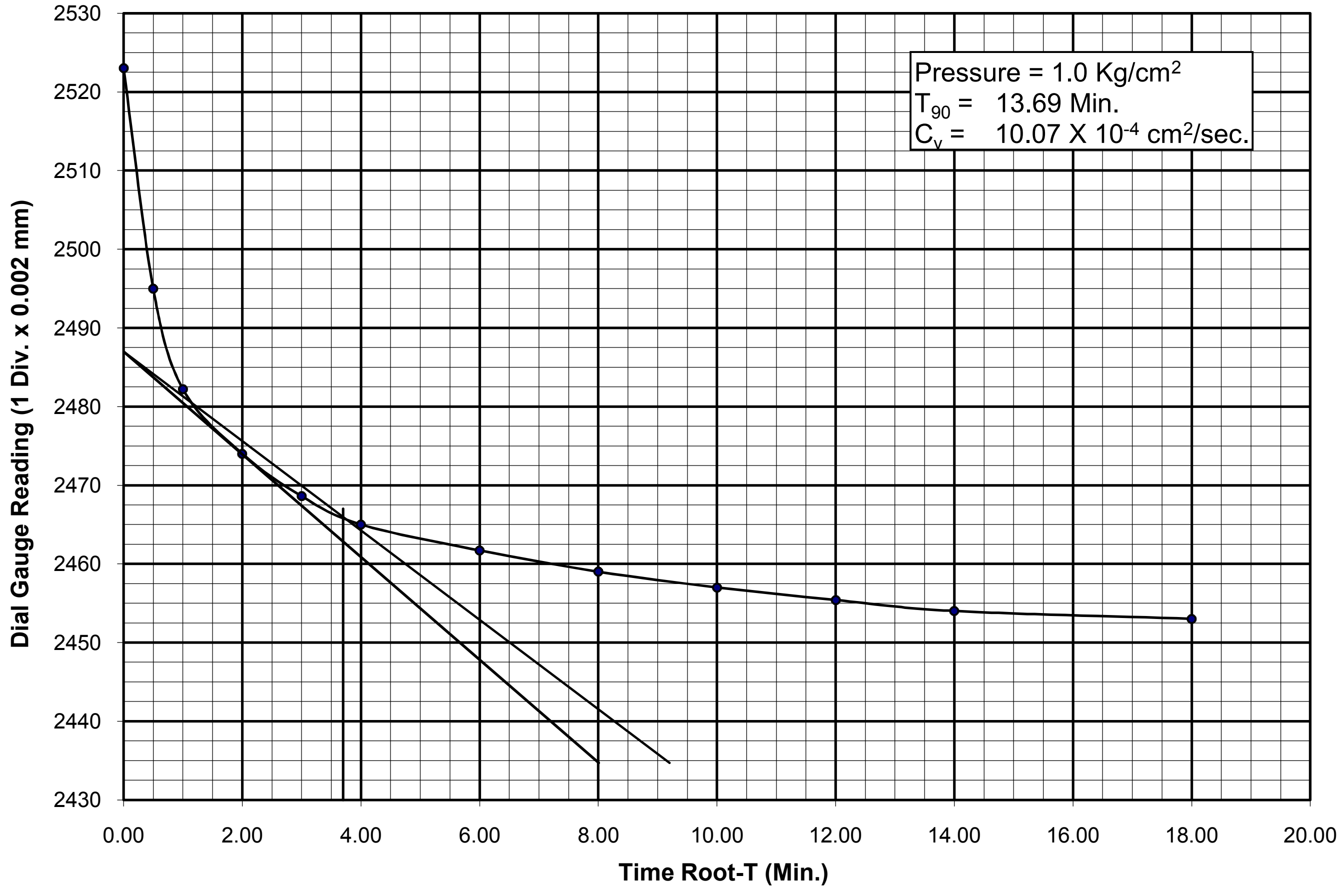
DRY DENSITY = 1.64 gm/cm^3

VOID RATIO (e_o) = 0.630

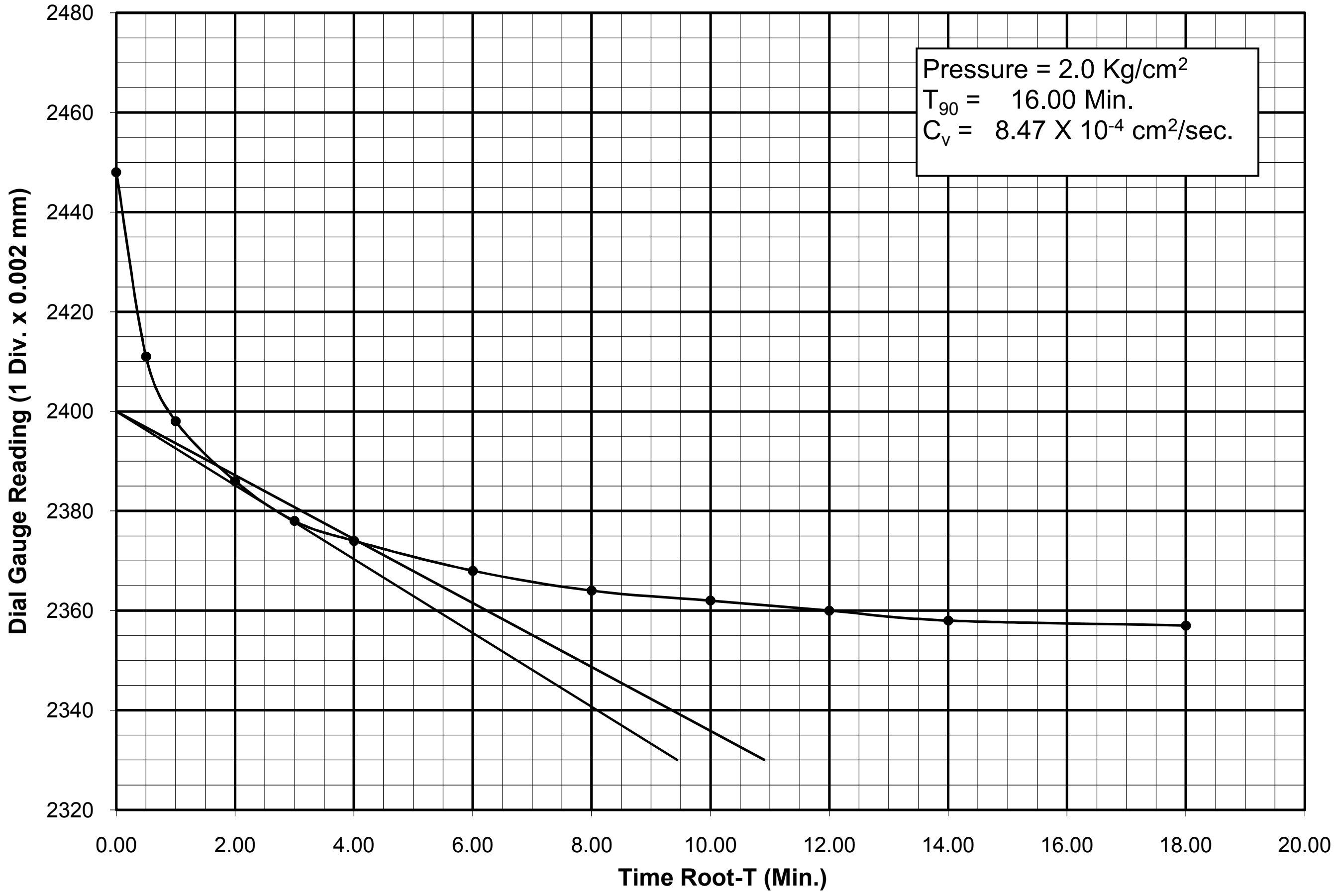
COMPRESSION INDEX (C_c) = 0.093

FIGURE NO. PRESSURE Vs VOID RATIO CURVE (e-log p)

BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-5
DEPTH = 13.00 M



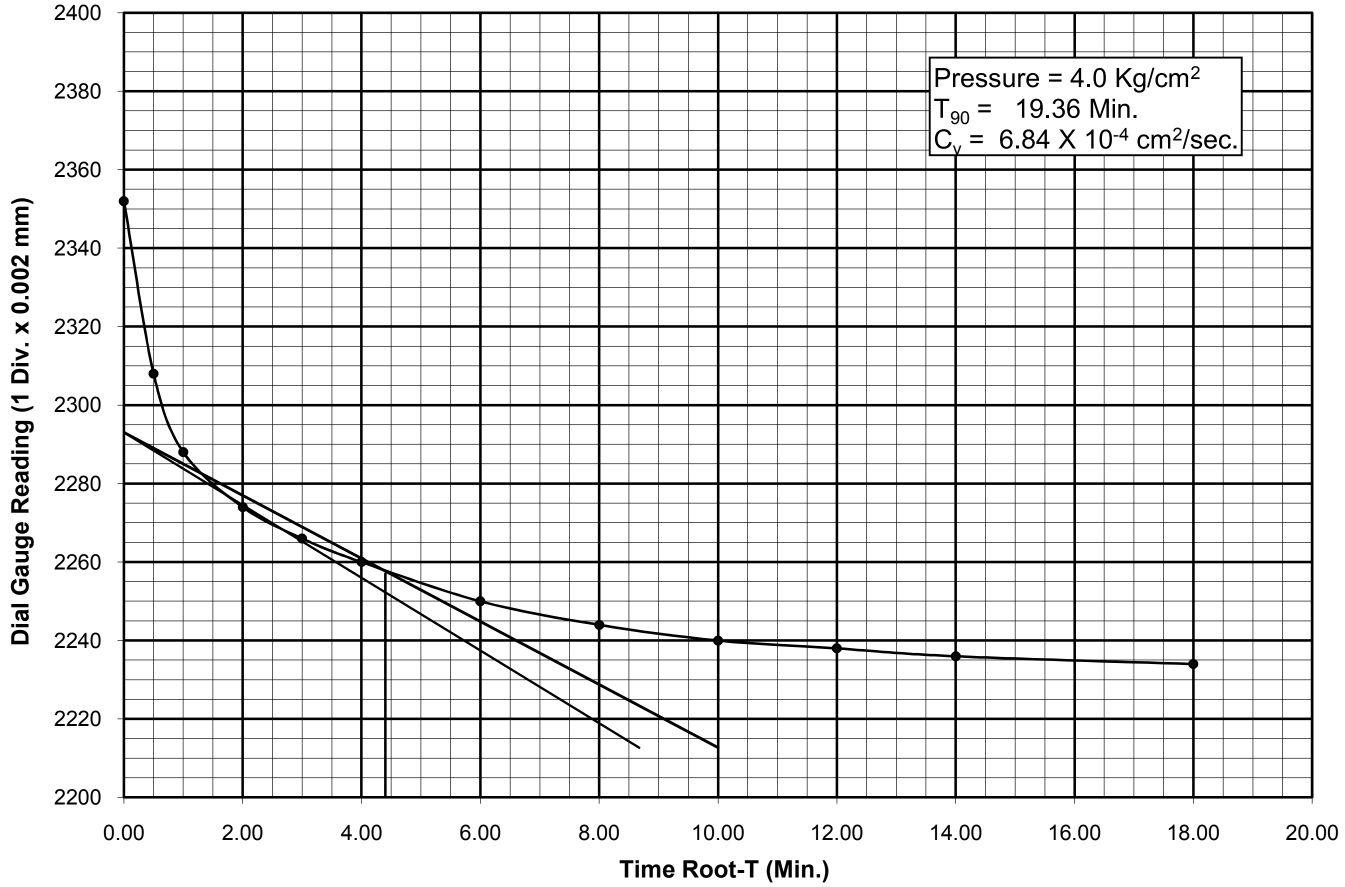
Pressure = 1.0 Kg/cm^2
T_{90} = 13.69 Min.
C_v = 10.07 X 10^{-4} cm^2/sec.



Pressure = 2.0 Kg/cm^2
T_{90} = 16.00 Min.
C_v = 8.47 X 10^{-4} cm^2/sec.

Figure No. -

BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-5
DEPTH = 13.00 M



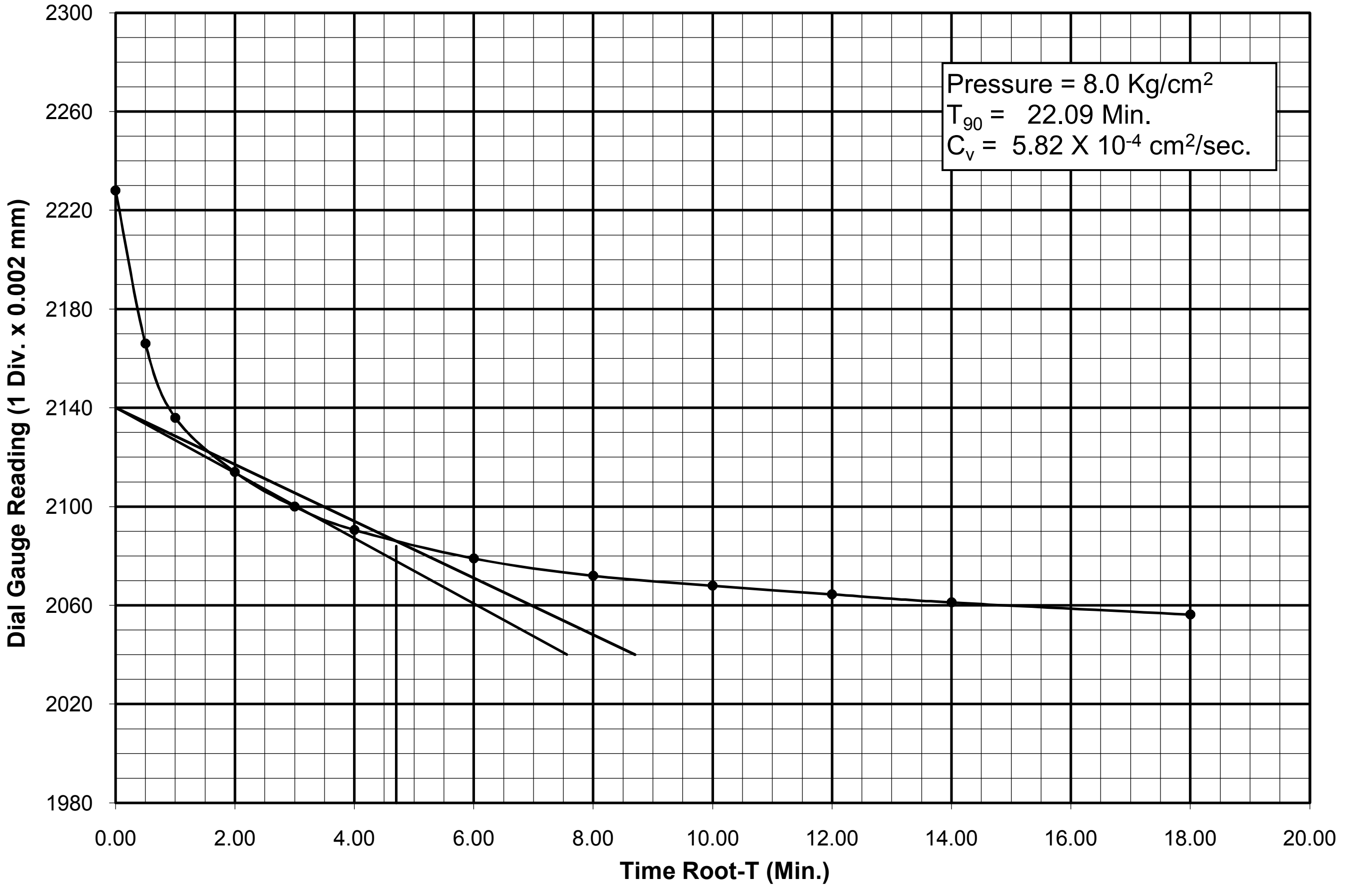


Figure No. -

Section 7

General Conditions of Contract

Table of Contents

GENERAL CONDITIONS OF CONTRACT (GCC)

1. Definitions

The following words and expressions shall have the meanings assigned to them except where the context otherwise requires**:**

(i) **"**Agreement" means a legally binding written agreement signed between the Employer and the Consultant and includes the Conditions of Contract (General Conditions of Contract and Special Conditions of Contract) together with Employer's Requirements, Bid Drawings, Documents, Schedules, Contract Forms, Instruction to Consultants, Specifications, and Letter of Acceptance;

(ii) "Applicable Law" means the laws and any other instruments having the force of law in India, as they may be issued and in force from time to time;

(iii) "Approved/approval" means the approval in writing.

(iv) "Contract" means the Contract signed by the Parties, to which these General Conditions of Contract are attached, together with all the documents listed in Contract Agreement;

(v) "Consultant/Bidder/Third Party Consultant " means any entity or person that may provide or provides the Services to the Employer under the Contract.

(vi) "Consultant's Representative" means the person referred to in the Contract or appointed from time to time by the Consultant, and communicated by Notice to the Employer to be its authorised representative for the administration of the Agreement.

(vii) "Contractor" means entity who has been awarded the EPC Contract for Tunnelling Works of HORC Project and named in SCC.

(viii) "Day" means the period between any one midnight and the next.

(ix) "Third Party Consultant/Consultant" means the Consultant named in the Agreement, who has been awarded the contract & entered into agreement, and which expression shall include his/their legal successors and permitted assigns.

(x) "Employer" means the Haryana Orbital Rail Corporation Limited (also referred to as HORCL) which expression shall also include their legal successors and permitted assigns.

(xi) "Employer's Representative" means the person/Entity employed by HORCL to undertake duties in connection with the Haryana Orbital Rail Corridor (HORC) Project and notified as such, or any of its officers nominated by HORCL and notified from time to time, to Third Party consultant.

(xii) "Engineer" shall mean RITES Limited in Consortium with SMEC International Pty Ltd.

(xiii) "Effective Date" means the date on which this Contract comes into force.

(xiv) "Foreign Personnel" means such persons who at the time of being so hired had their domicile outside India.

(xv) “GCC” means General Conditions of Contract.

(xvi) “HORCL” means Haryana Orbital Rail Corporation Limited

(xvii) “HRIDC” means Haryana Rail Infrastructure Development Corporation Limited

(xviii) “Key Personnel” means persons specified in Clause 6 of Section 5, Employer’s Requirements of Bidding Document.

(xix) "Local Personnel" means such persons who at the time of being so hired had their domicile inside India.

(xx) Deleted.

(xxi) Deleted.

(xxii) "Month" means a period of one month according to the Gregorian calendar commencing with any day of the month.

(xxiii) "Party" means HORCL or Third Party Consultant as the case may be and "parties" means both of them.

(xxiv) "Project" means the project named in Special Conditions of Contract.

(xxv) "Personnel " means persons hired by the Consultants as employees and assigned to the performance of the Services or any part thereof;

(xxvi) ‘Proposal/Package/Bid’ means the Technical Proposal/Technical Part/ Packages/Bid and the Price Proposal/Financial Part /packages/Bid as the context so required.

(xxvii) "Rupees" means the currency of India and shall be the currency used for the Project.

(xxviii) "SCC" means Special Conditions of Contract.

(xxix) "Services" means the work to be performed by the Consultants pursuant to this Contract for the purposes of the Project, as described in Bid document hereto;

(xxx) "Third Party" means any person or entity other than the Government, the Employer or the Consultants.

2. Interpretation

(i) The headings shall not limit, alter or affect the meaning of this Contract and in the Agreement shall not be used in its interpretation.

(ii) The singular includes the plural, the masculine includes the feminine, and vice-versa where the context requires.

(iii) If there is a conflict between provisions of the Agreement, the priority of documents shall be as specified below:

(a) The Contract Agreement;

(b) The Letter of Acceptance;

(c) Letters of Clarifications, if any;

(d) Addenda/Corrigenda to the Bid Document, if any;

(e) The Financial Bid;

(f) The Special Conditions of Contract including Schedules, if any;

(g) The General Conditions of Contract;

(h) The Work's Requirements;

(i) Instructions to Consultants; and

(j) Any other document forming part of the Contract

3. Obligations of the Third Party Consultant

3.1 Scope of Work/Services to be performed

(i) Third Party Consultant shall perform Services relating to the Project. The Scope of the Work/Services is stated in **Section 5: Employer's Requirements**.

(ii) Third Party Consultant shall exercise reasonable skill, care and diligence in the performance of his obligations under the Agreement.

(iii) Where the Services include the co-ordination between the Third Party consultant and design consultant of the Contractor on the Project, the Third Party Consultant shall provide such co-ordination. The Third Party consultant shall obtain, co-ordinate and submit to the Engineer's Representative for his information and approval, all details, drawings, quantities,specifications arising from such co-ordination with others. Such co-ordination will take place throughout the period of the Services.

3.2 Performance Security

3.2.1 The Consultant shall, within 28 days of the date of issuing the Letter of Acceptance, provide to the Employer, the Performance Security in a sum equal to the amount specified in the Contract Data, for the due observance and performance by the Consultant of the Contract. In the event the Consultant fails to provide the Performance Security within 28 days from the date of issue of the LOA, it may seek an extension of time for providing the performance security for a period not exceeding a further 7 days on payment of damages for such extended period in a sum calculated at the rate of 0.005% of the Accepted Contract Amount for each day until the Performance Guarantee is provided. The Contractor shall maintain the said Performance Guarantee at its own expense, so that it shall remain in full force and effect until the issue of Performance Certificate. In the event of a revision of the Contract Price, the value of the Performance Guarantee shall be increased proportionately by the Contractor, if required by the Employer. The cost of obtaining the Performance Guarantee shall be at the expense of the Contractor. The Contractor shall submit the Performance Guarantee in any of the following forms:

(a) Unconditional and irrevocable Bank Guarantee from a scheduled bank (excluding co-operative banks) in India, in the form appearing in Section 9 [Contract Forms]; or

(b) Banker's Cheque or Demand Draft drawn on a scheduled bank (excluding co-operative banks).

The scheduled bank issuing the bank guarantee shall be on "Structure Financial Messaging System (SFMS)" platform. A separate advice of the bank guarantee shall invariably be sent by the issuing bank to Employer's Bank through SFMS and only of the same by the Employer's Bank, the bank guarantee shall become operative and acceptable to the Employer. Further, the bank guarantees in original form along with a copy of "MT760COV (in case of bank guarantee message)/ MT767COV (in case of bank guarantee amendment message) Report" sent by the concerned issuing bank sealed in an envelope shall be submitted to the Employer.

The Issuing Bank shall send the SFMS to:

Beneficiary: Haryana Orbital Rail Corporation Limited

Bank Name:
Account No.
IFSC Code:

Note: All the instruments mentioned in (a) & (b) above should be in favour of:

Haryana Orbital Rail Corporation Limited, Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram.

3.2.2 The Consultant shall ensure that the Performance Security is valid and enforceable until the Consultant has executed and completed the Works and remedied defects, if any. If, (a) the Consultant does not complete the Works for any reasons whatsoever, and (b) the Consultant has not become entitled to receive the Performance Certificate by 28 days prior to the expiry date of the Performance Security, the Consultant shall be bound to extend the validity of the Performance Security until the Works have been completed and the defects have been remedied. If the Performance Security is or becomes invalid or unenforceable for any reason whatsoever, or if such security is withdrawn or expires, the Consultant must immediately notify the Employer and obtain within 3 days a replacement guarantee in the form appearing in Section 9 [Contract Forms] and which is acceptable to the Employer in its absolute discretion.

3.2.3 The provision, maintenance and renewal by the Consultant of the Performance Security in accordance with this Sub-Clause 3.2 [Performance Security] shall be a condition precedent to any payment by the Employer to the Consultant under the Contract.

3.2.4 If the Consultant fails to provide, maintain and renew the Performance Security in accordance with the Contract, the Employer shall, without prejudice to any other rights and remedies to which it may be entitled, shall have the right to invoke the Performance Security for the value equal to the damages to the Employer as a result of the Consultant's failure and/or by written notice terminate the Contract in accordance with Clause 17.

3.3 Consultant's Design Warranty

3.3.1 The Consultant shall be fully responsible for the suitability, adequacy, integrity, durability and practicality of the design and drawings checked by the Consultant.

3.3.2 The Consultant warrants that the design checked by them meets the Works Requirements and are fit for purpose thereof. Where there is any inadequacy, insufficiency, impracticality or unsuitability in or of the Works Requirements or any part thereof, the modified/amended design shall take into account, address or rectify such inadequacy, insufficiency, impracticality or unsuitability at Consultant's own cost.

3.3.3 The Consultant warrants that the Works have been or will be designed to the highest standards available using proven up-to-date good practice.

3.3.4 The Consultant shall be responsible for the safety of the design checked by him.

3.3.5 The Consultant shall indemnify the Employer against any damage, expense, liability, loss or claim which the Employer might incur, sustain or be subject to arising from any breach of the Consultant's checking responsibility and/or warranty set out in this Clause.

3.3.6 The consultant further is deemed to have checked and accepted full responsibility for design checked by them and warrants absolutely that the same meets the Works Requirements:

(a) Notwithstanding that such design may be or have been prepared, developed or issued by the Employer, any of Consultant's consultants, and/ or his qualified personnel/ persons or cause to be prepared developed or issued by others.

(b) Notwithstanding any warranties, guaranties and/or indemnities that may be or may have been submitted by any other person.

(c) Notwithstanding that the same have been accepted by the Employer/Engineer.

3.3.7 All design documents, drawings, plans, calculations and reports produced by the Third Party consultant shall be accompanied by a `Design Checking Certificate', when the final design is submitted to the Engineer.

4. Change in Constitution

The Consultant shall promptly notify to the Employer of any changes in the constitution of the consultant. Employer reserves the right to terminate the Agreement upon death, retirement, insanity or insolvency of any person being the proprietor/partner in the consultant, or on the addition or introduction of a new partner managing the Project for the consultant without the previous approval in writing of the Employer. But in absence of and until its termination by the Employer as aforesaid, this Agreement shall be in full force and effect, notwithstanding any changes in the constitution of the firm bydeath, retirement, insanity or insolvency of any of its proprietors/partners or addition or introduction of any new partners. In case of death or retirement, the surviving or remaining partners of the firm shall be jointly and severally liable for the due and satisfactory performance of all terms and conditions of the Agreement, and likewise on the addition of a new partner, the latter will also become jointly and severally liable.

5. Information

EPC tunnel Contractor shall within a reasonable time give to the Consultant, free of cost, all required information pertaining to the Services.

6. Decisions

On all matters referred to it in writing by the Consultant, the Engineer shall give a decision in writing within a reasonable time.

7. Assistance

The Employer shall assist the Consultant in:

(i) providing unobstructed access wherever it is required for providing the Services as per the Scope of Work.

(ii) Providing access to other organisations/Institutions for collection of information.

8. Mobilisation of Personnel

The qualifications and experience of the Consultant's Representative and Key Personnel who shall be mobilised by the Consultant to work on the project shall have to be got approved from the Engineer.

9. Consultant's Representatives

For the administration of the Agreement, the Consultant shall designate the official or individual to be his representative and who shall be responsible to the Engineer/Employer for various deliverables as per Section:5, Employer's Requirements

The Consultant shall notify the Employer of the extent of powers and authority delegated to the Consultant's Representative.

10. Changes in Personnel

(a) Except as the Employer may otherwise agree, no changes shall be made in the Key Personnel as stipulated in Clause 6 of Section 5 for the initial one year from the date of commencement of consultancy services. If, for any reason beyond the reasonable control of the Consultants, it becomes necessary to replace any of the Personnel, the Consultant shall forthwith, provide as a replacement a person of equivalent or better qualifications with the approval of the Engineer.

(b) If the Engineer

(i) finds that any of the Personnel has committed serious misconduct or has been charged with having committed a criminal action or

(ii) has reasonable cause to be dissatisfied with the performance of any of the Personnel, then the Consultant shall, at the Engineer's written request specifying the grounds therefore, forthwith, provide as a replacement a person with qualifications and experience acceptable to the Engineer.

11. Liability of Consultant to the Employer

Consultant shall be liable to pay compensation to the Employer arising out of or in connection with the Agreement, if a breach of Contract is established against him. Such compensation shall be limited to the amount of reasonably foreseeable loss and damage suffered as a result of such breach.

12. Agreement Effective Date

This Contract shall come into force and effect on the date notified in LoA by the Employer. This LOA shall be treated as agreement between the Employer and the Consultant till formal agreement is executed.

13. Commencement and Completion

The Services shall be commenced and completed at the times or within the periods stated in Special Conditions of Contract subject to extensions in accordance with the Agreement.

Completion of the services of Part-A shall be certified upon final submission of all the documents, designs, drawings covered in the scope of this Contract. If all the documents have been satisfactorily submitted, the Employer shall issue the Completion Certificate for Part-A.

Completion Certificate for Part-B of the Contract shall be issued after satisfactory completion of the services in accordance with the Contract.

14. Deleted

15. Delays

15.1 Liquidated damages

It shall be the bounden duty of the Consultant to strictly adhere to the time for performance of various services indicated in the Contract. In case of any delays, the Consultant shall be liable to pay liquidated damages as specified in Section

8 Special Condition of Contract Part A Contract Data.

16. Exceptional Circumstances

16.1 Force Majeure

If, at any time during the currency of the Contract, the performance in whole or in part by either party of any obligation under this Contract shall be prevented or delayed by reasons of any war, hostilities, invasion, acts of public or foreign enemies, rebellion, revolution, insurrection, civil commotion, sabotage, large scale arson, floods, earthquake, large scale epidemics, nuclear accidents, any other catastrophic unforeseeable circumstances, quarantine restrictions, any statutory rules, regulations, proclamation, orders for requisitions issued by a Government department or competent authority or acts of God (hereinafter referred to as “event”) or any other cause whether of similar or dissimilar nature beyond the reasonable control of the party affected then, provided notice of the happening of such an event as given by either party to the other within 21 days of the occurrence thereof:-

a) Neither party shall by reason of such event, be entitled to terminate the Contract or have claim for damages against the other in respect of such non-performance or delay in performance.

b) The obligation under the Contract shall be resumed as soon as practicable after the event has come to an end or ceased to exist.

c) If the performance in whole or part of any obligation under the Contract is prevented or delayed by reason of the event beyond a period mutually agreed to, if any, or 90 days, whichever is more, either party may at its option terminate the Contract.

d) In case of doubt or dispute, whether a particular occurrence should be considered an “event” as defined under this clause, the decision of the Engineer shall be final and binding.

e) If the Contract is terminated under this Clause, the Consultant shall be paid fully for the work done under the Contract up to date of termination of contract.

f) If neither party issues notice regarding the event within 21 days of its occurrence, the said event shall be deemed not have occurred and the Contract will continue to have effect as such.

16.2 Delays not on Account of the Consultant

If circumstances arise for which the Consultant is not responsible and which make it impossible for him to perform in whole or in part the Services in accordance with the Contract including force majeure, the Consultant shall promptly notify to the Engineer. In these circumstances, including force majeure, if certain Services have to be suspended, the time for their completion shall be extended until circumstances no longer exist plus a reasonable period not exceeding 7 days for resumption of them.

17. Abandonment, Suspension or Termination by Notice of the Employer

(i) The Employer on recommendation by the Engineer may suspend all or part of the Works or terminate the Agreement by noticeof at least 30 days to consultant who shall immediately make arrangements to stop the Services and minimize expenditure.

(ii) If the Employer considers that Consultant is not discharging its obligations, the Employer can inform the Consultant by written notice sent as per this clause stating grounds therein. If a satisfactory reply is not received within 7 days of receipt of the notice from the consultant, the Employer can by further notice terminate the Agreement provided that such further notice is given within 30 days of the Employer's former notice.

(iii) If Consultant is adjudged a bankrupt, or if he makes a general assignment for the benefit of his creditors, or if a receiver is appointed on account of his insolvency, or persistently disregards laws, ordinances, rules, regulations or orders of any public authority having jurisdiction, or otherwise is guilty of a breach of the Agreement,then the Employer may terminate the Services of the Consultant as per the proceduregiven in the contract document.

The Employer may complete the project by whatever method may be deemed expedient and the Consultant shall not be entitled to receive any additional payment. Also, Clause 11 of GCC shall be applied in cases of (ii) and (iii) above.

18. Rights and Liabilities of the Parties

Termination of the Agreement shall not prejudice or affect the accrued rights or claims and liabilities of either party.

19. Payment to the Consultant

19.1. The Employer shall pay the Lump Sum Price (which shall cover the sum total of all costs quoted by the Consultant in Section 4, Financial Bid) as Contract Price to the Consultant.

The Consultant shall raise invoices on completion of Milestones for interim payment for the performance of services.

19.2. The payment shall be based on stage payment schedules as described in Section 4 (Financial Bid) of Bid documents.

19.3. Deduction towards Income Tax, and any other tax, may be made at source from each payment made by the Employer, as may be directed by Income Tax Department and other statutory bodies or as provided in statute, relevant acts, rules, circulars and directions issued there under.

19.4. No advance payment shall be made to the Consultant.

19.5. The accepted contract value shall be adjusted to take into account any increase or decrease in cost after the date of submission of proposal from:

a. a change in the Laws of India including introduction of new laws and repeal or modification of existing laws; or

b. in the judicial or official governmental interpretation of such laws of India; or

c. the commencement of any Indian law which has not entered into effect until the date of submission of proposal; or

d. any change in the rates of any of the Indian taxes that have direct effect on the contract If as a result of change in law, interpretation or rates of taxes defined above, Consultant benefits from any reduction in cost for the execution of the Contract, save and except as expressly provided for in this clause or in accordance with the provisions of the Contract, Consultant shall within 28 days from the date he becomes reasonably aware of such reduction in cost, notify Employer of such reduction in cost.

19.6. The accepted contract value shall be increased at the rate of 5 % at the end of every 12 month from Effective Date. In case Extension of time is granted to Consultant for the reasons not attributable to Consultant, the price adjustment shall be made as mentioned above for the extended period of time. No price adjustment shall be made if the extension of time is granted to the Consultant due to reasons attributable to the Consultant.

20. Time for Payment

Amounts due to the Consultant shall be paid as specified in the Part-A Contract Data, Section 8, SCC and after deducting any amount to be withheld as due to the Employer, or has been awarded by an adjudicator or an arbitrator to the Employer pursuant to a referral under Sub-Clause 33.3[Arbitration] under Clause 22 [Disputed Invoices]. The Employer shall not be bound by any sum previously considered by him to be due to the Consultant. The Employer may withhold payments until he receives the Performance Security under Sub-Clause 3.2 of General Conditions of Contract, (if any)

21. Currency of Payment

All payments shall be made in Indian Rupees (INR) only.

22. Disputed Invoices

If any item or part of an item in an invoice submitted by the Consultant is contested by the Engineer/Employer then the Engineer shall within twenty-one (21) days of the date of issue of the Consultant’s invoice give prompt notice in writing with reasons and shall not delay payment of the balance of the invoice.

23. Languages and Law

This Contract shall be executed in the English language, which shall be binding and controlling language for all matters relating to the meaning or interpretation of this contract. This Contract, its meaning and interpretation, and the relation between the Parties shall be governed by the Applicable Law in India. The Consultants shall perform the Services in accordance with the Applicable Law and shall take all practicable steps to ensure that any Personnel of the Consultant comply with the Applicable Law.

24. Copyright

The copyright of all documents and drawings checked by the Consultant in performance of the Services under the Agreement shall be vested in the Employer.

25. Titles to Documents

Titles to all technical data including, but not limited to specifications, drawings, flow diagrams, layout details and the contents thereof, furnished by the Company or the Authorised Representative to the Consultant shall remain with the Company or the Authorised Representative as the case may be. The Consultant shall not use or divulge the data to others except to the extent necessary in connection with the performance by the Consultant. The Consultant shall take all steps of use his best efforts to prevent any disclosure of such data to others by the consultant’s personnel and shall take all reasonable steps necessary to prevent such disclosures. Upon the completion of the work or partial completion or partial termination, as the case may be, the Consultant shall return all specifications, drawings or technical data furnished.

26. Confidentiality

The Consultant shall during the tenure of the contract and at any time thereafter maintain strict confidence for all information relating to the work and shall not, unless so authorized in writing by the Employer, divulge or grant access to any information about the workor its results and shall prevent anyone becoming acquainted with either through managers or its personnel. The Consultant shall not, either during the term or after the expiration of this Contract, disclose any proprietary or confidential information relating to the Project, the Services, this Contract or the Employer's business or operations without the prior written consent of the Employer. The Consultant shall also return all reports, notes and technical data relating to the operational matters to the Employer.

The Consultant shall keep secret and confidential and shall not disclose to any third party does not use any unauthorized manner any confidential information regarding the present processing technology and the business affairs of the Employer which the Consultant may have acquired through the negotiations, discussions, examination of drawings, designs, process layout, use of infrastructures, etc., leading to the conclusions of this Contract. The parties further agree not use such information for any purpose whatsoever except in the manner expressly provided for in this Contract. The obligations hereunder shall survive any termination or cancellation of this Contract.

The documents, all original field records, reports, spread sheets or other materials developed by the Consultant under this Contract shall be delivered to the Employer and shall become the property of the Employer, to be used by the Employer in any manner required for the implementation ofthe project.

27. Patents

The Consultant shall at all times indemnify the Employer against all claims which may be made in respect of the items for infringement of any right protected by patent, registration of design or trade mark.

28. Conflict of Interest during the term of this Contract

The remuneration of the consultant shall constitute the consultant's sole remuneration in connection with this Contract or the Services and, the Consultant shall not accept for their own benefit any trade commission, discount or similar payment in connection with activities pursuant to this Contract or to the Services or in the discharge of their obligations hereunder, and the Consultant shall use their best efforts to ensure that any Personnel either of them, similarly shall not receive any such additional remuneration.

Neither the Consultant nor the Personnel of either of them shall engage, either directly or indirectly, during the term of this Contract, in any business or professional activities in India which would conflict with the activities assigned to them under this Contract.

Consultant' shall not combine itself with those of a Construction Contractor (RVNL) and designer of construction Contractor and shall furnish an undertaking to the effect that the 'Third Party Consultant' agrees to limit its role to that of a consultant and to disassociate itself, its associates/affiliates from work in any other capacity (including Biding relating to any goods or services for any part of the work) on this work other than that of consultant.

29. Communication

Any notice, request or consent required or permitted to be given or made pursuant to this Contract shall be in writing. Any such notice, request or consent shall be deemed to have been given or made when delivered in person to an authorised representative of the party to whom the communication is addressed, or when sent by registered mail and email to such Party at the address given in the proposal document for issue of proposal document.

30. Publication

Unless otherwise specified in Condition of Contract, the consultant alone or jointly with others can not publish material relating to the Services. Publication shall be subject to prior approval by the Employer.

31. Claims for Loss or Damage

Subject to Clause 11, any claim for loss or damage arising out of breach or termination of the Agreement shall be agreed between the Employer and the Consultant, failing which the same shall be referred to arbitration in accordance with Clause 34.

32. Taxes and Duties

The Contract Price pertaining to provision of consultancy services, shall cover all costs incurred by the Consultant for performing the stipulated Services. This shall not only include salaries, overheads and non-salary expenses, all allowance for contingencies, fees and profits, but all other costs and expenses incurred in carrying out the requirements of the Services, and the taxes including Goods and Services Tax (GST), duties, fees and other impositions under the Applicable Laws including any Withholding taxes etc. These costs shall include all costs for Sub-Consultants, and any other professional fees or services incurred by the Consultant. The Contract Price shall also include all costs, office expenses, travel charges, expenses and allowance paid to or on behalf of International staff working in their own country or in India.

Consultant and their personnel shall pay all taxes including Goods and Services Taxes (GST), cess, duties, fees and other impositions as may be levied under the Applicable Laws in India. In addition, they shall pay all taxes, fees and other impositions as may be applicable in their country of origin, as per their laws and regulations. All payments to the Consultant, will be subject to deduction of tax at source in accordance with the provisions of the Indian Income tax Act and any other applicable law. The Consultant shall take necessary clearance/exemption and registration certificate for Income Tax/ other Taxes/ GST, as applicable.

If rates of existing GST or cess on GST for Consultancy Contract is increased or any new tax /cess on Consultancy Contract is imposed by Statute after the Base Date (i.e. 28 days prior to the deadline for submission of bids) but within the original date of completion/date of completion extended under clause 13 of Conditions of Contract, the Consultant thereupon properly pays such taxes/cess, The Consultant shall be reimbursed the amount so paid.

Further, if rates of existing GST or cess on GST for Consultancy Contract is decreased or any tax/cess on Consultancy Contract is decreased / removed by Statute after the Base date (i.e. 28 days prior to the deadline for submission of bids), the reduction in tax amount shall be recovered from Consultant's payments /Bid Security or any other dues of the Consultant with the Government of India.

GST levied on the invoices raised by the Consultant will be temporarily withheld at the time of making payment for the invoice. GST withheld will be released by HORCL/ HRIDC on submission of proof, i.e. copy of Form GSTR-1 (reflecting the particular invoice) after due verification from the GST portal by the Employer.

33. CLAIMS, DISPUTES AND ARBITRATION

33.1 Procedure for Claims

If the Consultant considers himself to be entitled to any extension of the Time for Completion and/or any additional payment, under any Clause of these Conditions or otherwise in connection with the Contract, the Consultant shall give notice to the Engineer, describing the event or circumstance giving rise to the claim. The notice shall be given as soon as practicable, and not later than 28 days after the Consultant became aware, or should have become aware, of the event or circumstance.

If the Consultant fails to give notice of a claim within such period of 28 days, theTime for Completion shall not be extended, the Consultant shall not be entitled to additional payment, and the Employer shall be discharged from all liability in connection withthe claim.

The Consultant shall also submit any other notices which are required by the Contract,and supporting particulars for the claim, all as relevant to such event or circumstance.

The Consultant shall keep such contemporary records as may be necessary to substantiate any claim at location acceptable to the Engineer. Without admitting the Employer's liability, the Engineer may, after receiving any notice under this Sub-Clause, monitor the record-keeping and/or instruct the Consultant to keep further contemporary records. The Consultant shall permit the Engineer to inspect all these records, and shall (if instructed) submit copies to the Engineer.

Within 42 days after the Consultant became aware (or should have become aware) of the event or circumstance giving rise to the claim, or within such other period as may be proposed by the Consultant and approved by the Engineer, the Consultant shall send to the Engineer a fully detailed claim which includes full supporting particulars of the basis of the claim and of the extension of time and/or additional payment claimed.

33.2 Amicable Settlement

In case any dispute between the Engineer and the Consultant remains unresolved, the Consultant shall, then, give notice of dissatisfaction and intention to commence arbitration to the Employer within 28 days after the occurrence of such event of dissatisfaction. The Parties shall make attempts to settle the dispute amicably before the commencement of arbitration.

33.3 Arbitration

33.3.1 If the efforts to resolve all or any of the disputes through amicable settlement fails, then such disputes or differences, whatsoever arising between the parties, arising out of touching or relating to effect of the Contract or the breach thereof shall be referred to Arbitration in accordance with the following provisions:

a) The Arbitration proceedings shall be assumed to have commenced from the day, a written and valid demand for arbitration is received by Managing Director of the Employer (MD/HRIDC).

b) The disputes so referred to arbitration shall be settled in accordance with the Indian Arbitration & Conciliation Act, 1996 and amended by the Arbitration and Conciliation (Amendment) act, 2015 and any statutory modification or re-enactment thereof; Further, it is agreed between the parties as under:

Number of Arbitrators-The Arbitral tribunal shall consist of:

(i) Sole Arbitrator (or)

(ii) 3 (three) arbitrators

1. Procedure for Appointment of Arbitrators

The arbitrators shall be appointed as per following procedure;

(i) In case of Sole Arbitrator:

Within 30 days from the day when a written and valid demand for Arbitration is received by MD/HRIDC, the Employer will forward a panel of 03 names to the Consultant. The Consultant shall have to choose one Arbitrator from the panel of three, to be appointed as Sole Arbitrator within 30 days of dispatch of the request by the Employer. In case the Consultant fails to choose one Arbitrator within 30 days of dispatch of the request by the Employer, then MD/HRIDC shall appoint any one Arbitrator from the panel of Arbitrators as sole Arbitrator.

(ii) In case of 03 Arbitrators:

(a) Within 30 days from the day when a written and valid demand for Arbitration is received by MD/HRIDC, the Employer will forward a panel of not fewer than 5 nominees to the Consultant. The Consultant will then give his consent for any one name out of the panel to be appointed as one of the arbitrators within 30 days of dispatch of the request by the Employer.

(b) The Employer will decide the second Arbitrator. MD/HRIDC shall appoint the two Arbitrators, including the name of one Arbitrator for whom consent was given by the Consultant, within 30 days from the receipt of the consent for one name of the Arbitrator from the Consultant. In case the Consultant fails to give his consent within 30 days of the request of the Employer then MD/HRIDC shall nominate both the

Arbitrators from the panel. The third Arbitrator shall be chosen by the two Arbitrators so appointed by the parties out of the panel of Arbitrators provided to Consultant or from the larger panel of Arbitrators to be provided to them by Employer at the request of two appointed Arbitrators (if so desired by them) and who shall act as presiding Arbitrator. In case of failure of the two appointed Arbitrators to reach upon consensus within a period of 30 days from their appointment, then, upon the request of either or both parties, the presiding Arbitrator shall be appointed by the MD/HRIDC within 14 days of receipt of request from either party or both parties.

(c) If one or more of the Arbitrators appointed as above refuses to act as Arbitrator, withdraws from his office as Arbitrator, or vacates his/their office/offices or is/are unable or unwilling to perform his functions as Arbitrator for any reason whatsoever or dies or in the opinion of the MD/HRIDC fails to act without undue delay, the MD/HRIDC shall appoint new Arbitrator/Arbitrators to act in his/their place except in case of new presiding Arbitrator who shall be chosen following the same procedure as mentioned in para ii(b) above. Such reconstituted Tribunal may, at its discretion, proceed with the reference from the stage at which it was left by the previous Arbitrator(s).

(d) The Employer at the time of offering the panel of Arbitrator(s) to be appointed as Arbitrator shall also supply the information with regard to the qualifications of the said Arbitrators nominated in the panel along with their professional experience, phone nos. and addresses to the Consultant. The minimum qualification and experience of the arbitrators which may be appointed by the Parties in accordance with the contract is set out below:

(i) A working/retired officer (not below E-8 grade in a central public sector undertaking in India, with which the Employer has no direct business relationship), of engineering or accounts/finance discipline, having experience in management of construction contracts; or

(ii) A retired officer (not below the SAG level in Indian Railways) of any Engineering Services of Indian Railways or Indian Railway Accounts Service, having experience in management of construction contracts;

2. **Miscellaneous:** In any arbitration proceeding hereunder:

(a) The language of arbitration shall be English. This arbitration shall be governed in accordance with the laws of India.

(b) The venue of the arbitration shall be Gurugram, India. The cost of Arbitration including the fees of the Arbitrator shall be borne equally by both the parties.

(c) The decision of the sole arbitrator or of a majority of the arbitrators (or of the third arbitrator if there is no such majority) shall be final and binding and shall be enforceable in the court at Gurugram, and the Parties hereby waive any objections to or claims of immunity in respect of such enforcement.

33.3.2 In the event that the Consultant wishes to refer a dispute to arbitration in accordance with this Sub-Clause, it shall be required to serve a notice in this regard to the Managing Director, of the Employer for commencement of arbitration.

33.3.3 Pending the submission of and/or decision on a dispute and until the arbitral award is published, the Parties shall continue to perform their respective obligations under the contract without prejudice to a final adjustment in accordance with such award.

33.3.4 The arbitrators shall have full power to open up, review and revise any certificate, determination, instruction, opinion or valuation of the Engineer relevant to the dispute. Nothing shall disqualify representatives of the Parties and the Engineer from being called as a witness and giving evidence before the arbitrators on any matter whatsoever relevant to the dispute. However, Conciliator cannot be present as a witness by either party in the arbitral proceedings.

33.3.5 Neither party shall be limited in the proceedings before such arbitrators to the evidence or arguments put before the Engineer to obtain his decision. No decision given by the Engineer in accordance with the contract shall disqualify him from being called as a witness and giving evidence before the arbitrators on any matter, whatsoever, relevant to dispute referred to arbitration.

33.3.6 Arbitration may be commenced prior to or after completion of the Works. The obligations of the Parties and the Engineer shall not be altered by reason of any arbitration being conducted during the progress of the Works.

33.4 DELETED

33.5 Jurisdiction of Courts

Where recourse to a Court is to be made in respect of any matter related to the Contract, the court mentioned in the Contract Data shall have the exclusive jurisdiction to try all disputes between the parties

33.6 Suspension of Work on Account of Arbitration

The reference to Conciliation / Arbitration shall proceed not withstanding that the Works shall not then be or be alleged to be complete, provided always that the obligations of the Employer, Engineer and the Consultant shall not be altered by reasons of arbitration being conducted during the progress of the Works. Neither party shall be entitled to suspend the work or part of the work to which the dispute relates on account of arbitration and payments to the Consultant shall continue to be made in terms of the Contract

34. Clarification;

(i) If the work to be done is not sufficiently detailed or explained in the Contract Document, the consultant shall apply to the authorities in writing for further written clarification and shall conform to the clarification provided. The Consultant shall within the period stated in Part A, Contract Data notify the authority of all errors, omissions, inconsistencies, or other defects (including inaccuracies and inconsistencies) which it discovers in the contract Documents and shall obtain from authorities specific instructions in writing regarding any such error, omission, or defect before proceeding with the design work affected thereby.

(ii) The Consultant is fully responsible for checking of all the designs of the work. The Consultant is responsible for correcting any errors, omissions and defects in such design through the design consultant of the tunnel Contractor, and shall not be entitled to an increase in the Lump Sum fixed price or extension of the contract time in connection with such correction.

35. Relations between the Parties

Nothing contained herein shall be construed as establishing a relation of master and servant or of agent and principal as between the Employer and the Consultant. The Consultant subject to this contract, have complete charge of Personnel performing the Services and shall be fully responsible for the services performed by them or on their behalf hereunder.

36. Amendment to Agreement

Modification of the terms and conditions of this Contract, including any modification of the scope of the Services, may only be made by written agreement between the Parties.

37. Standard of Performance

The Consultant shall perform the Services and carry out their obligations hereunder with all due diligence, efficiency and economy, in accordance with generally accepted professional techniques and practices, and shall observe sound management practices, and employ appropriate advanced technology and safe and effective equipment, machinery, materials and methods. The Consultant shall always act, in respect of any matter relating to this Contract or to the Services, as faithful advisers to the Employer, and shall at all times support and safeguard the Employer's legitimate interest in any dealings with sub-consultants.

38. Indemnifications: -

The Consultant shall indemnify, protect and defend at the their own expense, the Employer, the Engineer and employees from and against any and all actions, claims, losses or damages arising out of any violation by the consultant or in the course of the services of any legal provisions, or any rights or third parties, in respect of literary property rights, copyrights, or patents. Prior approval of the Employer shall be obtained in writing for actions require so. **Some of the actions are listed below but not limited to:**

(a) Appointing such members of the Personnel which are not listed in proposed Key personnel.

(b) Documents Prepared by the Consultant to be the Property of the Employer. All plans, drawings, specifications, designs, reports correspondence and other documents prepared by the Consultant in performing the Services shall become and remain the property of the Employer, and the Consultant shall, not later than upon termination or expiration of this Contract,deliver all such documents to the Employer, together with a detailed inventory thereof. The Consultant shall not use these documents for purposes unrelated to this Contract without the prior written approval of the Employer.

39. Service of Notices

39.1 Notices to Consultant

(i) All notices to the Consultant shall be served by email or by post or by hand to the Consultant or his authorized representatives. In case of notices delivered by post, they will be deemed to have been delivered after 7 days of dispatch.

(ii) The Consultant shall, on award of the Contract, furnish to the Engineer, the name, designation, address and telephone numbers and telefax numbers and e-mail address of his representative.

39.2 Notice to Employer and Engineer

All notices to the Employer or Engineer shall be signed by authorised representative only and served by email or by post or by hand to the address nominated for the purpose.

39.3 Change of Address

Parties to the Contract may change the nominated address with a notice to all concerned

40. Professional Indemnity Insurance)

The Consultant shall effect and maintain Professional Indemnity Insurance (PII) for the amount in Indian Rupees stipulated in Part A-Contract Data, Section 8, SCC in respect of any design of the Works to be checked by the Consultant. This insurance shall ensure the Consultant's liability by reason of professional negligence and errors in the checking of design and drawings.

This insurance shall be valid from the date of commencement of Works until 5 years after the date of issue of Performance Certificate. Alternatively, the Consultant shall redeem the insurance before the expiry of the Yearly Insurance in such a way that the entire validity period is covered.

The Engineer will not issue Final Payment Certificate until the Consultant has produced evidence that coverage of the PII has been provided for the aforesaid period.

SECTION 8

Special Conditions of Contract (SCC)

Part A: Contract Data (CD)

Special Conditions of Contract (SCC)

Part A - Contract Data

The following Special Conditions of Contract (SCC) shall supplement the General Conditions of Contract (GCC). Whenever there is a conflict, the provisions herein shall prevail over those in the GCC.

Sr. No.	Conditions	Reference to GCC	Data
1.	Contractor	1 (vii)	Rail Vikas Nigam Limited (RVNL)
2.	Employer's name and address	1 (x)	Haryana Orbital Rail Corporation Limited (HORCL) Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram, Haryana-122003 E-mail: gminfrahridc@gmail.com
3.	Employer's Representative	1(xi)	Chief Project Manager/West, Haryana Rail Infrastructure Development Corporation Limited, Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram, Haryana-122003 E-mail: gminfrahridc@gmail.com
4.	Engineer's name and address	1(xii)	RITES Limited in Consortium with SMEC International Pty Ltd, 4th Floor, Plot No.144, RITES Limited, Sector-44, Gurugram, Haryana-122003
5.	Project Name	1(xxiv)	Haryana Orbital Rail Corridor (HORC) Project
6.	Performance Security	3.2	5% (Five percent) of the Accepted Contract Amount in the form of an unconditional Bank Guarantee for the stated amounts in two parts as mentioned below: (i) Bank Guarantee for the first part of Performance Security shall be

Sr. No.	Conditions	Reference to GCC	Data
			equal to seventy percent (70%) of required Performance Security. (ii) Bank Guarantee for the second part of Performance Security shall be equal to thirty percent (30%) of required Performance Security. Bank Guarantee for the first part of Performance Security shall be valid for a period of 28 days beyond the date of issue of completion certificate for Part-A of Scope of work as stated in Section 3, Works Requirements. Bank Guarantee for the second part of the Performance Security shall be valid for a period of 28 days beyond the date of issue of Performance Certificate.
7.	Completion period	13	Completion period: 48 Months
8.	Date of commencement of Works	13	Date Notified in LOA.
9.	Liquidated Damages	15.1	0.05% of the Accepted Contract Amount for each week or part thereof for delayed services for each Milestone of Cost centre ‘P’ given under Sub-Clause 1.1.1 of Section 4: Bidding Forms (BDF). The maximum limit of Liquidated Damages shall be 5% of the accepted Contract Price.
10.	Time for Payment	20	Within thirty days (30) days from the submission of invoice to the Engineer.
11.	Communication	29	By email/Speed Post/Courier/receipt in GC office
12.	Place of Arbitration	33.3	Gurugram
13.	Jurisdiction of Courts	33.5	Gurugram

Sr. No.	**Conditions**	**Reference to GCC**	**Data**
14.	Period of notification of all errors, omissions, inconsistencies, or other defects (including inaccuracies and inconsistencies) in the Contract Documents	34 (i)	28 days calculated from the issue of Letter of Acceptance
15.	Notice to Employer and Engineer	39.2	Haryana Rail Infrastructure Development Corporation (HRIDC) Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram, Haryana-122003 E-mail: gminfrahridc@gmail.com **And** GC/HORC RITES Limited in Consortium with SMEC International Pty Ltd, 4th Floor, Plot No.144, RITES Limited, Sector-44, Gurugram, Haryana-122003
16.	Insurance for Design (Professional Indemnity Insurance)	40.0	Equal to the Accepted Contract Amount.

Section 9

Contract Forms (COF)

Section 9 - Contract Forms (COF)

This Section contains forms which, once completed, will form part of the Contract. The forms for Performance Security when required, shall only be completed by the successful Bidder after contract award.

Table of Forms

FORM No. COF/1

Letter of Acceptance

[on letterhead paper of the Employer]

To

__________(Name & Address of the Consultant)

Dear Sir,

Kind Attention: Mr. ________________

Sub: BID No.____________________FOR THE WORK OF

Ref: a. Your Bid dated _________________

b. Your letter No.___________________________dated ______

c. Your letter No.___________________________dated ______

1. This is to notify you that your Bid dated _______*[Insert Date]* for execution of the _________*[Insert name of the contract and identification number]* for the Accepted Contract Amount of the equivalent of INR___________*[Insert amount in numbers and words and name of the currency]* as corrected and modified in accordance with the Instructions to Consultants, is hereby accepted.
2. The Works/Services are to be completed within ____*[insert period of completion]* of date of issue of "Letter of Acceptance". The date of issue of this "Letter of Acceptance" will be treated as "Effective Date" for the purpose of this Contract for commencement of the Works/Services.
3. You are requested to furnish the Performance Security within 28 days from the date of issue of Letter of Acceptance for the amount stated in the Bid documents in accordance with the Conditions of Contract as per Contract Form No. COF/3 included in the Bidding Document.
4. You shall furnish the Bonds, Guarantees, Undertakings and Warrantees as stipulated in the Bid Documents as per the Contract Forms.
5. You shall ensure full compliance with tax laws of India with regard to this Contract and shall be solely responsible for the same. You shall submit copies of acknowledgements evidencing filing of returns every year and shall keep the Employer fully indemnified against your liability of tax, interest, penalty etc. in respect thereof, which may arise.
6. You shall also undertake not to use information gained in the performing of the works for any purpose without obtaining the prior approval of HRIDC and shall not make any public announcement or divulge any material relating to the project either in India or overseas without the prior written consent of HRIDC.
7. Until a formal agreement is signed, this Letter of Acceptance will constitute a binding contract between you and HORCL.

8. This Letter of Acceptance is sent to you in duplicate. You are required to return one copy duly signed and stamped on all pages including your unconditional acceptance thereof so as to reachthe undersigned within four days of issuance of this letter, as a token of your acknowledgement.

Yours faithfully,

____
Signature of Authorized Signatory

____
Name and Title of Signatory

Attachment: Contract Agreement

FORM No. COF/2

Contract Agreement

This Agreement (hereinafter called the "Contract") is made at _________*[insert place of work]* on the_____day of________*[month] 2023* between_________(*[Name and address of the Employer*] hereinafter called "the Employer") of the one part and ___________[*Name and Address of the Third Party Consultant (TPC)*]

_____(hereinafter called "the Consultant") of the other part:

Whereas the Employer is desirous that the___*[Name of the Services]*___hereinafter called"the Services") should be executed and has accepted a bid by the Consultant for the execution and completion of such services and the remedying of any defects therein.

The Employer and the Consultant agree as follows:

1) In this Agreement words and expression shall have the same meanings as are respectively assigned to them in the Contract Documents hereinafter referred to.

2) The following documents shall be deemed to form and be read and construed as part of thisAgreement. This Agreement shall prevail over all other Contract documents.

    a) The Contract Agreement
    b) The Letter of Acceptance
    c) Letters of Clarifications, if any
    d) Addenda/Corrigenda to the Bid Document, if any
    e) The Financial Bid
    f) The Special Conditions of Contract including Schedules, if any
    g) The General Conditions of Contract
    h) The Work's Requirements
    i) Instructions to Consultants
    j) The Bid Documents including all the Sections
    k) The Technical Bid
    l) Any other document forming part of the Contract

3) In consideration of the payments to be made by the Employer to the Consultant as hereinafter mentioned, the Consultant hereby covenants with the Employer to complete the Services as stipulated in Bid Document issued by the Employer and to remedy any defects therein in conformity in all respects with the provisions of the Contract.

4) The Employer hereby covenants to pay the Consultant in consideration of the completion of the services and the remedying of defects therein, the Contract

Price being the sum stated in the Letter of Acceptance subject to such additions there to or deductions there from as may be made under the provisions of the Contract at the times and in the manner prescribed by the Contract.

5) OBLIGATION OF THE CONSULTANT

The Consultant shall ensure full compliance with tax laws of India with regard to this Contract and shall be solely responsible for the same. The Consultant shall submit copies of acknowledgements evidencing filing of returns every year and shall keep the Employer fully indemnified against liability of tax, interest, penalty etc., of the PC in respect thereof, which may arise.

6) GOVERNING LAW

This Contract is enforceable and construed under the laws of the Republic of India.

7) JURISDICTION OF COURT

The Courts at Gurugram shall have the exclusive jurisdiction to try all disputes arising out of this agreement between the parties.

IN WITNESS WHEREOF the parties here to have caused this Agreement to be executed in accordance with the laws of the Republic of India. on the day, month and year specified above.

For and on behalf of the Consultant	For and on behalf of the Employer
Signature of the authorized official	Signature of the authorized official
Name of the official	Name of the official
Stamp/Seal of the Consultant	Stamp/Seal of the Employer
in the presence of:	in the presence of:
Sign of Witness ____________________	Sign of Witness ____________________
Name______________________________	Name __________________
Address____________________________	Address________________
__________________________________	__________________________________

FORM No. COF/3

FORM OF PERFORMANCE SECURITY

(Demand Guarantee)

[Guarantor letterhead or SWIFT identifier code]

Form: -

[Name and Address of the Bank]____________________________________

Beneficiary: Chief Project Manager,
Haryana Rail Infrastructure Development Corporation Limited,
5th Floor, Plot No. 143, Rail Tel Tower, Sector 44,
Gurugram,
Haryana: 122003

Date: ________________ *[Insert date of issue]*

PERFORMANCE GUARANTEE No.: _________________

Guarantor: *[Insert name and address of place of issue, unless indicated in the letterhead]*

We have been informed that _________________ (hereinafter called "the Applicant") has entered into Contract No. ______________ *dated* _____________ with the Beneficiary, for the performance of Services for "Third Party Consultancy for checking of Detailed Design and Drawings of Twin NATM and Cut & Cover Tunnels from Km 24.850 to Km 29.580 including associated structures and Third Party Consultant's association during construction of NATM and Cut & Cover Tunnels for Haryana Orbital Rail Corridor (HORC) Project in the State of Haryana." (hereinafter called "the Contract").

Furthermore, we understand that, according to the conditions of the Contract, a Performance Guarantee is required.

At the request of the Applicant, we as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of ____________ (),[1] such sum being payable in the currency in which the Contract Price is payable, upon receipt by us of the Beneficiary's complying demand supported by the Beneficiary's

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[1] *The Guarantor shall insert an amount representing the percentage of the Accepted Contract Amount specified in the Letter of Acceptance, less provisional sums, if any, to the Beneficiary.*

statement, whether in the demand itself or in a separate signed document accompanying or identifying the demand, stating that the Applicant is in breach of its obligation(s) under the Contract, without the Beneficiary needing to prove or to show grounds for your demand or the sum specified therein.

This guarantee shall expire, no later than the …. Day of ……, 2…[2], and any demand for payment under it must be received by us at this office indicated above on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758, except that the supporting statement under Article 15(a) is hereby excluded.

____

[signature(s)]

Note: All italicized text (including footnotes) is for use in preparing this form and shall be deleted from the final product.

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[2] *Insert the date twenty-eight days after the expected completion date as described in GC Clause 13. The Employer should note that in the event of an extension of this date for completion of the Contract, the Employer would need to request an extension of this guarantee from the Guarantor. Such request must be in writing and must be made prior to the expiration date established in the guarantee. In preparing this guarantee, the Employer might consider adding the following text to the form, at the end of the penultimate paragraph. "The Guarantor agrees to a one-time extension of this guarantee for a period not to exceed [six months] [one year], in response to the Beneficiary's written request for such extension, such request to be presented to the Guarantor before the expiry of the guarantee."*

FORM No. COF/4

CONSULTANT'S DESIGN CHECKING CERTIFICATE

This Design checking Certificate refers to Submission No. .... which comprises:

[*Design No. ..../the Final Detailed Design Submission/Good For Construction Drawings Submission No. ..../Technical Submission No. ....] in respect of:*[description of the Permanent Works to which the submission refers]*

The contents of this submission are scheduled in Section A below.

The documents scheduled in Section A below, has been checked by us, and meets the requirements of the Contract.

CONSULTANT'S STATEMENT

We certify that:

(a) the design of the Permanent Works, as illustrated and described in the documents scheduled in Section A below, complies with the Section 3, Works Requirements, local regulations and standards;

(b) a detailed review and design check has been undertaken and completed to confirm the completeness, adequacy and validity of the design of the Permanent Works as illustrated and described in the documents scheduled in Section A below;

(c) all necessary and required approvals relating to the design of the Permanent Works, as illustrated and described in the documents scheduled in Section A below, have been obtained by the tunnel contractor and copies of such approvals are annexed in Section B below;

AND (in the case of a submission covering a part of the Permanent Works only):

all effects of the design comprising the submission on the design of adjacent or other parts of the Works have been fully taken into account in the design of those parts.

Signed by Authorised Representative
(For Consultant)

Name
Position / Designation

Date

Section A

Submission no. .... comprises the following:
Drawings: *(Title, drawing number and revision)*
Documents: *(Title, reference number and revision)*
Others:

Section B

[Consultant to attach copies of necessary and required approvals from statutory bodies, etc.]