Transys Consulting Pvt. Ltd

Geotechnical Investigation work for Proposed Greenfield project from Spur to Haridwar.

Job No 2152

Report
MJB, MNB, VUP & Flyover-R1

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TRANSYS CONSULTING PVT. LTD. GURUGRAM

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1.0 INTRODUCTION

M/s Transys Consulting Pvt Ltd has awarded the work of Geo technical Investigation for the proposed Greenfield project from Spur to Haridwar to M/s Soil Engineering Consultants, New Delhi.

Geotechnical investigation was conducted to characterize and assess the subsurface conditions at the locations of various Structures viz. proposed Major Bridges, Minor Bridges, ROBs, Elevated Viaduct, Vehicular Underpass (VUP). The overall objectives of the exploration were to study and evaluate the stratigraphy of the said project corridor and to obtain geotechnical / geological parameters of the subsurface formations for design and construction of various foundations.

This report presents the details of Geotechnical investigations carried out and data obtained from various field and laboratory tests, their presentation in graphical form, and their compilation for the proposed Structures.

2.0 SCOPE OF WORK

a) Drilling bore holes upto the maximum depth of 30.0 m as per IS code of practice and as per the direction of the Engineer-in-Charge.

b) Conducting Standard Penetration tests in the bore holes at regular intervals of 1.50m or wherever possible as per IS Code of Practice.

c) Collecting undisturbed soil samples / core samples from the bore holes at regular intervals or change of strata or wherever possible as per IS Code of Practice.

d) Recording of water table level in the bore holes after completion of borehole.

e) Preparation of report summarizing the details of soil classification, analysis of test data, type of foundation etc.

3.0 FIELD WORK

3.1 Boring

Bore holes of 150 mm dia. were drilled as per IS code of practice (IS 1892-1979) and as per the directions of the Engineer in charge. The details of Bore holes drilled, Depth of bore hole and the depth of water table are as given below:

Table 1 : Detail of the Boreholes.

Chainge	BH No.	Structure	Depth of Borehole (m)	Water Table (m)
0+800	BH 1	Flyover	30.00	4.50
1+530	BH 2	MJB	30.00	2.70
6+380	BH 3	VUP	20.00	13.80
8+020	BH 5	Flyover	30.00	14.10
16+690	BH 6	VUP	20.00	13.30
21+810	BH 7	MNB	20.00	11.30
22+980	BH 8	VUP	20.00	14.20
25+430	BH 9	VUP	20.00	12.25
29+260	BH 11	MNB	20.00	5.50
32+170	BH 12	Flyover	30.00	13.20
33+420	BH 13	MJB	30.00	2.10
33+490	BH 14	MJB	30.00	3.20
35+860	BH 15	MJB	30.00	5.30
38+010	BH 16	MNB	20.00	8.75
39+510	BH 17	MJB	30.00	4.50
39+690	BH 18	MJB	30.00	4.50
40+940	BH 19	VUP	20.00	11.80
42+550	BH 20	MJB	30.00	3.35
43+910	BH 21	Flyover	30.00	10.25
47+950	BH 22	MJB	30.00	3.80
49+900	BH 23	Flyover	30.00	9.80

3.2 Standard Penetration Test (SPT)

These tests were conducted at every 1.50m intervals and every change of strata or wherever possible. The tests were performed by driving into the soil (bore holes cleaned of any loose material) a standard split spoon sampler with the help of a standard hammer with a free fall of 75 cms on a driving head as described in IS: 2131. This head was attached to "A" drill rod to the other end of which the sampler was fitted. The number of blows needed to penetrate the first, second and third stages (each of 15 cms) depth of the sampler length, were noted. The number of blows (N - value) as given in the bore hole data sheets is the numerical sum of blows counted during the second & third stage only i.e. for a depth of 30 cms.

3.3 Collection of Samples

Disturbed and Undisturbed soil samples were collected from the boreholes at regular intervals as per IS Code of practice.

3.4 Recording of water table

Water table was met at varying depth in the boreholes at the time of Soil investigation which was carried out during the month of April 2021. The details are given at Table I above. Fluctuations may occur in measured water levels due to seasonal variation in rainfall and surface evaporation rates as well as flow of water.

4.0 LABORATORY TESTS

A visual and discrete examination of all the soil samples collected was carried out for deciding the number and type of tests to be tested from each bore hole. Based on the strata met at site the following tests were conducted on samples to classify them and to evaluate their index and Engineering properties.

4.1 SOIL SAMPLES & BIS CODES

a) Grain size distribution as per IS: 2720(Part IV).

b) Hydrometer Analysis as per IS: 2720(Part IV).

c) Specific gravity as per IS: 2720(Part III).

d) Bulk density and dry density as per IS: 2720(Part II).

e) Moisture content as per IS: 2720(Part II).

f) Liquid and plastic limits as per IS: 2720(Part V).

g) Unconsolidated undrained shear tests as per IS: 2720(Part XIII).

h) Direct Shear Tests as per IS: 2720 (Part XIII).

i) Consolidation test as per IS: 2720 (Part XII).

5.0 General Geology of the Area

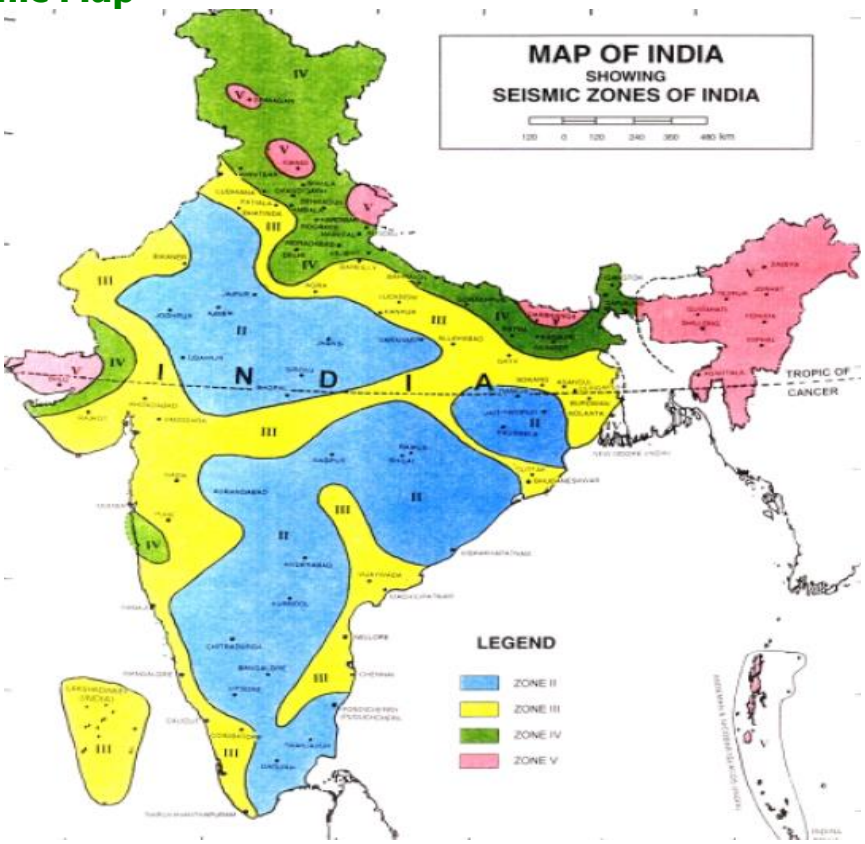
The present location is in the state of Uttarakhand situated on the northern Gangetic plains of India. Most of the state of Uttarakhand lies in the Gangetic Plain. This is a fore-deep, a downwarp of the Himalayan foreland, of variable depth, converted into flat plains by long-vigorous sedimentation. This is known as a geosyncline and the Gangetic Plain is the Indo-Gangetic Geosyncline. This has shown considerable amounts of flexure and dislocation at the northern end and is bounded on the north by the Himalayan Frontal Thrust. The floor of the Gangetic trough (if see without all the sediments) is not an even plain, but shows corrugated inequalities and buried ridges (shelf faults). Beneath Uttar Pradesh, run the Delhi-Haridwar Ridge (DHR), trending NNE-SSW along New Delhi to the Gharwal region. The Delhi-Muzaffarnagar Ridge (DMR), which trends east to west, running from New Delhi to Kathgodam, in Nepal. The last ridge is the Faizabad ridge (FR), which runs in a curved manner, first east to west from Allahabad to Kanpur and then starts to bend towards the north-east towards Lucknow and carries on in this direction towards the Himalayas in Nepal. The depression that forms between the DMR and the FR, forms the West Uttar Pradesh shelf in the west and the Sharda Depression in the east. The region to the south of the FR, forms the East Uttar Pradesh shelf. There are several faults in the region, among them the Moradabad Fault which trends NE-SW and the Bhairwan Fault in the vicinity of Allahabad. Apart from these there are east-west running tear faults in the region that control

the courses of the main rivers. Earthquakes have occurred in mostly all parts of Uttarakhand. Major earthquakes in the neighbouring states of New Delhi, Uttaranchal, Bihar and from across the Indo-Nepal border have also shaken many parts of Uttar Pradesh.However, it must be stated that proximity to faults does not necessarily translate into a higher hazard as compared to areas located further away, as damage from earthquakes depends on numerous factors such as subsurface geology as well as adherence to the building codes.

6.0 SEISMICITY

The seismic hazard map of India was updated in 2016 by the Bureau of Indian Standard (BIS). The project site lies in Zone IV. The tectonic elements of the area are considered capable of generating an earthquake of intensity MSK 7.0. In Seismic design Zone factor, Z of 0.24 is recommended.

Seismic Map



7.0 LIQUEFACTION

Liquefaction is a process in which a saturated soil loose strength during an earthquake and acquires a degree of mobility sufficient to permit significant movements. In general, fine uniform sands are found to be most susceptible for liquefaction in terms of grain size. It can be stated that soils containing less than 10% fines, D_{60} between 0.20 mm to 1.0mm, uniformity coefficient between 2 to 5 are most susceptible to liquefaction for given relative density of soil and intensity of earthquake. Thus, uniformly graded materials are more susceptible to liquefaction than well graded materials. Also fine sands are more susceptible than gravelly soils, silty sands, silts or clays.

Assessment of liquefaction potential of foundation strata is made by simplified approach proposed by Seed & Idriss (1983 - 1985) from the SPT data and peak ground acceleration likely to occur at the site. In this method, cyclic shear stress likely to be induced in the foundation strata is first evaluated. Next threshold cyclic shear stress, which is good enough to cause liquefaction, is determined from SPT data and the empirical relations. Finally, comparison of these two stresses is used in the estimation of liquefaction susceptibility of the foundation strata

7.1 Liquefaction Analysis:

Cyclic Stress Ratio under Earth Quake (CSR)

Stress ratio under earth quake (CSR)

$$= (\tau / \sigma_o)_{\text{earthquake}} = 0.65\ (\gamma h\ a_{max} / \sigma_o\ g)\lambda$$

σ_o= Effective overburden pressure at depth h

γ = Bulk density of soil

a_{max}= Max. Ground acceleration = 0.24g

Evaluation of Liquefaction Resistance (CRR)

$CRR_{7.50} = 1/\{(34-(N_1)_{60CS}\} + (N_1)_{60CS} / 135 + 50/\{10*(N_1)_{60CS} + 45\}^2 - 1/200$

$(N_1)_{60} = NC_{60}C_N$

N= Uncorrected SPT count

C_N= factor to normalize N_m to a common reference effective overburden stress = $(p_o / \sigma_o)^{0.5}$

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

C_{HT} =Correction for Hammer Energy Ratio

C_{BD}= Correction factor for the borehole diameter

C_{RL}= correction factor for rod length

C_{SS}= Correction for samples with or without liners

Correction for Fineness content

$(N_1)_{60cs} = a + \beta (N_1)_{60}$

$CRR_L = CRR_{7.50} * k_m$

k_m Correction factor

For earthquake magnitude other than 7.5 = $10_{2.24}/ (M_{7.5})^{2.56}$

Liquefaction occurs if $CSR_L \geq$ CRR

Data considered for Liquefaction:

Magnitude of Earth quake = 7.0.

a_{max}/g = 0.24

Water table assumed for Calculation = considered 3.0m rise water table encounter at the time investigation.

The Liquefaction analysis has been calculated and given at **Annexure II**.

8.0 SUB SOIL PROFILE & STRENGTH CHARACTERISTICS OF SOIL

Flyover @ 0+800

At this structure One Borehole namely (BH 1) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. However from 14.50m to 17.50m depth a layer of Silty Clay of

Medium Plasticity (CI) was observed. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 5 to 30 upto the depth drilled. For evaluating the shear parameters Direct shear Tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

MJB @ 1+530

At this structure One Borehole namely (BH 2) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. However from 14.0m to 20.5m depth a layer of Silty Clay of Low to Medium Plasticity (CL-CI) was observed. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 6 to 30 upto the depth drilled. For

evaluating the shear parameters Direct shear Tests/Unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

VUP @ 6+380

At this structure One Borehole namely (BH 3) was drilled upto 20.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelog. It can be seen from the plot that the SPT values are generally varying from 10 to 26 upto the depth drilled. For evaluating the shear parameters Direct shear Tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

Flyover @ 8+020

At this structure One Borehole namely (BH 5) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting

sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. However from 10.0m to 12.0m depth a layer of Silty Clay of Medium Plasticity (CI) was observed. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 9 to 14 upto 8.0m depth and below 8m depth SPT values are varying from 17 to 34 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

VUP @ 16+690

At this structure One Borehole namely (BH 6) was drilled upto 20.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of alternate layers of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) and Silty Clay of Medium Plasticity (CI) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and

High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 11 to 34 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ Unconsolidated undrained shear test were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

MNB @ 21+810

At this structure One Borehole namely (BH 7) was drilled upto 20.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 8 to 29upto the depth drilled. For evaluating the shear parameters Direct shear Tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

VUP @ 22+980

At this structure One Borehole namely (BH 8) was drilled upto 20.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of Silty clay of Medium Plasticity (CI) upto 5.0 m depth followed by medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 17 to 30 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ Unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

VUP @ 25+430

At this structure One Borehole namely (BH 9) was drilled upto 20.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of alternate layers of Silty Clay of Medium Plasticity (CI) and medium dense

Sandy Silt with Gravel (SM-ML) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 6 to 22 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ Unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

MNB @ 29+260

At this structure One Borehole namely (BH 11) was drilled upto 20.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-MLupto the depth drilled. However from 0.0m to 2.0m depth and from 15.50m to 17.50m depth a layer of Silty Clay of High plasticity (CH)/ Silty Clay of Medium Plasticity (CI) was observed. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 6 to 19 upto the

depth drilled. For evaluating the shear parameters Direct shear Tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

Flyover @ 32+170

At this structure One Borehole namely (BH 12) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of alternate layers of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) and Silty Clay of Medium Plasticity (CI) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 10 to 35 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

MJB @ 33+420

At this structure One Borehole namely (BH 13) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular

intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of alternate layers of medium dense Silty Sand with Gravel (SM) and Silty Clay of Medium Plasticity (CI) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 2 to 6 upto 12.0m depth and below 12 m depth SPT values are varying from 15 to 40 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

MJB @ 33+490

At this structure One Borehole namely (BH 14) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of alternate layers of medium dense Silty Sand with Gravel (SM) and Silty Clay of Medium Plasticity (CI) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to

presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 6 to 41 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

MJB @ 35+860

At this structure One Borehole namely (BH 15) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of alternate layers of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) and Silty Clay of Low to Medium Plasticity (CL-CI) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 9 to 29 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at

Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

MNB @ 38+010

At this structure One Borehole namely (BH 16) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto 6m depth followed by Silty Clay of Low to Medium Plasticity (CL-CI) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 4 to 26 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

MJB @ 39+510

At this structure One Borehole namely (BH 17) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the

classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto 16m depth followed by Silty Clay of High Plasticity (CH) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 6 to 21 upto 22m depth and below 22m depth SPT values are varying from 23 to 35 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

MJB @ 39+690

At this structure One Borehole namely (BH 18) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of alternate layers of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) and Silty Clay of Medium Plasticity (CI) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been

plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 6 to 37 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

VUP @ 40+940

At this structure One Borehole namely (BH 19) was drilled upto 20.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of Silty Clay of Medium Plasticity (CI) upto 8.0 m depth followed by medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto 17.50m depth. Below 17.50m depth the strata is classified as Silty Clay of High Plasticity (CH) upto the depth drilled. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 7 to 11 upto 7.0 m depth and below 7m depth SPT values are varying from 19 to 35 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been

carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

MJB @ 42+550

At this structure One Borehole namely (BH 20) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. However from 17.50m to 20.50m depth a layer of Silty Clay of Medium Plasticity (CI) wasw observed. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 9 to 28 upto the depth drilled. For evaluating the shear parameters Direct shear Tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

Flyover @ 43+910

At this structure One Borehole namely (BH 21) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the

classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. However from 5.0m to 9.0m depth and from 14.50m to 16.0m depth a layer of Silty Clay of Medium Plasticity (CI) was observed. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 8 to 28 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ Unconsolidated undrained shear tets were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

MJB @ 47+950

At this structure One Borehole namely (BH 22) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. However from 6.0m to 9.0m depth a layer of Silty Clay of Medium to High Plasticity (CI-CH) was observed. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic

strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 10 to 32 upto the depth drilled. For evaluating the shear parameters Direct shear Tests/ Unconsolidated undrained shear tets were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is susceptible to liquefaction.

9.0 DESIGN CRITERIA

Any foundation is to be safe against possible failure against

a) Excessive Shear failure (the bearing pressure should be within permissible limits) and
b) Excessive settlement.

The latter depends upon not only on the type of soil in the foundation but also on the type of foundation, material used for construction and functionality of the structure.

9.1 Design Methodology

Flyover @ 0+800, 8+020, 32+170, 43+910 & 49+900

Bored - Cast - in situ Piles of 1.0m and 1.20m diameter are analyzed.

VUP @ 6+380, 16+690, 22+980, 25+430 & 40+94

Bored - Cast - in situ Piles of 1.0m and 1.20m diameter are analyzed. Scour levels provided by the client.

MNB @ 21+810 & 29+280

Raft foundation has been analysed at 1.0 m depth below bed level with an allowable settlements of 75 mm has been considered.

MNB @ 38+010

Bored - Cast - in situ Piles of 1.0m and 1.20m diameter are analyzed. Scour levels provided by the client.

MJB @ 1+530, 33+420,33+90,35+860,39+510,39+690,42+550 & 49+900

Bored - Cast - in situ Piles of 1.0m and 1.20m diameter are analyzed. Scour levels provided by the client.

9.1.1 Open foundation

The safe bearing pressure from Shear failure criteria can be obtained, using the Equation given below

$Qu = q (Nq - 1) Sq Dq Iq + 0.5 B \gamma N\gamma S\gamma D\gamma I\gamma W'$

where,

B = Width of the footing in m

Dq,Dγ = Depth factors

Sq,Sγ = Shape factors

Iq,Iγ = Inclination factors

Nq,Nγ = Bearing capacity factor

q = Effective overburden pressure at foundation, in t/sqm

W' = Water table correction factor

γ = Bulk unit wt. of foundation soil, in t/cu.m

b) Settlements:

i) Soil profiles are given for each bore hole. The Soil profile which is likely to cause greater settlements is to be considered for calculations.

ii) The imposed load at the foundation level is likely to compress the soil upto a depth of approximately equal to 1.5 B below the foundations.

iii) The settlements can be calculated using IS-8009 part-I.

When the strata consists of Plastic strata

when the Foundation resting on plastic strata and its influence within the plastic strata the settlements can be obtained using the equation as per **IS: 8009 (part I)**

$S_t = H*m_v*\Delta P$

Where

H =thickness of layer under consideration (cm).

m_v= volume of compressibility

ΔP = Increase in the effective stress due to external load.

9.1.2 Bored cast in-situ concrete pile

The ultimate load carrying capacity (P_U) of piles is given by the following formula:

$P_U = A_p (N_c.C_p + ½ D \gamma N_r + P_d N_q) + \sum K P_{di} \tan \delta A_{si} + \alpha c.As$

$P_U = P_{pu} + P_{su}$

P_{pu} = Ultimate bearing resistance

$= A_p (N_c. C_p + ½ D \gamma N_r + P_d N_q)$

P_{Su}= Ultimate shaft resistance

$\sum K P_{di} \tan \delta A_{si} + \alpha c.As$

A_p = Cross sectional area of the pile toe m^2

D = Stem diameter in mm

γ = Effective unit weight of soil at pile toe in t/m^3

P_d = Effective overburden pressure at pile toe in t/m^2

i.e 20 X diameter (as per IRC 78-2014).

N_r & N_q = Bearing capacity factors depending upon the angle of internal friction $\varnothing$ at toe

$\sum$ = Summation of n layers in which pile is installed

K = Coefficient of earth pressure

= Taken 1.5 (as per IRC 78- 2014 Appendix 5)

P_{di} = Effective overburden pressure in t/m^2 for the i^{th} layer where i varies from i to n

δ = Angle of wall friction between pile and soil (may be taken equal to $\varnothing$)

A_{si} = Surface area of pile stem in m^2 in i^{th} layer where i varies from 1 to n.

FOS= Factor of Safety considered as 2.5 (as per IS 2911 part 1 sec 2)

For vertical Capacity of pile, weight of pile has not been considered.

10.0 COMPUTATIONS

The Net Safe bearing capacity for the Box foundation, Vertical, Uplift and lateral carrying capacities of the Bored Cast in Situ Piles of 1.0m and 1.20m dia are calculated and are given at **Annexure I.**

11.0 RECOMMENDATIONS

Flyover @ 0+800, 8+020, 32+170,43+910 & 49+900

Bored Cast in-situ Pile Foundation of 1.0 m and 1.20m dia are recommended at cut off level of 2.0m and 2.30m respectively. The Length of pile and Safe load carrying capacity of the pile can be taken as given below:

Chainage	BH No.	Pile Dia (cms)	Length of Pile (m)	Safe Load carrying capacity of Pile (t)		
				Vertical	Uplift	Lateral
0+800	BH 1	100	29.0	300.0	160.0	10.0
		120	29.0	400.0	210.0	18.0
8+020	BH 5	100	20.0	330.0	150.0	20.0
		120	20.0	400.0	180.0	40.0
32+170	BH 12	100	24.0	140.0	100.0	30.0
			26.0	160.0	110.0	30.0
			28.0	170.0	120.0	30.0
		120	24.0	180.0	130.0	50.0
			26.0	200.0	140.0	50.0
			28.0	220.0	150.0	50.0
43+910	BH 21	100	21.0	300.0	150.0	20.0
		120	21.0	400.0	180.0	30.0
49+900	BH 23	100	23.0	330.0	150.0	20.0
		120	23.0	400.0	190.0	35.0

VUP @ 6+380, 16+690, 22+980, 25+430 & 40+940

Bored Cast in-situ Pile Foundation of 1.0 m and 1.20m dia are recommended at cut off level of 2.0m and 2.30m respectively. The Length of pile and Safe load carrying capacity of the pile can be taken as given below:

Chainage	BH No.	Pile Dia (cms)	Length of Pile (m)	Safe Load carrying capacity of Pile (t)		
				Vertical	Uplift	Lateral
6+380	BH 3	100	18.0	280.0	120.0	20.0
			19.0	300.0	140.0	20.0
		120	18.0	370.0	160.0	40.0
			19.0	400.0	170.0	40.0
16+690	BH 6	100	18.0	250.0	110.0	20.0
			20.0	300.0	140.0	20.0
		120	18.0	340.0	140.0	50.0
			20.0	400.0	180.0	50.0
22+980	BH 8	100	18.0	300.0	140.0	35.0
		120	18.0	400.0	170.0	50.0
25+430	BH 9	100	18.0	250.0	110.0	25.0
			19.0	270.0	120.0	25.0
		120	18.0	330.0	140.0	40.0
			19.0	360.0	160.0	40.0
40+940	BH 19	100	18.0	160.0	100.0	15.0
			21.0	180.0	120.0	15.0
		120	18.0	200.0	130.0	25.0
			21.0	220.0	150.0	25.0

MNB @ 38+010 & MJB @ 1+530, 33+420, 33+490, 35+860, 39+510, 39+690, & 42+550

Bored Cast in-situ Pile Foundation of 1.0 m and 1.20m dia are recommended at cut off level of 2.0m and 2.30m respectively. The Length of pile and Safe load carrying capacity of the pile can be taken as given below:

Chainage	BH No.	Pile Dia (cms)	Length of Pile (m)	Safe Load carrying capacity of Pile (t)		
				Vertical	Uplift	Lateral
1+530	BH 2	100	27.0	300.0	150.0	10.0
		120	27.0	400.0	200.0	20.0
33+420	BH 13	100	31.0	280.0	150.0	5.0
		120	31.0	400.0	200.0	10.0
33+490	BH 14	100	30.0	300.0	150.0	10.0
		120	30.0	400.0	200.0	18.0
35+860	BH 15	100	28.0	300.0	150.0	10.0
		120	28.0	400.0	190.0	18.0
38+010	BH 16	100	24.0	70.0	60.0	10.0
		120	24.0	95.0	80.0	18.0
39+510	BH 17	100	28.0	110.0	70.0	9.0
			30.0	120.0	80.0	9.0
		120	28.0	150.0	90.0	15.0
			30.0	160.0	110.0	15.0
39+690	BH 18	100	29.0	210.0	150.0	15.0
		120	29.0	270.0	190.0	30.0
42+550	BH 20	100	29.0	300.0	160.0	10.0
		120	29.0	400.0	200.0	20.0

MNB @ 21+810 & 29+280

Box foundation is recommended considering Bed protection work. The Depth of foundation below bed level , Size of foundation and the Net safe bearing pressure are as given below:

Chainage	BH	Depth of Foundation below Bed level (m)	Size of foundation (m)	Net Safe bearing pressure (t/m^2)
21+810	BH 7	1.0	10.0 X 20.0	10.0
			12.0 X20.0	11.0
29+280	BH11	1.0	10.0 X 20.0	9.0
			12.0 X20.0	10.0

For Soil Engineering Consultants

(A.V.S. RANGA RAO)
Consultant

Annexure I

(Calculation)

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	0+000	Location	FLYOVER	Based on Bore Hole No	**BH 1**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	10.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **8.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di}.\tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	4	0.00	0	25	25	1.79	0.92	0	0	10	10.9	0.79	0	0	5.000	0	0	12.6	0	0	0	0	0	4.39	0	4.39	4
2	SM-ML / SM	4	0.00	0	25	25	1.74	0.88	0	0	10	10.9	0.79	0	0	4.780	0	0	12.6	0	0	0	0	0	8.78	0	8.78	8
3	SM-ML / SM	4.5	0.00	0	29	29	1.74	0.89	4	0	18.1	19.3	0.79	0	72.31	8.600	63.51	2	14.1	23.49	0	0	23.49	87	13.72	34.8	20.29	12.5
4	Cl	3	0.00	8	0	0	1.74	0.90	6.7	9	0	0	0.79	72	0	0.000	56.52	5.35	9.42	0	0.3	22.6	46.09	102.61	17.01	41.04	29.91	15.5
5	SM-ML / SM	2	0.00	0	29	29	1.74	0.89	8.48	0	18.1	19.3	0.79	0	153.29	8.600	127.08	7.59	6.28	39.63	0	0	85.72	212.8	19.2	85.12	43.2	17.5
6	SM-ML / SM	2	0.00	0	29	29	1.74	0.89	10.26	0	18.1	19.3	0.79	0	185.47	8.600	152.34	9.37	6.28	48.92	0	0	134.6	286.98	21.39	114.79	59.08	19.5
7	SM-ML / SM	3	0.00	0	29	29	1.74	0.89	12.93	0	18.1	19.3	0.79	0	233.74	8.600	190.23	11.59	9.42	90.77	0	0	225.4	415.64	24.68	166.25	87.79	22.5
8	SM-ML / SM	2	0.00	0	29	29	1.74	0.89	14.71	0	18.1	19.3	0.79	0	265.92	8.600	215.49	13.82	6.28	72.16	0	0	297.6	513.06	26.87	205.22	110.18	24.5
9	SM-ML / SM	2	0.00	0	30	30	1.74	0.89	16.49	0	20.9	22.4	0.79	0	345.44	9.960	278.98	15.6	6.28	84.84	0	0	382.4	661.39	29.06	264.55	136.13	26.5
10	SM-ML / SM	1	0.00	0	30	30	1.74	0.89	17.38	0	20.9	22.4	0.79	0	364.09	9.960	293	16.93	3.14	46.03	0	0	428.4	721.44	30.15	288.57	150.11	27.5
11	SM-ML / SM	1.5	0.00	0	30	30	1.74	0.89	17.38	0	20.9	22.4	0.79	0	364.09	9.960	293	17.38	4.71	70.89	0	0	499.3	792.33	31.79	316.93	171.6	29

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	29.0
d) Vertical Pile Capacity (tonnes)	300.0
e) Uplift pile capacity (Tonnes)	160.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	0+000	Location	FLYOVER	Based on Bore Hole No	**BH 1**	Pile Cut -off level (m)	2.3		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	10.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **7.700**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di} \tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	3.7	0.00	0	25	25	1.79	0.92	0	0	10	10.9	1.13	0	0	6.000	0	0	13.9	0	0	0	0	0	5.85	0	5.85	3.7
2	SM-ML / SM	4	0.00	0	25	25	1.74	0.88	0	0	10	10.9	1.13	0	0	5.740	0	0	15.1	0	0	0	0	0	12.17	0	12.17	7.7
3	SM-ML / SM	4.5	0.00	0	29	29	1.74	0.89	4	0	18.1	19.3	1.13	0	72.31	10.320	93.37	2	17	28.18	0	0	28.18	121.55	19.28	48.62	27.17	12.2
4	Cl	3	0.00	8	0	0	1.74	0.90	6.7	9	0	0	1.13	72	0	0.000	81.36	5.35	11.3	0	0.3	27.12	55.3	136.66	24.02	54.66	39.5	15.2
5	SM-ML / SM	2	0.00	0	29	29	1.74	0.89	8.48	0	18.1	19.3	1.13	0	153.29	10.320	184.87	7.59	7.53	47.52	0	0	102.8	287.69	27.18	115.07	55.96	17.2
6	SM-ML / SM	2	0.00	0	29	29	1.74	0.89	10.26	0	18.1	19.3	1.13	0	185.47	10.320	221.24	9.37	7.53	58.66	0	0	161.5	382.72	30.34	153.08	75.55	19.2
7	SM-ML / SM	2.8	0.00	0	29	29	1.74	0.89	12.75	0	18.1	19.3	1.13	0	230.49	10.320	272.11	11.5	10.6	100.87	0	0	262.4	534.46	34.76	213.78	108.21	22
8	SM-ML / SM	2	0.00	0	29	29	1.74	0.89	14.53	0	18.1	19.3	1.13	0	262.67	10.320	308.47	13.64	7.53	85.39	0	0	347.7	656.21	37.92	262.48	135.28	24
9	SM-ML / SM	2	0.00	0	30	30	1.74	0.89	16.31	0	20.9	22.4	1.13	0	341.67	11.960	399.6	15.42	7.53	100.55	0	0	448.3	847.89	41.08	339.15	166.6	26
10	SM-ML / SM	1	0.00	0	30	30	1.74	0.89	17.2	0	20.9	22.4	1.13	0	360.32	11.960	420	16.75	3.76	54.54	0	0	502.8	922.83	42.66	369.13	183.45	27
11	SM-ML / SM	2	0.00	0	30	30	1.74	0.89	18.98	0	20.9	22.4	1.13	0	397.6	11.960	462	18.09	7.53	117.96	0	0	620.8	1082.79	45.82	433.11	219.64	29

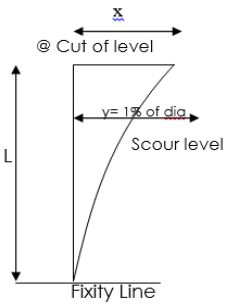
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	29.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	210.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	Flyover @ 0+800	
Borehole no :	BH 1	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	29.0	29.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	15.00	15.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) :	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.12E+03	2.12E+03
Stiffness factor for Cohesionless soil (T) in m :	3.67	4.25
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	8.000	7.700
therefore L_1/T or L_1/R :	2.18	1.81
Embedded Length of the Pile (L_e) in "m" :	21.00	21.30
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.92	1.94
Depth of Fixidity **L_F** in "m":	7.06	8.26
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	15.06	15.96
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" :	22.1	22.8
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	11.25	20.25
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	10.00	18.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	1+530	Location	MJB	Based on Bore Hole No	**BH 2**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	248.021
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	6.42	Liqefaction depth below Ground level (m	8.00	RL of the Borehole (m)	256.432

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **6.420**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	6.42	0.00	0	29	29	1.83	0.93	0	0	18.1	19.3	0.79	0	0	8.000	0	0	20.2	0	0	0	0	0	7.05	0	7.05	6.42
2	SM-ML / SM	4	0.00	0	30	30	1.86	0.95	3.8	0	20.9	22.4	0.79	0	79.6	10.640	70.83	1.9	12.6	20.66	0	0	20.66	91.49	11.44	36.59	17.22	10.42
3	SM-ML / SM	1.58	0.00	0	30	30	1.86	0.95	5.3	0	20.9	22.4	0.79	0	111.02	10.640	95.5	4.55	4.96	19.54	0	0	40.2	135.7	13.17	54.28	24.42	12
4	CL-CI	3	0.00	11	0	0	1.89	0.97	8.21	9	0	0	0.79	99	0	0.000	77.71	6.75	9.42	0	0.3	31.08	71.28	148.99	16.46	59.59	36.41	15
5	CL-CI	3.5	0.00	11	0	0	1.89	0.97	11.6	9	0	0	0.79	99	0	0.000	77.71	9.9	11	0	0.3	36.26	107.5	185.25	20.3	74.1	50.41	18.5
6	SM	1.5	0.00	0	30	30	1.89	0.97	13.05	0	20.9	22.4	0.79	0	273.38	10.860	223.12	12.32	4.71	50.25	0	0	157.8	380.91	21.94	152.36	66.12	20
7	SM	2.8	0.00	0	30	30	1.89	0.97	15.76	0	20.9	22.4	0.79	0	330.15	10.860	267.69	14.4	8.79	109.61	0	0	267.4	535.09	25.01	214.03	99.88	22.8
8	SM	2	0.00	0	30	30	1.89	0.97	17.7	0	20.9	22.4	0.79	0	370.79	10.860	299.59	16.73	6.28	90.98	0	0	358.4	657.97	27.2	263.18	127.54	24.8
9	SM	1.62	0.00	0	30	30	1.89	0.97	19.27	0	20.9	22.4	0.79	0	403.68	10.860	325.41	18.48	5.08	81.3	0	0	439.7	765.09	28.98	306.03	152.09	26.42
10	SM	0.58	0.00	0	30	30	1.89	0.97	19.27	0	20.9	22.4	0.79	0	403.68	10.860	325	19.27	1.82	30.37	0	0	470.1	795.05	29.61	318.02	161.22	27

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	27.0
d) Vertical Pile Capacity (tonnes)	300.0
e) Uplift pile capacity (Tonnes)	150.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	1+530	Location	MJB	Based on Bore Hole No	**BH 2**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	248.021
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	6.12	Liqefaction depth below Ground level (m	8.00	RL of the Borehole (m)	256.432

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **6.120**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	6.12	0.00	0	29	29	1.83	0.93	0	0	18.1	19.3	1.13	0	0	10.000	0	0	23.1	0	0	0	0	0	9.68	0	9.68	6.12
2	SM-ML / SM	4	0.00	0	30	30	1.86	0.95	3.8	0	20.9	22.4	1.13	0	79.6	12.760	104.36	1.9	15.1	24.79	0	0	24.79	129.15	16	51.66	22.94	10.12
3	SM-ML / SM	1.58	0.00	0	30	30	1.86	0.95	5.3	0	20.9	22.4	1.13	0	111.02	12.760	139.87	4.55	5.95	23.44	0	0	48.23	188.1	18.49	75.24	31.99	11.7
4	CL-CI	3	0.00	11	0	0	1.89	0.97	8.21	9	0	0	1.13	99	0	0.000	111.87	6.75	11.3	0	0.3	37.29	85.52	197.39	23.23	78.95	47.17	14.7
5	CL-CI	3.5	0.00	11	0	0	1.89	0.97	11.6	9	0	0	1.13	99	0	0.000	111.87	9.9	13.2	0	0.3	43.49	129	240.88	28.76	96.35	64.88	18.2
6	SM	1.5	0.00	0	30	30	1.89	0.97	13.05	0	20.9	22.4	1.13	0	273.38	13.030	323.64	12.32	5.65	60.28	0	0	189.3	512.93	31.13	205.17	84.13	19.7
7	SM	2.8	0.00	0	30	30	1.89	0.97	15.76	0	20.9	22.4	1.13	0	330.15	13.030	387.79	14.4	10.6	131.56	0	0	320.9	708.64	35.55	283.45	125.38	22.5
8	SM	2	0.00	0	30	30	1.89	0.97	17.7	0	20.9	22.4	1.13	0	370.79	13.030	433.71	16.73	7.53	109.09	0	0	429.9	863.65	38.71	345.46	159.09	24.5
9	SM	2.5	0.00	0	30	30	1.89	0.97	20.12	0	20.9	22.4	1.13	0	421.49	13.030	491	18.91	9.42	154.26	0	0	584.2	1075.2	42.66	430.08	206.23	27

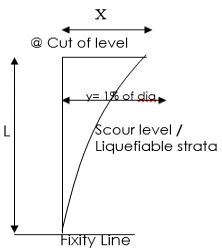
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	27.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	200.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MJB @ 1+530	
Borehole no :	BH 2	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	27.0	27.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	18.00	18.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) :	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.55E+03	2.55E+03
Stiffness factor for Cohesionless soil (T) in m :	3.54	4.09
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	6.420	6.120
therefore L_1/T or L_1/R :	1.81	1.50
Embedded Length of the Pile (L_e) in "m" :	20.58	20.88
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.94	1.96
Depth of Fixidity **L_F** in "m":	6.88	8.02
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	13.30	14.14
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" :	19.0	20.0
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	14.07	25.54
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	10.00	20.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	6+380	Location	VUP	Based on Bore Hole No	BH 3	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	13.80	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_U=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, α	a.c.A_{si}	P_{su}					
1	SM-ML	4	0.00	0	29	29	1.82	0.98	3.92	0	18.1	19.3	0.79	0	70.86	9.000	62.69	1.96	12.6	20.46	0	0	0	62.69	4.39	25.07	4.39	4
2	SM	4	0.00	0	30	30	1.85	1.03	8.04	0	20.9	22.4	0.79	0	168.42	11.530	141.26	5.98	12.6	65.04	0	0	65.04	206.3	8.78	82.52	26.99	8
3	SM	4	0.00	0	30	30	1.85	1.03	12.16	0	20.9	22.4	0.79	0	254.73	11.530	209.01	10.1	12.6	109.86	0	0	174.9	383.91	13.17	153.56	62.14	12
4	SM	3	0.00	0	30	30	1.87	1.03	15.25	0	20.9	22.4	0.79	0	319.47	11.530	259.83	13.7	9.42	111.76	0	0	286.7	546.49	16.46	218.59	96.72	15
5	SM	2	0.00	0	30	30	1.87	1.03	17.31	0	20.9	22.4	0.79	0	362.62	11.530	293.7	16.28	6.28	88.54	0	0	375.2	668.9	18.65	267.56	123.7	17
6	SM	1	0.00	0	30	30	1.87	1.03	18.34	0	20.9	22.4	0.79	0	384.2	11.530	310.64	17.82	3.14	48.45	0	0	423.7	734.29	19.74	293.71	138.36	18
7	SM	1	0.00	0	30	30	1.87	1.03	19.37	0	20.9	22.4	0.79	0	405.77	11.530	327.58	18.85	3.14	51.25	0	0	474.9	802.48	20.83	320.99	153.8	19

Recommendation :

a) Pile Diameter (mm)	1000	
b) Pile cut off level (m)	**2.0**	
c) Pile Shaft Length from Cut off Level (m)	18.0	19.0
d) Vertical Pile Capacity (tonnes)	280.0	300.0
e) Uplift pile capacity (Tonnes)	120.0	140.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	6+380	Location	VUP	Based on Bore Hole No	BH 3	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	13.80	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_U=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, α	a.c.A_{si}	P_{su}					
1	SM-ML	3.7	0.00	0	29	29	1.82	0.98	3.62	0	18.1	19.3	1.13	0	65.44	11.000	86.37	1.81	13.9	20.97	0	0	0	86.37	5.85	34.54	5.85	3.7
2	SM	4	0.00	0	30	30	1.85	1.03	7.74	0	20.9	22.4	1.13	0	162.14	13.840	198.85	5.68	15.1	74.12	0	0	74.12	272.97	12.17	109.18	32.92	7.7
3	SM	4	0.00	0	30	30	1.85	1.03	11.86	0	20.9	22.4	1.13	0	248.45	13.840	296.38	9.8	15.1	127.89	0	0	202	498.39	18.49	199.35	75.05	11.7
4	SM	3	0.00	0	30	30	1.87	1.03	14.95	0	20.9	22.4	1.13	0	313.18	13.840	369.53	13.4	11.3	131.13	0	0	333.1	702.67	23.23	281.06	116.5	14.7
5	SM	2.3	0.00	0	30	30	1.87	1.03	17.31	0	20.9	22.4	1.13	0	362.62	13.840	425.39	16.13	8.66	120.97	0	0	454.1	879.5	26.86	351.8	154.01	17
6	SM	1	0.00	0	30	30	1.87	1.03	18.34	0	20.9	22.4	1.13	0	384.2	13.840	449.78	17.82	3.76	58.02	0	0	512.1	961.91	28.44	384.76	171.83	18
7	SM	1	0.00	0	30	30	1.87	1.03	19.37	0	20.9	22.4	1.13	0	405.77	13.840	474.15	18.85	3.76	61.38	0	0	573.5	1047.66	30.02	419.06	190.6	19

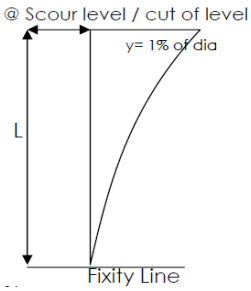
Recommendation :

a) Pile Diameter (mm)	1200	
b) Pile cut off level (m)	**2.3**	
c) Pile Shaft Length from Cut off Level (m)	18.0	19.0
d) Vertical Pile Capacity (tonnes)	370.0	400.0
e) Uplift pile capacity (Tonnes)	160.0	170.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	VUP @ 6+380	
Borehole no :	BH 3	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" **:**	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	18.0	18.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	14.00	14.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	1.97E+03	1.97E+03
Stiffness factor for Cohesionless soil (T) in m :	3.73	4.31
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m"**:**	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	18.00	18.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	8.17	9.44
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	8.17	9.44
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	31.96	51.55
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	20.00	40.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	8+020	Location	FLYOVER	Based on Bore Hole No	**BH 5**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	14.10	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = Ap^*(cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di} \tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	4	0.00	0	29	29	1.8	1.00	4	0	18.1	19.3	0.79	0	72.31	9.000	63.82	2	12.6	20.88	0	0	0	63.82	4.39	25.52	4.39	4
2	SM-ML / SM	4	0.00	0	30	30	1.8	1.01	8.04	0	20.9	22.4	0.79	0	168.42	11.310	141.08	6.02	12.6	65.48	0	0	65.48	206.56	8.78	82.62	27.11	8
3	Cl	2	0.00	14	0	0	1.83	1.05	10.14	9	0	0	0.79	126	0	0.000	98.91	9.09	6.28	0	0.3	26.37	91.85	190.76	10.97	76.3	36.68	10
4	SM-ML / SM	3	0.00	0	30	30	1.9	1.00	13.14	0	20.9	22.4	0.79	0	275.26	11.200	224.87	11.64	9.42	94.95	0	0	186.8	411.67	14.26	164.66	66.56	13
5	SM-ML / SM	2	0.00	0	30	30	1.9	1.00	15.14	0	20.9	22.4	0.79	0	317.16	11.200	257.76	14.14	6.28	76.9	0	0	263.7	521.46	16.45	208.58	90.28	15
6	SM-ML / SM	2	0.00	0	30	30	1.9	1.00	17.14	0	20.9	22.4	0.79	0	359.06	11.200	290.65	16.14	6.28	87.77	0	0	351.5	642.12	18.64	256.84	117.05	17
7	SM-ML / SM	1	0.00	0	30	30	1.9	1.00	18.14	0	20.9	22.4	0.79	0	380.01	11.200	307.09	17.64	3.14	47.96	0	0	399.4	706.52	19.73	282.6	131.57	18
8	SM-ML / SM	2	0.00	0	30	30	1.9	1.00	20.14	0	20.9	22.4	0.79	0	421.91	11.200	339.99	19.14	6.28	104.09	0	0	503.5	843.51	21.92	337.4	162.9	20

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	20.0
d) Vertical Pile Capacity (tonnes)	330.0
e) Uplift pile capacity (Tonnes)	150.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	8+020	Location	FLYOVER	Based on Bore Hole No	**BH 5**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	14.10	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = Ap^*(cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	$c.N_C$	PdN_q	$0.5\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	$(K_s P_{di} \tan\delta).A_{si}$	Adhesion Factor, α	a.c.A_{si}	P_{su}					
1	SM-ML / SM	3.7	0.00	0	29	29	1.8	1.00	3.7	0	18.1	19.3	1.13	0	66.88	11.000	88	1.85	13.9	21.44	0	0	0	88	5.85	35.2	5.85	3.7
2	SM-ML / SM	4	0.00	0	30	30	1.8	1.01	7.74	0	20.9	22.4	1.13	0	162.14	13.570	198.55	5.72	15.1	74.65	0	0	74.65	273.2	12.17	109.28	33.07	7.7
3	Cl	2	0.00	14	0	0	1.83	1.05	9.84	9	0	0	1.13	126	0	0.000	142.38	8.79	7.53	0	0.3	31.62	106.3	248.65	15.33	99.46	45.08	9.7
4	SM-ML / SM	3	0.00	0	30	30	1.9	1.00	12.84	0	20.9	22.4	1.13	0	268.98	13.440	319.13	11.34	11.3	110.97	0	0	217.2	536.37	20.07	214.54	80.89	12.7
5	SM-ML / SM	2	0.00	0	30	30	1.9	1.00	14.84	0	20.9	22.4	1.13	0	310.88	13.440	366.48	13.84	7.53	90.25	0	0	307.5	673.97	23.23	269.58	109.32	14.7
6	SM-ML / SM	2	0.00	0	30	30	1.9	1.00	16.84	0	20.9	22.4	1.13	0	352.77	13.440	413.81	15.84	7.53	103.29	0	0	410.8	824.59	26.39	329.83	141.4	16.7
7	SM-ML / SM	1.3	0.00	0	30	30	1.9	1.00	18.14	0	20.9	22.4	1.13	0	380.01	13.440	444.59	17.49	4.89	74.06	0	0	484.8	929.43	28.44	371.77	164.19	18
8	SM-ML / SM	2	0.00	0	30	30	1.9	1.00	20.14	0	20.9	22.4	1.13	0	421.91	13.440	491.94	19.14	7.53	124.81	0	0	609.7	1101.59	31.6	440.63	202.3	20

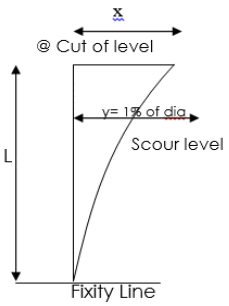
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	20.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	180.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	Flyover @ 8+020	
Borehole no :	BH 5	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	20.0	20.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	12.00	12.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	1.68E+03	1.68E+03
Stiffness factor for Cohesionless soil (T) in m :	3.85	4.45
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	20.00	20.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	8.43	9.75
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	8.43	9.75
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" **:**	10.0	12.0
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	29.06	46.84
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	25.00	40.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	16+690	Location	VUP	Based on Bore Hole No	BH 6	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	13.80	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s $P_{di}\tan\delta$).A_{si}	Adhesion Factor, α	a.c.A_{si}	P_{su}					
1	CI	2	0.00	6	0	0	1.84	1.03	2.06	9	0	0	0.79	54	0	0.000	42.39	1.03	6.28	0	0.3	11.3	0	42.39	2.19	16.95	2.19	2
2	SM-ML	2	0.00	0	30	30	1.86	0.99	4.04	0	20.9	22.4	0.79	0	84.63	11.080	75.13	3.05	6.28	16.58	0	0	16.58	91.71	4.38	36.68	9.02	4
3	SM	4	0.00	0	30	30	1.8	0.99	8	0	20.9	22.4	0.79	0	167.59	11.080	140.25	6.02	12.6	65.48	0	0	82.06	222.31	8.77	88.92	31.74	8
4	CI	2	0.00	13	0	0	1.87	0.99	9.98	9	0	0	0.79	117	0	0.000	91.84	8.99	6.28	0	0.3	24.49	106.6	198.39	10.96	79.35	40.79	10
5	CI	2	0.00	13	0	0	1.87	0.99	11.96	9	0	0	0.79	117	0	0.000	91.84	10.97	6.28	0	0.3	24.49	131	222.88	13.15	89.15	49.84	12
6	SM	2	0.00	0	30	30	1.87	0.99	13.94	0	20.9	22.4	0.79	0	292.02	11.080	237.93	12.95	6.28	70.43	0	0	201.5	439.4	15.34	175.76	71.75	14
7	SM	2	0.00	0	30	30	1.87	0.99	15.92	0	20.9	22.4	0.79	0	333.5	11.080	270.49	14.93	6.28	81.19	0	0	282.7	553.15	17.53	221.26	96.67	16
8	SM	2	0.00	0	30	30	1.87	0.99	17.9	0	20.9	22.4	0.79	0	374.98	11.080	303.05	16.91	6.28	91.96	0	0	374.6	677.67	19.72	271.06	124.61	18
9	SM	2	0.00	0	30	30	1.87	0.99	19.88	0	20.9	22.4	0.79	0	416.46	11.080	335.61	18.89	6.28	102.73	0	0	477.4	812.96	21.91	325.18	155.56	20

Recommendation :

a) Pile Diameter (mm)	1000	
b) Pile cut off level (m)	**2.0**	
c) Pile Shaft Length from Cut off Level (m)	18.0	20.0
d) Vertical Pile Capacity (tonnes)	250.0	300.0
e) Uplift pile capacity (Tonnes)	110.0	140.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**			Structure @ Chainage	16+690	Location	VUP	Based on Bore Hole No	**BH 6**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	13.80	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, α	a.c.A_{si}	P_{su}					
1	CI	1.7	0.00	6	0	0	1.84	1.03	1.75	9	0	0	1.13	54	0	0.000	61.02	0.87	6.4	0	0.3	11.52	0	61.02	2.68	24.4	2.68	1.7
2	SM-ML	2	0.00	0	30	30	1.86	0.99	3.73	0	20.9	22.4	1.13	0	78.13	13.300	103.31	2.74	7.53	17.86	0	0	17.86	121.17	5.84	48.46	10.84	3.7
3	SM	4	0.00	0	30	30	1.8	0.99	7.69	0	20.9	22.4	1.13	0	161.09	13.300	197.06	5.71	15.1	74.52	0	0	92.38	289.44	12.16	115.77	38.02	7.7
4	CI	2	0.00	13	0	0	1.87	0.99	9.67	9	0	0	1.13	117	0	0.000	132.21	8.68	7.53	0	0.3	29.36	121.7	253.95	15.32	101.58	49.4	9.7
5	CI	2	0.00	13	0	0	1.87	0.99	11.65	9	0	0	1.13	117	0	0.000	132.21	10.66	7.53	0	0.3	29.36	151.1	283.31	18.48	113.32	60.78	11.7
6	SM	2.3	0.00	0	30	30	1.87	0.99	13.92	0	20.9	22.4	1.13	0	291.6	13.300	344.53	12.78	8.66	95.84	0	0	246.9	591.47	22.11	236.58	91.25	14
7	SM	2	0.00	0	30	30	1.87	0.99	15.9	0	20.9	22.4	1.13	0	333.08	13.300	391.4	14.91	7.53	97.23	0	0	344.2	735.57	25.27	294.22	121.63	16
8	SM	2	0.00	0	30	30	1.87	0.99	17.88	0	20.9	22.4	1.13	0	374.56	13.300	438.28	16.89	7.53	110.14	0	0	454.3	892.59	28.43	357.03	155.63	18
9	SM	2	0.00	0	30	30	1.87	0.99	19.86	0	20.9	22.4	1.13	0	416.04	13.300	485.15	18.87	7.53	123.05	0	0	577.4	1062.51	31.59	425	193.25	20

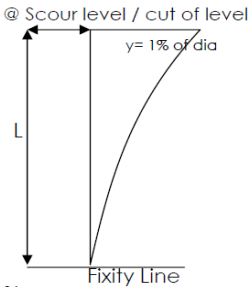
Recommendation :

a) Pile Diameter (mm)	1200	
b) Pile cut off level (m)	**2.3**	
c) Pile Shaft Length from Cut off Level (m)	18.0	20.0
d) Vertical Pile Capacity (tonnes)	340.0	400.0
e) Uplift pile capacity (Tonnes)	140.0	180.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	VUP @ 16+690	
Borehole no :	BH 6	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" **:**	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	18.0	18.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	15.00	15.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.12E+03	2.12E+03
Stiffness factor for Cohesionless soil (T) in m :	3.67	4.25
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m"**:**	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	18.00	18.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	8.04	9.31
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	8.04	9.31
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	33.56	53.77
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	20.00	40.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Project no: 2152	BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS as per IS: 6403-1981		
Structure @ Chainage :		MNB @ 21+810	MNB @ 21+810
Borehole no:		BH 7	BH 7
Type of Foundation :		**Raft**	**Raft**
Depth of Foundation below Bed level (D_F) :		**1.000**	**1.000**
Width of the foundation (B) in "m":		**10.000**	**12.000**
Length of the foundation (L) in "m" :		**20.000**	**20.000**
Angle of Internal Friction ,Φ :		29	29
Cohension , C (T/m^2) :		0	0
Density of soil (Υ) T/m^3 :		1.87	1.87
Effective unit weight (Υ') T/m^3 :		0.87	0.87
Depth of water table (W.T) m from G.L :		11.3	11.3
Design water table depth (W.T ')m :		0	0
Angle of Inclination factor :		0	0
Depth factors (assumed that backilling is not compacted properly		1.00	1.00
Surcharge at sub-base foundation level q= $\Upsilon * D_f$		0.3	0.3
Shape factors :	S_C	1.1	1.12
	S_q	1.1	1.12
	S_Υ	0.8	0.76
Inclination factors :	i_c	1.00	1.00
	i_q	1.00	1.00
	i_Υ	1.00	1.00
Depth factors :	dc =1+0.2(Df/B)√(NΦ)	1.00	1.00
	dq= 1+0.1*(Df/B)√(NΦ) for >10°	1.00	1.00
	dΥ = 1+0.1*(Df/B)√(NΦ) for >10°	1.00	1.00
Shear failure criteria			
Bearing capacity factor's for General Shear :	Φ	29	29
	N_c = (Nq-1)/tanø	27.83	27.83
	N_q = Nγ/(2*tanø)-1	16.43	16.43
	N_Υ = 2[{(exp[π*tanø)*] tan2(45+ø/2)+1}tanø]	19.33	19.33
Bearing capacity factor's for Local Shear :	Φ'	20	20
	N'c	15.15	15.15
	N'q	6.63	6.63
	N'Υ	5.67	5.67
Correction factor for W.T (W')		0.50	0.50
Factor of safety		2.50	2.50
General shear Net safe bearing pressure (T/m2) : C*NC*Sc*ic*dc+q(Nq-1)*sq*iq*dq+0.50*B*Υ*NΥ*sΥ*iΥ*dΥ*W'		26.78	30.28
Local shear safe bearing pressure (T/m2) : C*NC*Sc*ic*dc+q(Nq-1)*sq*iq*dq+0.50*B*Υ*NΥ*sΥ*iΥ*dΥ*W'		8.00	9.03
On interpolation Safe Bearing pressure (T/m2)		10.35	11.69

* Considering bed protection work

Settlement criteria as per IS 8009(Part I),fig 12 :

Structure @ Chainage :	**MNB @ 21+810**	**MNB @ 21+810**
Borehole no:	**BH 7**	**BH 7**
Depth of Foundation below Bed level (DF) :	**1.00**	**1.00**
Width of the foundation (B) in "m":	**10.00**	**12.00**
Corrected SPT (N) value =	**16**	**16**
settlement under footing with a load of 10 T/m2 in dry cohensioness soil :	21	21
Settlement under footing with a load intensity of 10 T/m2 after water table correction :	42	42
Settlement under footing with load intensity of 10 T/m2 after Depth correction and rigidity correction	34	34
Net safe bearing pressure for 75 mm of settlements :	22	22

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	22+980	Location	VUP	Based on Bore Hole No	BH 8	Pile Cut -off level (m)	2.0		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	14.20	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	CI	3	0.00	10	0	0	1.9	1.07	3.21	9	0	0	0.79	90	0	0.000	70.65	1.6	9.42	0	0.3	28.26	0	70.65	3.29	28.26	3.29	3
2	SM	2	0.00	0	31	31	1.9	1.05	5.31	0	23.9	26	0.79	0	127.04	13.640	110.43	4.26	6.28	24.11	0	0	24.11	134.54	5.48	53.81	12.23	5
3	SM	4	0.00	0	31	31	1.8	1.04	9.47	0	23.9	26	0.79	0	226.57	13.510	188.46	7.39	12.6	83.65	0	0	107.8	296.22	9.87	118.48	40.04	9
4	SM	2	0.00	0	31	31	1.87	1.04	11.55	0	23.9	26	0.79	0	276.33	13.510	227.52	10.51	6.28	59.48	0	0	167.2	394.76	12.06	157.9	58.88	11
5	SM	2	0.00	0	31	31	1.87	1.04	13.63	0	23.9	26	0.79	0	326.1	13.510	266.59	12.59	6.28	71.26	0	0	238.5	505.09	14.25	202.03	81.03	13
6	SM	2	0.00	0	31	31	1.87	1.04	15.71	0	23.9	26	0.79	0	375.86	13.510	305.65	14.67	6.28	83.03	0	0	321.5	627.18	16.44	250.87	106.46	15
7	SM	1	0.00	0	31	31	1.87	1.04	16.75	0	23.9	26	0.79	0	400.75	13.510	325.19	16.23	3.14	45.93	0	0	367.5	692.65	17.53	277.06	120.41	16
8	SM	2	0.00	0	31	31	1.87	1.04	18.83	0	23.9	26	0.79	0	450.51	13.510	364.25	17.79	6.28	100.69	0	0	468.2	832.4	19.72	332.96	150.8	18

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	18.0
d) Vertical Pile Capacity (tonnes)	300.0
e) Uplift pile capacity (Tonnes)	140.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	22+980	Location	VUP	Based on Bore Hole No	**BH 8**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	14.20	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^*(cN_c+P_{di}N_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di}\tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	CI	2.7	0.00	10	0	0	1.9	1.07	2.88	9	0	0	1.13	90	0	0.000	101.7	1.44	10.2	0	0.3	30.51	0	101.7	4.27	40.68	4.27	2.7
2	SM	2	0.00	0	31	31	1.9	1.05	4.98	0	23.9	26	1.13	0	119.14	16.370	153.12	3.93	7.53	26.67	0	0	26.67	179.79	7.43	71.91	14.89	4.7
3	SM	4	0.00	0	31	31	1.8	1.04	9.14	0	23.9	26	1.13	0	218.67	16.220	265.42	7.06	15.1	95.89	0	0	122.6	387.98	13.75	155.19	48.06	8.7
4	SM	2	0.00	0	31	31	1.87	1.04	11.22	0	23.9	26	1.13	0	268.44	16.220	321.66	10.18	7.53	69.08	0	0	191.6	513.3	16.91	205.32	70.56	10.7
5	SM	2.3	0.00	0	31	31	1.87	1.04	13.61	0	23.9	26	1.13	0	325.62	16.220	386.27	12.41	8.66	96.86	0	0	288.5	674.77	20.54	269.9	101.32	13
6	SM	2	0.00	0	31	31	1.87	1.04	15.69	0	23.9	26	1.13	0	375.38	16.220	442.5	14.65	7.53	99.42	0	0	387.9	830.42	23.7	332.16	132.31	15
7	SM	1	0.00	0	31	31	1.87	1.04	16.73	0	23.9	26	1.13	0	400.27	16.220	470.63	16.21	3.76	54.93	0	0	442.9	913.48	25.28	365.39	149.27	16
8	SM	2	0.00	0	31	31	1.87	1.04	18.81	0	23.9	26	1.13	0	450.03	16.220	526.86	17.77	7.53	120.6	0	0	563.5	1090.31	28.44	436.12	186.2	18

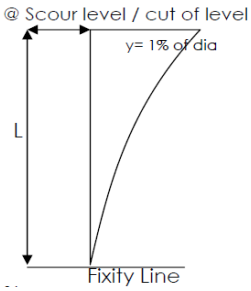
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	18.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	170.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	VUP @ 22+980	
Borehole no :	BH 8	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" **:**	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	18.0	18.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	20.00	20.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.84E+03	2.84E+03
Stiffness factor for Cohesionless soil (T) in m :	3.46	4.01
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m"**:**	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	18.00	18.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	7.58	8.78
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	7.58	8.78
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	40.04	64.01
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	35.00	50.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	25+430	Location	VUP	Based on Bore Hole No	**BH 9**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	12.25	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^*(cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	CI	3	0.00	5	0	0	1.82	1.01	3.03	9	0	0	0.79	45	0	0.000	35.32	1.51	9.42	0	0.3	14.13	0	35.32	3.29	14.12	3.29	3
2	SM-ML	2	0.00	0	30	30	1.84	0.99	5.01	0	20.9	22.4	0.79	0	104.95	11.080	73.8	4.02	6.28	21.86	0	0	21.86	95.66	5.48	38.26	11.6	5
3	SM-ML	3	0.00	0	30	30	1.84	0.99	7.98	0	20.9	22.4	0.79	0	167.17	11.080	73.58	6.49	9.42	52.94	0	0	74.8	148.38	8.77	59.35	29.71	8
4	SM-ML	2	0.00	0	30	30	1.82	0.95	9.88	0	20.9	22.4	0.79	0	206.97	10.640	57	8.93	6.28	48.56	0	0	123.4	180.36	10.96	72.14	45.5	10
5	CL	2.5	0.00	8	0	0	1.82	0.97	12.3	9	0	0	0.79	72	0	0.000	56.52	11.09	7.85	0	0.3	18.84	142.2	198.72	13.7	79.48	53.51	12.5
6	SM	2.5	0.00	0	30	30	1.82	0.95	14.67	0	20.9	22.4	0.79	0	307.32	10.640	249.59	13.48	7.85	91.64	0	0	233.8	483.43	16.44	193.37	81.91	15
7	SM	3	0.00	0	30	30	1.82	0.95	17.52	0	20.9	22.4	0.79	0	367.02	10.640	296.46	16.09	9.42	131.26	0	0	365.1	661.56	19.73	264.62	121.95	18
8	SM	1	0.00	0	30	30	1.82	0.95	18.47	0	20.9	22.4	0.79	0	386.92	10.640	312.08	17.99	3.14	48.92	0	0	414	726.1	20.82	290.44	136.74	19

Recommendation :

a) Pile Diameter (mm)	1000	
b) Pile cut off level (m)	**2.0**	
c) Pile Shaft Length from Cut off Level (m)	18.0	19.0
d) Vertical Pile Capacity (tonnes)	250.0	270.0
e) Uplift pile capacity (Tonnes)	110.0	120.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	25+430	Location	VUP	Based on Bore Hole No	**BH 9**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	12.25	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	CI	2.7	0.00	5	0	0	1.82	1.01	2.72	9	0	0	1.13	45	0	0.000	50.85	1.36	10.2	0	0.3	15.25	0	50.85	4.27	20.34	4.27	2.7
2	SM-ML	2	0.00	0	30	30	1.84	0.99	4.7	0	20.9	22.4	1.13	0	98.45	13.300	100.07	3.71	7.53	24.19	0	0	24.19	124.26	7.43	49.7	14.2	4.7
3	SM-ML	3	0.00	0	30	30	1.84	0.99	7.67	0	20.9	22.4	1.13	0	160.67	13.300	100.56	6.18	11.3	60.47	0	0	84.66	185.22	12.17	74.08	35.87	7.7
4	SM-ML	2	0.00	0	30	30	1.82	0.95	9.57	0	20.9	22.4	1.13	0	200.48	12.760	81.36	8.62	7.53	56.21	0	0	140.9	222.23	15.33	88.89	54.77	9.7
5	CL	2.5	0.00	8	0	0	1.82	0.97	11.99	9	0	0	1.13	72	0	0.000	81.36	10.78	9.42	0	0.3	22.6	163.5	244.83	19.28	97.93	65.05	12.2
6	SM	2.8	0.00	0	30	30	1.82	0.95	14.65	0	20.9	22.4	1.13	0	306.9	12.760	361.21	13.32	10.6	121.69	0	0	285.2	646.37	23.7	258.54	103.54	15
7	SM	3	0.00	0	30	30	1.82	0.95	17.5	0	20.9	22.4	1.13	0	366.6	12.760	428.67	16.07	11.3	157.26	0	0	442.4	871.09	28.44	348.43	152.31	18
8	SM	1	0.00	0	30	30	1.82	0.95	18.45	0	20.9	22.4	1.13	0	386.5	12.760	451.16	17.97	3.76	58.51	0	0	500.9	952.09	30.02	380.83	170.28	19

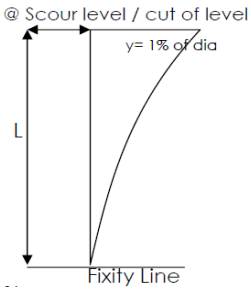
Recommendation :

a) Pile Diameter (mm)	1200	
b) Pile cut off level (m)	**2.3**	
c) Pile Shaft Length from Cut off Level (m)	18.0	19.0
d) Vertical Pile Capacity (tonnes)	330.0	360.0
e) Uplift pile capacity (Tonnes)	140.0	160.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	VUP @ 25+430	
Borehole no :	BH 9	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" **:**	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	18.0	18.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	14.00	14.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	1.97E+03	1.97E+03
Stiffness factor for Cohesionless soil (T) in m :	3.73	4.31
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m"**:**	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	18.00	18.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	8.17	9.44
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	8.17	9.44
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	31.96	51.55
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	25.00	40.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Project no: 2152	BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS as per IS: 6403-1981	

Structure @ Chainage :		MNB @ 29+260	MNB @ 29+260
Borehole no:		BH 11	BH 11
Type of Foundation :		**Raft**	**Raft**
Depth of Foundation below Grond level (D_F) :		**1.000**	**1.000**
Width of the foundation (B) in "m":		**10.000**	**12.000**
Length of the foundation (L) in "m" :		**20.000**	**20.000**
Angle of Internal Friction ,Φ :		28	28
Cohension , C (T/m^2) :		0	0
Density of soil (ϒ) T/m^3 :		1.8	1.8
Effective unit weight (ϒ') T/m^3 :		0.8	0.8
Depth of water table (W.T) m from G.L :		5.5	5.5
Design water table depth (W.T ')m :		0	0
Angle of Inclination factor :		0	0
Depth factors (assumed that backilling is not compacted properly		1.00	1.00
Surcharge at sub-base foundation level q= $ϒ*D_f$		1.5	1.5
Shape factors :	S_C	1.1	1.12
	S_q	1.1	1.12
	$S_ϒ$	0.8	0.76
Inclination factors :	i_c	1.00	1.00
	i_q	1.00	1.00
	$i_ϒ$	1.00	1.00
Depth factors :	dc =1+0.2(Df/B)√(NΦ)	1.00	1.00
	dq= 1+0.1*(Df/B)√(NΦ) for >10°	1.00	1.00
	dϒ = 1+0.1*(Df/B)√(NΦ) for >10°	1.00	1.00
Shear failure criteria			
Bearing capacity factor's for General Shear :	Φ	28	28
	N_c = (Nq-1)/tanø	25.78	25.78
	N_q = Nγ/(2∗tanø)-1	14.71	14.71
	$N_ϒ$ = 2[{(exp[π tanø)∗] tan2(45+ø/2)+1}tanø]	16.71	16.71
Bearing capacity factor's for Local Shear :	Φ'	20	20
	N'c	14.42	14.42
	N'q	6.14	6.14
	N'ϒ	5.09	5.09
Correction factor for W.T (W')		0.50	0.50
Factor of safety		2.50	2.50
safe bearing pressure (T/m2) : C*NC*Sc*ic*dc+q(Nq-1)*sq*iq*dq+0.50*B*ϒ*Nϒ*sϒ*iϒ*dϒ*W'		9.91	10.88

* Considering Bed protection work

Settlement criteria as per IS 8009(Part I),fig 12 :

Structure @ Chainage :	**MNB @ 29+260**	**MNB @ 29+260**
Borehole no:	**BH 11**	**BH 11**
Depth of Foundation below Grond level (DF) :	**1.00**	**1.00**
Width of the foundation (B) in "m":	**10.00**	**12.00**
Corrected SPT (N) value =	**11**	**11**
settlement under footing with a load of 10 T/m2 in dry cohensioness soil :	33	33
Settlement under footing with a load intensity of 10 T/m2 after water table correction :	66	66
Settlement under footing with load intensity of 10 T/m2 after Depth correction and rigidity correction	53	53
Net safe bearing pressure for 75 mm of settlements :	14	14

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	32+170	Location	FLYOVER	Based on Bore Hole No	**BH 12**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	13.20	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = Ap^* (cN_c+P_{di}N_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}				
1	SM-ML / SM	1.7	0.00	0	29	29	1.82	1.01	1.71	0	18.1	19.3	0.79	0	30.91	9.000	31.32	0.85	5.33	3.76	0	0	0	31.32	1.86	12.52	1.86	1.7
2	CI	3	0.00	8	0	0	1.85	1.01	4.74	9	0	0	0.79	72	0	0.000	56.52	3.22	9.42	0	0	0	0	56.52	5.15	22.6	5.15	4.7
3	CI	2	0.00	14	0	0	1.88	1.02	6.78	9	0	0	0.79	126	0	0.000	98.91	5.76	6.28	0	0.3	26.37	26.37	125.28	7.34	50.11	14.72	6.7
4	CI	2	0.00	14	0	0	1.88	1.02	8.82	9	0	0	0.79	126	0	0.000	98.91	7.8	6.28	0	0.3	26.37	52.74	151.65	9.53	60.66	24.29	8.7
5	SM-ML / SM	2	0.00	0	30	30	1.88	0.96	10.74	0	20.9	22.4	0.79	0	224.99	10.750	185.05	9.78	6.28	53.18	0	0	105.9	290.97	11.72	116.38	41.37	10.7
6	SM-ML / SM	2	0.00	0	30	30	1.88	0.95	12.64	0	20.9	22.4	0.79	0	264.79	10.640	216.21	11.69	6.28	63.57	0	0	169.5	385.7	13.91	154.28	61.36	12.7
7	CH	2	0.00	14	0	0	1.88	0.97	14.58	9	0	0	0.79	126	0	0.000	98.91	13.61	6.28	0	0.3	26.37	195.9	294.77	16.1	117.9	70.94	14.7
8	CH	2	0.00	14	0	0	1.88	0.97	16.52	9	0	0	0.79	126	0	0.000	98.91	15.55	6.28	0	0.3	26.37	222.2	321.14	18.29	128.45	80.51	16.7
9	CH	2.3	0.00	11	0	0	1.88	0.97	18.75	9	0	0	0.79	99	0	0.000	77.71	17.63	7.22	0	0.3	23.82	246.1	323.76	20.81	129.5	89.7	19
10	CH	1	0.00	11	0	0	1.88	0.97	19.72	9	0	0	0.79	99	0	0.000	77	19.23	3.14	0	0.3	10.36	256.4	333.41	21.9	133.36	93.69	20
11	CH	2	0.00	11	0	0	1.88	0.97	19.72	9	0	0	0.79	99	0	0.000	77	19.72	6.28	0	0.3	20.72	277.1	354.13	24.09	141.65	101.68	22
12	CH	2	0.00	11	0	0	1.88	0.97	19.72	9	0	0	0.79	99	0	0.000	77	19.72	6.28	0	0.3	20.72	297.9	374.85	26.28	149.94	109.67	24
13	CH	2	0.00	15	0	0	1.88	0.97	19.72	9	0	0	0.79	135	0	0.000	105	19.72	6.28	0	0.3	28.26	326.1	431.11	28.47	172.44	119.78	26
14	CH	2	0.00	15	0	0	1.88	0.97	19.72	9	0	0	0.79	135	0	0.000	105	19.72	6.28	0	0.3	28.26	354.4	459.37	30.66	183.74	129.88	28

Recommendation :

a) Pile Diameter (mm)	1000		
b) Pile cut off level (m)	**2.0**		
c) Pile Shaft Length from Cut off Level (m)	24.0	26.0	28.0
d) Vertical Pile Capacity (tonnes)	140.0	160.0	170.0
e) Uplift pile capacity (Tonnes)	100.0	110.0	120.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	32+170	Location	FLYOVER	Based on Bore Hole No	**BH 12**	Pile Cut -off level (m)	2.3		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	13.20	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = Ap^* (cN_c+P_{di}N_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_c	N_q	N_γ	A_p (m²)	c.N_c	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	1.7	0.00	0	29	29	1.82	1.01	1.71	0	18.1	19.3	1.13	0	30.91	11.000	47.35	0.85	6.4	4.52	0	0	0	47.35	2.68	18.94	2.68	1.7
2	CI	3	0.00	8	0	0	1.85	1.01	4.74	9	0	0	1.13	72	0	0.000	81.36	3.22	11.3	0	0	0	0	81.36	7.42	32.54	7.42	4.7
3	CI	2	0.00	14	0	0	1.88	1.02	6.78	9	0	0	1.13	126	0	0.000	142.38	5.76	7.53	0	0.3	31.62	31.62	174	10.58	69.6	19.43	6.7
4	CI	2	0.00	14	0	0	1.88	1.02	8.82	9	0	0	1.13	126	0	0.000	142.38	7.8	7.53	0	0.3	31.62	63.24	205.62	13.74	82.24	31.44	8.7
5	SM-ML / SM	2	0.00	0	30	30	1.88	0.96	10.74	0	20.9	22.4	1.13	0	224.99	12.900	268.81	9.78	7.53	63.77	0	0	127	395.82	16.9	158.32	52.46	10.7
6	SM-ML / SM	2	0.00	0	30	30	1.88	0.95	12.64	0	20.9	22.4	1.13	0	264.79	12.760	313.63	11.69	7.53	76.23	0	0	203.2	516.87	20.06	206.74	76.96	12.7
7	CH	2	0.00	14	0	0	1.88	0.97	14.58	9	0	0	1.13	126	0	0.000	142.38	13.61	7.53	0	0.3	31.62	234.9	377.24	23.22	150.89	88.98	14.7
8	CH	2	0.00	14	0	0	1.88	0.97	16.52	9	0	0	1.13	126	0	0.000	142.38	15.55	7.53	0	0.3	31.62	266.5	408.86	26.38	163.54	100.99	16.7
9	CH	2.3	0.00	11	0	0	1.88	0.97	18.75	9	0	0	1.13	99	0	0.000	111.87	17.63	8.66	0	0.3	28.57	295.1	406.92	30.01	162.76	112.62	19
10	CH	1	0.00	11	0	0	1.88	0.97	19.72	9	0	0	1.13	99	0	0.000	111	19.23	3.76	0	0.3	12.4	307.5	418.45	31.59	167.38	117.67	20
11	CH	2	0.00	11	0	0	1.88	0.97	21.66	9	0	0	1.13	99	0	0.000	111	20.69	7.53	0	0.3	24.84	332.3	443.29	34.75	177.31	127.79	22
12	CH	2	0.00	11	0	0	1.88	0.97	23.6	9	0	0	1.13	99	0	0.000	111	22.63	7.53	0	0.3	24.84	357.1	468.13	37.91	187.25	137.9	24
13	CH	2	0.00	15	0	0	1.88	0.97	23.6	9	0	0	1.13	135	0	0.000	152	23.6	7.53	0	0.3	33.88	391	543.01	41.07	217.2	150.55	26
14	CH	2	0.00	15	0	0	1.88	0.97	23.6	9	0	0	1.13	135	0	0.000	152	23.6	7.53	0	0.3	33.88	424.9	576.89	44.23	230.75	163.19	28

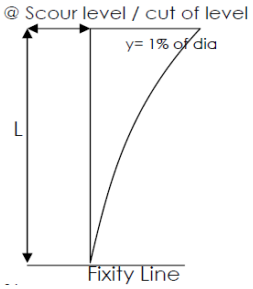
Recommendation :

a) Pile Diameter (mm)	1200		
b) Pile cut off level (m)	**2.3**		
c) Pile Shaft Length from Cut off Level (m)	24.0	26.0	28.0
d) Vertical Pile Capacity (tonnes)	180.0	200.0	220.0
e) Uplift pile capacity (Tonnes)	130.0	140.0	150.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	Flyover @ 32+170	
Borehole no :	BH 12	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" **:**	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	24.0	24.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	21.00	21.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.98E+03	2.98E+03
Stiffness factor for Cohesionless soil (T) in m :	3.43	3.97
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m"**:**	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	24.00	24.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	7.51	8.69
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	7.51	8.69
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	41.10	65.97
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	30.00	50.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	33+420	Location	MJB	Based on Bore Hole No	**BH 13**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	252.798
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	4.06	Liqefaction depth below Ground level (m	15.00	RL of the Borehole (m)	258.852

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **13.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	$c.N_C$	PdN_q	$0.5\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	1	0.00	0	26	26	1.73	0.87	0	0	11.6	12.5	0.79	0	0	5.000	0	0	3.14	0	0	0	0	0	1.09	0	1.09	1
2	CI-CH	5	0.00	1	0	0	1.74	0.90	0	9	0	0	0.79	9	0	0.000	0	0	15.7	0	0.4	6.28	6.28	0	6.58	0	8.33	6
3	SM-ML / SM	3	0.00	0	26	26	1.74	0.89	0	0	11.6	12.5	0.79	0	0	5.570	0	0	9.42	0	0	0	0	0	9.87	0	9.87	9
4	SM-ML / SM	4	0.00	0	26	26	1.74	0.90	0	0	11.6	12.5	0.79	0	0	5.640	0	0	12.6	0	0	0	0	0	14.26	0	14.26	13
5	CL-CH	3.5	0.00	18	0	0	1.74	0.91	3.18	9	0	0	0.79	162	0	0.000	127.17	1.59	11	0	0.3	59.34	59.34	186.51	18.1	74.6	34.71	16.5
6	CL-CH	1.5	0.00	18	0	0	1.74	0.91	4.54	9	0	0	0.79	162	0	0.000	127.17	3.86	4.71	0	0.3	25.43	84.77	211.94	19.74	84.77	43.47	18
7	CL-CH	2	0.00	18	0	0	1.74	0.91	6.36	9	0	0	0.79	162	0	0.000	127.17	5.45	6.28	0	0.3	33.91	118.7	245.85	21.93	98.34	55.16	20
8	SM	2	0.00	0	30	30	1.74	0.90	8.16	0	20.9	22.4	0.79	0	170.94	10.080	142.1	7.26	6.28	39.48	0	0	158.2	300.26	24.12	120.1	68.4	22
9	SM	2.5	0.00	0	30	30	1.74	0.90	10.41	0	20.9	22.4	0.79	0	218.07	10.080	179.09	9.28	7.85	63.08	0	0	221.2	400.33	26.86	160.13	88.8	24.5
10	SM	2	0.00	0	30	30	1.74	0.90	12.21	0	20.9	22.4	0.79	0	255.78	10.080	208	11.31	6.28	61.51	0	0	282.8	490.75	29.05	196.3	108.22	26.5
11	SM	2	0.00	0	30	30	1.74	0.90	14.01	0	20.9	22.4	0.79	0	293.49	10.080	238	13.11	6.28	71.3	0	0	354.1	592.05	31.24	236.82	130.37	28.5
12	SM	2.5	0.00	0	30	30	1.74	0.90	16.26	0	20.9	22.4	0.79	0	340.62	10.080	275	15.13	7.85	102.85	0	0	456.9	731.9	33.98	292.76	161.91	31

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	31.0
d) Vertical Pile Capacity (tonnes)	280.0
e) Uplift pile capacity (Tonnes)	150.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	33+420	Location	MJB	Based on Bore Hole No	**BH 13**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	252.798
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	3.76	Liqefaction depth below Ground level (m	15.00	RL of the Borehole (m)	258.852

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **12.700**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = \sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	$c.N_C$	PdN_q	$0.5\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s $P_{di}\tan\delta$).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}				
1	SM-ML / SM	0.7	0.00	0	26	26	1.73	0.87	0	0	11.6	12.5	1.13	0	0	6.000	0	0	2.63	0	0	0	0	0	1.1	0	1.1	0.7
2	CI-CH	5	0.00	1	0	0	1.74	0.90	0	9	0	0	1.13	9	0	0.000	0	0	18.8	0	0.4	7.53	7.53	0	9.01	0	11.11	5.7
3	SM-ML / SM	3	0.00	0	26	26	1.74	0.89	0	0	11.6	12.5	1.13	0	0	6.690	0	0	11.3	0	0	0	0	0	13.75	0	13.75	8.7
4	SM-ML / SM	4	0.00	0	26	26	1.74	0.90	0	0	11.6	12.5	1.13	0	0	6.770	0	0	15.1	0	0	0	0	0	20.07	0	20.07	12.7
5	CL-CH	3.5	0.00	18	0	0	1.74	0.91	3.18	9	0	0	1.13	162	0	0.000	183.06	1.59	13.2	0	0.3	71.17	71.17	254.23	25.6	101.69	45.52	16.2
6	CL-CH	1.5	0.00	18	0	0	1.74	0.91	4.54	9	0	0	1.13	162	0	0.000	183.06	3.86	5.65	0	0.3	30.51	101.7	284.74	27.97	113.89	56.44	17.7
7	CL-CH	2	0.00	18	0	0	1.74	0.91	6.36	9	0	0	1.13	162	0	0.000	183.06	5.45	7.53	0	0.3	40.66	142.3	325.4	31.13	130.16	70.98	19.7
8	SM	2	0.00	0	30	30	1.74	0.90	8.16	0	20.9	22.4	1.13	0	170.94	12.090	206.82	7.26	7.53	47.34	0	0	189.7	396.5	34.29	158.6	87.4	21.7
9	SM	2.5	0.00	0	30	30	1.74	0.90	10.41	0	20.9	22.4	1.13	0	218.07	12.090	260.08	9.28	9.42	75.7	0	0	265.4	525.46	38.24	210.18	112.54	24.2
10	SM	2	0.00	0	30	30	1.74	0.90	12.21	0	20.9	22.4	1.13	0	255.78	12.090	302	11.31	7.53	73.75	0	0	339.1	641.13	41.4	256.45	136.35	26.2
11	SM	2	0.00	0	30	30	1.74	0.90	14.01	0	20.9	22.4	1.13	0	293.49	12.090	345	13.11	7.53	85.49	0	0	424.6	769.62	44.56	307.84	163.45	28.2
12	SM	1.8	0.00	0	30	30	1.74	0.90	15.63	0	20.9	22.4	1.13	0	327.43	12.090	383	14.82	6.78	87.01	0	0	511.6	894.63	47.4	357.85	190.65	30
13	SM	1	0.00	0	30	30	1.74	0.90	16.53	0	20.9	22.4	1.13	0	346.28	12.090	404	16.08	3.76	52.36	0	0	564	967.99	48.98	387.19	206.89	31

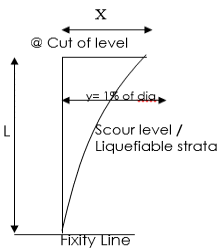
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	31.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	200.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MJB @ 33+420	
Borehole no :	BH 13	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	31.0	31.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	18.00	18.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) :	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.55E+03	2.55E+03
Stiffness factor for Cohesionless soil (T) in m :	3.54	4.09
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	13.000	12.700
therefore L_1/T or L_1/R :	3.67	3.11
Embedded Length of the Pile (L_e) in "m" :	18.00	18.30
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.86	1.88
Depth of Fixidity **L_F** in "m":	6.60	7.71
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	19.60	20.41
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" :	37.9	37.5
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	8.77	15.94
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	5.00	10.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	33+490	Location	MJB	Based on Bore Hole No	**BH 14**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	247.233
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	9.51	Liqefaction depth below Ground level (m	9.00	RL of the Borehole (m)	258.740

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **9.510**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	2	0.00	0	27	27	1.75	0.92	0	0	13.5	14.5	0.79	0	0	6.000	0	0	6.28	0	0	0	0	0	2.19	0	2.19	2
2	CH	4	0.00	7	0	0	1.84	0.96	0	9	0	0	0.79	63	0	0.000	0	0	12.6	0	0.4	35.16	35.16	0	6.58	0	16.42	6
3	CH	2	0.00	8	0	0	1.86	0.97	0	9	0	0	0.79	72	0	0.000	0	0	6.28	0	0.4	20.09	0	0	8.77	0	8.77	8
4	SM	1.51	0.00	0	29	29	1.86	0.95	0	0	18.1	19.3	0.79	0	0	9.180	0	0	4.74	0	0	0	0	0	10.42	0	10.42	9.51
5	SM	3	0.00	0	29	29	1.86	0.95	2.85	0	18.1	19.3	0.79	0	51.52	9.180	47.64	1.42	9.42	11.12	0	0	11.12	58.76	13.71	23.5	16.82	12.51
6	SM	3	0.00	0	30	30	1.86	0.95	5.7	0	20.9	22.4	0.79	0	119.4	10.640	102.08	4.27	9.42	34.83	0	0	45.95	148.03	17	59.21	29.86	15.51
7	Cl	3.49	0.00	14	0	0	1.86	0.97	9.08	9	0	0	0.79	126	0	0.000	98.91	7.39	11	0	0.3	45.99	91.94	190.85	20.83	76.34	46.57	19
8	Cl	3	0.00	14	30	0	1.86	0.97	11.99	9	20.9	22.4	0.79	126	251.17	10.860	304.6	10.53	9.42	0	0.3	39.56	131.5	436.1	24.12	174.44	60.94	22
9	SM	2.5	0.00	0	30	30	1.86	0.95	14.36	0	20.9	22.4	0.79	0	300.82	10.640	244.49	13.17	7.85	89.53	0	0	221	465.52	26.86	186.2	88.74	24.5
10	SM	2	0.00	0	30	30	1.86	0.95	16.26	0	20.9	22.4	0.79	0	340.62	10.640	275	15.31	6.28	83.26	0	0	304.3	579.29	29.05	231.71	114.25	26.5
11	SM	3.01	0.00	0	30	30	1.86	0.95	19.11	0	20.9	22.4	0.79	0	400.33	10.640	322	17.68	9.45	144.69	0	0	449	770.98	32.35	308.39	158.06	29.51
12	SM	0.49	0.00	0	30	30	1.86	0.95	19.11	0	20.9	22.4	0.79	0	400.33	10.640	322	19.11	1.53	25.32	0	0	474.3	796.3	32.88	318.52	165.68	30

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	30.0
d) Vertical Pile Capacity (tonnes)	300.0
e) Uplift pile capacity (Tonnes)	150.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	33+490	Location	MJB	Based on Bore Hole No	**BH 14**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	247.233
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	9.21	Liqefaction depth below Ground level (m	9.00	RL of the Borehole (m)	258.740

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **9.210**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	1.7	0.00	0	27	27	1.75	0.92	0	0	13.5	14.5	1.13	0	0	7.000	0	0	6.4	0	0	0	0	0	2.68	0	2.68	1.7
2	CH	4	0.00	7	0	0	1.84	0.96	0	9	0	0	1.13	63	0	0.000	0	0	15.1	0	0.4	42.19	42.19	0	9	0	20.81	5.7
3	CH	2	0.00	8	0	0	1.86	0.97	0	9	0	0	1.13	72	0	0.000	0	0	7.53	0	0.4	24.09	0	0	12.16	0	12.16	7.7
4	SM	1.51	0.00	0	29	29	1.86	0.95	0	0	18.1	19.3	1.13	0	0	11.020	0	0	5.68	0	0	0	0	0	14.54	0	14.54	9.21
5	SM	3	0.00	0	29	29	1.86	0.95	2.85	0	18.1	19.3	1.13	0	51.52	11.020	70.67	1.42	11.3	13.34	0	0	13.34	84.01	19.28	33.6	23.01	12.21
6	SM	3	0.00	0	30	30	1.86	0.95	5.7	0	20.9	22.4	1.13	0	119.4	12.760	149.34	4.27	11.3	41.78	0	0	55.12	204.46	24.02	81.78	39.45	15.21
7	CI	3.49	0.00	14	0	0	1.86	0.97	9.08	9	0	0	1.13	126	0	0.000	142.38	7.39	13.2	0	0.3	55.23	110.4	252.73	29.54	101.09	60.43	18.7
8	CI	3	0.00	14	30	0	1.86	0.97	11.99	9	20.9	22.4	1.13	126	251.17	13.030	440.92	10.53	11.3	0	0.3	47.46	157.8	598.73	34.28	239.49	78.46	21.7
9	SM	2.5	0.00	0	30	30	1.86	0.95	14.36	0	20.9	22.4	1.13	0	300.82	12.760	354.34	13.17	9.42	107.44	0	0	265.3	619.59	38.23	247.83	112.5	24.2
10	SM	2	0.00	0	30	30	1.86	0.95	16.26	0	20.9	22.4	1.13	0	340.62	12.760	399	15.31	7.53	99.83	0	0	365.1	764.08	41.39	305.63	143.61	26.2
11	SM	2	0.00	0	30	30	1.86	0.95	18.16	0	20.9	22.4	1.13	0	380.43	12.760	444	17.21	7.53	112.22	0	0	477.3	921.3	44.55	368.52	178.19	28.2
12	SM	1.8	0.00	0	30	30	1.86	0.95	19.87	0	20.9	22.4	1.13	0	416.25	12.760	484	19.01	6.78	111.62	0	0	588.9	1072.92	47.39	429.16	212.28	30

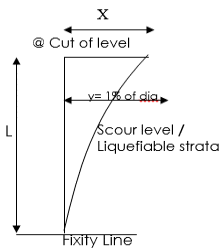
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	30.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	200.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MJB @ 33+490	
Borehole no :	BH 14	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	30.0	30.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	20.00	20.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) :	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.84E+03	2.84E+03
Stiffness factor for Cohesionless soil (T) in m :	3.46	4.01
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	9.510	9.210
therefore L_1/T or L_1/R :	2.75	2.30
Embedded Length of the Pile (L_e) in "m" :	20.49	20.79
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.90	1.92
Depth of Fixidity **L_F** in "m":	6.57	7.69
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	16.08	16.90
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" :	27.5	27.7
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	11.51	20.75
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	10.00	18.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	35+860	Location	MJB	Based on Bore Hole No	BH 15	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	255.860
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	2.56	Liqefaction depth below Ground level (m	9.00	RL of the Borehole (m)	260.414

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **7.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	4	0.00	0	29	29	1.83	0.97	0	0	18.1	19.3	0.79	0	0	9.000	0	0	12.6	0	0	0	0	0	4.39	0	4.39	4
2	SM	1	0.00	0	30	30	1.85	1.14	0	0	20.9	22.4	0.79	0	0	12.760	0	0	3.14	0	0	0	0	0	5.48	0	5.48	5
3	CI-CH	2	0.00	7	0	0	1.86	0.98	0	9	0	0	0.79	63	0	0.000	0	0	6.28	0	0.3	13.18	0	0	7.67	0	7.67	7
4	CI-CH	4	0.00	7	0	0	1.86	0.98	3.92	9	0	0	0.79	63	0	0.000	49.45	1.96	12.6	0	0.3	26.37	26.37	75.82	12.06	30.32	19.44	11
5	SM / SM-ML	2	0.00	0	29	29	1.86	0.96	5.84	0	18.1	19.3	0.79	0	105.57	9.280	64	4.88	6.28	25.48	0	0	51.85	115.85	14.25	46.34	28.76	13
6	CL-CI	3	0.00	9	0	0	1.86	0.98	8.78	9	0	0	0.79	81	0	0.000	63.58	7.31	9.42	0	0.3	25.43	77.28	140.86	17.54	56.34	39.17	16
7	CL-CI	2	0.00	9	0	0	1.86	0.98	10.74	9	0	0	0.79	81	0	0.000	63.58	9.76	6.28	0	0.3	16.95	94.23	157.81	19.73	63.12	46.11	18
8	CL-CI	2	0.00	9	0	0	1.86	0.98	12.7	9	0	0	0.79	81	0	0.000	63.58	11.72	6.28	0	0.3	16.95	111.2	174.76	21.92	69.9	53.05	20
9	SM	2	0.00	0	29	29	1.86	0.96	14.62	0	18.1	19.3	0.79	0	264.29	9.280	214.75	13.66	6.28	71.32	0	0	182.5	397.25	24.11	158.9	75.21	22
10	SM	2	0.00	0	29	29	1.86	0.96	16.54	0	18.1	19.3	0.79	0	299	9.280	241	15.58	6.28	81.35	0	0	263.9	504.85	26.3	201.94	100.17	24
11	SM	3	0.00	0	30	30	1.86	0.96	19.42	0	20.9	22.4	0.79	0	406.82	10.750	327	17.98	9.42	146.68	0	0	410.5	737.53	29.59	295.01	144.53	27
12	SM	1	0.00	0	30	30	1.86	0.96	19.42	0	20.9	22.4	0.79	0	406.82	10.750	327	19.42	3.14	52.8	0	0	463.3	790.33	30.68	316.13	160.41	28

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	28.0
d) Vertical Pile Capacity (tonnes)	300.0
e) Uplift pile capacity (Tonnes)	150.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	35+860	Location	MJB	Based on Bore Hole No	BH 15	Pile Cut -off level (m)	2.3		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	255.860
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	2.26	Liqefaction depth below Ground level (m	9.00	RL of the Borehole (m)	260.414

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **6.700**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p(cN_c+P_dN_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = \sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di}\tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	3.7	0.00	0	29	29	1.83	0.97	0	0	18.1	19.3	1.13	0	0	11.000	0	0	13.9	0	0	0	0	0	5.85	0	5.85	3.7
2	SM	1	0.00	0	30	30	1.85	1.14	0	0	20.9	22.4	1.13	0	0	15.320	0	0	3.76	0	0	0	0	0	7.43	0	7.43	4.7
3	CI-CH	2	0.00	7	0	0	1.86	0.98	0	9	0	0	1.13	63	0	0.000	0	0	7.53	0	0.3	15.81	0	0	10.59	0	10.59	6.7
4	CI-CH	4	0.00	7	0	0	1.86	0.98	3.92	9	0	0	1.13	63	0	0.000	71.19	1.96	15.1	0	0.3	31.64	31.64	102.83	16.91	41.13	25.76	10.7
5	SM / SM-ML	2	0.00	0	29	29	1.86	0.96	5.84	0	18.1	19.3	1.13	0	105.57	11.130	92	4.88	7.53	30.55	0	0	62.19	154.19	20.07	61.67	37.48	12.7
6	CL-CI	3	0.00	9	0	0	1.86	0.98	8.78	9	0	0	1.13	81	0	0.000	91.53	7.31	11.3	0	0.3	30.51	92.7	184.23	24.81	73.69	50.76	15.7
7	CL-CI	2	0.00	9	0	0	1.86	0.98	10.74	9	0	0	1.13	81	0	0.000	91.53	9.76	7.53	0	0.3	20.33	113	204.56	27.97	81.82	59.61	17.7
8	CL-CI	2	0.00	9	0	0	1.86	0.98	12.7	9	0	0	1.13	81	0	0.000	91.53	11.72	7.53	0	0.3	20.33	133.4	224.89	31.13	89.95	68.47	19.7
9	SM	2	0.00	0	29	29	1.86	0.96	14.62	0	18.1	19.3	1.13	0	264.29	11.130	311.22	13.66	7.53	85.52	0	0	218.9	530.1	34.29	212.04	95.57	21.7
10	SM	2	0.00	0	29	29	1.86	0.96	16.54	0	18.1	19.3	1.13	0	299	11.130	350	15.58	7.53	97.54	0	0	316.4	666.42	37.45	266.56	126.04	23.7
11	SM	2	0.00	0	30	30	1.86	0.96	18.46	0	20.9	22.4	1.13	0	386.71	12.900	451	17.5	7.53	114.12	0	0	430.5	881.54	40.61	352.61	161.16	25.7
12	SM	2.3	0.00	0	30	30	1.86	0.96	20.66	0	20.9	22.4	1.13	0	432.8	12.900	503	19.56	8.66	146.69	0	0	577.2	1080.23	44.24	432.09	205.86	28

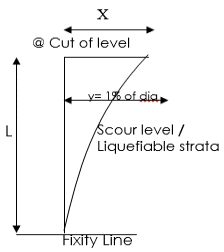
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	28.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	190.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MJB @ 35+860	
Borehole no :	BH 15	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	28.0	28.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	15.00	15.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) :	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.12E+03	2.12E+03
Stiffness factor for Cohesionless soil (T) in m :	3.67	4.25
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	7.000	6.700
therefore L_1/T or L_1/R :	1.91	1.58
Embedded Length of the Pile (L_e) in "m" :	21.00	21.30
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.94	1.96
Depth of Fixidity **L_F** in "m":	7.12	8.32
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	14.12	15.02
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" **:**	19.7	20.7
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	12.22	22.05
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	10.00	18.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**			Structure @ Chainage	38+010	Location	MNB	Based on Bore Hole No	**BH 16**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	262.707
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	9.00	RL of the Borehole (m)	263.430

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 20 m and below to be same.

Liquefaction depth below cut-off level(m) : **7.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p * (cN_c + P_d N_q + 0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si} + a.c.A_s)$						Total Ultimate Capacity, $P_u = P_{pu} + P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di} \tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	2	0.00	0	26	26	1.75	0.93	0	0	11.6	12.5	0.79	0	0	5.000	0	0	6.28	0	0	0	0	0	2.19	0	2.19	2
2	SM	2	0.00	0	28	28	1.77	0.93	0	0	15.6	16.7	0.79	0	0	7.770	0	0	6.28	0	0	0	0	0	4.38	0	4.38	4
3	CI-CH	3	0.00	2	0	0	1.8	0.93	0	9	0	0	0.79	18	0	0.000	0	0	9.42	0	0.3	5.65	0	0	7.67	0	7.67	7
4	CI-CH	4	0.00	7	0	0	1.86	0.93	3.72	9	0	0	0.79	63	0	0.000	49.45	1.86	12.6	0	0.3	26.37	26.37	75.82	12.06	30.32	19.44	11
5	CI-CH	2	0.00	7	0	0	1.86	0.93	5.58	9	0	0	0.79	63	0	0.000	49.45	4.65	6.28	0	0.3	13.18	39.55	89	14.25	35.6	25.32	13
6	CI-CH	3	0.00	9	0	0	1.86	0.93	8.37	9	0	0	0.79	81	0	0.000	63.58	6.97	9.42	0	0.3	25.43	64.98	128.56	17.54	51.42	35.73	16
7	CI-CH	2	0.00	9	0	0	1.86	0.93	10.23	9	0	0	0.79	81	0	0.000	63.58	9.3	6.28	0	0.3	16.95	81.93	145.51	19.73	58.2	42.67	18
8	CI-CH	2	0.00	9	0	0	1.86	0.93	12.09	9	0	0	0.79	81	0	0.000	63.58	11.16	6.28	0	0.3	16.95	98.88	162.46	21.92	64.98	49.6	20
9	CI-CH	2	0.00	9	0	0	1.86	0.93	13.95	9	0	0	0.79	81	0	0.000	63.58	13.02	6.28	0	0.3	16.95	115.8	179.41	24.11	71.76	56.54	22
10	CI-CH	2	0.00	9	0	0	1.86	0.93	15.81	9	0	0	0.79	81	0	0.000	63	14.88	6.28	0	0.3	16.95	132.8	195.78	26.3	78.31	63.47	24

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	24.0
d) Vertical Pile Capacity (tonnes)	70.0
e) Uplift pile capacity (Tonnes)	60.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	38+010	Location	MNB	Based on Bore Hole No	**BH 16**	Pile Cut -off level (m)	2.3		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	262.707
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	9.00	RL of the Borehole (m)	263.430

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 20 m and below to be same.

Liquefaction depth below cut-off level(m) : **6.700**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p * (cN_c + P_d N_q + 0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si} + a.c.A_s)$						Total Ultimate Capacity, $P_u = P_{pu} + P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di} \tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	1.7	0.00	0	26	26	1.75	0.93	0	0	11.6	12.5	1.13	0	0	6.000	0	0	6.4	0	0	0	0	0	2.68	0	2.68	1.7
2	SM	2	0.00	0	28	28	1.77	0.93	0	0	15.6	16.7	1.13	0	0	9.320	0	0	7.53	0	0	0	0	0	5.84	0	5.84	3.7
3	CI-CH	3	0.00	2	0	0	1.8	0.93	0	9	0	0	1.13	18	0	0.000	0	0	11.3	0	0.3	6.78	0	0	10.58	0	10.58	6.7
4	CI-CH	4	0.00	7	0	0	1.86	0.93	3.72	9	0	0	1.13	63	0	0.000	71.19	1.86	15.1	0	0.3	31.64	31.64	102.83	16.9	41.13	25.75	10.7
5	CI-CH	2	0.00	7	0	0	1.86	0.93	5.58	9	0	0	1.13	63	0	0.000	71.19	4.65	7.53	0	0.3	15.81	47.45	118.64	20.06	47.45	33.34	12.7
6	CI-CH	3	0.00	9	0	0	1.86	0.93	8.37	9	0	0	1.13	81	0	0.000	91.53	6.97	11.3	0	0.3	30.51	77.96	169.49	24.8	67.79	46.62	15.7
7	CI-CH	2	0.00	9	0	0	1.86	0.93	10.23	9	0	0	1.13	81	0	0.000	91.53	9.3	7.53	0	0.3	20.33	98.29	189.82	27.96	75.92	55.48	17.7
8	CI-CH	2.3	0.00	9	0	0	1.86	0.93	12.36	9	0	0	1.13	81	0	0.000	91.53	11.29	8.66	0	0.3	23.38	121.7	213.2	31.59	85.28	65.65	20
9	CI-CH	2	0.00	9	0	0	1.86	0.93	14.22	9	0	0	1.13	81	0	0.000	91.53	13.29	7.53	0	0.3	20.33	142	233.53	34.75	93.41	74.51	22
10	CI-CH	2	0.00	9	0	0	1.86	0.93	16.08	9	0	0	1.13	81	0	0.000	91	15.15	7.53	0	0.3	20.33	162.3	253.33	37.91	101.33	83.36	24

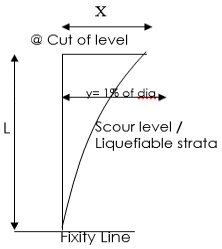
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	24.0
d) Vertical Pile Capacity (tonnes)	95.0
e) Uplift pile capacity (Tonnes)	80.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MNB @ 38+010	
Borehole no :	BH 16	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	24.0	24.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	16.00	16.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.26E+03	2.26E+03
Stiffness factor for Cohesionless soil (T) in m :	3.62	4.19
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	7.000	6.700
therefore L_1/T or L_1/R :	1.93	1.60
Embedded Length of the Pile (L_e) in "m" :	17.00	17.30
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.94	1.96
Depth of Fixidity **L_F** in "m":	7.02	8.19
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	14.02	14.89
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" **:**	20.0	20.9
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	12.62	22.83
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	10.00	18.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	39+510	Location	MJB	Based on Bore Hole No	**BH 17**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	12.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **10.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = Ap^* (cN_c+P_{di}N_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} =(\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_c	N_q	N_γ	A_p (m²)	c.N_c	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	2	0.00	0	28	28	1.75	0.93	0	0	15.6	16.7	0.79	0	0	7.000	0	0	6.28	0	0	0	0	0	2.19	0	2.19	2
2	SM-ML / SM	3	0.00	0	28	28	1.75	0.93	0	0	15.6	16.7	0.79	0	0	7.770	0	0	9.42	0	0	0	0	0	5.48	0	5.48	5
3	SM-ML / SM	3	0.00	0	28	28	1.76	0.89	0	0	15.6	16.7	0.79	0	0	7.430	0	0	9.42	0	0	0	0	0	8.77	0	8.77	8
4	SM-ML / SM	2	0.00	0	29	29	1.76	0.89	0	0	18.1	19.3	0.79	0	0	8.600	0	0	6.28	0	0	0	0	0	10.96	0	10.96	10
5	SM-ML / SM	2	0.00	0	29	29	1.76	0.90	1.8	0	18.1	19.3	0.79	0	32.54	8.700	32.37	0.9	6.28	4.69	0	0	4.69	37.06	13.15	14.82	14.46	12
6	SM-ML / SM	2	0.00	0	29	29	1.76	0.90	3.6	0	18.1	19.3	0.79	0	65.08	8.700	57.91	2.7	6.28	14.09	0	0	18.78	76.69	15.34	30.67	20.59	14
7	CH	2	0.00	8	0	0	1.8	0.91	5.42	9	0	0	0.79	72	0	0.000	56.52	4.51	6.28	0	0.3	15.07	33.85	90.37	17.53	36.14	27	16
8	CH	2	0.00	8	0	0	1.8	0.91	7.24	9	0	0	0.79	72	0	0.000	56.52	6.33	6.28	0	0.3	15.07	48.92	105.44	19.72	42.17	33.41	18
9	CH	2	0.00	12	0	0	1.8	0.91	9.06	9	0	0	0.79	108	0	0.000	84.78	8.15	6.28	0	0.3	22.6	71.52	156.3	21.91	62.52	41.93	20
10	CH	2	0.00	12	0	0	1.8	0.91	10.88	9	0	0	0.79	108	0	0.000	84	9.97	6.28	0	0.3	22.6	94.12	178.12	24.1	71.24	50.45	22
11	CH	2	0.00	12	0	0	1.86	0.91	12.7	9	0	0	0.79	108	0	0.000	84	11.79	6.28	0	0.3	22.6	116.7	200.72	26.29	80.28	58.97	24
12	CH	2	0.00	12	0	0	1.86	0.91	14.52	9	0	0	0.79	108	0	0.000	84	13.61	6.28	0	0.3	22.6	139.3	223.32	28.48	89.32	67.48	26
13	CH	2	0.00	17	0	0	1.86	0.91	16.34	9	0	0	0.79	153	0	0.000	120	15.43	6.28	0	0.3	32.02	171.3	291.34	30.67	116.53	78.64	28
14	CH	2	0.00	17	0	0	1.86	0.91	18.16	9	0	0	0.79	153	0	0.000	120	17.25	6.28	0	0.3	32.02	203.4	323.36	32.86	129.34	89.8	30

Recommendation :

a) Pile Diameter (mm)	1000	
b) Pile cut off level (m)	**2.0**	
c) Pile Shaft Length from Cut off Level (m)	28.0	30.0
d) Vertical Pile Capacity (tonnes)	110.0	120.0
e) Uplift pile capacity (Tonnes)	70.0	80.0

* **For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	39+510	Location	MJB	Based on Bore Hole No	**BH 17**	Pile Cut -off level (m)	2.3		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	12.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **9.700**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} =(\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_c	N_q	N_γ	A_p (m²)	c.N_c	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	1.7	0.00	0	28	28	1.75	0.93	0	0	15.6	16.7	1.13	0	0	9.000	0	0	6.4	0	0	0	0	0	2.68	0	2.68	1.7
2	SM-ML / SM	3	0.00	0	28	28	1.75	0.93	0	0	15.6	16.7	1.13	0	0	9.320	0	0	11.3	0	0	0	0	0	7.42	0	7.42	4.7
3	SM-ML / SM	3	0.00	0	28	28	1.76	0.89	0	0	15.6	16.7	1.13	0	0	8.920	0	0	11.3	0	0	0	0	0	12.16	0	12.16	7.7
4	SM-ML / SM	2	0.00	0	29	29	1.76	0.89	0	0	18.1	19.3	1.13	0	0	10.320	0	0	7.53	0	0	0	0	0	15.32	0	15.32	9.7
5	SM-ML / SM	2	0.00	0	29	29	1.76	0.90	1.8	0	18.1	19.3	1.13	0	32.54	10.440	48.56	0.9	7.53	5.63	0	0	5.63	54.19	18.48	21.67	20.05	11.7
6	SM-ML / SM	2	0.00	0	29	29	1.76	0.90	3.6	0	18.1	19.3	1.13	0	65.08	10.440	85.33	2.7	7.53	16.9	0	0	22.53	107.86	21.64	43.14	27.94	13.7
7	CH	2	0.00	8	0	0	1.8	0.91	5.42	9	0	0	1.13	72	0	0.000	81.36	4.51	7.53	0	0.3	18.07	40.6	121.96	24.8	48.78	36.16	15.7
8	CH	2.3	0.00	8	0	0	1.8	0.91	7.51	9	0	0	1.13	72	0	0.000	81.36	6.46	8.66	0	0.3	20.78	61.38	142.74	28.43	57.09	45.61	18
9	CH	2	0.00	12	0	0	1.8	0.91	9.33	9	0	0	1.13	108	0	0.000	122.04	8.42	7.53	0	0.3	27.1	88.48	210.52	31.59	84.2	56.36	20
10	CH	2	0.00	12	0	0	1.8	0.91	11.15	9	0	0	1.13	108	0	0.000	122	10.24	7.53	0	0.3	27.1	115.6	237.58	34.75	95.03	67.11	22
11	CH	2	0.00	12	0	0	1.86	0.91	12.97	9	0	0	1.13	108	0	0.000	122	12.06	7.53	0	0.3	27.1	142.7	264.68	37.91	105.87	77.86	24
12	CH	2	0.00	12	0	0	1.86	0.91	14.79	9	0	0	1.13	108	0	0.000	122	13.88	7.53	0	0.3	27.1	169.8	291.78	41.07	116.71	88.6	26
13	CH	2	0.00	17	0	0	1.86	0.91	16.61	9	0	0	1.13	153	0	0.000	172	15.7	7.53	0	0.3	38.4	208.2	380.18	44.23	152.07	102.52	28
14	CH	2	0.00	17	0	0	1.86	0.91	18.43	9	0	0	1.13	153	0	0.000	172	17.52	7.53	0	0.3	38.4	246.6	418.58	47.39	167.43	116.43	30

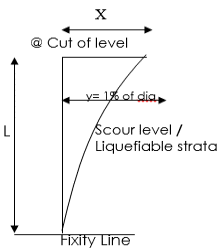
Recommendation :

a) Pile Diameter (mm)	1200	
b) Pile cut off level (m)	**2.3**	
c) Pile Shaft Length from Cut off Level (m)	28.0	30.0
d) Vertical Pile Capacity (tonnes)	150.0	160.0
e) Uplift pile capacity (Tonnes)	110.0	110.0

* **For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MJB @ 39+690	
Borehole no :	BH 18	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	29.0	29.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	16.00	16.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.26E+03	2.26E+03
Stiffness factor for Cohesionless soil (T) in m :	3.62	4.19
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	4.000	3.700
therefore L_1/T or L_1/R :	1.10	0.88
Embedded Length of the Pile (L_e) in "m" :	25.00	25.30
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.99	2.01
Depth of Fixidity **L_F** in "m":	7.20	8.43
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	11.20	12.13
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" **:**	14.1	15.4
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	17.48	31.19
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	15.00	30.00



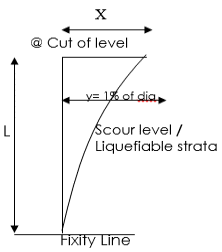
Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MJB @ 39+510	
Borehole no :	BH 17	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	28.0	28.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	16.00	16.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.26E+03	2.26E+03
Stiffness factor for Cohesionless soil (T) in m :	3.62	4.19
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m"**:**	10.000	9.700
therefore L_1/T or L_1/R :	2.76	2.32
Embedded Length of the Pile (L_e) in "m" :	18.00	18.30
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.90	1.92
Depth of Fixidity **L_F** in "m":	6.87	8.04
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	16.87	17.74
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" **:**	27.6	27.9
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	10.01	18.07
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	9.00	15.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	39+690	Location	MJB	Based on Bore Hole No	**BH 18**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	6.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **4.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} =(\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_c	N_q	N_γ	A_p (m²)	c.N_c	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	CI	3	0.00	2	0	0	1.79	0.93	0	9	0	0	0.79	18	0	0.000	0	0	9.42	0	0.45	8.47	0	0	3.29	0	3.29	3
2	SM-ML / SM	1	0.00	0	30	30	1.84	0.93	0	0	20.9	22.4	0.79	0	0	10.410	0	0	3.14	0	0	0	0	0	4.38	0	4.38	4
3	SM-ML / SM	3	0.00	0	30	30	1.86	0.89	2.67	0	20.9	22.4	0.79	0	55.93	9.960	51.72	1.33	9.42	10.85	0	0	10.85	62.57	7.67	25.02	10.7	7
4	SM-ML / SM	2	0.00	0	30	30	1.86	0.89	4.45	0	20.9	22.4	0.79	0	93.22	9.960	80.33	3.56	6.28	19.36	0	0	30.21	110.54	9.86	44.21	18.31	9
5	SM-ML / SM	2	0.00	0	30	30	1.86	0.90	6.25	0	20.9	22.4	0.79	0	130.93	10.080	97.49	5.35	6.28	29.09	0	0	59.3	156.79	12.05	62.71	28.65	11
6	SM-ML / SM	2	0.00	0	30	30	1.86	0.90	8.05	0	20.9	22.4	0.79	0	168.63	10.080	102.74	7.15	6.28	38.88	0	0	98.18	200.92	14.24	80.36	41.73	13
7	SM-ML / SM	2	0.00	0	30	30	1.86	0.91	9.87	0	20.9	22.4	0.79	0	206.76	10.190	96.22	8.96	6.28	48.73	0	0	146.9	243.13	16.43	97.25	57.56	15
8	SM-ML / SM	2	0.00	0	30	0	1.86	0.91	11.69	0	20.9	22.4	0.79	0	244.89	10.190	77.71	10.78	6.28	0	0	0	146.9	224.62	18.62	89.84	59.75	17
9	CI	2	0.00	11	0	0	1.86	0.91	13.51	9	0	0	0.79	99	0	0.000	77.71	12.6	6.28	0	0.3	20.72	167.6	245.34	20.81	98.13	67.74	19
10	CI	2.5	0.00	11	0	0	1.86	0.91	15.78	9	0	0	0.79	99	0	0.000	77	14.64	7.85	0	0.3	25.9	193.5	270.53	23.55	108.21	77.73	21.5
11	SM-ML	2.5	0.00	0	29	29	1.86	0.91	18.05	0	18.1	19.3	0.79	0	326.3	8.790	136.6	16.91	7.85	110.37	0	0	303.9	440.5	26.29	176.2	111.38	24
12	SM-ML	2	0.00	0	29	29	1.86	0.91	18.05	0	18.1	19.3	0.79	0	326.3	8.790	105	18.05	6.28	94.24	0	0	398.1	503.14	28.48	201.25	139.95	26
13	CI	2	0.00	15	0	0	1.86	0.91	18.05	9	0	0	0.79	135	0	0.000	105	18.05	6.28	0	0.3	28.26	426.4	531.4	30.67	212.56	150.06	28
14	CI	1	0.00	15	0	0	1.86	0.91	18.05	9	0	0	0.79	135	0	0.000	105	18.05	3.14	0	0.3	14.13	440.5	545.53	31.76	218.21	155.1	29

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	29.0
d) Vertical Pile Capacity (tonnes)	210.0
e) Uplift pile capacity (Tonnes)	150.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	39+690	Location	MJB	Based on Bore Hole No	**BH 18**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	6.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **3.700**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} =(\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_c	N_q	N_γ	A_p (m²)	c.N_c	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, α	a.c.A_{si}	P_{su}				
1	CI	2.7	0.00	2	0	0	1.79	0.93	0	9	0	0	1.13	18	0	0.000	0	0	10.2	0	0.45	9.15	0	0	4.27	0	4.27	2.7
2	SM-ML / SM	1	0.00	0	30	30	1.84	0.93	0	0	20.9	22.4	1.13	0	0	12.500	0	0	3.76	0	0	0	0	0	5.85	0	5.85	3.7
3	SM-ML / SM	3	0.00	0	30	30	1.86	0.89	2.67	0	20.9	22.4	1.13	0	55.93	11.960	76.71	1.33	11.3	13.01	0	0	13.01	89.72	10.59	35.88	14.23	6.7
4	SM-ML / SM	2	0.00	0	30	30	1.86	0.89	4.45	0	20.9	22.4	1.13	0	93.22	11.960	116.52	3.56	7.53	23.21	0	0	36.22	152.74	13.75	61.09	23.89	8.7
5	SM-ML / SM	2	0.00	0	30	30	1.86	0.90	6.25	0	20.9	22.4	1.13	0	130.93	12.090	136.74	5.35	7.53	34.88	0	0	71.1	207.84	16.91	83.13	36.81	10.7
6	SM-ML / SM	2	0.00	0	30	30	1.86	0.90	8.05	0	20.9	22.4	1.13	0	168.63	12.090	142.65	7.15	7.53	46.62	0	0	117.7	260.37	20.07	104.14	53.03	12.7
7	SM-ML / SM	2	0.00	0	30	30	1.86	0.91	9.87	0	20.9	22.4	1.13	0	206.76	12.230	134.46	8.96	7.53	58.42	0	0	176.1	310.6	23.23	124.24	72.54	14.7
8	SM-ML / SM	2	0.00	0	30	0	1.86	0.91	11.69	0	20.9	22.4	1.13	0	244.89	12.230	111.87	10.78	7.53	0	0	0	176.1	288.01	26.39	115.2	75.7	16.7
9	CI	2	0.00	11	0	0	1.86	0.91	13.51	9	0	0	1.13	99	0	0.000	111.87	12.6	7.53	0	0.3	24.84	201	312.85	29.55	125.14	85.82	18.7
10	CI	2.5	0.00	11	0	0	1.86	0.91	15.78	9	0	0	1.13	99	0	0.000	111	14.64	9.42	0	0.3	31.08	232.1	343.06	33.5	137.22	98.47	21.2
11	SM-ML	2	0.00	0	29	29	1.86	0.91	17.6	0	18.1	19.3	1.13	0	318.16	10.550	197.71	16.69	7.53	104.49	0	0	336.6	534.26	36.66	213.7	130.89	23.2
12	SM-ML	2.5	0.00	0	29	29	1.86	0.91	19.87	0	18.1	19.3	1.13	0	359.2	10.550	152	18.73	9.42	146.7	0	0	483.3	635.25	40.61	254.1	175.92	25.7
13	CI	2	0.00	15	0	0	1.86	0.91	21.69	9	0	0	1.13	135	0	0.000	152	20.78	7.53	0	0.3	33.88	517.1	669.13	43.77	267.65	188.56	27.7
14	CI	1.3	0.00	15	0	0	1.86	0.91	21.69	9	0	0	1.13	135	0	0.000	152	21.69	4.89	0	0.3	22	539.1	691.13	45.82	276.45	196.77	29

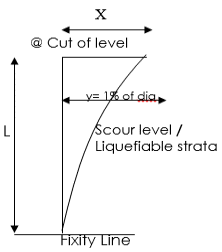
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	29.0
d) Vertical Pile Capacity (tonnes)	270.0
e) Uplift pile capacity (Tonnes)	190.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MJB @ 39+690	
Borehole no :	BH 18	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	29.0	29.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	16.00	16.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.26E+03	2.26E+03
Stiffness factor for Cohesionless soil (T) in m :	3.62	4.19
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	4.000	3.700
therefore L_1/T or L_1/R :	1.10	0.88
Embedded Length of the Pile (L_e) in "m" :	25.00	25.30
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.99	2.01
Depth of Fixidity **L_F** in "m":	7.20	8.43
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	11.20	12.13
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" **:**	14.1	15.4
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	17.48	31.19
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	15.00	30.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.		Structure @ Chainage	40+940	Location	VUP	Based on Bore Hole No	BH 19	Pile Cut -off level (m)	2.0	
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	11.80	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance P pu = Ap* (cN_c+$P_{di}N_q$+0.5.γ.D.N_γ)					Ultimate Shaft Friction P_{SU} =(∑(K_s P_{di}tanδ).A_{si}+a.c.A_s)						Total Ultimate Capacity, P_U=P_{pu}+ P_{su} (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	c.N_C	PdN_q	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	CI	3	0.00	4	0	0	1.78	1.02	3.06	9	0	0	0.79	36	0	0.000	28.26	1.53	9.42	0	0.3	11.3	0	28.26	3.29	11.3	3.29	3
2	CI	3	0.00	5	0	0	1.82	1.03	6.15	9	0	0	0.79	45	0	0.000	45.92	4.6	9.42	0	0.3	14.13	14.13	60.05	6.58	24.02	10.53	6
3	SM-ML/ SM	3	0.00	0	31	31	1.91	1.02	9.21	0	23.9	26	0.79	0	220.35	13.250	82.27	7.68	9.42	65.2	0	0	79.33	161.6	9.87	64.64	32.08	9
4	SM-ML/ SM	2	0.00	0	31	31	1.91	1.02	11.25	0	23.9	26	0.79	0	269.16	13.250	57	10.23	6.28	57.9	0	0	137.2	194.23	12.06	77.69	50.48	11
5	SM-ML/ SM	2.5	0.00	0	31	31	1.91	1.02	13.8	0	23.9	26	0.79	0	330.17	13.250	269.58	12.52	7.85	88.58	0	0	225.8	495.39	14.8	198.15	78.02	13.5
6	SM-ML/ SM	2	0.00	0	31	31	1.91	1.02	15.84	0	23.9	26	0.79	0	378.97	13.250	307.89	14.82	6.28	83.88	0	0	309.7	617.58	16.99	247.03	103.7	15.5
7	CH	2.5	0.00	13	0	0	1.91	1.05	18.46	9	0	0	0.79	117	0	0.000	91.84	17.15	7.85	0	0.3	30.61	340.3	432.14	19.73	172.85	115.01	18
8	CH	2	0.00	13	0	0	1.91	1.05	20.56	9	0	0	0.79	117	0	0.000	91.84	19.51	6.28	0	0.3	24.49	364.8	456.63	21.92	182.65	124.06	20
9	CH	1	0.00	13	0	0	1.91	1.04	20.56	9	0	0	0.79	117	0	0.000	91.84	20.56	3.14	0	0.3	12.24	377	468.87	23.01	187.54	128.57	21

Recommendation :

a) Pile Diameter (mm)	1000	
b) Pile cut off level (m)	**2.0**	
c) Pile Shaft Length from Cut off Level (m)	18.0	21.0
d) Vertical Pile Capacity (tonnes)	160.0	180.0
e) Uplift pile capacity (Tonnes)	100.0	120.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.		Structure @ Chainage	40+940	Location	VUP	Based on Bore Hole No	BH 19	Pile Cut -off level (m)	2.3	
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	11.80	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 20 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_{di}N_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_U=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	$(K_s P_{di}\tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	CI	2.7	0.00	4	0	0	1.78	1.02	2.75	9	0	0	1.13	36	0	0.000	40.68	1.37	10.2	0	0.3	12.2	0	40.68	4.27	16.27	4.27	2.7
2	CI	3	0.00	5	0	0	1.82	1.03	5.84	9	0	0	1.13	45	0	0.000	54.15	4.29	11.3	0	0.3	16.95	16.95	71.1	9.01	28.44	13.75	5.7
3	SM-ML/ SM	3	0.00	0	31	31	1.91	1.02	8.9	0	23.9	26	1.13	0	212.93	15.900	90.59	7.37	11.3	75.06	0	0	92.01	182.6	13.75	73.04	39.51	8.7
4	SM-ML/ SM	2	0.00	0	31	31	1.91	1.02	10.94	0	23.9	26	1.13	0	261.74	15.900	57	9.92	7.53	67.32	0	0	159.3	216.33	16.91	86.53	61.52	10.7
5	SM-ML/ SM	2.5	0.00	0	31	31	1.91	1.02	13.49	0	23.9	26	1.13	0	322.75	15.900	382.67	12.21	9.42	103.66	0	0	263	645.66	20.86	258.26	94.49	13.2
6	SM-ML/ SM	2	0.00	0	31	31	1.91	1.02	15.53	0	23.9	26	1.13	0	371.56	15.900	437.82	14.51	7.53	98.47	0	0	361.5	799.28	24.02	319.71	125.22	15.2
7	CH	2.8	0.00	13	0	0	1.91	1.05	18.47	9	0	0	1.13	117	0	0.000	132.21	17	10.6	0	0.3	41.14	402.6	534.81	28.44	213.92	141.16	18
8	CH	1	0.00	13	0	0	1.91	1.05	19.52	9	0	0	1.13	117	0	0.000	132.21	18.99	3.76	0	0.3	14.66	417.3	549.47	30.02	219.78	146.85	19
9	CH	2	0.00	13	0	0	1.91	1.04	21.6	9	0	0	1.13	117	0	0.000	132.21	20.56	7.53	0	0.3	29.36	446.6	578.83	33.18	231.53	158.23	21

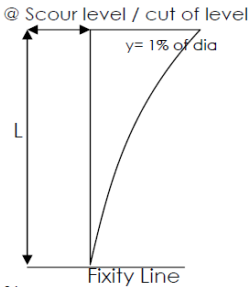
Recommendation :

a) Pile Diameter (mm)	1200	
b) Pile cut off level (m)	**2.3**	
c) Pile Shaft Length from Cut off Level (m)	18.0	21.0
d) Vertical Pile Capacity (tonnes)	200.0	220.0
e) Uplift pile capacity (Tonnes)	130.0	150.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	VUP @40+940	
Borehole no :	BH 19	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	18.0	18.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	8.00	8.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) :	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	1.00E+03	1.00E+03
Stiffness factor for Cohesion soil (T) in m :	4.27	4.94
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	18.00	18.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	9.35	10.82
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	9.35	10.82
Type of Pile Behavviour :	Long Flexible Pile	Rigid &Elastic pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	21.30	34.24
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	15.00	25.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	42+550	Location	MJB	Based on Bore Hole No	BH 20	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	251.181
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	3.73	Liqefaction depth below Ground level (m	10.00	RL of the Borehole (m)	256.912

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **8.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p(cN_c+P_dN_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM	2.7	0.00	0	29	29	1.81	0.95	0	0	18.1	19.3	0.79	0	0	9.000	0	0	8.47	0	0.45	0	0	0	2.96	0	2.96	2.7
2	SM-ML / SM	2	0.00	0	30	30	1.84	0.93	0	0	20.9	22.4	0.79	0	0	10.410	0	0	6.28	0	0	0	0	0	5.15	0	5.15	4.7
3	SM-ML / SM	3	0.00	0	30	30	1.84	0.93	0	0	20.9	22.4	0.79	0	0	10.410	36.6	0	9.42	0	0	0	0	0	8.44	0	8.44	7.7
4	SM-ML / SM	2	0.00	0	30	30	1.86	0.94	1.88	0	20.9	22.4	0.79	0	39.38	10.520	80.58	0.94	6.28	5.11	0	0	5.11	85.69	10.63	34.27	12.06	9.7
5	SM-ML / SM	2	0.00	0	30	30	1.86	0.94	3.76	0	20.9	22.4	0.79	0	78.76	10.520	106.42	2.82	6.28	15.33	0	0	20.44	126.86	12.82	50.74	18.54	11.7
6	SM-ML / SM	3	0.00	0	30	30	1.86	0.94	6.58	0	20.9	22.4	0.79	0	137.84	10.520	122.04	5.17	9.42	42.17	0	0	62.61	184.65	16.11	73.86	33.64	14.7
7	CI	3	0.00	12	0	0	1.86	0.96	9.46	9	0	0	0.79	108	0	0.000	84.78	8.02	9.42	0	0.3	33.91	96.52	181.3	19.4	72.52	46.42	17.7
8	SM-ML	2	0.00	0	30	0	1.86	0.94	11.34	0	20.9	22.4	0.79	0	237.56	10.520	194.74	10.4	6.28	0	0	0	96.52	291.26	21.59	116.5	48.61	19.7
9	SM-ML	2	0.00	0	30	30	1.86	0.94	13.22	0	20.9	22.4	0.79	0	276.94	10.520	225.65	12.28	6.28	66.78	0	0	163.3	388.95	23.78	155.58	69.5	21.7
10	SM-ML	2.5	0.00	0	30	30	1.86	0.94	15.57	0	20.9	22.4	0.79	0	326.17	10.520	264	14.39	7.85	97.82	0	0	261.1	525.12	26.52	210.04	99.63	24.2
11	SM-ML	3.8	0.00	0	30	30	1.86	0.94	19.14	0	20.9	22.4	0.79	0	400.96	10.520	323	17.35	11.9	179.25	0	0	440.4	763.37	30.69	305.34	153.99	28
12	SM-ML	1	0.00	0	30	30	1.86	0.94	19.14	0	20.9	22.4	0.79	0	400.96	10.520	323	19.14	3.14	52.04	0	0	492.4	815.41	31.78	326.16	169.65	29

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	29.0
d) Vertical Pile Capacity (tonnes)	310.0
e) Uplift pile capacity (Tonnes)	160.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	42+550	Location	MJB	Based on Bore Hole No	BH 20	Pile Cut -off level (m)	2.3		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	251.181
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	3.43	Liqefaction depth below Ground level (m	10.00	RL of the Borehole (m)	256.912

Maximum effective overburden pressure= 20*Diameter of pile.
R.L's and scour level provided by the client.Assuming the strata @ 30 m and below to be same.

Liquefaction depth below cut-off level(m) : **7.700**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance P pu = Ap* (cN_c+P_dN_q+0.5.γ.D.$N_γ$)					Ultimate Shaft Friction P_{SU} =(∑(K_s P_{di}tanδ).A_{si}+a.c.A_s)						Total Ultimate Capacity, P_u=P_{pu}+ P_{su} (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	$N_γ$	A_p (m²)	c.N_C	PdN$_q$	0.5.γ.D.$N_γ$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}				
1	SM	2.7	0.00	0	29	29	1.81	0.95	0	0	18.1	19.3	1.13	0	0	11.000	0	0	10.2	0	0.45	0	0	0	4.27	0	4.27	2.7
2	SM-ML / SM	2	0.00	0	30	30	1.84	0.93	0	0	20.9	22.4	1.13	0	0	12.500	0	0	7.53	0	0	0	0	0	7.43	0	7.43	4.7
3	SM-ML / SM	3	0.00	0	30	30	1.84	0.93	0	0	20.9	22.4	1.13	0	0	12.500	50.83	0	11.3	0	0	0	0	0	12.17	0	12.17	7.7
4	SM-ML / SM	2	0.00	0	30	30	1.86	0.94	1.88	0	20.9	22.4	1.13	0	39.38	12.630	95.65	0.94	7.53	6.12	0	0	6.12	101.77	15.33	40.7	17.04	9.7
5	SM-ML / SM	2	0.00	0	30	30	1.86	0.94	3.76	0	20.9	22.4	1.13	0	78.76	12.630	117.31	2.82	7.53	18.38	0	0	24.5	141.81	18.49	56.72	25.35	11.7
6	SM-ML / SM	3	0.00	0	30	30	1.86	0.94	6.58	0	20.9	22.4	1.13	0	137.84	12.630	122.04	5.17	11.3	50.59	0	0	75.09	197.13	23.23	78.85	44.25	14.7
7	CI	3	0.00	12	0	0	1.86	0.96	9.46	9	0	0	1.13	108	0	0.000	122.04	8.02	11.3	0	0.3	40.68	115.8	237.81	27.97	95.12	60.38	17.7
8	SM-ML	2	0.00	0	30	0	1.86	0.94	11.34	0	20.9	22.4	1.13	0	237.56	12.630	282.71	10.4	7.53	0	0	0	115.8	398.48	31.13	159.39	63.54	19.7
9	SM-ML	2	0.00	0	30	30	1.86	0.94	13.22	0	20.9	22.4	1.13	0	276.94	12.630	327.21	12.28	7.53	80.07	0	0	195.8	523.05	34.29	209.22	89.12	21.7
10	SM-ML	2.5	0.00	0	30	30	1.86	0.94	15.57	0	20.9	22.4	1.13	0	326.17	12.630	382	14.39	9.42	117.39	0	0	313.2	695.23	38.24	278.09	125.94	24.2
11	SM-ML	2	0.00	0	30	30	1.86	0.94	17.45	0	20.9	22.4	1.13	0	365.55	12.630	427	16.51	7.53	107.66	0	0	420.9	847.89	41.4	339.15	159.24	26.2
12	SM-ML	2.8	0.00	0	30	30	1.86	0.94	20.08	0	20.9	22.4	1.13	0	420.65	12.630	489	18.76	10.6	171.4	0	0	592.3	1081.29	45.82	432.51	211.66	29

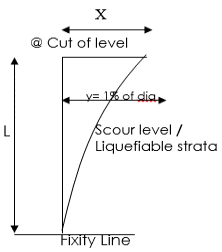
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	29.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	200.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MJB @ 42+550	
Borehole no :	BH 20	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	29.0	29.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	18.00	18.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) :	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.55E+03	2.55E+03
Stiffness factor for Cohesionless soil (T) in m :	3.54	4.09
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	8.000	7.700
therefore L_1/T or L_1/R :	2.26	1.88
Embedded Length of the Pile (L_e) in "m" :	21.00	21.30
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.92	1.94
Depth of Fixidity **L_F** in "m":	6.80	7.94
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	14.80	15.64
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" :	22.8	23.5
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	12.24	22.16
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	10.00	20.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	43+910	Location	FLYOVER	Based on Bore Hole No	BH 21	Pile Cut -off level (m)	2.0		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	10.25	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN$_q$	0.5.γ.D.N$_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	3	0.00	0	27	27	1.81	1.00	3	0	13.5	14.5	0.79	0	40.38	7.000	37.19	1.5	9.42	10.79	0	0	0	37.19	3.29	14.87	3.29	3
2	CI	2	0.00	3.9	0	0	1.83	1.02	5.04	9	0	0	0.79	35.1	0	0.000	27.55	4.02	6.28	0	0.3	7.34	7.34	34.89	5.48	13.95	7.53	5
3	CI	2	0.00	5	0	0	1.83	0.99	7.02	9	0	0	0.79	45	0	0.000	35.32	6.03	6.28	0	0.3	9.42	16.76	52.08	7.67	20.83	12.36	7
4	SM-ML / SM	1.5	0.00	0	30	30	1.86	0.95	8.44	0	20.9	22.4	0.79	0	176.8	10.640	147.14	7.73	4.71	31.53	0	0	48.29	195.43	9.31	78.17	22.83	8.5
5	SM-ML / SM	2	0.00	0	30	30	1.86	0.95	10.34	0	20.9	22.4	0.79	0	216.61	10.640	178.39	9.39	6.28	51.06	0	0	99.35	277.74	11.5	111.09	39.31	10.5
6	SM-ML / SM	2	0.00	0	30	30	1.86	0.95	12.24	0	20.9	22.4	0.79	0	256.41	10.640	209.63	11.29	6.28	61.4	0	0	160.8	370.38	13.69	148.15	58.7	12.5
7	CH	1.5	0.00	10	0	0	1.86	0.97	13.69	9	0	0	0.79	90	0	0.000	70.65	12.96	4.71	0	0.3	14.13	174.9	245.53	15.33	98.21	64.29	14
8	SM	2	0.00	0	30	30	1.86	0.95	15.59	0	20.9	22.4	0.79	0	326.59	10.640	264.72	14.64	6.28	79.62	0	0	254.5	519.22	17.52	207.68	88.78	16
9	SM	2	0.00	0	30	30	1.86	0.95	17.49	0	20.9	22.4	0.79	0	366.39	10.640	295.96	16.54	6.28	89.95	0	0	344.5	640.41	19.71	256.16	116.15	18
10	SM	2	0.00	0	30	30	1.86	0.95	19.39	0	20.9	22.4	0.79	0	406.19	10.640	327	18.44	6.28	100.28	0	0	444.7	771.73	21.9	308.69	146.42	20
11	SM	1	0.00	0	30	30	1.86	0.95	19.39	0	20.9	22.4	0.79	0	406.19	10.640	327	19.39	3.14	52.72	0	0	497.5	824.45	22.99	329.78	162.27	21

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	21.0
d) Vertical Pile Capacity (tonnes)	300.0
e) Uplift pile capacity (Tonnes)	150.0

* **For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	43+910	Location	FLYOVER	Based on Bore Hole No	BH 21	Pile Cut -off level (m)	2.3		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	10.25	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di} \tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	2.7	0.00	0	27	27	1.81	1.00	2.7	0	13.5	14.5	1.13	0	36.34	8.000	50.1	1.35	10.2	10.49	0	0	0	50.1	4.27	20.04	4.27	2.7
2	CI	2	0.00	3.9	0	0	1.83	1.02	4.74	9	0	0	1.13	35.1	0	0.000	39.66	3.72	7.53	0	0.3	8.81	8.81	48.47	7.43	19.38	9.89	4.7
3	CI	2	0.00	5	0	0	1.83	0.99	6.72	9	0	0	1.13	45	0	0.000	50.85	5.73	7.53	0	0.3	11.29	20.1	70.95	10.59	28.38	16.21	6.7
4	SM-ML / SM	1.5	0.00	0	30	30	1.86	0.95	8.14	0	20.9	22.4	1.13	0	170.52	12.760	207.1	7.43	5.65	36.35	0	0	56.45	263.55	12.96	105.42	28.76	8.2
5	SM-ML / SM	2	0.00	0	30	30	1.86	0.95	10.04	0	20.9	22.4	1.13	0	210.32	12.760	252.08	9.09	7.53	59.27	0	0	115.7	367.8	16.12	147.12	48.52	10.2
6	SM-ML / SM	2	0.00	0	30	30	1.86	0.95	11.94	0	20.9	22.4	1.13	0	250.12	12.760	297.05	10.99	7.53	71.66	0	0	187.4	484.43	19.28	193.77	71.74	12.2
7	CH	1.5	0.00	10	0	0	1.86	0.97	13.39	9	0	0	1.13	90	0	0.000	101.7	12.66	5.65	0	0.3	16.95	204.3	306.03	21.65	122.41	78.86	13.7
8	SM	2	0.00	0	30	30	1.86	0.95	15.29	0	20.9	22.4	1.13	0	320.3	12.760	376.35	14.34	7.53	93.51	0	0	297.8	674.19	24.81	269.67	108.2	15.7
9	SM	2.3	0.00	0	30	30	1.86	0.95	17.47	0	20.9	22.4	1.13	0	365.97	12.760	427.96	16.38	8.66	122.84	0	0	420.7	848.64	28.44	339.45	146.23	18
10	SM	1	0.00	0	30	30	1.86	0.95	18.42	0	20.9	22.4	1.13	0	385.87	12.760	450	17.94	3.76	58.41	0	0	479.1	929.09	30.02	371.63	164.16	19
11	SM	2	0.00	0	30	30	1.86	0.95	20.32	0	20.9	22.4	1.13	0	425.68	12.760	495	19.37	7.53	126.31	0	0	605.4	1100.4	33.18	440.16	202.69	21

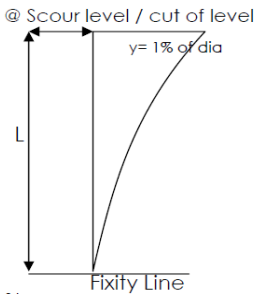
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	21.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	180.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	Flyover @ 43+910	
Borehole no :	BH 21	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" **:**	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	21.0	21.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	9.00	9.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	1.20E+03	1.20E+03
Stiffness factor for Cohesionless soil (T) in m :	4.11	4.76
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (**L_1**) in "m"**:**	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	21.00	21.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	9.00	10.42
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	9.00	10.42
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	23.89	38.27
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	20.00	30.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	47+950	Location	MJB	Based on Bore Hole No	**BH 22**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	15.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Considering No Scour.Assuming the strata @ 20 m and below to be same.

Liquefaction depth below cut-off level(m) : **13.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = Ap^* (cN_c+P_dN_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di}\tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	3	0.00	0	30	30	1.86	0.98	0	0	20.9	22.4	0.79	0	0	10.000	0	0	9.42	0	0	0	0	0	3.29	0	3.29	3
2	SM	1	0.00	0	29	29	1.85	0.94	0	0	18.1	19.3	0.79	0	0	9.080	0	0	3.14	0	0	0	0	0	4.38	0	4.38	4
3	CI-CH	3	0.00	8	0	0	1.87	0.99	0	9	0	0	0.79	72	0	0.000	0	0	9.42	0	0.3	22.6	0	0	7.67	0	7.67	7
4	SM-ML / SM	4	0.00	0	29	29	1.87	0.97	0	0	18.1	19.3	0.79	0	0	9.370	0	0	12.6	0	0	0	0	0	12.06	0	12.06	11
5	SM-ML / SM	2	0.00	0	29	29	1.87	0.97	0	0	18.1	19.3	0.79	0	0	9.370	0	0	6.28	0	0	0	0	0	14.25	0	14.25	13
6	SM-ML / SM	3	0.00	0	30	30	1.87	0.97	2.91	0	20.9	22.4	0.79	0	60.96	10.860	56.37	1.45	9.42	11.82	0	0	11.82	68.19	17.54	27.27	20.84	16
7	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	4.85	0	20.9	22.4	0.79	0	101.6	10.860	88.28	3.88	6.28	21.1	0	0	32.92	121.2	19.73	48.48	28.94	18
8	SM-ML / SM	2	0.00	0	30	0	1.87	0.97	6.79	0	20.9	22.4	0.79	0	142.24	10.860	120.18	5.82	6.28	0	0	0	32.92	153.1	21.92	61.24	31.13	20
9	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	8.73	0	20.9	22.4	0.79	0	182.88	10.860	152.08	7.76	6.28	42.2	0	0	75.12	227.2	24.11	90.88	45.14	22
10	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	10.67	0	20.9	22.4	0.79	0	223.52	10.860	183	9.7	6.28	52.75	0	0	127.9	310.87	26.3	124.34	62.1	24
11	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	12.61	0	20.9	22.4	0.79	0	264.16	10.860	215	11.64	6.28	63.3	0	0	191.2	406.17	28.49	162.46	82.01	26
12	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	14.55	0	20.9	22.4	0.79	0	304.8	10.860	247	13.58	6.28	73.85	0	0	265	512.02	30.68	204.8	104.88	28
13	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	16.49	0	20.9	22.4	0.79	0	345.44	10.860	279	15.52	6.28	84.4	0	0	349.4	628.42	32.87	251.36	130.7	30

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	30.0
d) Vertical Pile Capacity (tonnes)	240.0
e) Uplift pile capacity (Tonnes)	120.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	47+950	Location	MJB	Based on Bore Hole No	**BH 22**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	15.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Considering No Scour.Assuming the strata @ 20 m and below to be same.

Liquefaction depth below cut-off level(m) : **12.700**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance P pu = Ap* (cN_c+P_dN_q+0.5.γ.D.N_γ)					Ultimate Shaft Friction P_{SU} =(∑(K_s P_{di}tanδ).A_{si}+a.c.A_s)						Total Ultimate Capacity, P_u=P_{pu}+ P_{su} (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	c.N_C	PdN$_q$	0.5.γ.D.N_γ	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}				
1	SM-ML / SM	2.7	0.00	0	30	30	1.86	0.98	0	0	20.9	22.4	1.13	0	0	13.000	0	0	10.2	0	0	0	0	0	4.27	0	4.27	2.7
2	SM	1	0.00	0	29	29	1.85	0.94	0	0	18.1	19.3	1.13	0	0	10.900	0	0	3.76	0	0	0	0	0	5.85	0	5.85	3.7
3	CI-CH	3	0.00	8	0	0	1.87	0.99	0	9	0	0	1.13	72	0	0.000	0	0	11.3	0	0.3	27.12	0	0	10.59	0	10.59	6.7
4	SM-ML / SM	4	0.00	0	29	29	1.87	0.97	0	0	18.1	19.3	1.13	0	0	11.250	0	0	15.1	0	0	0	0	0	16.91	0	16.91	10.7
5	SM-ML / SM	2	0.00	0	29	29	1.87	0.97	0	0	18.1	19.3	1.13	0	0	11.250	0	0	7.53	0	0	0	0	0	20.07	0	20.07	12.7
6	SM-ML / SM	3	0.00	0	30	30	1.87	0.97	2.91	0	20.9	22.4	1.13	0	60.96	13.030	83.6	1.45	11.3	14.18	0	0	14.18	97.78	24.81	39.11	28.78	15.7
7	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	4.85	0	20.9	22.4	1.13	0	101.6	13.030	129.53	3.88	7.53	25.3	0	0	39.48	169.01	27.97	67.6	39.02	17.7
8	SM-ML / SM	2.3	0.00	0	30	0	1.87	0.97	7.08	0	20.9	22.4	1.13	0	148.31	13.030	182.31	5.96	8.66	0	0	0	39.48	221.79	31.6	88.71	42.65	20
9	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	9.02	0	20.9	22.4	1.13	0	188.95	13.030	228.23	8.05	7.53	52.49	0	0	91.97	320.2	34.76	128.08	60.51	22
10	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	10.96	0	20.9	22.4	1.13	0	229.59	13.030	274	9.99	7.53	65.14	0	0	157.1	431.11	37.92	172.44	81.91	24
11	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	12.9	0	20.9	22.4	1.13	0	270.24	13.030	320	11.93	7.53	77.79	0	0	234.9	554.9	41.08	221.96	106.85	26
12	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	14.84	0	20.9	22.4	1.13	0	310.88	13.030	366	13.87	7.53	90.44	0	0	325.3	691.34	44.24	276.53	135.33	28
13	SM-ML / SM	2	0.00	0	30	30	1.87	0.97	16.78	0	20.9	22.4	1.13	0	351.52	13.030	411	15.81	7.53	103.09	0	0	428.4	839.43	47.4	335.77	167.36	30

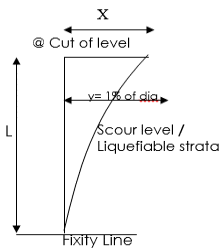
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	30.0
d) Vertical Pile Capacity (tonnes)	320.0
e) Uplift pile capacity (Tonnes)	160.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	MJB @ 47+950	
Borehole no :	BH 22	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" :	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	30.0	30.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	24.00	24.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) :	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	3.41E+03	3.41E+03
Stiffness factor for Cohesionless soil (T) in m :	3.34	3.86
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m":	13.000	12.700
therefore L_1/T or L_1/R :	3.89	3.29
Embedded Length of the Pile (L_e) in "m" :	17.00	17.30
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	1.86	1.88
Depth of Fixidity **L_F** in "m":	6.20	7.25
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	19.20	19.95
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Horizontal Deflection on the top of the pile (**x**) " in mm" :	40.7	40.0
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	10.02	18.21
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	9.00	17.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) $=[QLxx^3]/3EI$; For Fixed head (Y)$=[QLxx^3]/12EI$

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	49+900	Location	FLYOVER	Based on Bore Hole No	**BH 23**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	10.25	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m^2)	c.N_C	PdN$_q$	0.5.γ.D.N$_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m^2)	A_{si} (m^2)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	1	0.00	0	29	29	1.81	0.99	0.99	0	18.1	19.3	0.79	0	17.89	9.000	21.1	0.49	3.14	1.27	0	0	0	21.1	1.09	8.44	1.09	1
2	Cl	3	0.00	6	0	0	1.84	1.01	4.02	9	0	0	0.79	54	0	0.000	42.39	2.5	9.42	0	0.3	16.95	16.95	59.34	4.38	23.73	9.12	4
3	SM	2	0.00	0	29	29	1.87	0.99	6	0	18.1	19.3	0.79	0	108.46	9.570	92.65	5.01	6.28	26.16	0	0	43.11	135.76	6.57	54.3	18.64	6
4	SM	1.5	0.00	0	29	29	1.87	0.99	7.48	0	18.1	19.3	0.79	0	135.22	9.570	113.66	6.74	4.71	26.39	0	0	69.5	183.16	8.21	73.26	27.67	7.5
5	SM	2	0.00	0	29	29	1.87	0.99	9.46	0	18.1	19.3	0.79	0	171.01	9.570	141.75	8.47	6.28	44.22	0	0	113.7	255.47	10.4	102.18	42.24	9.5
6	SM	2	0.00	0	29	29	1.87	0.99	11.44	0	18.1	19.3	0.79	0	206.81	9.570	169.85	10.45	6.28	54.56	0	0	168.3	338.13	12.59	135.25	59.7	11.5
7	SM	1.5	0.00	0	29	29	1.87	0.99	12.92	0	18.1	19.3	0.79	0	233.56	9.570	190.85	12.18	4.71	47.69	0	0	216	406.82	14.23	162.72	74.7	13
8	SM	2	0.00	0	29	29	1.87	0.99	14.9	0	18.1	19.3	0.79	0	269.35	9.570	218.95	13.91	6.28	72.63	0	0	288.6	507.55	16.42	203.02	97.22	15
9	SM	2	0.00	0	30	30	1.87	0.99	16.88	0	20.9	22.4	0.79	0	353.61	11.080	286.28	15.89	6.28	86.41	0	0	375	661.29	18.61	264.51	123.61	17
10	SM	1	0.00	0	30	30	1.87	0.99	17.87	0	20.9	22.4	0.79	0	374.35	11.080	302	17.37	3.14	47.23	0	0	422.2	724.24	19.7	289.69	137.92	18
11	SM	2	0.00	0	30	30	1.87	0.99	19.85	0	20.9	22.4	0.79	0	415.83	11.080	335	18.86	6.28	102.57	0	0	524.8	859.81	21.89	343.92	168.83	20

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	20.0
d) Vertical Pile Capacity (tonnes)	330.0
e) Uplift pile capacity (Tonnes)	150.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	49+900	Location	FLYOVER	Based on Bore Hole No	**BH 23**	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	10.25	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m²)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m³	Total/ Submerged Unit Weight of Soil (t/m³)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m²)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN$_q$	0.5.γ.D.N$_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s P_{di}.Tanδ).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	0.7	0.00	0	29	29	1.81	0.99	0.69	0	18.1	19.3	1.13	0	12.47	11.000	26.52	0.34	2.63	0.74	0	0	0	26.52	1.1	10.6	1.1	0.7
2	Cl	3	0.00	6	0	0	1.84	1.01	3.72	9	0	0	1.13	54	0	0.000	61.02	2.2	11.3	0	0.3	20.34	20.34	81.36	5.84	32.54	11.53	3.7
3	SM	2	0.00	0	29	29	1.87	0.99	5.7	0	18.1	19.3	1.13	0	103.04	11.480	129.4	4.71	7.53	29.48	0	0	49.82	179.22	9	71.68	22.94	5.7
4	SM	1.5	0.00	0	29	29	1.87	0.99	7.18	0	18.1	19.3	1.13	0	129.79	11.480	159.63	6.44	5.65	30.25	0	0	80.07	239.7	11.37	95.88	33.78	7.2
5	SM	2	0.00	0	29	29	1.87	0.99	9.16	0	18.1	19.3	1.13	0	165.59	11.480	200.08	8.17	7.53	51.15	0	0	131.2	331.3	14.53	132.52	51.27	9.2
6	SM	2	0.00	0	29	29	1.87	0.99	11.14	0	18.1	19.3	1.13	0	201.38	11.480	240.53	10.15	7.53	63.54	0	0	194.8	435.29	17.69	174.11	72.22	11.2
7	SM	1.5	0.00	0	29	29	1.87	0.99	12.62	0	18.1	19.3	1.13	0	228.14	11.480	270.77	11.88	5.65	55.8	0	0	250.6	521.33	20.06	208.53	90.21	12.7
8	SM	2	0.00	0	29	29	1.87	0.99	14.6	0	18.1	19.3	1.13	0	263.93	11.480	311.21	13.61	7.53	85.21	0	0	335.8	646.98	23.22	258.79	117.23	14.7
9	SM	2.3	0.00	0	30	30	1.87	0.99	16.87	0	20.9	22.4	1.13	0	353.4	13.300	414.37	15.73	8.66	117.97	0	0	453.7	868.11	26.85	347.24	153.89	17
10	SM	1	0.00	0	30	30	1.87	0.99	17.86	0	20.9	22.4	1.13	0	374.14	13.300	437	17.36	3.76	56.52	0	0	510.3	947.26	28.43	378.9	171.3	18
11	SM	2	0.00	0	30	30	1.87	0.99	19.84	0	20.9	22.4	1.13	0	415.62	13.300	484	18.85	7.53	122.92	0	0	633.2	1117.18	31.59	446.87	208.88	20

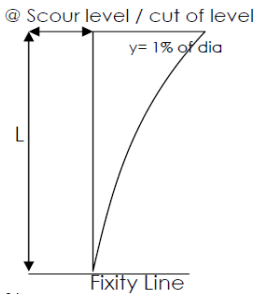
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	20.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	190.0

* **For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	Flyover @ 49+900	
Borehole no :	BH 23	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" **:**	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	20.0	20.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	12.00	12.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	1.68E+03	1.68E+03
Stiffness factor for Cohesionless soil (T) in m :	3.85	4.45
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m"**:**	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	20.00	20.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	8.43	9.75
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	8.43	9.75
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	29.06	46.84
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	20.00	35.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Annexure II
Liquefaction Analysis

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage : Flyover @ 0+800

Borehole no : BH 1

Water Table Depth (m) : 4.50

Water Table Depth considered (m) : 0.00

Seimsmic Parameters

Magnitude of Earthquake : 7.0

Design PGA : 0.24 g

Importance Factor of the Structure : 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "%" : 60

Borehole diameter (mm) : 150

Was liner used in SPT boring : No

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o) at site, kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	10	17.90	7.90	94	0.99	32.22	32.22	14.22	0.35	1.70	1.06	18.02	5.00	1.20	26.62	0.33	0.39	1.12	Non Liquefiable
3.3	SM-ML	5	17.90	7.90	43	0.97	59.07	59.07	26.07	0.34	1.30	1.06	6.90	5.00	1.20	13.28	0.14	0.17	0.50	Liquefiable
4.8	SM-ML	8	17.90	7.90	32	0.96	85.92	82.92	37.92	0.34	1.10	1.06	9.31	4.83	1.17	15.73	0.17	0.20	0.59	Liquefiable
6.3	SM-ML	11	17.40	7.40	37	0.95	112.02	94.02	49.02	0.34	1.03	1.06	12.03	5.00	1.20	19.43	0.21	0.25	0.73	Liquefiable
7.80	SM	13	17.40	7.40	29	0.94	138.12	105.12	60.12	0.34	0.98	1.06	13.44	4.64	1.15	20.04	0.22	0.26	0.76	Liquefiable
9.30	SM	17	17.40	7.40	24	0.93	164.22	116.22	71.22	0.33	0.93	1.06	16.72	4.18	1.11	22.69	0.25	0.30	0.90	Liquefiable
10.80	SM	21	17.40	7.40	30	0.89	190.32	127.32	82.32	0.32	0.89	1.06	19.73	4.71	1.15	27.48	0.35	0.42	1.32	Non Liquefiable
12.30	SM	23	17.40	7.40	27	0.85	216.42	138.42	93.42	0.31	0.85	1.06	20.72	4.48	1.13	27.90	0.37	0.44	1.43	Non Liquefiable
13.80	SM	28	17.40	7.40	19	0.81	242.52	149.52	104.52	0.29	0.82	1.06	24.27	3.43	1.07	29.47	0.43	0.52	1.78	Non Liquefiable
15.30	Cl	17	17.40	7.40	89	0.77	268.62	160.62	115.62	0.28	0.79	1.06	14.22	5.00	1.20	22.06	0.24	0.29	1.04	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage: MJB @ 1+530

Borehole no : BH 2

Water Table Depth (m): 2.70

Water Table Depth considered (m): 0.00

Seimsmic Parameters

Magnitude of Earthquake: 7.00

Design PGA: 0.24 g

Importance Factor of the Structure: 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "?: 60

Borehole diameter (mm): 150

Was liner used in SPT boring: No

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	$C_{\delta 0}$	SPT $(N_1)_{\delta 0}$	α	β	SPT $(N_1)_{\delta 0 cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM	5	17.40	7.40	29	0.99	31.32	31.32	13.32	0.36	1.70	1.06	9.01	4.64	1.15	14.96	0.16	0.19	0.53	Liquefiable
3.3	SM	6	17.40	7.40	33	0.97	57.42	51.42	24.42	0.36	1.39	1.06	8.87	4.88	1.18	15.34	0.16	0.20	0.55	Liquefiable
4.8	SM-ML	10	17.40	7.40	69	0.96	83.52	62.52	35.52	0.35	1.26	1.06	13.41	5.00	1.20	21.09	0.23	0.27	0.77	Liquefiable
6.3	SM	13	18.30	8.30	33	0.95	110.97	74.97	47.97	0.34	1.15	1.06	15.91	4.88	1.18	23.65	0.27	0.32	0.93	Liquefiable
7.80	SM	15	18.30	8.30	46	0.94	138.42	87.42	60.42	0.34	1.07	1.06	17.01	5.00	1.20	25.41	0.30	0.36	1.07	Non Liquefiable
9.30	SM	23	18.60	8.60	31	0.93	166.32	100.32	73.32	0.33	1.00	1.06	24.34	4.77	1.16	33.07	NA	NA	>1	Non Liquefiable
10.80	SM	33	18.60	8.60	39	0.89	194.22	113.22	86.22	0.31	0.94	1.06	32.87	5.00	1.20	44.45	NA	NA	>1	Non Liquefiable
12.30	SM	27	18.60	8.60	36	0.85	222.12	126.12	99.12	0.30	0.89	1.06	25.48	5.00	1.20	35.58	NA	NA	>1	Non Liquefiable
13.80	SM	17	18.90	8.90	98	0.81	250.47	139.47	112.47	0.28	0.85	1.06	15.26	5.00	1.20	23.31	0.26	0.31	1.12	Non Liquefiable
15.30	CL-CI	21	18.90	8.90	99	0.77	278.82	152.82	125.82	0.26	0.81	1.06	18.01	5.00	1.20	26.61	0.33	0.39	1.48	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location	
Structure @ chainage	VUP @ 6+380
Borehole no :	BH 3
Water Table Depth (m)	13.80
Water Table Depth considered (m)	9.00

Seimsmic Parameters

Magnitude of Earthquake	7.00
DesignPGA	0.24 g
Importance Factor of the Structure	1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "%	60
Borehole diameter (mm)	150
Was liner used in SPT boring	No

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	12	18.20	8.20	95	0.99	32.76	32.76	32.76	0.15	1.70	1.06	21.62	5.00	1.20	30.95	NA	NA	>1	Non Liquefiable
3.3	SM-ML	9	18.20	8.20	86	0.97	60.06	60.06	60.06	0.15	1.29	1.06	12.31	5.00	1.20	19.77	0.21	0.25	1.67	Non Liquefiable
4.8	SM-ML	27	18.20	8.20	92	0.96	87.36	87.36	87.36	0.15	1.07	1.06	30.62	5.00	1.20	41.74	NA	NA	>1	Non Liquefiable
6.3	SM	13	18.50	8.50	14	0.95	115.11	115.11	115.11	0.15	0.93	1.06	12.84	2.20	1.04	15.59	0.17	0.20	1.33	Non Liquefiable
7.8	SM	15	18.50	8.50	29	0.94	142.86	142.86	142.86	0.15	0.84	1.06	13.30	4.64	1.15	19.88	0.21	0.26	1.74	Non Liquefiable
9.3	SM	19	18.70	8.70	29	0.93	170.91	170.91	167.67	0.15	0.76	1.06	15.41	4.64	1.15	22.29	0.25	0.29	2.00	Non Liquefiable
10.8	SM	24	18.70	8.70	22	0.89	198.96	198.96	180.72	0.15	0.71	1.06	18.04	3.93	1.09	23.64	0.27	0.32	2.10	Non Liquefiable
12.3	SM	31	18.70	8.70	28	0.85	227.01	227.01	193.77	0.15	0.63	1.06	20.83	4.56	1.14	28.27	0.38	0.45	2.93	Non Liquefiable
13.8	SM	27	18.70	8.70	28	0.81	255.06	255.06	206.82	0.15	0.59	1.06	16.79	4.56	1.14	23.67	0.27	0.32	2.06	Non Liquefiable
15.3	SM	35	18.70	8.70	42	0.77	283.11	268.11	219.87	0.15	0.57	1.06	21.03	5.00	1.20	30.24	NA	NA	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage : FLYOVER @ 8+020

Borehole no : BH 5

Water Table Depth (m) 14.10

Water Table Depth considered (m) 10.00

Seimsmic Parameters

Magnitude of Earthquake 7

Design PGA 0.24 g

Importance Factor of the Structure 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) % 60

Borehole diameter (mm) 150

Was liner used in SPT boring No

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	7	18.00	8.00	65	0.99	32.80	32.80	32.80	0.15	1.70	1.06	12.61	5.00	1.20	20.14	0.22	0.26	1.68	Non Liquefiable
3.3	SM-ML	10	18.00	8.00	71	0.97	59.80	59.80	59.80	0.15	1.29	1.06	13.71	5.00	1.20	21.45	0.23	0.28	1.84	Non Liquefiable
4.8	SM-ML	12	18.00	8.00	74	0.96	86.80	86.80	86.80	0.15	1.07	1.06	13.65	5.00	1.20	21.38	0.23	0.28	1.85	Non Liquefiable
6.3	SM	13	18.30	8.30	64	0.95	114.25	114.25	114.25	0.15	0.94	1.06	12.89	5.00	1.20	20.47	0.22	0.26	1.78	Non Liquefiable
7.80	SM	16	18.30	8.30	26	0.94	141.70	141.70	141.70	0.15	0.84	1.06	14.25	4.39	1.12	20.38	0.22	0.26	1.79	Non Liquefiable
9.30	CI	42	19.00	9.00	91	0.93	170.20	170.20	170.20	0.14	0.77	1.06	34.13	5.00	1.20	45.95	NA	NA	>1	Non Liquefiable
10.80	CI	32	19.00	9.00	88	0.89	198.70	198.70	190.70	0.14	0.71	1.06	24.06	5.00	1.20	33.88	NA	NA	>1	Non Liquefiable
12.30	SM-ML	24	19.00	9.00	95	0.85	227.20	227.20	204.20	0.15	0.63	1.06	16.12	5.00	1.20	24.34	0.28	0.33	2.27	Non Liquefiable
13.80	SM-ML	47	19.00	9.00	25	0.81	255.70	255.70	217.70	0.15	0.59	1.06	29.17	4.29	1.12	36.82	NA	NA	>1	Non Liquefiable
15.30	SM-ML	57	19.00	9.00	38	0.77	284.20	272.20	231.20	0.15	0.56	1.06	33.89	5.00	1.20	45.67	NA	NA	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage : VUP @ 16+690

Borehole no : BH 6

Water Table Depth (m) 13.30

Water Table Depth considered (m) 9.00

Seimsmic Parameters

Magnitude of Earthquake 7

Design PGA 0.24 g

Importance Factor of the Structure 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "%" : 60

Borehole diameter (mm) 150

Was liner used in SPT boring No

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	Cl	11	18.40	8.40	86	0.99	33.12	33.12	33.12	0.15	1.70	1.06	19.82	5.00	1.20	28.79	0.40	0.48	3.10	Non Liquefiable
3.3	Cl	19	18.40	8.40	93	0.97	60.72	60.72	60.72	0.15	1.28	1.06	25.85	5.00	1.20	36.02	NA	NA	>1	Non Liquefiable
4.8	Cl	15	18.40	8.40	95	0.96	88.32	88.32	88.32	0.15	1.06	1.06	16.92	5.00	1.20	25.30	0.30	0.36	2.37	Non Liquefiable
6.3	SM-ML	24	18.60	8.60	32	0.95	116.22	116.22	116.22	0.15	0.93	1.06	23.60	4.83	1.17	32.46	NA	NA	>1	Non Liquefiable
7.80	SM	15	18.60	8.60	31	0.94	144.12	144.12	144.12	0.15	0.83	1.06	13.24	4.77	1.16	20.17	0.22	0.26	1.77	Non Liquefiable
9.30	SM	25	18.60	8.60	35	0.93	172.02	172.02	169.02	0.15	0.76	1.06	20.20	5.00	1.20	29.25	0.42	0.50	3.43	Non Liquefiable
10.80	Cl	29	18.60	8.60	97	0.89	199.92	199.92	181.92	0.15	0.71	1.06	21.74	5.00	1.20	31.09	NA	NA	>1	Non Liquefiable
12.30	Cl	32	18.60	8.60	97	0.85	227.82	227.82	194.82	0.15	0.63	1.06	21.45	5.00	1.20	30.75	NA	NA	>1	Non Liquefiable
13.80	Cl	34	18.60	8.60	96	0.81	255.72	250.72	207.72	0.15	0.59	1.06	21.39	5.00	1.20	30.67	NA	NA	>1	Non Liquefiable
15.30	SM	38	18.60	8.60	20	0.77	283.62	263.62	220.62	0.15	0.57	1.06	23.10	3.61	1.08	28.55	0.39	0.47	3.03	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details		**Seimsmic Parameters**		**Parameters from SPT Boring**	
Location		Magnitude of Earthquake	7.0	Efficiency in SPT Boring (for C_E factor) "%" :	60
Structure @ Chainage	MNB @ 21+810	Design PGA	0.24 g	Borehole diameter (mm)	150
Borehole no :	BH 7	Importance Factor of the Structure	1	Was liner used in SPT boring	No
Water Table Depth (m)	11.30				
Water Table Depth considered (m)	7.00				

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o) at site, kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	6	17.90	7.90	82	0.99	32.22	32.22	32.22	0.15	1.70	1.06	10.81	5.00	1.20	17.97	0.19	0.23	1.48	Non Liquefiable
3.3	SM-ML	10	17.90	7.90	70	0.97	59.07	59.07	59.07	0.15	1.30	1.06	13.79	5.00	1.20	21.55	0.24	0.28	1.85	Non Liquefiable
4.8	SM-ML	28	17.90	7.90	64	0.96	85.92	85.92	85.92	0.15	1.08	1.06	32.02	5.00	1.20	43.42	NA	NA	>1	Non Liquefiable
6.3	SM-ML	31	18.70	8.70	58	0.95	113.97	113.97	113.97	0.15	0.94	1.06	30.78	5.00	1.20	41.94	NA	NA	>1	Non Liquefiable
7.80	SM	18	18.70	8.70	48	0.94	142.02	142.02	134.02	0.16	0.84	1.06	16.01	5.00	1.20	24.21	0.28	0.33	2.13	Non Liquefiable
9.30	SM-ML	13	18.70	8.70	87	0.93	170.07	170.07	147.07	0.17	0.77	1.06	10.57	5.00	1.20	17.68	0.19	0.22	1.34	Non Liquefiable
10.80	SM-ML	11	18.20	8.20	83	0.89	197.37	197.37	159.37	0.17	0.71	1.06	8.30	5.00	1.20	14.96	0.16	0.19	1.11	Non Liquefiable
12.30	SM-ML	18	18.20	8.20	91	0.85	224.67	214.67	171.67	0.17	0.66	1.06	12.54	5.00	1.20	20.05	0.22	0.26	1.49	Non Liquefiable
13.80	SM-ML	19	18.20	8.20	98	0.81	251.97	226.97	183.97	0.17	0.63	1.06	12.77	5.00	1.20	20.32	0.22	0.26	1.52	Non Liquefiable
15.30	SM-ML	24	18.20	8.20	82	0.77	279.27	239.27	196.27	0.17	0.61	1.06	15.58	5.00	1.20	23.69	0.27	0.32	1.88	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage : VUP @ 22+890

Borehole no : BH 8

Water Table Depth (m) : 14.20

Water Table Depth considered (m) : 10.00

Seimsmic Parameters

Magnitude of Earthquake : 7.00

Design PGA : 0.24 g

Importance Factor of the Structure : 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "? : 60

Borehole diameter (mm) : 150

Was liner used in SPT boring : No

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	$C_{\delta 0}$	SPT $(N_1)_{\delta 0}$	α	β	SPT $(N_1)_{\delta 0 cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	Cl	18	19.00	9.00	84	0.99	34.20	34.20	34.20	0.15	1.70	1.06	32.44	5.00	1.20	43.92	NA	NA	>1	Non Liquefiable
3.3	Cl	27	19.00	9.00	89	0.97	62.70	62.70	62.70	0.15	1.26	1.06	36.14	5.00	1.20	48.37	NA	NA	>1	Non Liquefiable
4.8	Cl	19	19.00	9.00	93	0.96	91.20	91.20	91.20	0.15	1.05	1.06	21.09	5.00	1.20	30.31	NA	NA	>1	Non Liquefiable
6.3	SM	32	19.00	9.00	30	0.95	119.70	119.70	119.70	0.15	0.91	1.06	31.00	4.71	1.15	40.49	NA	NA	>1	Non Liquefiable
7.80	SM	30	19.00	9.00	20	0.94	148.20	148.20	148.20	0.15	0.82	1.06	26.12	3.61	1.08	31.81	NA	NA	>1	Non Liquefiable
9.30	SM	28	18.80	8.80	27	0.93	176.40	176.40	176.40	0.14	0.75	1.06	22.35	4.48	1.13	29.74	0.45	0.54	3.72	Non Liquefiable
10.80	SM	29	18.80	8.80	30	0.89	204.60	204.60	196.60	0.14	0.68	1.06	20.83	4.71	1.15	28.76	0.40	0.48	3.31	Non Liquefiable
12.30	SM	32	18.80	8.80	20	0.85	232.80	232.80	209.80	0.15	0.62	1.06	21.15	3.61	1.08	26.45	0.32	0.39	2.64	Non Liquefiable
13.80	SM	34	18.80	8.80	27	0.81	261.00	261.00	223.00	0.15	0.58	1.06	20.81	4.48	1.13	28.00	0.37	0.44	3.00	Non Liquefiable
15.30	SM	51	18.80	8.80	26	0.77	289.20	278.20	236.20	0.15	0.55	1.06	29.87	4.39	1.12	37.92	NA	NA	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location	
Structure @ chainage	VUP @ 25+430
Borehole no :	BH 9
Water Table Depth (m)	12.25
Water Table Depth considered (m)	8.00

Seimsmic Parameters

Magnitude of Earthquake	7.00
DesignPGA	0.24 g
Importance Factor of the Structure	1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "%	60
Borehole diameter (mm)	150
Was liner used in SPT boring	No

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	Cl	8	18.50	8.50	95	0.99	33.30	33.30	33.30	0.15	1.70	1.06	14.42	5.00	1.20	22.30	0.25	0.29	1.91	Non Liquefiable
3.3	Cl	17	18.50	8.50	99	0.97	61.05	61.05	61.05	0.15	1.28	1.06	23.06	5.00	1.20	32.68	NA	NA	>1	Non Liquefiable
4.8	Cl	11	18.50	8.50	97	0.96	88.80	88.80	88.80	0.15	1.06	1.06	12.37	5.00	1.20	19.85	0.21	0.25	1.69	Non Liquefiable
6.3	SM-ML	21	18.60	8.60	87	0.95	116.70	116.70	116.70	0.15	0.93	1.06	20.61	5.00	1.20	29.73	0.45	0.54	3.61	Non Liquefiable
7.8	SM-ML	25	18.60	8.60	89	0.94	144.60	144.60	144.60	0.15	0.83	1.06	22.04	5.00	1.20	31.44	NA	NA	>1	Non Liquefiable
9.3	SM-ML	8	18.60	8.60	75	0.93	172.50	172.50	159.50	0.16	0.76	1.06	6.46	5.00	1.20	12.75	0.14	0.16	1.06	Non Liquefiable
10.8	SM-ML	12	18.60	8.60	96	0.89	200.40	200.40	172.40	0.16	0.69	1.06	8.73	5.00	1.20	15.48	0.16	0.20	1.22	Non Liquefiable
12.3	CL	18	18.60	8.60	87	0.85	228.30	227.80	185.30	0.16	0.63	1.06	12.07	5.00	1.20	19.48	0.21	0.25	1.53	Non Liquefiable
13.8	CL	19	19.40	9.40	98	0.81	257.40	241.90	199.40	0.16	0.61	1.06	12.24	5.00	1.20	19.69	0.21	0.25	1.56	Non Liquefiable
15.3	SM-ML	22	19.40	9.40	96	0.77	286.50	256.00	213.50	0.16	0.59	1.06	13.64	5.00	1.20	21.37	0.23	0.28	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage : MNB @ 29+260

Borehole no : BH 11

Water Table Depth (m) 5.50

Water Table Depth considered (m) 3.00

Seimsmic Parameters

Magnitude of Earthquake 7

Design PGA 0.24 g

Importance Factor of the Structure 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) % 60

Borehole diameter (mm) 150

Was liner used in SPT boring No

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	CH	6	18.00	8.00	80	0.99	32.80	32.80	32.80	0.15	1.70	1.06	10.81	5.00	1.20	17.97	0.19	0.23	1.48	Non Liquefiable
3.3	SM-ML	9	18.00	8.00	86	0.97	59.80	59.80	56.80	0.16	1.29	1.06	12.34	5.00	1.20	19.80	0.21	0.25	1.59	Non Liquefiable
4.8	SM-ML	11	18.00	8.00	77	0.96	86.80	86.80	68.80	0.19	1.07	1.06	12.52	5.00	1.20	20.02	0.22	0.26	1.36	Non Liquefiable
6.3	SM-ML	13	18.30	8.30	84	0.95	114.25	106.04	81.25	0.21	0.97	1.06	13.38	5.00	1.20	21.06	0.23	0.27	1.31	Non Liquefiable
7.80	SM-ML	18	18.30	8.30	83	0.94	141.70	118.49	93.70	0.22	0.92	1.06	17.53	5.00	1.20	26.03	0.31	0.37	1.69	Non Liquefiable
9.30	SM-ML	12	18.20	8.20	72	0.93	169.00	130.79	106.00	0.23	0.87	1.06	11.12	5.00	1.20	18.35	0.20	0.23	1.01	Non Liquefiable
10.80	SM-ML	13	18.20	8.20	93	0.89	196.30	143.09	118.30	0.23	0.84	1.06	11.52	5.00	1.20	18.82	0.20	0.24	1.05	Non Liquefiable
12.30	SM-ML	14	18.20	8.20	93	0.85	223.60	155.39	130.60	0.23	0.80	1.06	11.90	5.00	1.20	19.29	0.21	0.25	1.09	Non Liquefiable
13.80	SM-ML	17	18.20	8.20	94	0.81	250.90	167.69	142.90	0.22	0.77	1.06	13.92	5.00	1.20	21.70	0.24	0.28	1.29	Non Liquefiable
15.30	SM-ML	13	18.20	8.20	97	0.77	278.20	179.99	155.20	0.21	0.75	1.06	10.27	5.00	1.20	17.33	0.18	0.22	1.03	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage : FLYOVER @ 32+170

Borehole no : BH 12

Water Table Depth (m) 13.20

Water Table Depth considered (m) 9.00

Seimsmic Parameters

Magnitude of Earthquake 7

Design PGA 0.24 g

Importance Factor of the Structure 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "%" : 60

Borehole diameter (mm) 150

Was liner used in SPT boring No

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	18	18.20	8.20	76	0.99	32.76	32.76	32.76	0.15	1.70	1.06	32.44	5.00	1.20	43.92	NA	NA	>1	Non Liquefiable
3.3	SM	9	18.20	8.20	27	0.97	60.06	60.06	60.06	0.15	1.29	1.06	12.31	4.48	1.13	18.39	0.20	0.23	1.54	Non Liquefiable
4.8	CI	19	18.20	8.20	64	0.96	87.36	87.36	87.36	0.15	1.07	1.06	21.55	5.00	1.20	30.86	NA	NA	>1	Non Liquefiable
6.3	CI	23	18.50	8.50	98	0.95	115.11	115.11	115.11	0.15	0.93	1.06	22.72	5.00	1.20	32.27	NA	NA	>1	Non Liquefiable
7.80	CI	28	18.50	8.50	96	0.94	142.86	142.86	142.86	0.15	0.84	1.06	24.83	5.00	1.20	34.80	NA	NA	>1	Non Liquefiable
9.30	CI	29	18.80	8.80	98	0.93	171.06	171.06	167.70	0.15	0.76	1.06	23.50	5.00	1.20	33.20	NA	NA	>1	Non Liquefiable
10.80	CI	22	18.80	8.80	81	0.89	199.26	199.26	180.90	0.15	0.71	1.06	16.52	5.00	1.20	24.82	0.29	0.34	2.26	Non Liquefiable
12.30	SM	25	18.80	8.80	44	0.85	227.46	227.46	194.10	0.15	0.63	1.06	16.78	5.00	1.20	25.13	NA	NA	>1	Non Liquefiable
13.80	SM	30	18.80	8.80	34	0.81	255.66	249.66	207.30	0.15	0.60	1.06	18.93	4.93	1.19	27.42	0.35	0.42	2.70	Non Liquefiable
15.30	CH	29	18.80	8.80	89	0.77	283.86	262.86	220.50	0.15	0.57	1.06	17.66	5.00	1.20	26.20	0.32	0.38	2.47	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details		**Seimsmic Parameters**		**Parameters from SPT Boring**	
Location		Magnitude of Earthquake	7.0	Efficiency in SPT Boring (for C_E factor) "%" :	60
Structure @ Chainage	MJB @ 33+420	Design PGA	0.24 g	Borehole diameter (mm)	150
Borehole no :	BH 13	Importance Factor of the Structure	1	Was liner used in SPT boring	No
Water Table Depth (m)	2.10				
Water Table Depth considered (m)	0.00				

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o) at site, kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM	2	17.30	7.30	3	0.99	31.14	31.14	13.14	0.36	1.70	1.06	3.60	0.00	1.00	3.60	0.06	0.07	0.20	Liquefiable
3.3	CI-CH	3	17.30	7.30	91	0.97	57.09	45.09	24.09	0.36	1.49	1.06	4.74	5.00	1.20	10.68	0.12	0.14	0.39	Liquefiable
4.8	CI-CH	4	17.30	7.30	93	0.96	83.04	56.04	35.04	0.36	1.34	1.06	5.66	5.00	1.20	11.80	0.13	0.15	0.43	Liquefiable
6.3	CI-CH	2	17.40	7.40	90	0.95	109.14	67.14	46.14	0.35	1.22	1.06	2.59	5.00	1.20	8.10	0.10	0.12	0.33	Liquefiable
7.80	CI-CH	2	17.40	7.40	95	0.94	135.24	78.24	57.24	0.35	1.13	1.06	2.40	5.00	1.20	7.88	0.09	0.11	0.33	Liquefiable
9.30	SM	3	17.40	7.40	16	0.93	161.34	89.34	68.34	0.34	1.06	1.06	3.36	2.77	1.05	6.31	0.08	0.10	0.29	Liquefiable
10.80	SM	5	17.40	7.40	9	0.89	187.44	100.44	79.44	0.33	1.00	1.06	5.29	0.56	1.02	5.94	0.08	0.09	0.29	Liquefiable
12.30	SM	7	17.40	7.40	7	0.85	213.54	111.54	90.54	0.31	0.95	1.06	7.03	0.12	1.01	7.21	0.09	0.11	0.34	Liquefiable
13.80	SM	18	17.40	7.40	17	0.81	239.64	122.64	101.64	0.30	0.90	1.06	17.23	3.01	1.06	21.28	0.23	0.28	0.93	Liquefiable
15.30	CL-CI	34	17.40	7.40	83	0.77	265.74	133.74	112.74	0.28	0.86	1.06	31.16	5.00	1.20	42.40	NA	NA	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage: MJB @ 33+490

Borehole no : BH 14

Water Table Depth (m): 3.20

Water Table Depth considered (m): 0.00

Seimsmic Parameters

Magnitude of Earthquake: 7.00

Design PGA: 0.24 g

Importance Factor of the Structure: 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "?: 60

Borehole diameter (mm): 150

Was liner used in SPT boring: No

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	$C_{\delta 0}$	SPT $(N_1)_{\delta 0}$	α	β	SPT $(N_1)_{\delta 0 cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM	5	17.50	7.50	26	0.99	31.50	31.50	13.50	0.36	1.70	1.06	9.01	4.39	1.12	14.50	0.16	0.18	0.52	Liquefiable
3.3	SM	8	17.50	7.50	15	0.97	57.75	56.75	24.75	0.35	1.33	1.06	11.26	2.50	1.05	14.30	0.15	0.18	0.51	Liquefiable
4.8	CH	11	17.50	7.50	98	0.96	84.00	68.00	36.00	0.35	1.21	1.06	14.14	5.00	1.20	21.97	0.24	0.29	0.82	Liquefiable
6.3	CH	18	18.40	8.40	96	0.95	111.60	80.60	48.60	0.34	1.11	1.06	21.25	5.00	1.20	30.50	NA	NA	>1	Non Liquefiable
7.80	CH	13	18.40	8.40	96	0.94	139.20	93.20	61.20	0.33	1.04	1.06	14.27	5.00	1.20	22.13	0.24	0.29	0.87	Liquefiable
9.30	CH	17	18.60	8.60	98	0.93	167.10	106.10	74.10	0.33	0.97	1.06	17.49	5.00	1.20	25.99	0.31	0.37	1.15	Non Liquefiable
10.80	SM	22	18.60	8.60	11	0.89	195.00	119.00	87.00	0.31	0.92	1.06	21.38	1.21	1.03	23.15	0.26	0.31	1.00	Non Liquefiable
12.30	SM	27	18.60	8.60	20	0.85	222.90	131.90	99.90	0.29	0.87	1.06	24.92	3.61	1.08	30.51	NA	NA	>1	Non Liquefiable
13.80	SM	24	18.60	8.60	18	0.81	250.80	144.80	112.80	0.28	0.83	1.06	21.14	3.23	1.07	25.78	0.31	0.37	1.32	Non Liquefiable
15.30	SM	38	18.60	8.60	12	0.77	278.70	157.70	125.70	0.26	0.80	1.06	32.08	1.55	1.03	34.64	NA	NA	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details		**Seimsmic Parameters**		**Parameters from SPT Boring**	
Location		Magnitude of Earthquake	7.00	Efficiency in SPT Boring (for C_E factor) "%	60
Structure @ chainage	MJB @ 35+860	DesignPGA	0.24 g	Borehole diameter (mm)	150
Borehole no :	BH 15	Importance Factor of the Structure	1	Was liner used in SPT boring	No
Water Table Depth (m)	5.30				
Water Table Depth considered (m)	1.00				

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM	7	18.30	8.30	21	0.99	32.94	32.94	24.94	0.20	1.70	1.06	12.61	3.78	1.09	17.48	0.19	0.22	1.09	Non Liquefiable
3.3	SM	9	18.30	8.30	12	0.97	60.39	60.39	37.39	0.25	1.29	1.06	12.28	1.55	1.03	14.22	0.15	0.18	0.74	Liquefiable
4.8	SM	19	18.30	8.30	15	0.96	87.84	87.84	49.84	0.26	1.07	1.06	21.49	2.50	1.05	25.02	0.29	0.35	1.32	Non Liquefiable
6.3	SM	22	18.50	8.50	99	0.95	115.59	105.49	62.59	0.27	0.97	1.06	22.71	5.00	1.20	32.25	NA	NA	>1	Non Liquefiable
7.8	CI-CH	12	18.50	8.50	98	0.94	143.34	118.24	75.34	0.28	0.92	1.06	11.70	5.00	1.20	19.04	0.20	0.24	0.87	Liquefiable
9.3	CI-CH	29	18.60	8.60	94	0.93	171.24	131.14	88.24	0.28	0.87	1.06	26.84	5.00	1.20	37.21	NA	NA	>1	Non Liquefiable
10.8	CI-CH	16	18.60	8.60	98	0.89	199.14	144.04	101.14	0.27	0.83	1.06	14.13	5.00	1.20	21.96	0.24	0.29	1.06	Non Liquefiable
12.3	CI-CH	21	18.60	8.60	98	0.85	227.04	156.94	114.04	0.26	0.80	1.06	17.77	5.00	1.20	26.32	0.32	0.38	1.46	Non Liquefiable
13.8	SM	29	18.60	8.60	41	0.81	254.94	169.84	126.94	0.25	0.77	1.06	23.59	5.00	1.20	33.31	NA	NA	>1	Non Liquefiable
15.3	SM-ML	16	18.60	8.60	86	0.77	282.84	182.74	139.84	0.24	0.74	1.06	12.55	5.00	1.20	20.06	0.22	0.26	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location	
Structure @ Chainage	MNB @ 38+010
Borehole no :	BH 16
Water Table Depth (m)	8.75
Water Table Depth considered (m)	4.00

Seimsmic Parameters

Magnitude of Earthquake	7
Design PGA	0.24 g
Importance Factor of the Structure	1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "%	60
Borehole diameter (mm)	150
Was liner used in SPT boring	No

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o) at site, kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	$C_{\delta 0}$	SPT $(N_1)_{\delta 0}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	10	18.30	8.30	50	0.99	32.94	32.94	32.94	0.15	1.70	1.06	18.02	5.00	1.20	26.62	0.33	0.39	2.55	Non Liquefiable
3.3	SM-ML	4	18.30	8.30	60	0.97	60.39	60.39	60.39	0.15	1.29	1.06	5.46	5.00	1.20	11.55	0.13	0.15	1.00	Liquefiable
4.8	SM-ML	8	18.30	8.30	81	0.96	87.84	87.84	79.84	0.17	1.07	1.06	9.05	5.00	1.20	15.86	0.17	0.20	1.22	Non Liquefiable
6.3	SM-ML	4	18.30	8.30	91	0.95	115.29	100.29	92.29	0.19	1.00	1.06	4.23	5.00	1.20	10.08	0.11	0.14	0.73	Liquefiable
7.80	CI-CH	7	18.30	8.30	96	0.94	142.74	112.74	104.74	0.20	0.94	1.06	6.99	5.00	1.20	13.39	0.14	0.17	0.86	Liquefiable
9.30	CI-CH	13	18.60	8.60	97	0.93	170.64	164.53	117.64	0.21	0.78	1.06	10.74	5.00	1.20	17.89	0.19	0.23	1.09	Non Liquefiable
10.80	CI-CH	18	18.60	8.60	98	0.89	198.54	177.43	130.54	0.21	0.75	1.06	14.32	5.00	1.20	22.19	0.24	0.29	1.39	Non Liquefiable
12.30	CI-CH	15	18.60	8.60	98	0.85	226.44	190.33	143.44	0.21	0.72	1.06	11.53	5.00	1.20	18.83	0.20	0.24	1.15	Non Liquefiable
13.80	CI-CH	14	18.60	8.60	96	0.81	254.34	203.23	156.34	0.20	0.68	1.06	10.10	5.00	1.20	17.12	0.18	0.22	1.06	Non Liquefiable
15.30	CI-CH	17	19.80	9.80	98	0.77	284.04	217.93	171.04	0.20	0.65	1.06	11.73	5.00	1.20	19.08	0.20	0.24	1.23	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage : MJB @ 39+510

Borehole no : BH 17

Water Table Depth (m) 4.50

Water Table Depth considered (m) 0.00

Seimsmic Parameters

Magnitude of Earthquake 7

Design PGA 0.24 g

Importance Factor of the Structure 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) % 60

Borehole diameter (mm) 150

Was liner used in SPT boring No

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	5	17.50	7.50	99	0.99	32.30	32.30	14.30	0.35	1.70	1.06	9.01	5.00	1.20	15.81	0.17	0.20	0.58	Liquefiable
3.3	SM-ML	9	17.50	7.50	99	0.97	58.55	58.55	25.55	0.35	1.31	1.06	12.47	5.00	1.20	19.96	0.21	0.26	0.74	Liquefiable
4.8	SM-ML	7	17.50	7.50	90	0.96	84.80	81.80	36.80	0.35	1.11	1.06	8.20	5.00	1.20	14.84	0.16	0.19	0.55	Liquefiable
6.3	SM-ML	9	17.50	7.50	96	0.95	111.05	93.05	48.05	0.34	1.04	1.06	9.89	5.00	1.20	16.87	0.18	0.21	0.62	Liquefiable
7.80	SM-ML	11	17.50	7.50	99	0.94	137.30	104.30	59.30	0.34	0.98	1.06	11.42	5.00	1.20	18.70	0.20	0.24	0.70	Liquefiable
9.30	SM-ML	10	17.60	7.60	98	0.93	163.70	115.70	70.70	0.33	0.93	1.06	9.85	5.00	1.20	16.83	0.18	0.21	0.64	Liquefiable
10.80	SM-ML	14	17.60	7.60	95	0.89	190.10	127.10	82.10	0.32	0.89	1.06	13.16	5.00	1.20	20.80	0.23	0.27	0.84	Liquefiable
12.30	SM-ML	17	17.60	7.60	95	0.85	216.50	138.50	93.50	0.31	0.85	1.06	15.31	5.00	1.20	23.37	0.26	0.31	1.03	Non Liquefiable
13.80	SM	29	17.60	7.60	38	0.81	242.90	149.90	104.90	0.29	0.82	1.06	25.11	5.00	1.20	35.13	NA	NA	>1	Non Liquefiable
15.30	SM	33	17.60	7.60	46	0.77	269.30	161.30	116.30	0.28	0.79	1.06	27.54	5.00	1.20	38.05	NA	NA	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage : MJB @ 39+690

Borehole no : BH 18

Water Table Depth (m) 4.50

Water Table Depth considered (m) 0.00

Seimsmic Parameters

Magnitude of Earthquake 7

Design PGA 0.24 g

Importance Factor of the Structure 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "%" : 60

Borehole diameter (mm) 150

Was liner used in SPT boring No

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	Cl	6	18.20	8.20	93	0.99	32.76	32.76	14.76	0.34	1.70	1.06	10.81	5.00	1.20	17.97	0.19	0.23	0.67	Liquefiable
3.3	Cl	10	18.20	8.20	97	0.97	60.06	60.06	27.06	0.34	1.29	1.06	13.68	5.00	1.20	21.41	0.23	0.28	0.83	Liquefiable
4.8	Cl	13	18.20	8.20	92	0.96	87.36	84.36	39.36	0.33	1.09	1.06	15.00	5.00	1.20	23.00	0.26	0.31	0.92	Liquefiable
6.3	SM-ML	15	18.20	8.20	75	0.95	114.66	96.66	51.66	0.33	1.02	1.06	16.17	5.00	1.20	24.41	0.28	0.33	1.02	Non Liquefiable
7.80	SM-ML	23	18.20	8.20	72	0.94	141.96	108.96	63.96	0.33	0.96	1.06	23.36	5.00	1.20	33.03	NA	NA	>1	Non Liquefiable
9.30	SM	27	18.30	8.30	46	0.93	169.41	121.41	76.41	0.32	0.91	1.06	25.97	5.00	1.20	36.17	NA	NA	>1	Non Liquefiable
10.80	SM	24	18.30	8.30	31	0.89	196.86	133.86	88.86	0.31	0.86	1.06	21.99	4.77	1.16	30.33	NA	NA	>1	Non Liquefiable
12.30	SM	31	18.30	8.30	26	0.85	224.31	146.31	101.31	0.29	0.83	1.06	27.17	4.39	1.12	34.88	NA	NA	>1	Non Liquefiable
13.80	SM	24	20.30	10.30	26	0.81	254.76	161.76	116.76	0.27	0.79	1.06	20.00	4.39	1.12	26.84	0.33	0.40	1.45	Non Liquefiable
15.30	SM-ML	17	20.30	10.30	55	0.77	285.21	177.21	132.21	0.26	0.75	1.06	13.54	5.00	1.20	21.24	0.23	0.28	1.07	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details		**Seimsmic Parameters**		**Parameters from SPT Boring**	
Location		Magnitude of Earthquake	7.0	Efficiency in SPT Boring (for C_E factor) "%" :	60
Structure @ Chainage	VUP @ 40+940	Design PGA	0.24 g	Borehole diameter (mm)	150
Borehole no :	BH 19	Importance Factor of the Structure	1	Was liner used in SPT boring	No
Water Table Depth (m)	11.80				
Water Table Depth considered (m)	7.00				

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o) at site, kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	Cl	7	17.80	7.80	86	0.99	32.04	32.04	32.04	0.15	1.70	1.06	12.61	5.00	1.20	20.14	0.22	0.26	1.68	Non Liquefiable
3.3	Cl	7	17.80	7.80	91	0.97	58.74	58.74	58.74	0.15	1.30	1.06	9.68	5.00	1.20	16.62	0.18	0.21	1.39	Non Liquefiable
4.8	Cl	9	17.80	7.80	89	0.96	85.44	85.44	85.44	0.15	1.08	1.06	10.32	5.00	1.20	17.39	0.19	0.22	1.47	Non Liquefiable
6.3	Cl	11	18.20	8.20	92	0.95	112.74	112.74	112.74	0.15	0.94	1.06	10.98	5.00	1.20	18.18	0.19	0.23	1.56	Non Liquefiable
7.80	Cl	24	18.20	8.20	89	0.94	140.04	140.04	132.04	0.16	0.85	1.06	21.50	5.00	1.20	30.80	NA	NA	>1	Non Liquefiable
9.30	SM-ML	40	19.10	9.10	60	0.93	168.69	168.69	145.69	0.17	0.77	1.06	32.65	5.00	1.20	44.17	NA	NA	>1	Non Liquefiable
10.80	SM	37	19.10	9.10	42	0.89	197.34	197.34	159.34	0.17	0.71	1.06	27.92	5.00	1.20	38.50	NA	NA	>1	Non Liquefiable
12.30	SM	31	19.10	9.10	36	0.85	225.99	220.99	172.99	0.17	0.65	1.06	21.20	5.00	1.20	30.44	NA	NA	>1	Non Liquefiable
13.80	SM	35	19.10	9.10	18	0.81	254.64	234.64	186.64	0.17	0.62	1.06	23.01	3.23	1.07	27.78	0.36	0.43	2.52	Non Liquefiable
15.30	SM	36	19.10	9.10	35	0.77	283.29	248.29	200.29	0.17	0.60	1.06	22.80	5.00	1.20	32.35	NA	NA	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage: MJB @ 42+550

Borehole no : BH 20

Water Table Depth (m): 3.35

Water Table Depth considered (m): 0.00

Seimsmic Parameters

Magnitude of Earthquake: 7.00

Design PGA: 0.24 g

Importance Factor of the Structure: 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "?: 60

Borehole diameter (mm): 150

Was liner used in SPT boring: No

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM	7	18.10	8.10	17	0.99	32.58	32.58	14.58	0.34	1.70	1.06	12.61	3.01	1.06	16.38	0.17	0.21	0.60	Liquefiable
3.3	SM	10	18.10	8.10	24	0.97	59.73	59.73	26.73	0.34	1.29	1.06	13.72	4.18	1.11	19.37	0.21	0.25	0.73	Liquefiable
4.8	SM	12	18.10	8.10	12	0.96	86.88	72.38	38.88	0.34	1.18	1.06	14.95	1.55	1.03	16.98	0.18	0.22	0.64	Liquefiable
6.3	SM-ML	12	18.40	8.40	92	0.95	114.48	84.98	51.48	0.33	1.08	1.06	13.80	5.00	1.20	21.56	0.24	0.28	0.85	Liquefiable
7.80	SM-ML	14	18.40	8.40	87	0.94	142.08	97.58	64.08	0.33	1.01	1.06	15.02	5.00	1.20	23.03	0.26	0.31	0.94	Liquefiable
9.30	SM-ML	23	18.40	8.40	66	0.93	169.68	110.18	76.68	0.32	0.95	1.06	23.23	5.00	1.20	32.87	NA	NA	>1	Non Liquefiable
10.80	SM-ML	21	18.60	8.60	78	0.89	197.58	123.08	89.58	0.30	0.90	1.06	20.06	5.00	1.20	29.08	0.41	0.49	1.62	Non Liquefiable
12.30	SM	27	18.60	8.60	32	0.85	225.48	135.98	102.48	0.29	0.86	1.06	24.54	4.83	1.17	33.57	NA	NA	>1	Non Liquefiable
13.80	SM	25	18.60	8.60	27	0.81	253.38	148.88	115.38	0.28	0.82	1.06	21.72	4.48	1.13	29.03	0.41	0.49	1.78	Non Liquefiable
15.30	SM	32	18.60	8.60	16	0.77	281.28	161.78	128.28	0.26	0.79	1.06	26.67	2.77	1.05	30.88	NA	NA	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location	
Structure @ chainage	FLYOVER @ 43+910
Borehole no :	BH 21
Water Table Depth (m)	10.25
Water Table Depth considered (m)	6.00

Seimsmic Parameters

Magnitude of Earthquake	7.00
DesignPGA	0.24 g
Importance Factor of the Structure	1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "%	60
Borehole diameter (mm)	150
Was liner used in SPT boring	No

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	6	18.10	8.10	82	0.99	32.58	32.58	32.58	0.15	1.70	1.06	10.81	5.00	1.20	17.97	0.19	0.23	1.48	Non Liquefiable
3.3	SM-ML	7	18.10	8.10	84	0.97	59.73	59.73	59.73	0.15	1.29	1.06	9.60	5.00	1.20	16.52	0.18	0.21	1.38	Non Liquefiable
4.8	SM-ML	7	18.10	8.10	96	0.96	86.88	86.88	86.88	0.15	1.07	1.06	7.96	5.00	1.20	14.55	0.16	0.19	1.24	Non Liquefiable
6.3	CI	10	18.30	8.30	95	0.95	114.33	114.33	111.09	0.15	0.94	1.06	9.91	5.00	1.20	16.90	0.18	0.21	1.40	Non Liquefiable
7.8	CI	11	18.30	8.30	93	0.94	141.78	141.78	123.54	0.17	0.84	1.06	9.79	5.00	1.20	16.75	0.18	0.21	1.26	Non Liquefiable
9.3	SM-ML	21	18.30	8.30	91	0.93	169.23	169.23	135.99	0.18	0.77	1.06	17.11	5.00	1.20	25.53	0.30	0.36	2.01	Non Liquefiable
10.8	SM	20	18.60	8.60	45	0.89	197.13	191.35	148.89	0.18	0.72	1.06	15.33	5.00	1.20	23.39	0.26	0.31	1.72	Non Liquefiable
12.3	SM	29	18.60	8.60	33	0.85	225.03	204.25	161.79	0.18	0.68	1.06	20.86	4.88	1.18	29.48	0.44	0.52	2.83	Non Liquefiable
13.8	SM-ML	25	18.60	8.60	51	0.81	252.93	217.15	174.69	0.18	0.65	1.06	17.29	5.00	1.20	25.75	0.31	0.37	2.02	Non Liquefiable
15.3	CI	20	18.60	8.60	84	0.77	280.83	230.05	187.59	0.18	0.63	1.06	13.32	5.00	1.20	20.99	0.23	0.27	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details		**Seimsmic Parameters**		**Parameters from SPT Boring**	
Location		Magnitude of Earthquake	7	Efficiency in SPT Boring (for C_E factor) "%	60
Structure @ Chainage	MJB @ 47+950	Design PGA	0.24 g	Borehole diameter (mm)	150
Borehole no :	BH 22	Importance Factor of the Structure	1	Was liner used in SPT boring	No
Water Table Depth (m)	3.80				
Water Table Depth considered (m)	0.00				

Depth below EGL, m	Type of Strata	Field SPT N $_{Field}$	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o) at site, kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	$C_{\delta 0}$	SPT $(N_1)_{\delta 0}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	15	18.30	8.30	65	0.99	32.94	32.94	14.94	0.34	1.70	1.06	27.03	5.00	1.20	37.44	NA	NA	>1	Non Liquefiable
3.3	SM	24	18.30	8.30	20	0.97	60.39	60.39	27.39	0.34	1.29	1.06	32.74	3.61	1.08	38.95	NA	NA	>1	Non Liquefiable
4.8	SM-ML	10	18.30	8.30	84	0.96	87.84	87.84	39.84	0.33	1.07	1.06	11.31	5.00	1.20	18.57	0.20	0.24	0.71	Liquefiable
6.3	CI-CH	13	18.30	8.30	97	0.95	115.29	115.29	52.29	0.33	0.93	1.06	12.83	5.00	1.20	20.40	0.22	0.26	0.80	Liquefiable
7.80	CI-CH	16	18.30	8.30	92	0.94	142.74	142.74	64.74	0.32	0.84	1.06	14.20	5.00	1.20	22.03	0.24	0.29	0.89	Liquefiable
9.30	SM-ML	20	18.60	8.60	93	0.93	170.64	170.64	77.64	0.32	0.77	1.06	16.23	5.00	1.20	24.47	0.28	0.34	1.06	Non Liquefiable
10.80	SM-ML	19	18.60	8.60	95	0.89	198.54	183.54	90.54	0.30	0.74	1.06	14.87	5.00	1.20	22.84	0.25	0.30	1.00	Non Liquefiable
12.30	SM-ML	16	18.60	8.60	96	0.85	226.44	196.44	103.44	0.29	0.71	1.06	12.10	5.00	1.20	19.52	0.21	0.25	0.87	Liquefiable
13.80	SM-ML	18	18.60	8.60	98	0.81	254.34	209.34	116.34	0.27	0.67	1.06	12.75	5.00	1.20	20.29	0.22	0.26	0.95	Liquefiable
15.30	SM-ML	27	19.80	9.80	95	0.77	284.04	224.04	131.04	0.26	0.64	1.06	18.30	5.00	1.20	26.96	0.34	0.40	1.55	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details		**Seimsmic Parameters**		**Parameters from SPT Boring**	
Location		Magnitude of Earthquake	7	Efficiency in SPT Boring (for C_E factor) "%	60
Structure @ Chainage :	FLYOVER @ 49+900	Design PGA	0.24 g	Borehole diameter (mm)	150
Borehole no :	BH 23	Importance Factor of the Structure	1	Was liner used in SPT boring	No
Water Table Depth (m)	9.80				
Water Table Depth considered (m)	5.00				

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	11	17.50	7.50	99	0.99	32.30	32.30	32.30	0.15	1.70	1.06	19.82	5.00	1.20	28.79	0.40	0.48	3.10	Non Liquefiable
3.3	Cl	6	17.50	7.50	99	0.97	58.55	58.55	58.55	0.15	1.31	1.06	8.31	5.00	1.20	14.97	0.16	0.19	1.25	Non Liquefiable
4.8	Cl	10	17.50	7.50	90	0.96	84.80	84.80	84.80	0.15	1.09	1.06	11.51	5.00	1.20	18.81	0.20	0.24	1.60	Non Liquefiable
6.3	SM	12	17.50	7.50	96	0.95	111.05	111.05	98.05	0.17	0.95	1.06	12.07	5.00	1.20	19.48	0.21	0.25	1.48	Non Liquefiable
7.80	SM	18	17.50	7.50	99	0.94	137.30	137.30	109.30	0.18	0.85	1.06	16.28	5.00	1.20	24.54	0.28	0.34	1.83	Non Liquefiable
9.30	SM	21	17.60	7.60	98	0.93	163.70	163.70	120.70	0.20	0.78	1.06	17.40	5.00	1.20	25.88	0.31	0.37	1.89	Non Liquefiable
10.80	SM	20	17.60	7.60	95	0.89	190.10	180.10	132.10	0.20	0.75	1.06	15.80	5.00	1.20	23.96	0.27	0.33	1.64	Non Liquefiable
12.30	SM	31	17.60	7.60	95	0.85	216.50	191.50	143.50	0.20	0.72	1.06	23.75	5.00	1.20	33.49	NA	NA	>1	Non Liquefiable
13.80	SM	28	17.60	7.60	38	0.81	242.90	202.90	154.90	0.20	0.68	1.06	20.22	5.00	1.20	29.27	0.42	0.51	2.56	Non Liquefiable
15.30	SM	32	17.60	7.60	46	0.77	269.30	214.30	166.30	0.19	0.66	1.06	22.32	5.00	1.20	31.79	NA	NA	>1	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details

Location

Structure @ Chainage : MJB @ 39+690

Borehole no : BH 18

Water Table Depth (m) 4.50

Water Table Depth considered (m) 0.00

Seimsmic Parameters

Magnitude of Earthquake 7

Design PGA 0.24 g

Importance Factor of the Structure 1

Parameters from SPT Boring

Efficiency in SPT Boring (for C_E factor) "%" : 60

Borehole diameter (mm) 150

Was liner used in SPT boring No

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o), kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	Cl	6	18.20	8.20	93	0.99	32.76	32.76	14.76	0.34	1.70	1.06	10.81	5.00	1.20	17.97	0.19	0.23	0.67	Liquefiable
3.3	Cl	10	18.20	8.20	97	0.97	60.06	60.06	27.06	0.34	1.29	1.06	13.68	5.00	1.20	21.41	0.23	0.28	0.83	Liquefiable
4.8	Cl	13	18.20	8.20	92	0.96	87.36	84.36	39.36	0.33	1.09	1.06	15.00	5.00	1.20	23.00	0.26	0.31	0.92	Liquefiable
6.3	SM-ML	15	18.20	8.20	75	0.95	114.66	96.66	51.66	0.33	1.02	1.06	16.17	5.00	1.20	24.41	0.28	0.33	1.02	Non Liquefiable
7.80	SM-ML	23	18.20	8.20	72	0.94	141.96	108.96	63.96	0.33	0.96	1.06	23.36	5.00	1.20	33.03	NA	NA	>1	Non Liquefiable
9.30	SM	27	18.30	8.30	46	0.93	169.41	121.41	76.41	0.32	0.91	1.06	25.97	5.00	1.20	36.17	NA	NA	>1	Non Liquefiable
10.80	SM	24	18.30	8.30	31	0.89	196.86	133.86	88.86	0.31	0.86	1.06	21.99	4.77	1.16	30.33	NA	NA	>1	Non Liquefiable
12.30	SM	31	18.30	8.30	26	0.85	224.31	146.31	101.31	0.29	0.83	1.06	27.17	4.39	1.12	34.88	NA	NA	>1	Non Liquefiable
13.80	SM	24	20.30	10.30	26	0.81	254.76	161.76	116.76	0.27	0.79	1.06	20.00	4.39	1.12	26.84	0.33	0.40	1.45	Non Liquefiable
15.30	SM-ML	17	20.30	10.30	55	0.77	285.21	177.21	132.21	0.26	0.75	1.06	13.54	5.00	1.20	21.24	0.23	0.28	1.07	Non Liquefiable

Borelogs and Figures

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

Flyover @ CH 0+800
BH :1
Depth : 30.00m
Depth of Water table : 4.50 m

Date of start : 20/03/2021

Date of finish : 22/03/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	10 / 13	1	5	94				Non	Plastic					
	2.50	UDS						1.79	1.50	18.94				DST	0.14	25	
	3.30	SPT		5 / 5	0	57	43				Non	Plastic					
	4.80	SPT	Silty Sand with Gravel (SM)	8 / 8	0	68	32				Non	Plastic					
	5.50	UDS						1.74	1.43	21.32			2.65	DST		25	
	6.30	SPT		11 / 11	0	63	37				Non	Plastic					
	7.80	SPT		13 / 12	0	71	29				Non	Plastic					
	9.30	SPT		17 / 15	0	76	24				Non	Plastic					
	10.80	SPT		21 / 17	1	69	30				Non	Plastic					
	12.30	SPT		23 / 17	0	73	27				Non	Plastic					
	13.80	SPT		28 / 19	0	81	19				Non	Plastic					
	15.30	SPT	Silty Clay of Medium Plasticity (CI)	12 / 12	1	10	89										
	16.80	SPT		10 / 10	0	5	95				41	23					
	18.30	SPT	Sandy Silt with Gravel (SM-ML)	18 / 14	0	2	98				Non	Plastic					
	19.80	SPT		21 / 15	2	7	91				Non	Plastic					
	21.30	SPT	Silty Sand with Gravel (SM)	26 / 17	1	78	21				Non	Plastic					
	22.80	SPT		33 / 19	1	60	39				Non	Plastic					
	24.30	SPT	Sandy Silt with Gravel (SM-ML)	46 / 23	0	46	54				Non	Plastic					
	25.80	SPT		51 / 25	0	51	49				Non	Plastic					
	27.30	SPT	Silty Sand with Gravel (SM)	57 / 26	0	79	21				Non	Plastic					
	28.80	SPT		61 / 27	1	87	12				Non	Plastic					
	30.30	SPT		71 / 30	0	86	14				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

MJB @ CH 1+530
BH : 2
Depth : 30.00m
Depth of Water table : 2.70 m

Date of start : 21/03/2021

Date of finish : 23/03/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Sand with Gravel (SM)	5 / 6	0	71	29				Non	Plastic					
	2.50	UDS						2.50	2.09	19.86				DST		28	
	3.30	SPT		6 / 7	0	67	33				Non	Plastic					
	4.80	SPT	Sandy Silt with Gravel (SM-ML)	10 / 11	0	40	60				Non	Plastic					
	5.50	UDS						5.50	4.56	20.58			2.62	DST	0.12	29	
	6.30	SPT	Silty Sand with Gravel (SM)	13 / 14	0	67	33				Non	Plastic					
	7.80	SPT		15 / 15	0	54	46				Non	Plastic					
	8.50	UDS						8.50	7.10	19.79				DST		30	
	9.30	SPT		23 / 18	0	69	31				Non	Plastic					
	10.80	SPT		33 / 23	0	61	39				Non	Plastic					
	12.30	SPT		27 / 20	0	64	36				Non	Plastic					
	13.80	SPT		17 / 14	0	2	98				Non	Plastic					
	14.50	UDS						14.50	12.16	19.25			2.71	UU	1.18	4	
	15.30	SPT	Silty Clay of Low to Medium Plasticity (CL-CI)	21 / 21	0	1	99										
	16.80	SPT		24 / 24	2	7	91				38	21					
	18.30	SPT		22 / 22	0	1	99										
	19.80	SPT		27 / 27	0	5	95				44	27					
	21.30	SPT	Silty Sand with Gravel (SM)	33 / 20	1	82	17				Non	Plastic					
	22.80	SPT		38 / 21	1	68	31				Non	Plastic					
	24.30	SPT		43 / 23	1	74	25				Non	Plastic					
	25.80	SPT		53 / 26	1	68	31				Non	Plastic					
	27.30	SPT		48 / 24	1	75	24				Non	Plastic					
	28.80	SPT		58 / 27	1	80	19				Non	Plastic					
	30.30	SPT		67 / 29	0	69	31				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

VUP @ CH 6+380
BH :3
Depth : 20.00m
Depth of Water table : 13.80 m

Date of start : 24/03/2021

Date of finish : 25/03/2021

Project No. 2152

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	12 / 16	0	5	95				Non	Plastic					
	2.50	UDS						1.82	1.67	9.19				DST	0.14	29	
	3.30	SPT		9 / 10	0	14	86				Non	Plastic					
	4.80	SPT		13 / 13	0	8	92				Non	Plastic					
	5.50	UDS						1.85	1.68	10.34			2.61	DST	0.14	30	
	6.30	SPT		15 / 14	0	86	14				Non	Plastic					
	7.80	SPT	Silty Sand with Gravel (SM)	19 / 16	0	71	29				Non	Plastic					
	8.50	UDS						1.87	1.66	12.86			2.65	DST		32	
	9.30	SPT		24 / 19	0	71	29				Non	Plastic					
	10.80	SPT		31 / 24	1	77	22				Non	Plastic					
	12.30	SPT		27 / 19	0	72	28				Non	Plastic					
	13.80	SPT		35 / 24	0	72	28				Non	Plastic					
	15.30	SPT		52 / 25	1	57	42				Non	Plastic					
	16.80	SPT		47 / 23	0	72	28				Non	Plastic					
	18.30	SPT		57 / 26	0	69	31				Non	Plastic					
	20.30	SPT		61 / 26	0	75	25				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

Flyover @ CH 8+020
BH :5
Depth : 30.00m
Depth of Water table : 14.10 m

Date of start : 26/03/2021

Date of finish : 28/03/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	7 / 9	4	31	65				Non	Plastic					
	2.50	UDS						1.80	1.64	9.89			2.61	DST	0.15	29	
	3.30	SPT		10 / 11	2	27	71				Non	Plastic					
	4.80	SPT		12 / 12	2	24	74				Non	Plastic					
	5.50	UDS						1.83	1.64	11.45				DST	0.15	30	
	6.30	SPT		13 / 12	0	36	64				Non	Plastic					
	7.80	SPT	Silty Sand with Gravel (SM)	16 / 14	1	73	26				Non	Plastic					
	8.50	UDS						1.90	1.68	13.22				DST	0.15	32	
	9.30	SPT	Sandy Silt with Gravel (SM-ML)	42 / 34	4	5	91				Non	Plastic					
	10.80	SPT	Silty Clay of Medium Plasticity (CI)	32 / 32	1	11	88				40	22					
	11.50	UDS						1.90	1.63	16.56			2.71	UU	1.43	9	
	12.30	SPT	Sandy Silt with Gravel (SM-ML)	24 / 17	1	4	95				Non	Plastic					
	13.80	SPT	Silty Sand with Gravel (SM)	47 / 32	0	75	25				Non	Plastic					
	15.30	SPT		57 / 26	0	62	38				Non	Plastic					
	16.80	SPT		53 / 25	0	75	25				Non	Plastic					
	18.30	SPT		68 / 29	0	61	39				Non	Plastic					
	19.80	SPT		67 / 28	0	62	38				Non	Plastic					
	21.30	SPT		72 / 29	0	75	25				Non	Plastic					
	22.80	SPT		58 / 25	1	77	22				Non	Plastic					
	24.30	SPT		63 / 26	0	79	21				Non	Plastic					
	25.80	SPT		73 / 28	0	67	33				Non	Plastic					
	27.30	SPT		62 / 25	0	65	35				Non	Plastic					
	28.80	SPT		75 / 28	0	59	41				Non	Plastic					
	30.30	SPT		81 / 29	1	64	35				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

VUP @ CH 16+690
BH :6
Depth : 20.00m
Depth of Water table : 13.30 m

Date of start : 28/03/2021

Date of finish : 30/03/2021

Project No. 2152

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Clay of Medium Plasticity (CI)	11 / 11	0	14	86				47	23					
	2.50	UDS						1.84	1.63	12.86			2.74	UU	0.61	9	
	3.30	SPT		19 / 19	0	7	93										
	4.80	SPT	Sandy Silt with Gravel (SM-ML)	15 / 15	0	5	95				Non	Plastic					
	5.50	UDS						1.86	1.62	14.51			2.61	DST	0.14	30	
	6.30	SPT		24 / 23	0	68	32				Non	Plastic					
	7.80	SPT	Silty Sand with Gravel (SM)	15 / 13	0	69	31				Non	Plastic					
	9.30	SPT		25 / 20	0	65	35				Non	Plastic					
	10.80	SPT	Silty Clay of Medium Plasticity (CI)	29 / 29	0	3	97				43	22					
	12.30	SPT		32 / 32	0	3	97										
	13.80	SPT		34 / 34	0	4	96				44	23					
	15.30	SPT	Silty Sand with Gravel (SM)	38 / 20	1	79	20				Non	Plastic					
	16.80	SPT		44 / 22	1	75	24				Non	Plastic					
	18.30	SPT		47 / 22	0	74	26				Non	Plastic					
	20.30	SPT		39 / 20	0	72	28				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

MNB @ CH 21+810
BH :7
Depth : 20.00m
Depth of Water table : 11.30 m

Date of start : 31/03/2021

Date of finish : 01/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	6 / 8	1	17	82				Non	Plastic					
	2.50	UDS						1.79	1.58	13.21				DST	0.14	28	
	3.30	SPT		10 / 11	0	30	70				Non	Plastic					
	4.80	SPT		28 / 29	0	36	64				Non	Plastic					
	5.50	UDS						1.87	1.63	14.78			2.62	DST	0.12	31	
	6.30	SPT		31 / 29	0	42	58				Non	Plastic					
	7.80	SPT	Silty Sand with Gravel (SM)	18 / 15	0	52	48				Non	Plastic					
	8.50	UDS						1.82	1.56	16.82				DST	0.12	29	
	9.30	SPT		13 / 10	2	11	87				Non	Plastic					
	10.80	SPT	Sandy Silt with Gravel (SM-ML)	11 / 8	9	8	83				Non	Plastic					
	12.30	SPT		18 / 13	2	7	91				Non	Plastic					
	13.80	SPT		19 / 13	0	2	98				Non	Plastic					
	15.30	SPT		24 / 16	0	18	82				Non	Plastic					
	16.80	SPT		27 / 16	0	5	95				Non	Plastic					
	18.30	SPT		33 / 18	0	5	95				Non	Plastic					
	20.30	SPT		53 / 25	0	4	96				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

VUP @ CH 22+980
BH :8
Depth : 20.00m
Depth of Water table : 14.20 m

Date of start : 31/03/2021

Date of finish : 01/04/2021

Project No. 2152

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Clay of Medium Plasticity (CI)	18 / 18	1	15	84				40	25					
	2.50	UDS						1.90	1.71	11.42			2.71	UU	1.09	9	
	3.30	SPT		27 / 27	0	11	89										
	4.80	SPT		19 / 19	0	7	93				36	24					
	5.50	UDS						1.90	1.69	12.33			2.65	DST		31	
	6.30	SPT		32 / 30	0	70	30				Non	Plastic					
	7.80	SPT		30 / 26	0	80	20				Non	Plastic					
	8.50	UDS						1.88	1.62	15.86				DST		31	
	9.30	SPT		28 / 23	0	73	27				Non	Plastic					
	10.80	SPT	Silty Sand with Gravel (SM)	29 / 22	0	70	30				Non	Plastic					
	12.30	SPT		32 / 23	0	80	20				Non	Plastic					
	13.80	SPT		34 / 23	0	73	27				Non	Plastic					
	15.30	SPT		51 / 24	1	73	26				Non	Plastic					
	16.80	SPT		49 / 23	0	79	21				Non	Plastic					
	18.30	SPT		38 / 19	0	67	33				Non	Plastic					
	20.30	SPT		33 / 17	1	75	24				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

VUP @ CH 25+430
BH :9
Depth : 20.00m
Depth of Water table : 12.25 m

Date of start : 02/04/2021

Date of finish : 03/04/2021

Project No. 2152

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Clay of Medium Plasticity (CI)	8 / 8	0	5	95				46	22					
	2.50	UDS						1.82	1.61	12.89			2.71	UU	0.53	11	
	3.30	SPT		17 / 17	0	1	99										
	4.80	SPT		11 / 11	0	3	97				42	21					
	5.50	UDS	Sandy Silt with Gravel (SM-ML)					1.84	1.61	14.55			2.62	DST	0.14	30	
	6.30	SPT		21 / 20	5	8	87				Non	Plastic					
	7.80	SPT		25 / 22	1	10	89				Non	Plastic					
	8.50	UDS						1.82	1.55	17.43				DST	0.14	30	
	9.30	SPT		8 / 6	0	25	75				Non	Plastic					
	10.80	SPT		12 / 9	0	4	96				Non	Plastic					
	12.30	SPT	Silty Clay of Low Plasticity (CL)	18 / 18	0	13	87				33	18					
	13.80	SPT		19 / 19	0	2	98										
	15.30	SPT		22 / 15	0	4	96				Non	Plastic					
	16.80	SPT	Sandy Silt with Gravel (SM-ML)	23 / 15	2	8	90				Non	Plastic					
	18.30	SPT		33 / 18	1	46	53				Non	Plastic					
	20.30	SPT		53 / 24	0	49	51				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

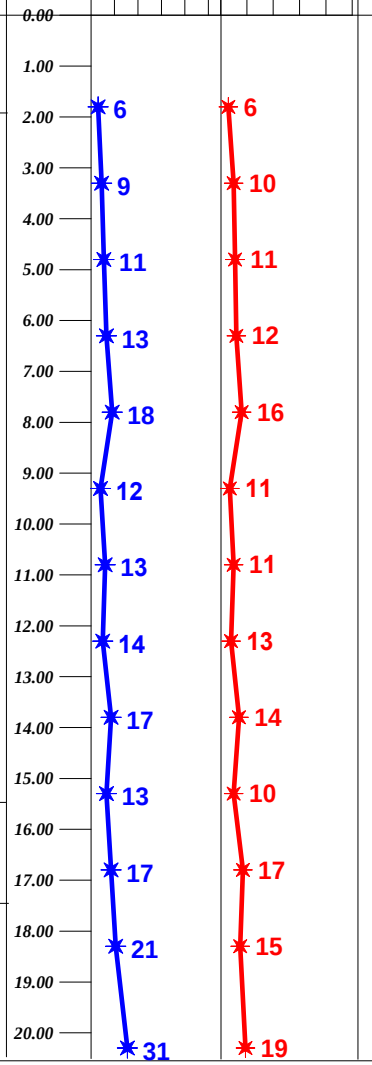
MNB @ CH 29+260
BH : 11
Depth : 20.00m
Depth of Water table : 5.50 m

Date of start : 04/04/2021

Date of finish : 05/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Clay of High Plasticity (CH)	2	18	80				54	36					
	2.50	UDS					1.80	1.55	15.93			2.61	DST	0.14	28	
	3.30	SPT		0	14	86				Non	Plastic					
	4.80	SPT		1	22	77				Non	Plastic					
	5.50	UDS					1.83	1.51	21.55				DST	0.1	29	
	6.30	SPT		2	14	84				Non	Plastic					
	7.80	SPT		1	16	83				Non	Plastic					
	8.50	UDS					1.82	1.52	19.76				DST	0.1	29	
	9.30	SPT		0	28	72				Non	Plastic					
	10.80	SPT	Sandy Silt with Gravel (SM-ML)	0	7	93				Non	Plastic					
	12.30	SPT		1	6	93				Non	Plastic					
	13.80	SPT		0	6	94				Non	Plastic					
	15.30	SPT		0	3	97				Non	Plastic					
	16.80	SPT	Silty Clay of Medium Plasticity (CI)	0	1	99				42	23					
	18.30	SPT	Sandy Silt with Gravel (SM-ML)	0	7	93				Non	Plastic					
	20.30	SPT		0	7	93				Non	Plastic					

S.P.T Plot



BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

Flyover @ CH 32+170
BH : 12
Depth : 30.00m
Depth of Water table : 13.20 m

Date of start : 06/04/2021

Date of finish : 07/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM)	18 / 24	0	24	76				Non	Plastic					
	2.50	UDS	Silty Sand with Gravel (SM)					1.82	1.64	10.32			2.65	DST		29	
	3.30	SPT		9 / 10	0	73	27				Non	Plastic					
	4.80	SPT	Silty Clay of Medium Plasticity (CI)	19 / 19	4	32	64				32	19					
	5.50	UDS						1.85	1.65	11.45				UU	0.81	9	
	6.30	SPT		23 / 23	0	2	98										
	7.80	SPT		28 / 28	0	4	96				44	20					
	8.50	UDS						1.88	1.63	14.76			2.71	UU	1.43	9	
	9.30	SPT		29 / 29	0	2	98										
	10.80	SPT		22 / 22	2	17	81				39	21					
	12.30	SPT	Silty Sand with Gravel (SM)	25 / 18	0	56	44				Non	Plastic					
	13.80	SPT		30 / 18	0	66	34				Non	Plastic					
	14.50	UDS						1.88	1.55	20.91			2.65	DST		30	
	15.30	SPT	Silty Clay of High Plasticity (CH)	29 / 29	0	11	89										
	16.80	SPT		26 / 26	0	1	99										
	18.30	SPT		27 / 27	0	2	98				76	33					
	19.80	SPT		30 / 30	0	3	97										
	21.30	SPT		28 / 28	0	2	98										
	22.80	SPT		22 / 22	0	1	99										
	24.30	SPT		24 / 24	0	1	99				63	32					
	25.80	SPT		25 / 25	1	3	96										
	27.30	SPT		31 / 31	0	2	98										
	28.80	SPT		34 / 34	1	17	82				53	28					
	30.30	SPT		35 / 35	1	10	89										

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

MJB @ CH 33+420
BH : 13
Depth : 30.00m
Depth of Water table : 2.10m

Date of start : 06/04/2021

Date of finish : 08/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Sand with Gravel (SM)	2 / 2	0	97	3				Non	Plastic					
	2.50	UDS						1.73	1.42	21.55				DST	0.1	26	
	3.30	SPT	Silty Clay of Medium to High Plasticity (CI-CH)	3 / 3	0	9	91				39	21					
	4.80	SPT		4 / 4	1	6	93										
	5.50	UDS						1.74	1.44	20.88				UU	0.18	2	
	6.30	SPT		2 / 2	2	8	90				48	23					
	7.80	SPT		2 / 2	1	4	95										
	8.50	UDS						1.74	1.46	19.32				DST		26	
	9.30	SPT	Silty Sand with Gravel (SM)	3 / 3	3	81	16				Non	Plastic					
	10.80	SPT		5 / 4	0	91	9				Non	Plastic					
	12.30	SPT		7 / 6	0	93	7				Non	Plastic					
	13.80	SPT		18 / 15	0	83	17				Non	Plastic					
	15.30	SPT	Silty Clay of Low to Medium Plasticity (CL-CI)	34 / 34	0	17	83										
	16.80	SPT		36 / 36	0	2	98				47	22					
	18.30	SPT		41 / 41	0	1	99										
	19.80	SPT		37 / 37	0	2	98				39	20					
	21.30	SPT		40 / 40	0	1	99										
	22.80	SPT	Silty Sand with Gravel (SM)	35 / 20	1	54	45				Non	Plastic					
	24.30	SPT		38 / 21	0	79	21				Non	Plastic					
	25.80	SPT		42 / 22	0	94	6				Non	Plastic					
	27.30	SPT		47 / 24	0	84	16				Non	Plastic					
	28.80	SPT		56 / 26	0	83	17				Non	Plastic					
	30.30	SPT		52 / 25	0	83	17				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

MJB @ CH 33+490
BH : 14
Depth : 30.00m
Depth of Water table : 3.20 m

Date of start : 09/04/2021

Date of finish : 10/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Sand with Gravel (SM)	5 / 6	0	74	26				Non	Plastic					
	2.50	UDS						1.75	1.49	17.51				DST		27	
	3.30	SPT		8 / 9	0	85	15				Non	Plastic					
	4.80	SPT	Silty Clay of High Plasticity (CH)	11 / 11	0	2	98				58	27					
	5.50	UDS						1.84	1.53	20.36				UU	0.74	2	
	6.30	SPT		18 / 18	1	3	96										
	7.80	SPT		13 / 13	0	4	96				54	25					
	8.50	UDS						1.86	1.55	20.09				UU	0.86	3	
	9.30	SPT		17 / 17	0	2	98										
	10.80	SPT	Silty Sand with Gravel (SM)	22 / 17	1	88	11				Non	Plastic					
	12.30	SPT		27 / 19	0	80	20				Non	Plastic					
	13.80	SPT		24 / 18	0	82	18				Non	Plastic					
	15.30	SPT		38 / 23	0	88	12				Non	Plastic					
	16.80	SPT		31 / 20	0	90	10				Non	Plastic					
	18.30	SPT	Silty Clay of High Plasticity (CI)	28 / 28	0	2	98										
	19.80	SPT		32 / 32	1	5	94				55	23					
	21.30	SPT		41 / 41	0	4	96										
	22.80	SPT		39 / 39	1	2	97				51	22					
	24.30	SPT	Silty Sand with Gravel (SM)	48 / 24	0	83	17				Non	Plastic					
	25.80	SPT		52 / 25	0	86	14				Non	Plastic					
	27.30	SPT		55 / 26	0	79	21				Non	Plastic					
	28.80	SPT		62 / 28	0	84	16				Non	Plastic					
	30.30	SPT		67 / 29	0	75	25				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

MJB @ CH 35+860
BH : 15
Depth : 30.00m
Depth of Water table : 5.30 m

Date of start : 09/04/2021

Date of finish : 10/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Sand with Gravel (SM)	7 / 9	0	79	21				Non	Plastic					
	2.50	UDS						1.83	1.58	15.86				DST		29	
	3.30	SPT		9 / 10	0	88	12				Non	Plastic					
	4.80	SPT		19 / 19	0	85	15				Non	Plastic					
	5.50	UDS						1.85	1.53	20.93				DST		30	
	6.30	SPT		22 / 18	0	1	99				Non	Plastic					
	7.80	SPT	Silty Clay of Medium to High Plasticity (CI-CH)	12 / 12	0	2	98				52	24					
	8.50	UDS						1.86	1.56	19.45				UU	0.71	4	
	9.30	SPT		29 / 29	1	5	94										
	10.80	SPT		10 / 10	0	2	98				60	27					
	12.30	SPT		21 / 21	0	2	98										
	13.80	SPT	Silty Sand with Gravel (SM)	29 / 19	1	58	41				Non	Plastic					
	15.30	SPT	Sandy Silt with Gravel (SM-ML)	16 / 13	0	14	86				Non	Plastic					
	16.80	SPT	Silty Clay of Low to Medium Plasticity (CL-CI)	18 / 18	0	4	96										
	18.30	SPT		20 / 20	1	3	96				61	26					
	19.80	SPT		19 / 19	1	3	96										
	21.30	SPT		29 / 29	1	4	95										
	22.80	SPT	Sandy Silt with Gravel (SM-ML)	24 / 16	3	10	87				Non	Plastic					
	24.30	SPT		24 / 15	3	13	84				Non	Plastic					
	25.80	SPT		27 / 16	5	12	83				Non	Plastic					
	27.30	SPT		25 / 15	0	6	94				Non	Plastic					
	28.80	SPT	Silty Sand with Gravel (SM)	44 / 21	1	63	36				Non	Plastic					
	30.30	SPT	Sandy Silt with Gravel (SM-ML)	33 / 18	5	10	85				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

MNB @ CH 38+010
BH : 16
Depth : 20.00m
Depth of Water table : 8.75 m

Date of start : 12/04/2021

Date of finish : 13/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	10 / 13	0	50	50				Non	Plastic					
	2.50	UDS						1.75	1.51	15.86				DST	0.13	26	
	3.30	SPT		4 / 4	1	39	60				Non	Plastic					
	4.80	SPT	Silty Sand with Gravel (SM)	8 / 8	1	18	81				Non	Plastic					
	5.50	UDS						1.77	1.51	17.21				DST		28	
	6.30	SPT		4 / 4	1	8	91				52	23					
	7.80	SPT		7 / 7	0	4	96										
	8.50	UDS						1.80	1.48	21.64				UU	0.23	4	
	9.30	SPT		13 / 13	0	3	97				66	28					
	10.80	SPT		18 / 18	0	2	98										
	12.30	SPT	Silty Clay of Medium to High Plasticity (CI-CH)	15 / 15	0	2	98				56	27					
	13.80	SPT		14 / 14	1	3	96										
	15.30	SPT		17 / 17	0	2	98				55	25					
	16.80	SPT		22 / 22	0	4	96										
	18.30	SPT		19 / 19	0	6	94										
	20.30	SPT		26 / 26	0	2	98				54	25					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

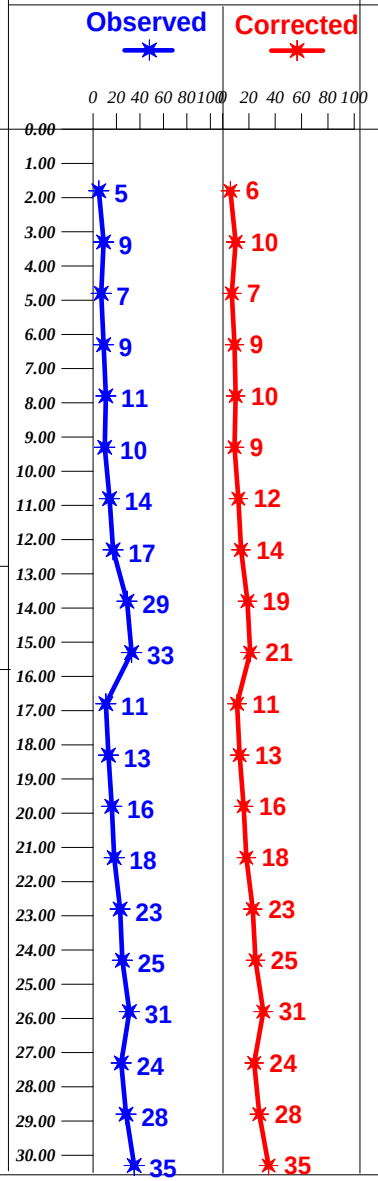
Project No. 2152

MJB @ CH 39+510
BH : 17
Depth : 30.00m
Depth of Water table : 4.50 m

Date of start : 12/04/2021

Date of finish : 13/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	0	1	99				Non	Plastic					
	2.50	UDS					1.75	1.51	15.68				DST	0.13	28	
	3.30	SPT		0	1	99				Non	Plastic					
	4.80	SPT		0	10	90				Non	Plastic					
	5.50	UDS					1.75	1.45	21.04			2.61	DST	0.1	28	
	6.30	SPT		0	4	96				Non	Plastic					
	7.80	SPT		0	1	99				Non	Plastic					
	8.50	UDS					1.76	1.46	20.59				DST	0.1	29	
	9.30	SPT		0	2	98				Non	Plastic					
	10.80	SPT		0	5	95				Non	Plastic					
	12.30	SPT		0	5	95				Non	Plastic					
	13.80	SPT	Silty Sand with Gravel (SM)	0	62	38				Non	Plastic					
	15.30	SPT		0	54	46				Non	Plastic					
	16.80	SPT	Silty Clay of High Plasticity (CH)	0	2	98				57	27					
	18.30	SPT		0	1	99										
	19.80	SPT		0	2	98				57	28					
	21.30	SPT		0	1	99										
	22.80	SPT		2	7	91										
	24.30	SPT		1	3	96				64	31					
	25.80	SPT		1	6	93										
	27.30	SPT		2	2	96										
	28.80	SPT		1	5	94				54	27					
	30.30	SPT		4	15	81										



BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

MJB @ CH 39+690
BH : 18
Depth : 30.00m
Depth of Water table : 4.50 m

Date of start : 14/04/2021

Date of finish : 16/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Clay of Medium Plasticity (CI)	6 / 6	0	7	93				50	23					
	2.50	UDS						1.79	1.53	16.89				UU	0.28	8	
	3.30	SPT		10 / 10	0	3	97										
	4.80	SPT		13 / 13	0	8	92				51	24					
	5.50	UDS	Sandy Silt with Gravel (SM-ML)					1.84	1.52	21.32				DST	0.1	30	
	6.30	SPT		15 / 15	0	25	75				Non	Plastic					
	7.80	SPT		23 / 18	0	28	72				Non	Plastic					
	8.50	UDS						1.86	1.54	20.53				DST	0.1	30	
	9.30	SPT		27 / 20	0	54	46				Non	Plastic					
	10.80	SPT	Silty Sand with Gravel (SM)	24 / 18	0	69	31				Non	Plastic					
	12.30	SPT		31 / 21	1	73	26				Non	Plastic					
	13.80	SPT		24 / 17	0	74	26				Non	Plastic					
	15.30	SPT		17 / 14	0	45	55				Non	Plastic					
	16.80	SPT	Sandy Silt with Gravel (SM-ML)	21 / 15	0	3	97				Non	Plastic					
	18.30	SPT		20 / 15	0	2	98				Non	Plastic					
	19.80	SPT		23 / 23	0	3	97				53	25					
	21.30	SPT	Silty Clay of Medium Plasticity (CI)	25 / 25	1	4	95										
	22.80	SPT		28 / 28	0	12	88				51	23					
	24.30	SPT		23 / 15	1	40	59				Non	Plastic					
	25.80	SPT	Sandy Silt with Gravel (SM-ML)	19 / 13	0	44	56				Non	Plastic					
	27.30	SPT		27 / 16	0	49	51				Non	Plastic					
	28.80	SPT	Silty Clay of Medium Plasticity (CI)	29 / 29	0	2	98				65	27					
	30.30	SPT		37 / 37	15	9	76										

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

VUP @ CH 40+940
BH : 19
Depth : 20.00m
Depth of Water table : 11.80 m

Date of start : 14/04/2021

Date of finish : 15/04/2021

Project No. 2152

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Clay of Medium Plasticity (CI)	7 / 7	0	14	86				39	21					
	2.50	UDS						1.78	1.61	10.45			2.75	UU	0.41	9	
	3.30	SPT		7 / 7	0	9	91										
	4.80	SPT		9 / 9	0	11	89				44	23					
	5.50	UDS						1.82	1.62	12.68			2.75	UU	0.55	11	
	6.30	SPT		11 / 11	0	8	92										
	7.80	SPT	Sandy Silt with Gravel (SM-ML)	24 / 24	0	11	89				45	21					
	8.50	UDS						1.91	1.66	15.36			2.61	DST	0.13	31	
	9.30	SPT		40 / 33	0	40	60				Non	Plastic					
	10.80	SPT	Silty Sand with Gravel (SM)	37 / 28	0	58	42				Non	Plastic					
	12.30	SPT		31 / 19	0	64	36				Non	Plastic					
	13.80	SPT		35 / 20	0	82	18				Non	Plastic					
	15.30	SPT		36 / 20	0	65	35				Non	Plastic					
	16.80	SPT		42 / 22	0	75	25				Non	Plastic					
	18.30	SPT	Silty Clay of High Plasticity (CH)	35 / 35	0	3	97				62	27					
	20.30	SPT		31 / 31	0	3	97										

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

MJB @ CH 42+550
BH : 20
Depth : 30.00m
Depth of Water table : 3.35 m

Date of start : 17/04/2021

Date of finish : 18/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Silty Sand with Gravel (SM)	7 / 9	1	82	17				Non	Plastic					
	2.50	UDS						1.81	1.55	16.59				DST		29	
	3.30	SPT		10 / 11	0	76	24				Non	Plastic					
	4.80	SPT		12 / 12	4	84	12				Non	Plastic					
	5.50	UDS	Sandy Silt with Gravel (SM-ML)					1.84	1.51	21.84			2.61	DST	0.1	30	
	6.30	SPT		12 / 12	0	8	92				Non	Plastic					
	7.80	SPT		14 / 13	0	13	87				Non	Plastic					
	8.50	UDS						1.86	1.54	20.98				DST	0.1	30	
	9.30	SPT		23 / 18	0	34	66				Non	Plastic					
	10.80	SPT		21 / 17	7	15	78				Non	Plastic					
	12.30	SPT		27 / 19	4	64	32				Non	Plastic					
	13.80	SPT	Silty Sand with Gravel (SM)	25 / 18	1	72	27				Non	Plastic					
	15.30	SPT		32 / 20	1	83	16				Non	Plastic					
	16.80	SPT		31 / 19	0	81	19				Non	Plastic					
	18.30	SPT	Silty Clay of Medium Plasticity (CI)	24 / 24	0	4	96				47	21					
	19.80	SPT		28 / 28	1	5	94										
	21.30	SPT		30 / 18	6	9	85				Non	Plastic					
	22.80	SPT		29 / 18	0	8	92				Non	Plastic					
	24.30	SPT	Sandy Silt with Gravel (SM-ML)	33 / 19	0	5	95				Non	Plastic					
	25.80	SPT		41 / 21	1	4	95				Non	Plastic					
	27.30	SPT		43 / 22	0	22	78				Non	Plastic					
	28.80	SPT		48 / 23	1	23	76				Non	Plastic					
	30.30	SPT		53 / 24	1	50	49				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

Flyover @ CH 43+910
BH : 21
Depth : 30.00m
Depth of Water table : 10.25 m

Date of start : 16/04/2021

Date of finish : 17/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	Density (gm/cc) r(dry)	W/C W(%)	Limits (%) L.L	Limits (%) P . L	Sp.Gr	Shear Parameters Type of test	Shear Parameters C(kg/sq.cm)	Shear Parameters phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	6 / 8	1	17	82					Non Plastic					
	2.50	UDS												DST			
	3.30	SPT		7 / 8	1	15	84					Non Plastic					
	4.80	SPT		7 / 7	0	4	96					Non Plastic					
	5.50	UDS	Silty Clay of Medium Plasticity (CI)											DST			
	6.30	SPT		10 / 10	0	5	95				46	22					
	7.80	SPT		11 / 11	1	6	93										
	8.50	UDS												DST			
	9.30	SPT	Sandy Silt with Gravel (SM-ML)	21 / 17	0	9	91					Non Plastic					
	10.80	SPT	Silty Sand with Gravel (SM)	20 / 15	1	54	45					Non Plastic					
	12.30	SPT		29 / 18	0	67	33					Non Plastic					
	13.80	SPT	Sandy Silt with Gravel (SM-ML)	25 / 16	0	49	51					Non Plastic					
	15.30	SPT	Silty Clay of Medium Plasticity (CI)	20 / 20	5	11	84				46	23					
	16.80	SPT		19 / 19	3	75	22										
	18.30	SPT		28 / 17	0	61	39					Non Plastic					
	19.80	SPT		32 / 18	3	72	25					Non Plastic					
	21.30	SPT		33 / 18	2	58	40					Non Plastic					
	22.80	SPT	Silty Sand with Gravel (SM)	41 / 20	1	73	26					Non Plastic					
	24.30	SPT		40 / 20	0	69	31					Non Plastic					
	25.80	SPT		55 / 24	0	84	16					Non Plastic					
	27.30	SPT		52 / 23	1	86	13					Non Plastic					
	28.80	SPT		65 / 26	3	79	18					Non Plastic					
	30.30	SPT		72 / 28	1	82	17					Non Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

MJB @ CH 47+950
BH : 22
Depth : 30.00m
Depth of Water table : 3.80 m

Date of start : 19/04/2021

Date of finish : 20/04/2021

Project No. 2152

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	15 / 20	0	35	65				Non	Plastic					
	2.50	UDS						1.86	1.60	16.41				DST	0.13	30	
	3.30	SPT	Silty Sand with Gravel (SM)	24 / 28	0	80	20				Non	Plastic					
	4.80	SPT	Sandy Silt with Gravel (SM-ML)	10 / 10	0	16	84				Non	Plastic					
	5.50	UDS						1.85	1.53	20.59				DST	0.1	29	
	6.30	SPT	Silty Clay of Medium to High Plasticity (CI-CH)	13 / 13	0	3	97				56	27					
	7.80	SPT		16 / 15	0	8	92										
	8.50	UDS						1.87	1.58	18.45				UU	0.81	3	
	9.30	SPT		20 / 17	0	7	93				Non	Plastic					
	10.80	SPT	Sandy Silt with Gravel (SM-ML)	19 / 16	1	4	95				Non	Plastic					
	12.30	SPT		16 / 14	0	4	96				Non	Plastic					
	13.80	SPT		18 / 15	0	2	98				Non	Plastic					
	15.30	SPT		27 / 18	0	5	95				Non	Plastic					
	16.80	SPT	Silty Sand with Gravel (SM)	39 / 23	1	67	32				Non	Plastic					
	18.30	SPT		43 / 24	0	69	31				Non	Plastic					
	19.80	SPT		49 / 26	1	84	15				Non	Plastic					
	21.30	SPT		42 / 23	1	85	14				Non	Plastic					
	22.80	SPT		55 / 27	1	81	18				Non	Plastic					
	24.30	SPT		63 / 30	0	78	22				Non	Plastic					
	25.80	SPT		53 / 26	0	74	26				Non	Plastic					
	27.30	SPT		61 / 28	1	80	19				Non	Plastic					
	28.80	SPT		73 / 32	1	88	11				Non	Plastic					
	30.30	SPT		76 / 32	2	88	10				Non	Plastic					

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

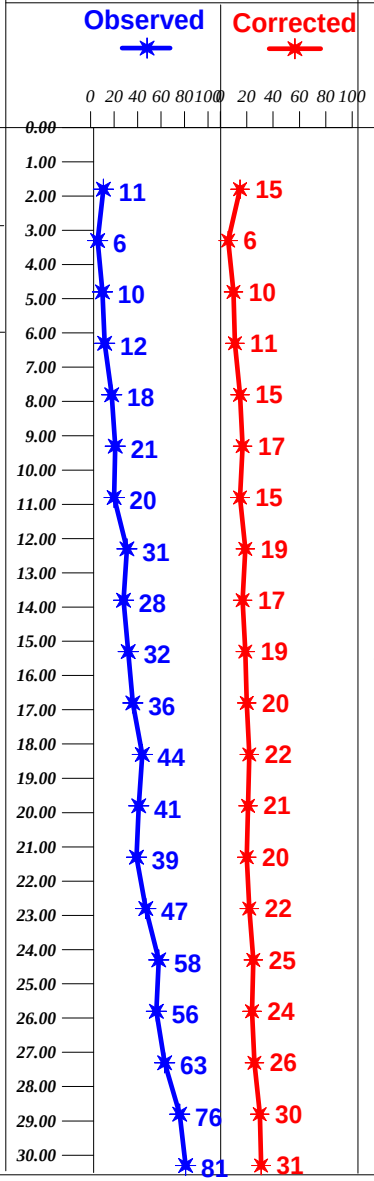
Flyover @ CH 49+900
BH : 23
Depth : 30.00m
Depth of Water table : 9.80 m

Date of start : 20/04/2021

Date of finish : 21/04/2021

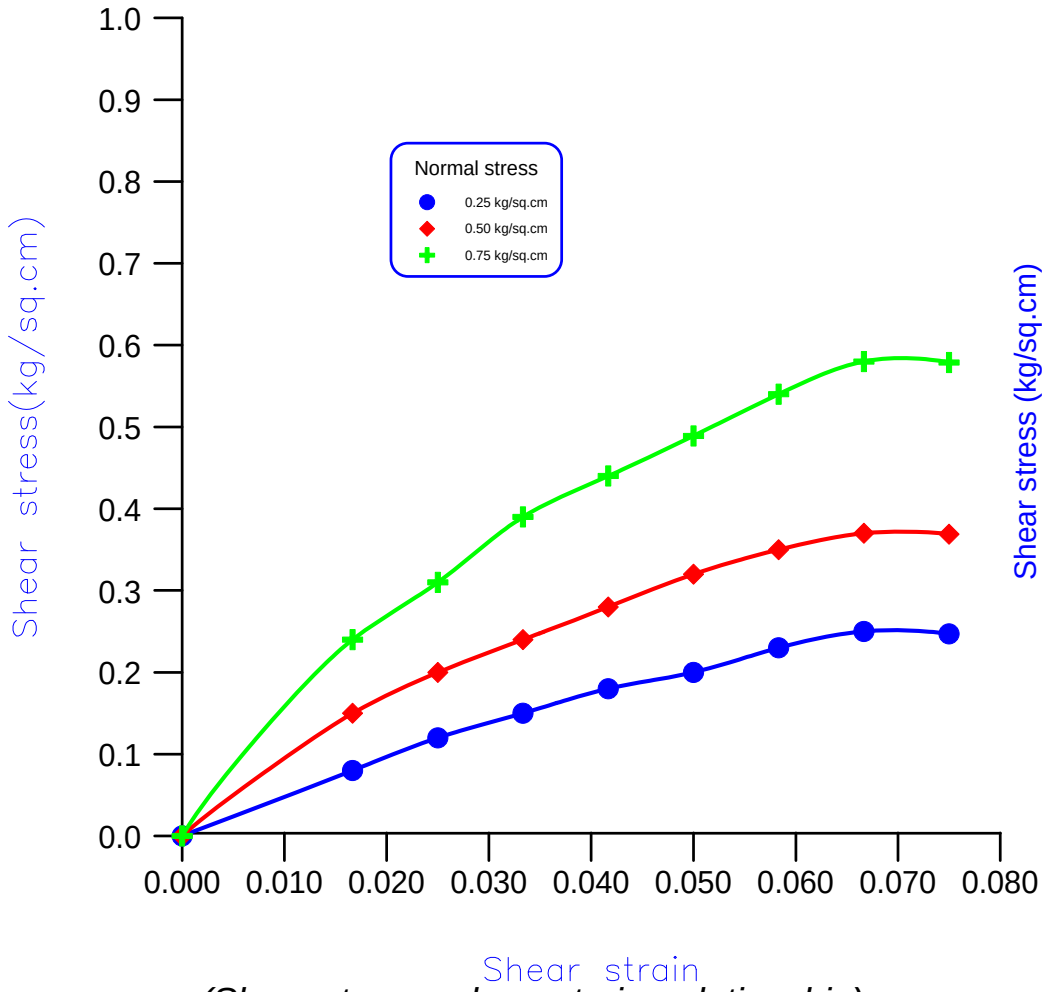
Project No. 2152

Reduced Level	Depth (m)	Type of sample	Soil Classification	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P. L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	0	33	67				Non	Plastic					
	2.50	UDS											DST			
	3.30	SPT	Silty Clay of Medium Plasticity (CI)	0	2	98				48	24					
	4.80	SPT		0	2	98										
	5.50	UDS											DST			
	6.30	SPT		0	65	35				Non	Plastic					
	7.80	SPT		0	56	44				Non	Plastic					
	8.50	UDS											DST			
	9.30	SPT		0	79	21				Non	Plastic					
	10.80	SPT		0	76	24				Non	Plastic					
	12.30	SPT		0	80	20				Non	Plastic					
	13.80	SPT		1	83	16				Non	Plastic					
	15.30	SPT	Silty Sand with Gravel (SM)	18	74	8				Non	Plastic					
	16.80	SPT		1	78	21				Non	Plastic					
	18.30	SPT		6	88	6				Non	Plastic					
	19.80	SPT		1	83	16				Non	Plastic					
	21.30	SPT		1	81	18				Non	Plastic					
	22.80	SPT		0	81	19				Non	Plastic					
	24.30	SPT		0	93	7				Non	Plastic					
	25.80	SPT		2	86	12				Non	Plastic					
	27.30	SPT		0	72	28				Non	Plastic					
	28.80	SPT		0	89	11				Non	Plastic					
	30.30	SPT		1	87	12				Non	Plastic					

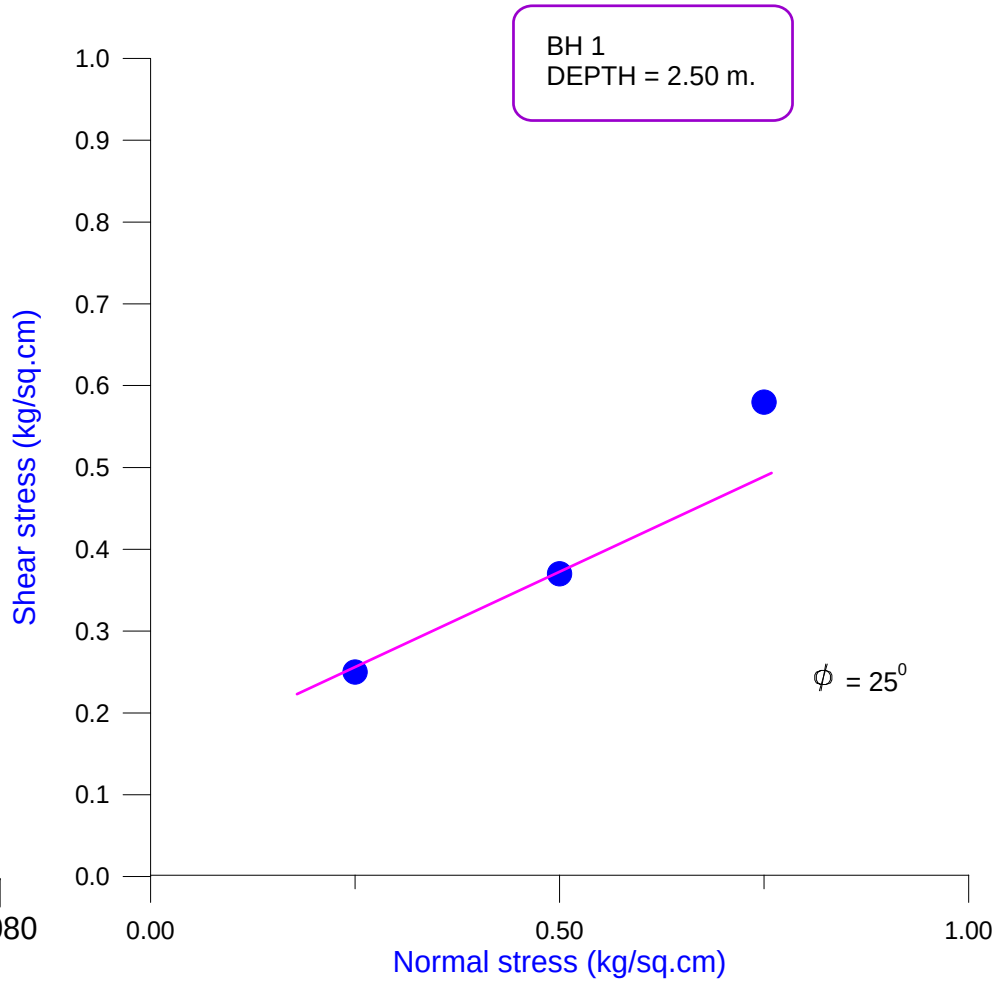


Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



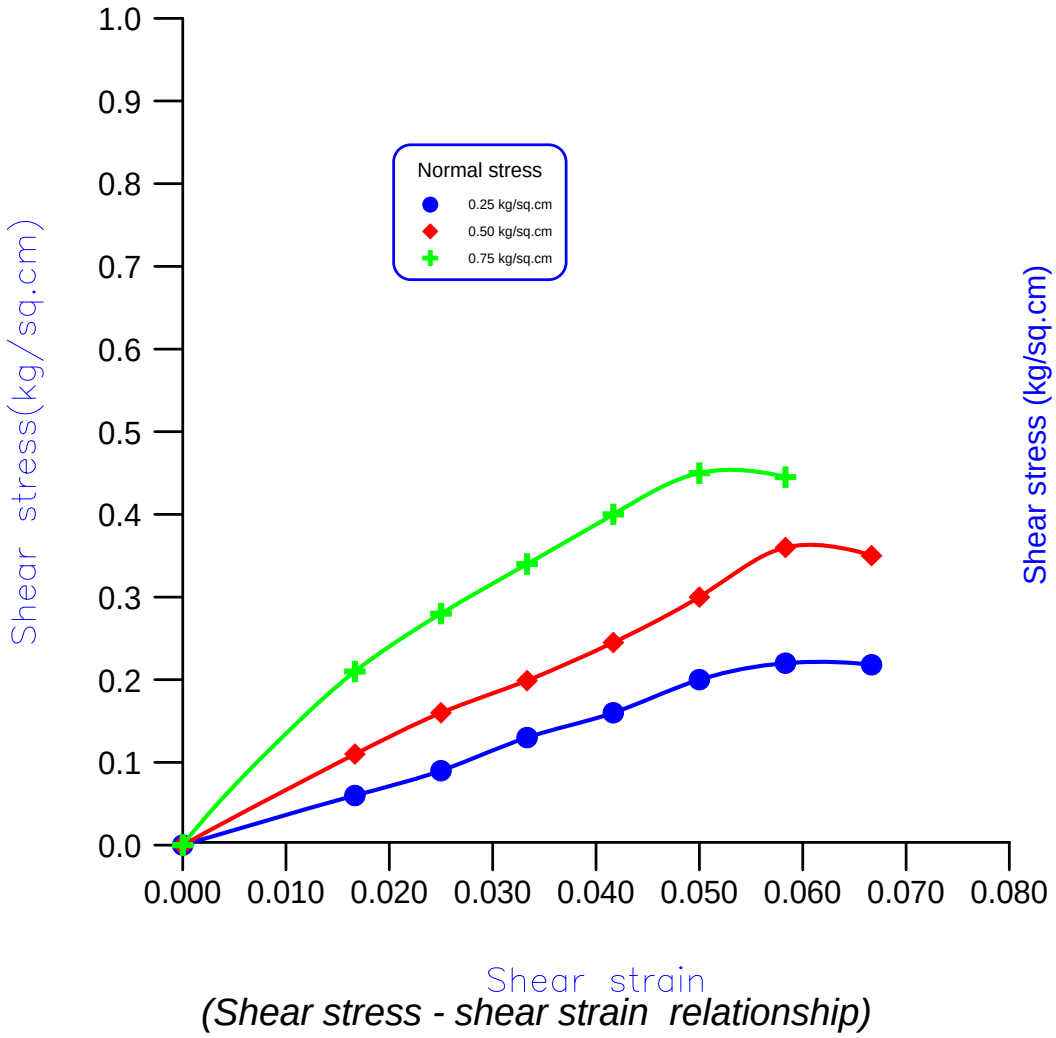
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

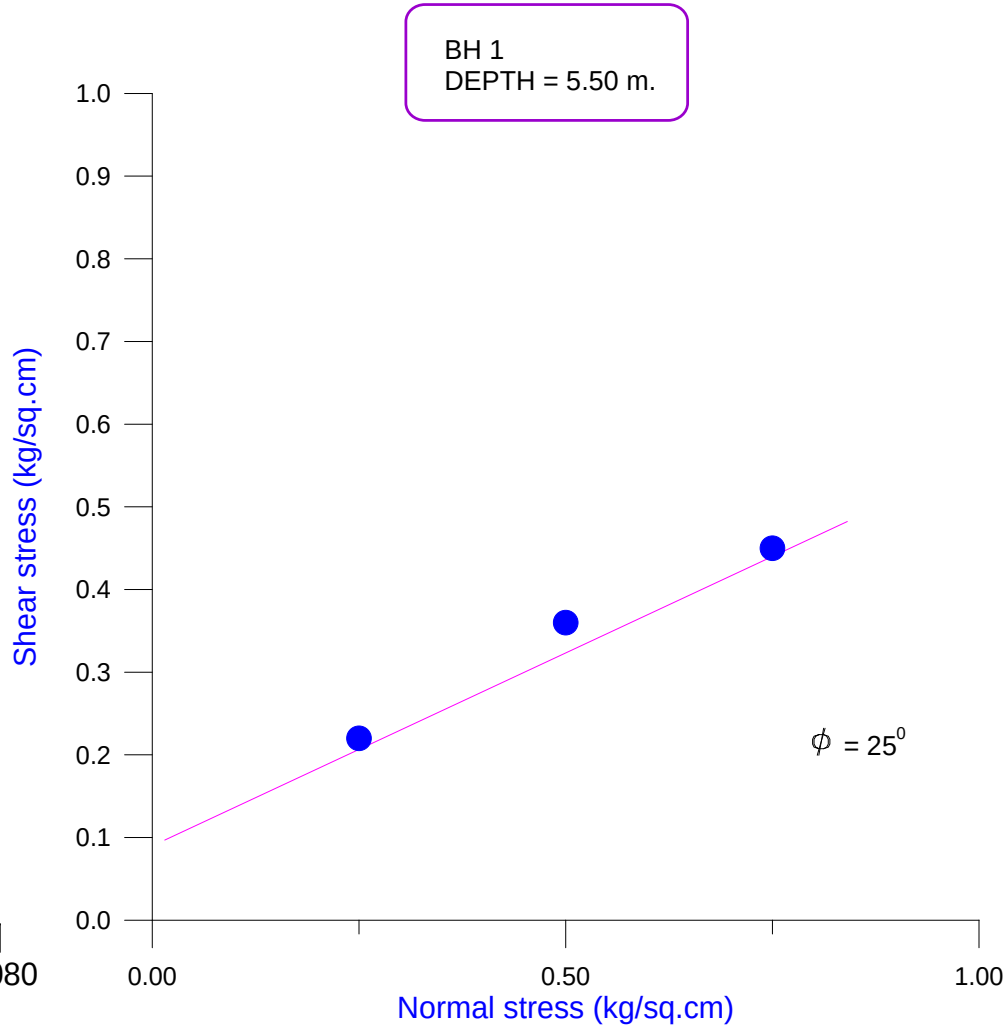
FIG- DS 1-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



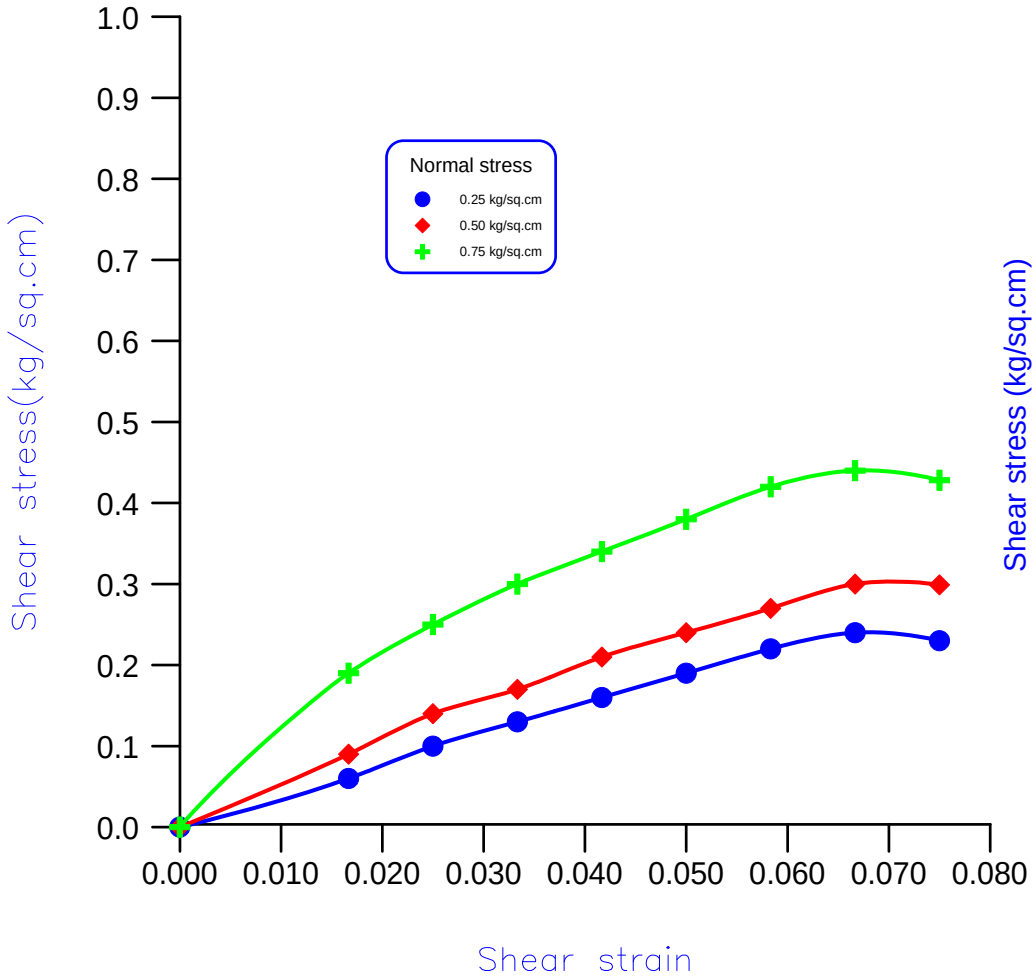
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

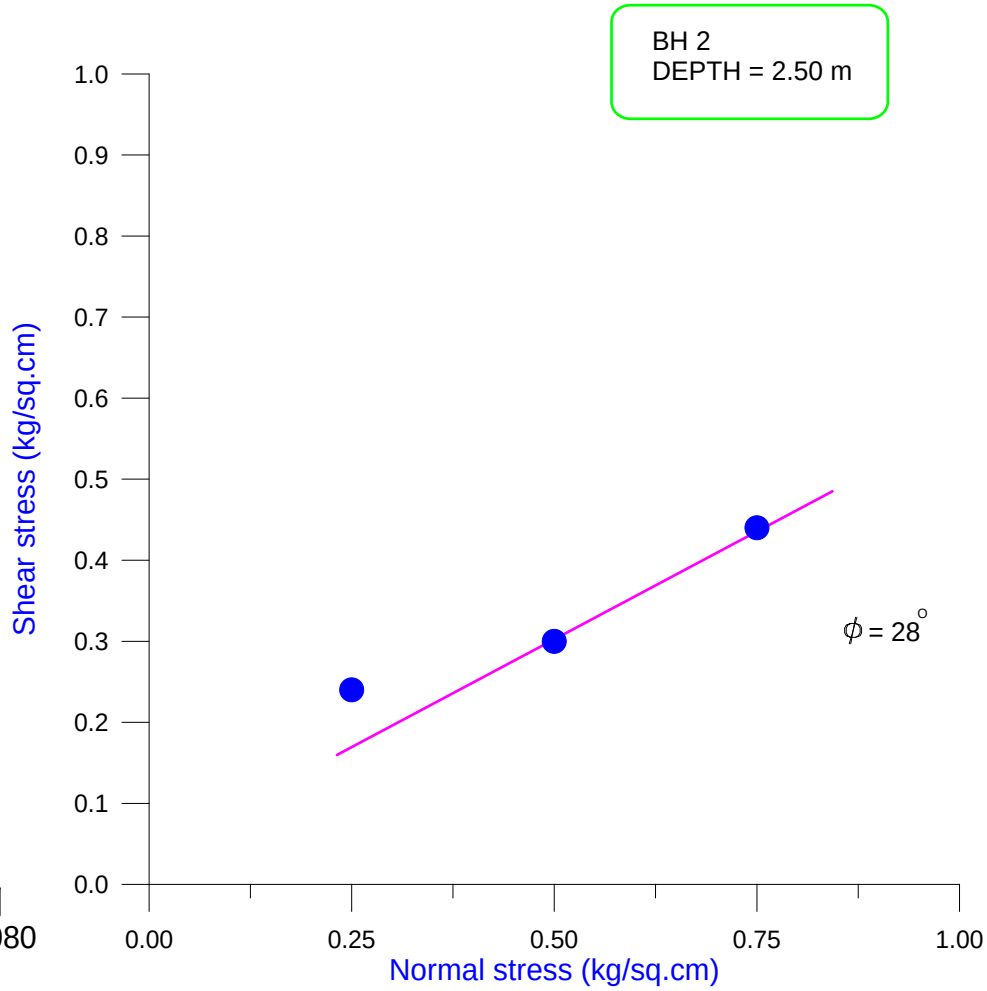
FIG- DS 1-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



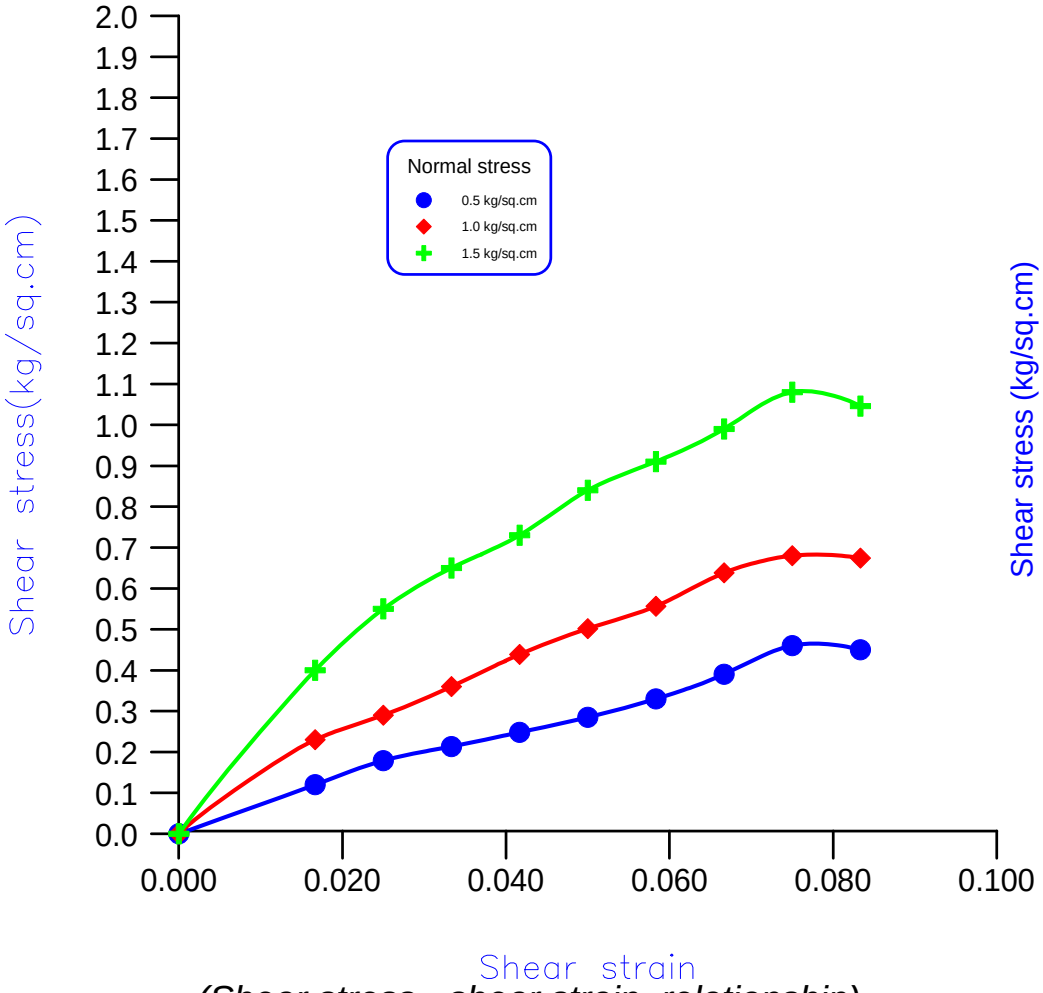
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

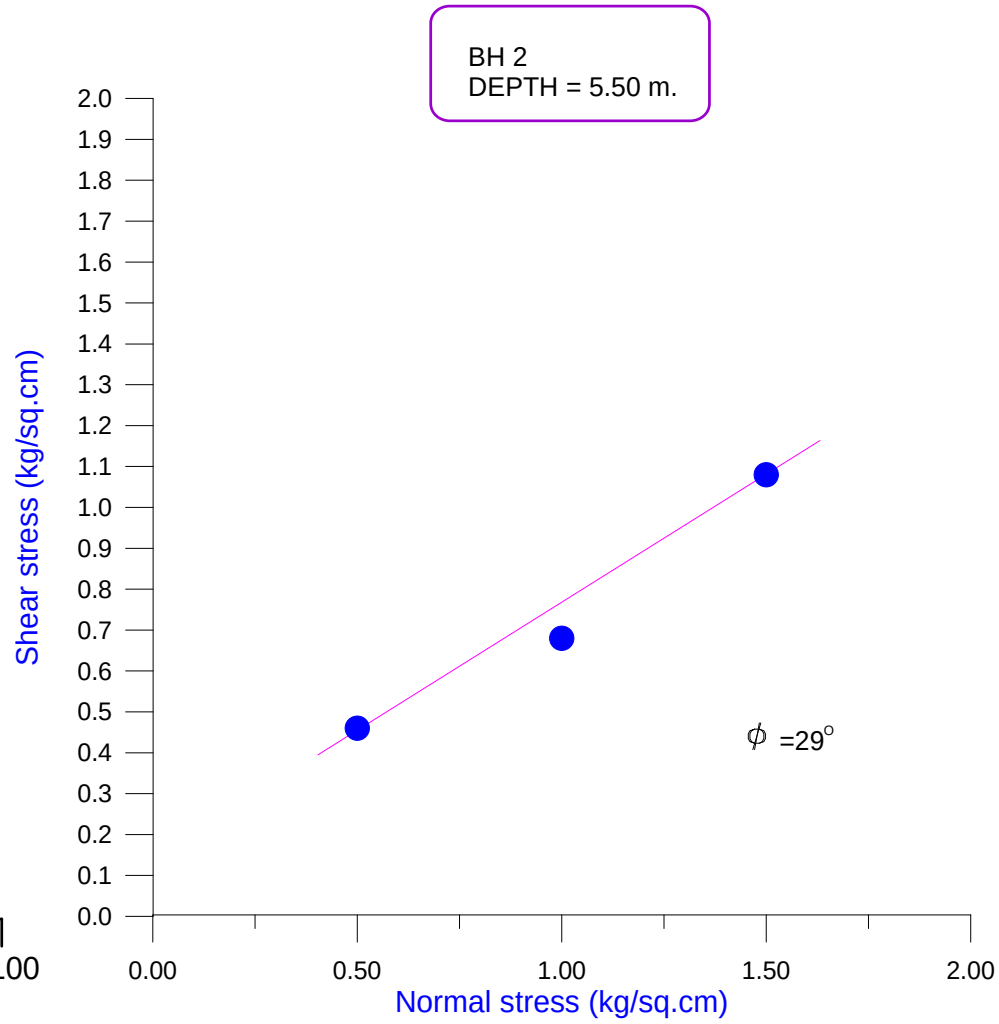
FIG- DS 2-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



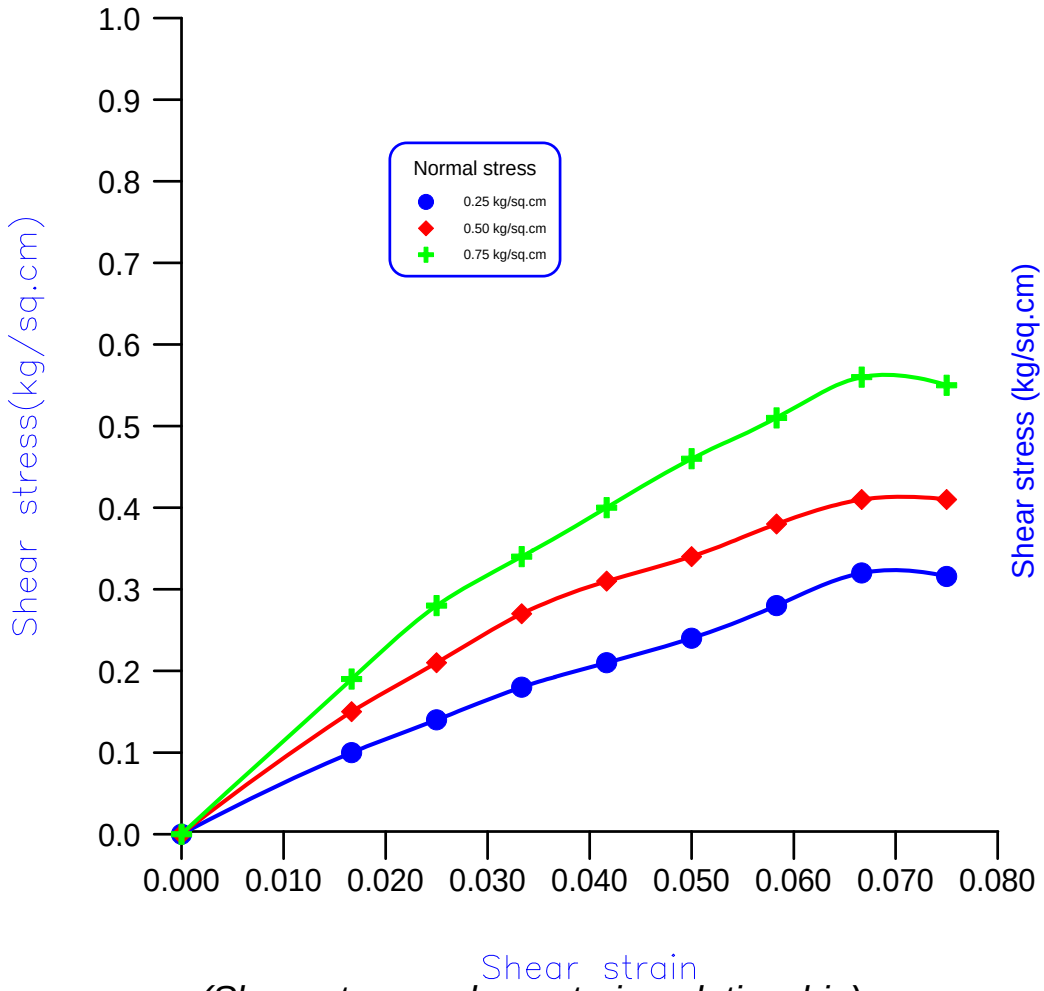
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

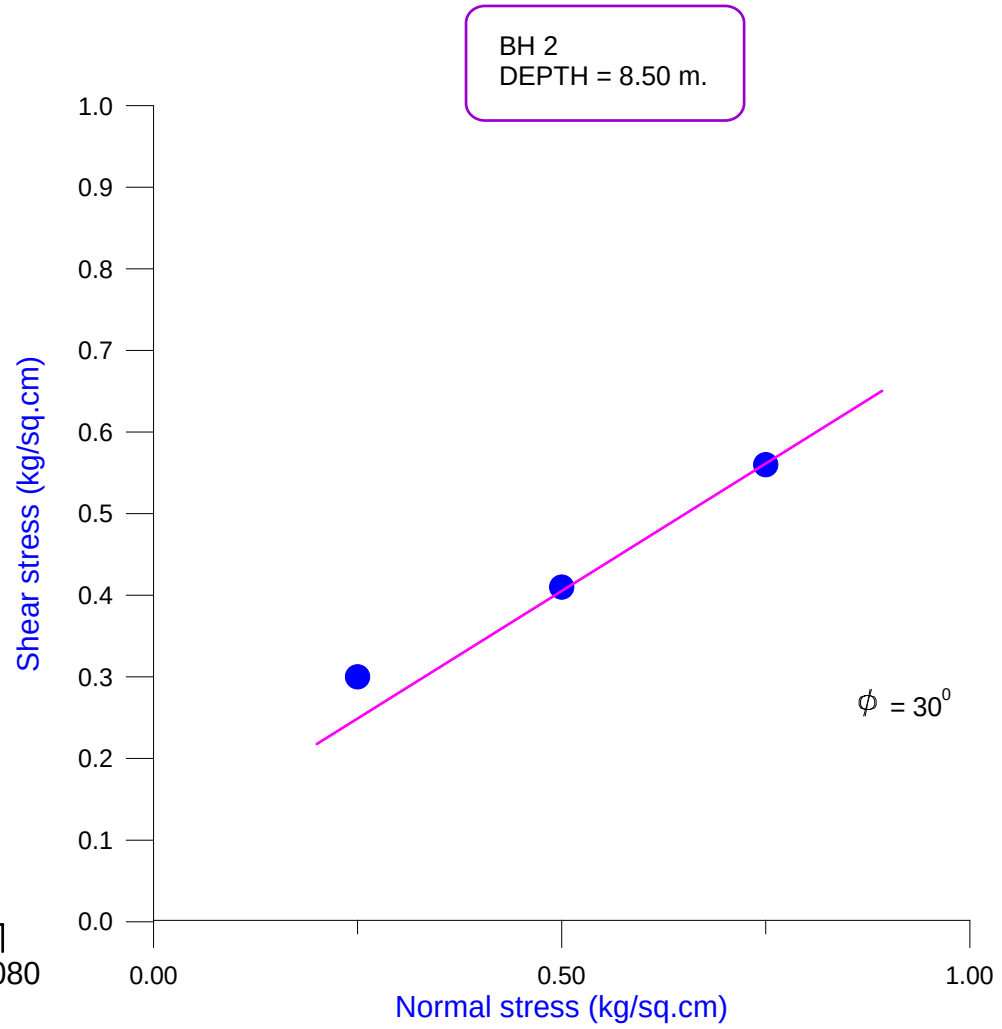
FIG- DS 2-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



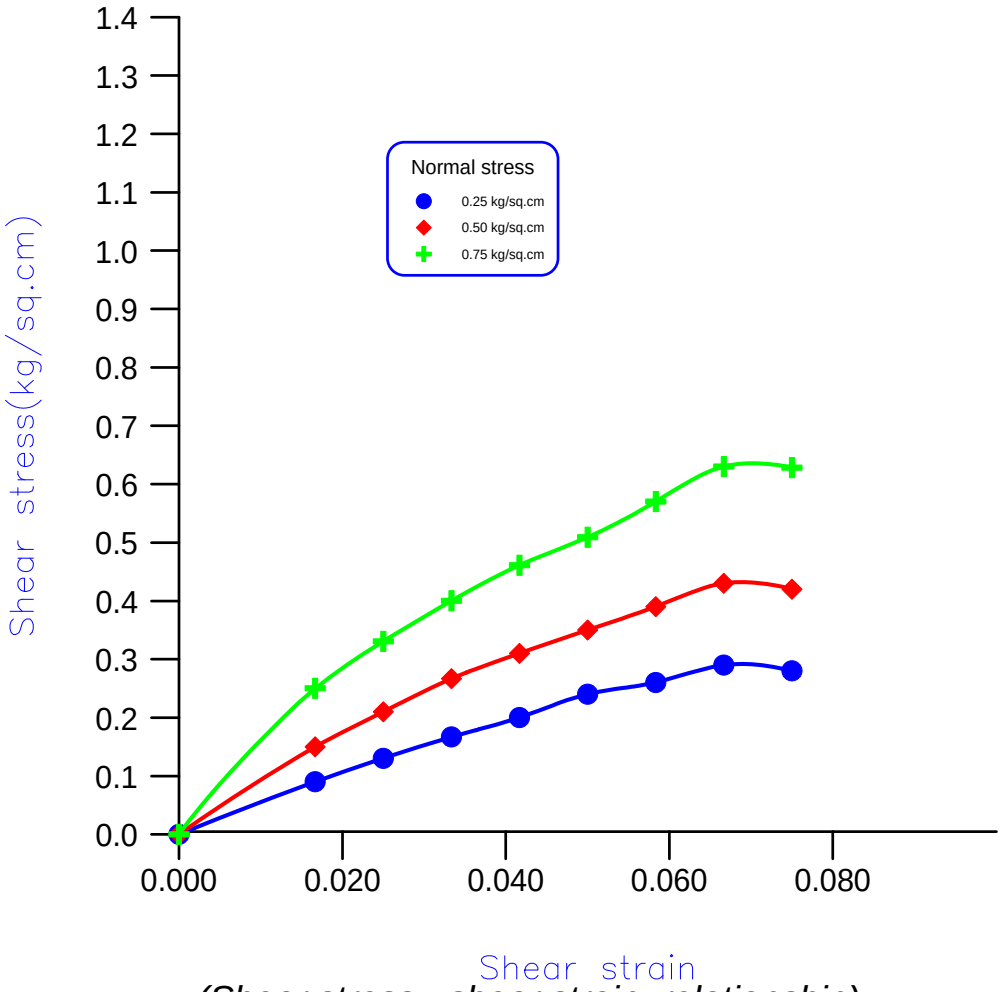
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

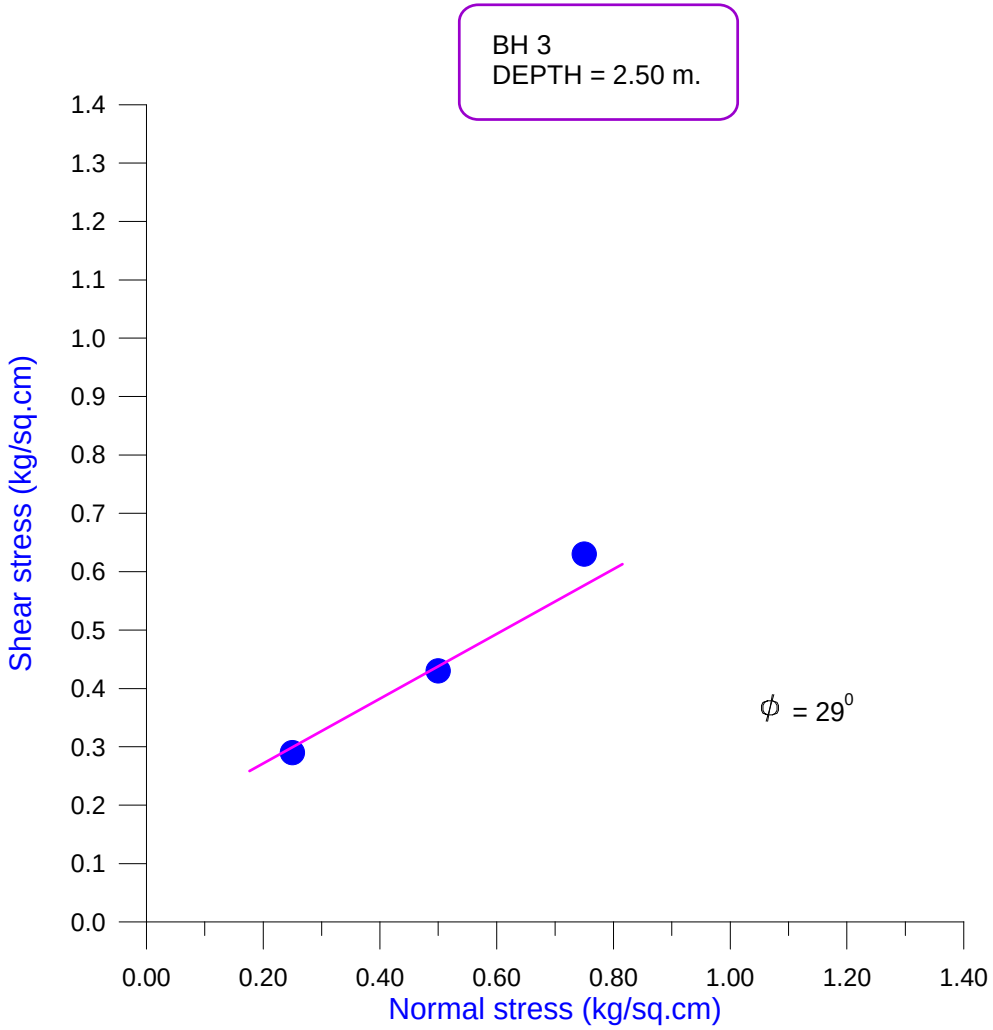
FIG- DS 2-3

Soil Engineering Conslants

Job. 2152



(Shear stress - shear strain relationship)



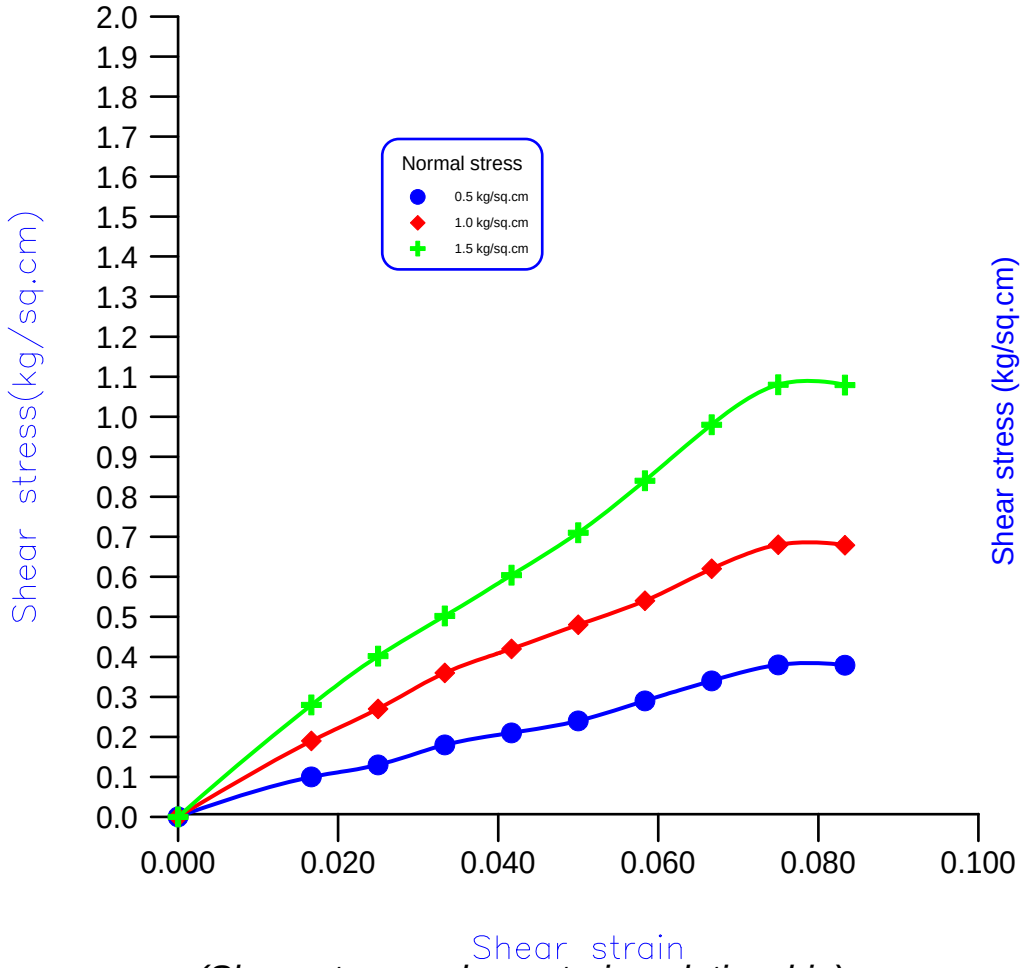
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

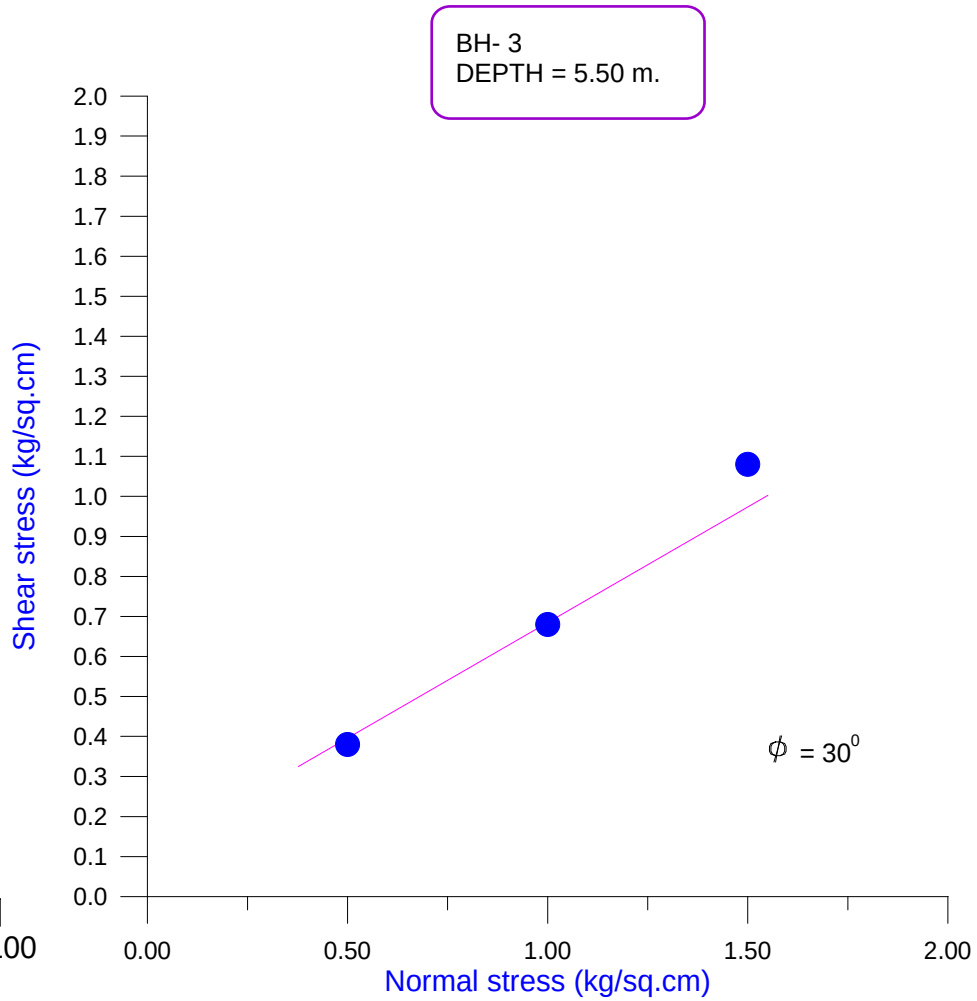
FIG- DS 3-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)

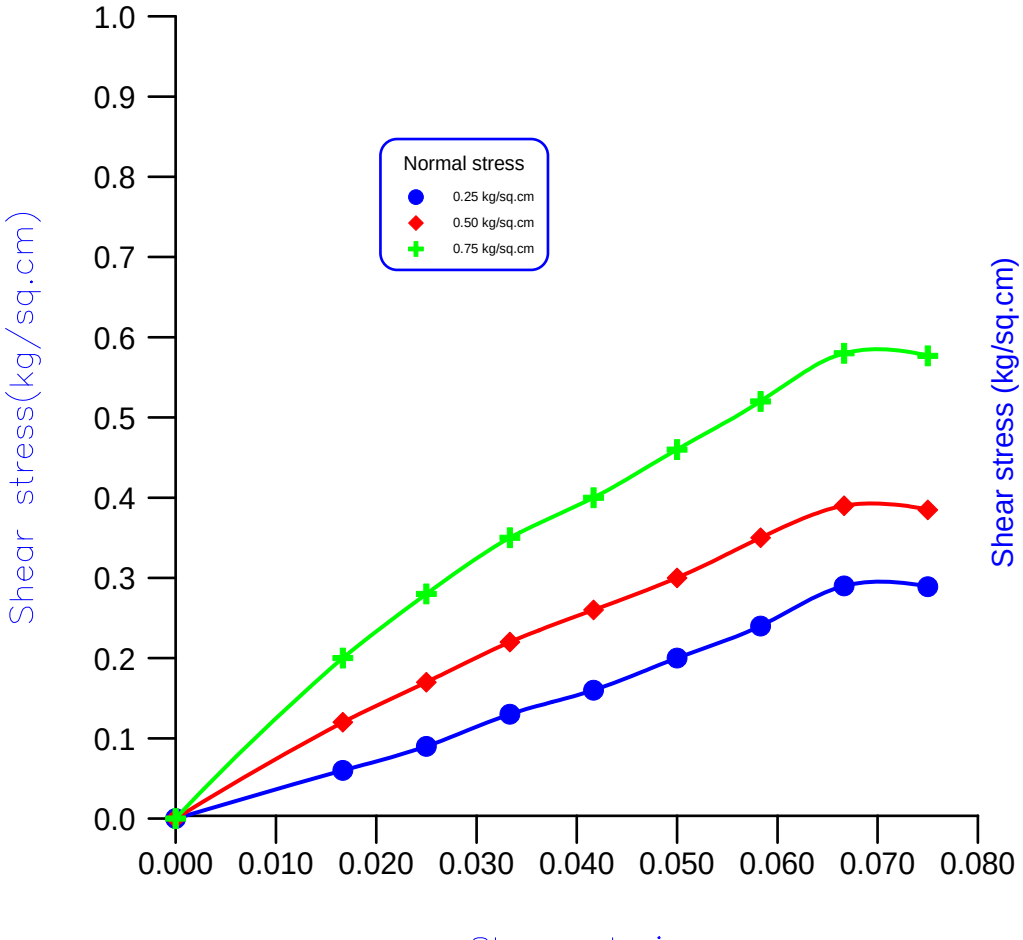


(Shear stress - Normal stress relationship)

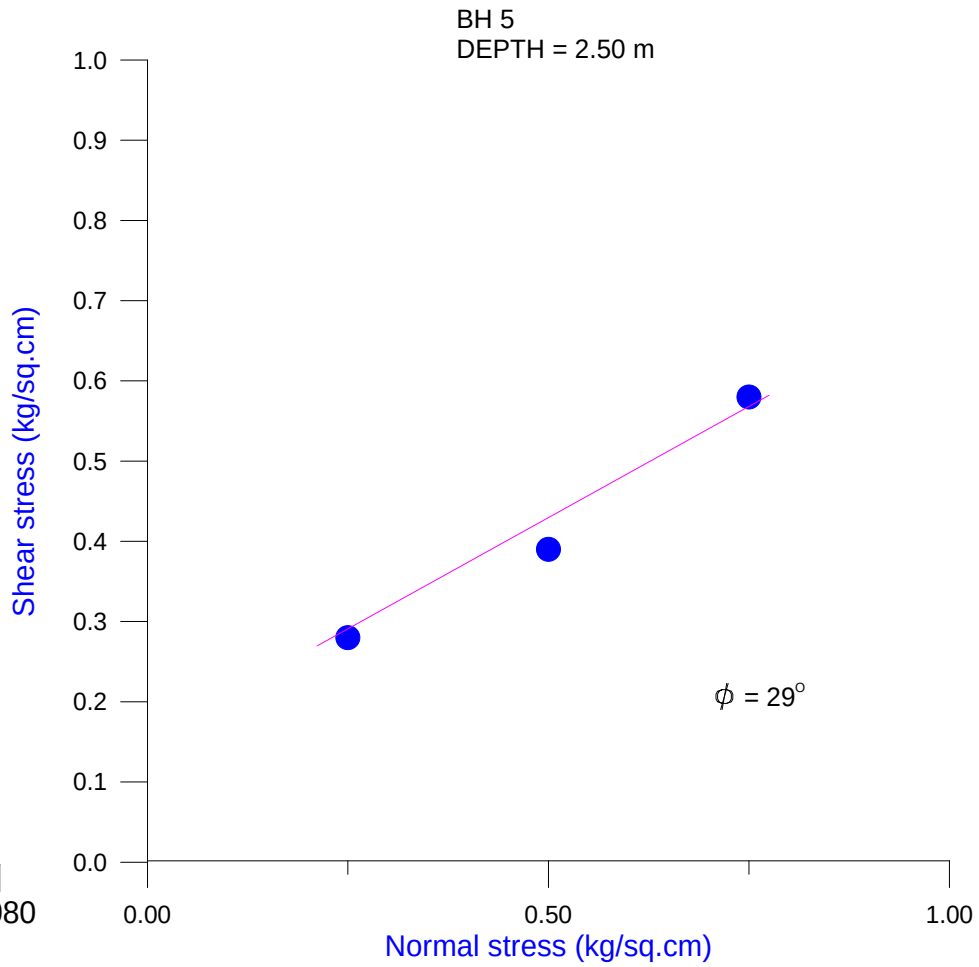
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

FIG- DS 3-2

Soil Engineering Consltants *Job. 2152*



(Shear stress - shear strain relationship)



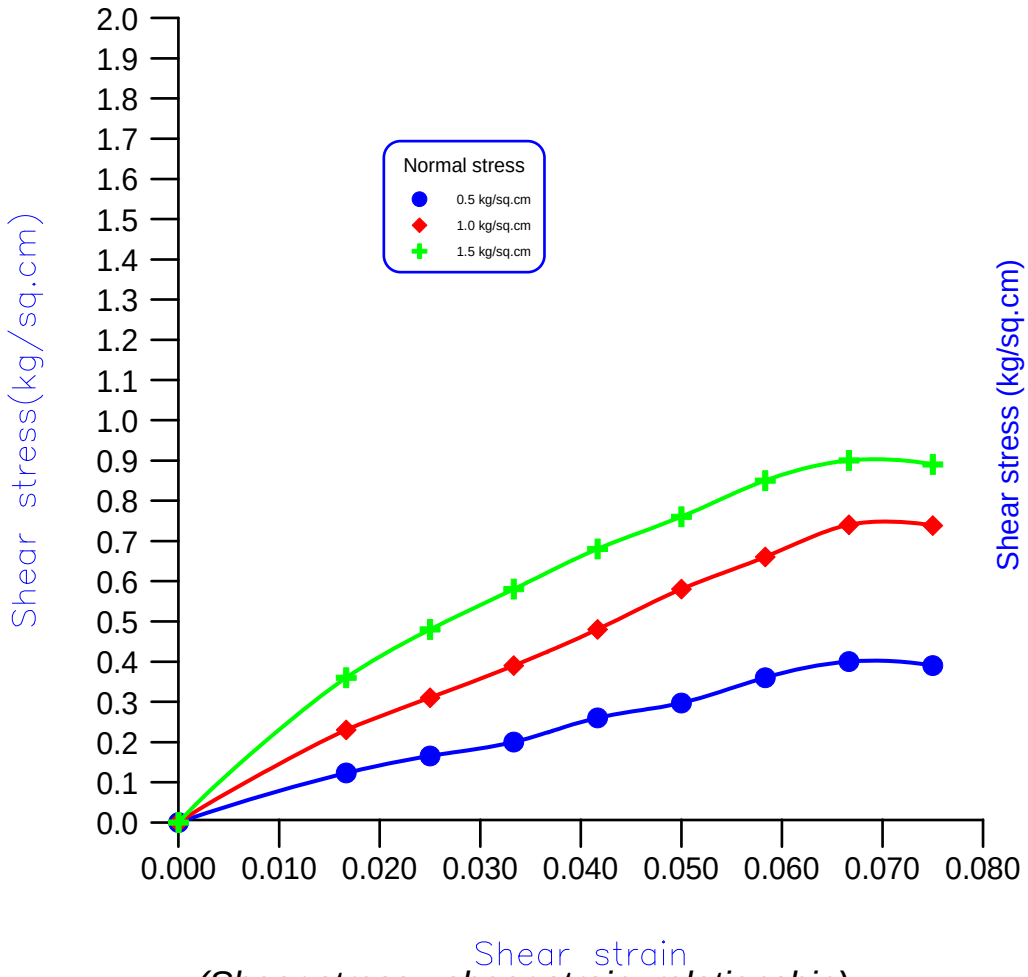
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

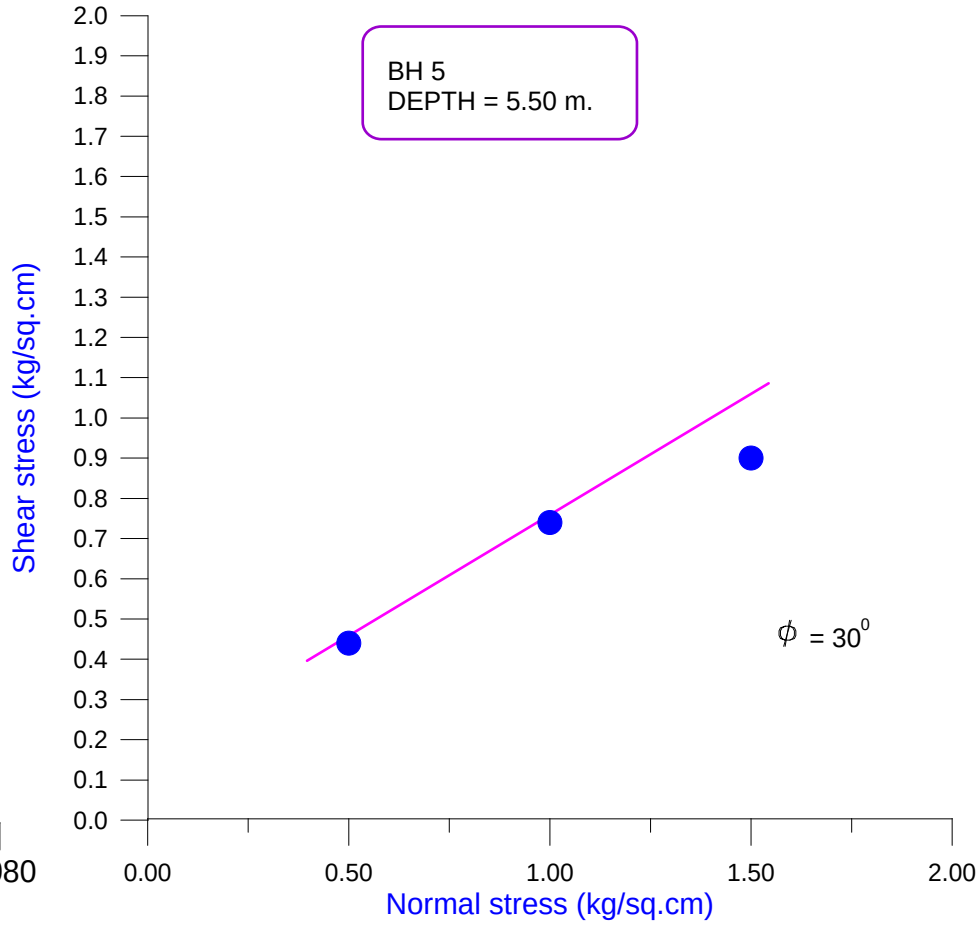
FIG- DS 5-1

Soil Engineering Conslants

Job. 2152



(Shear stress - shear strain relationship)



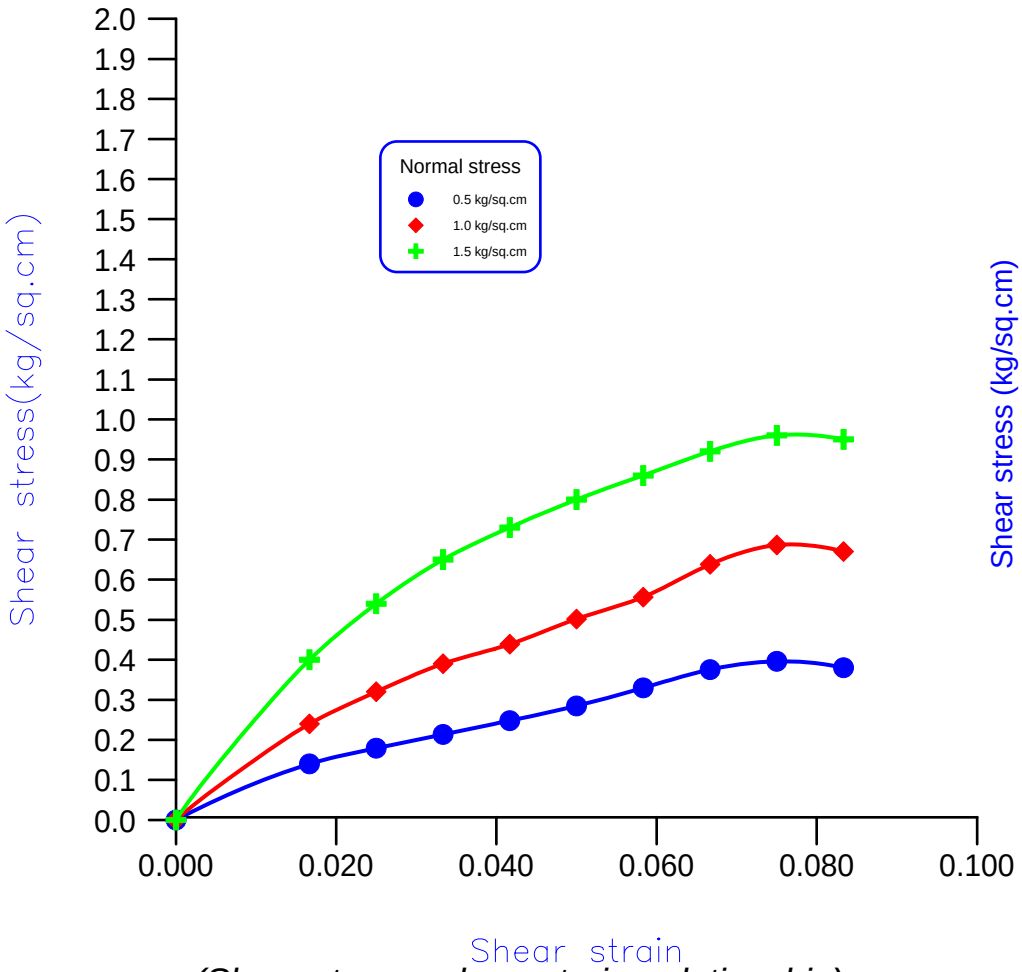
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

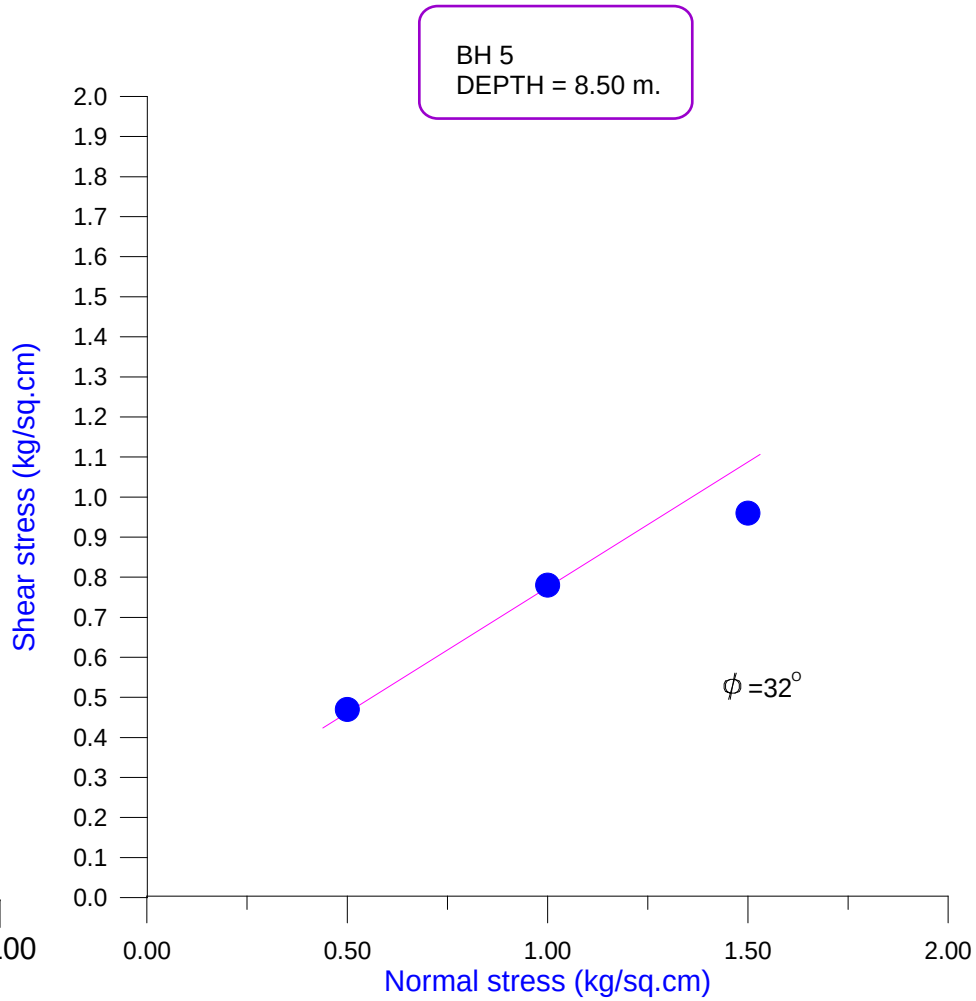
FIG- DS 5-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



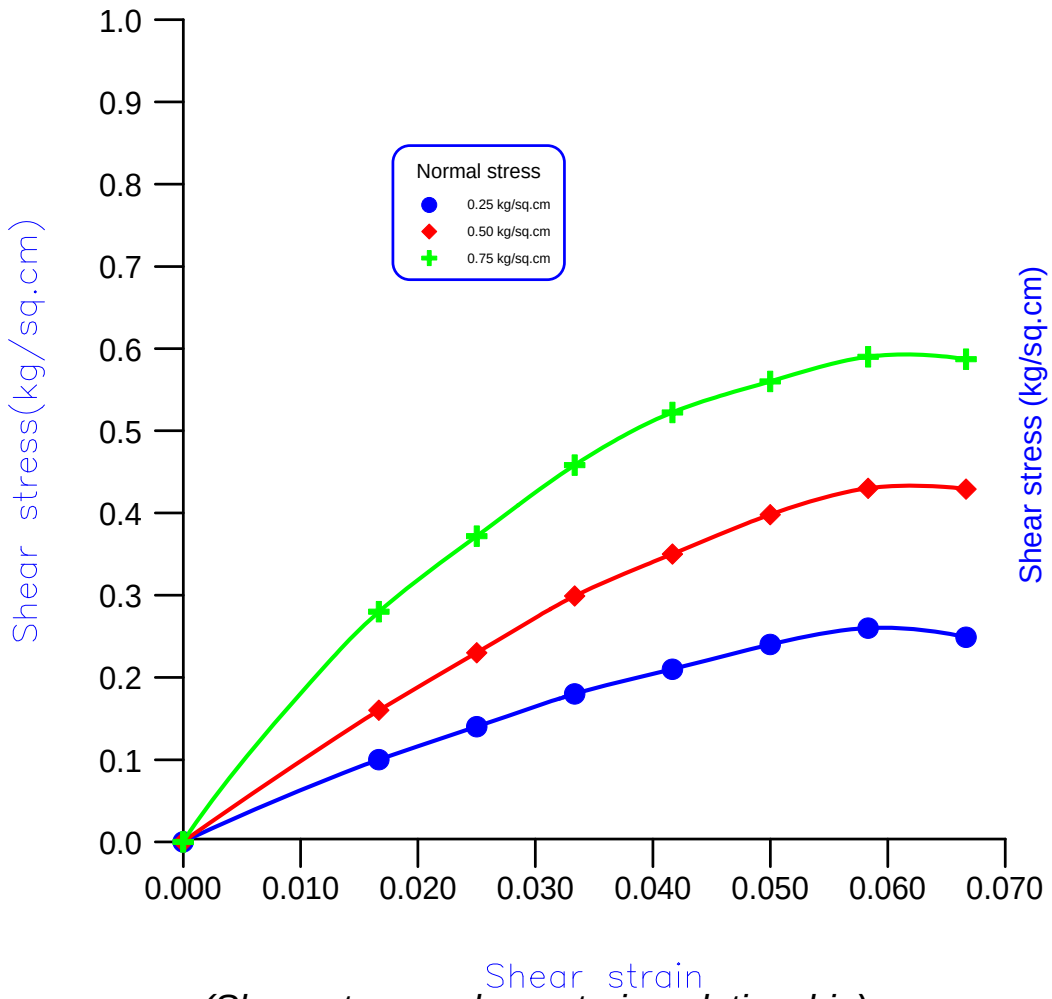
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

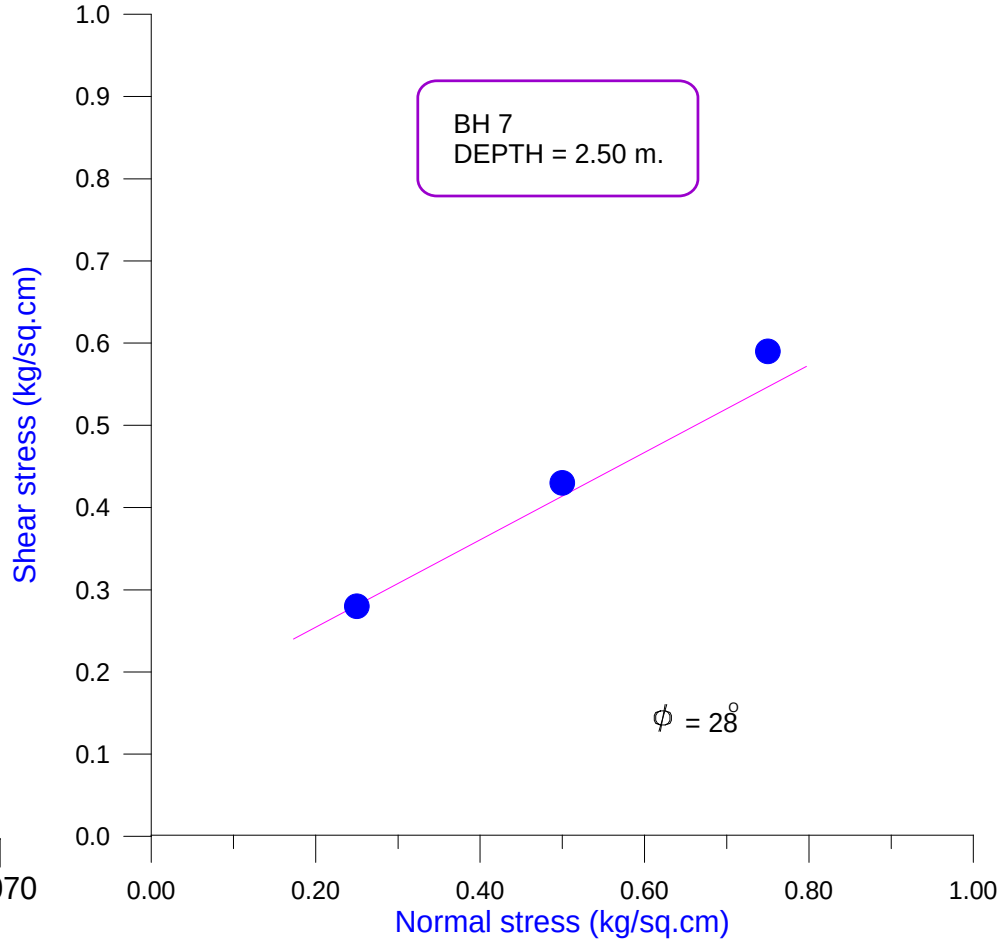
FIG- DS 5-3

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



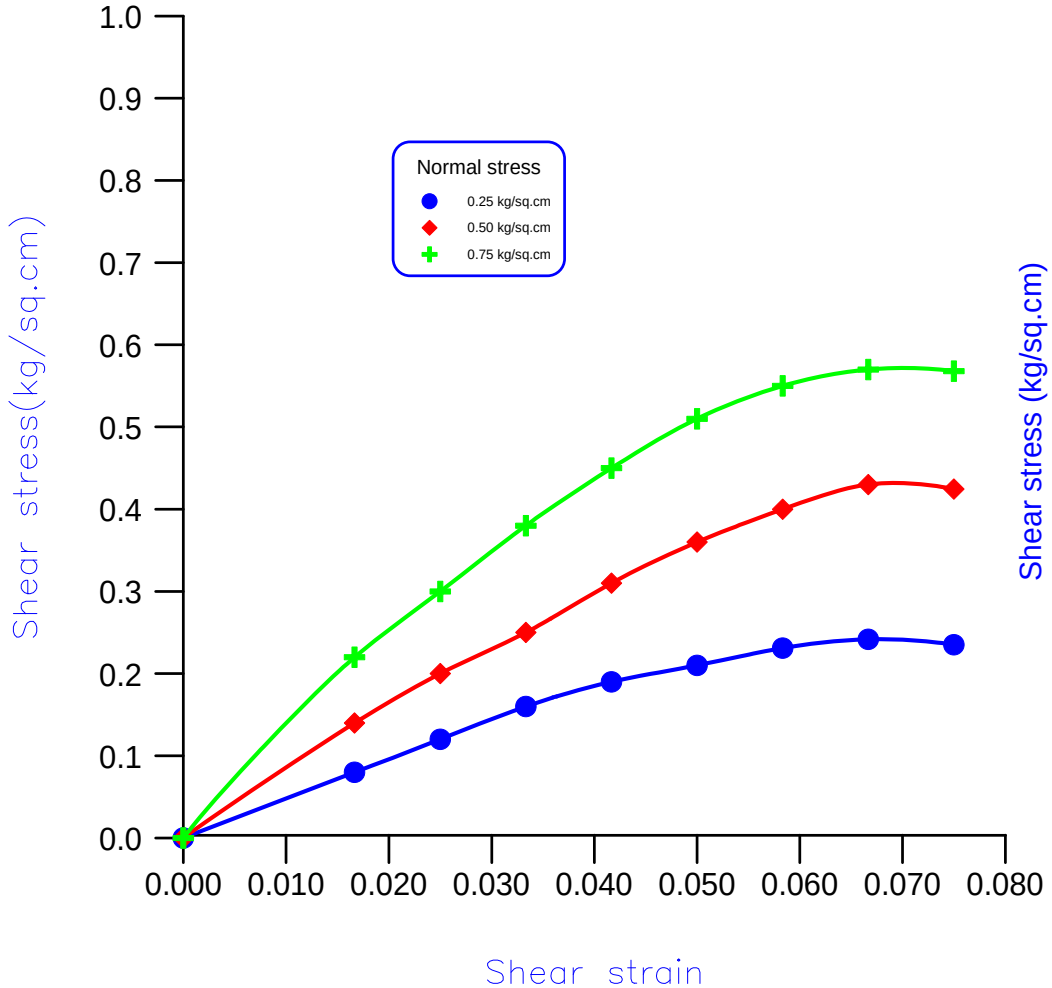
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

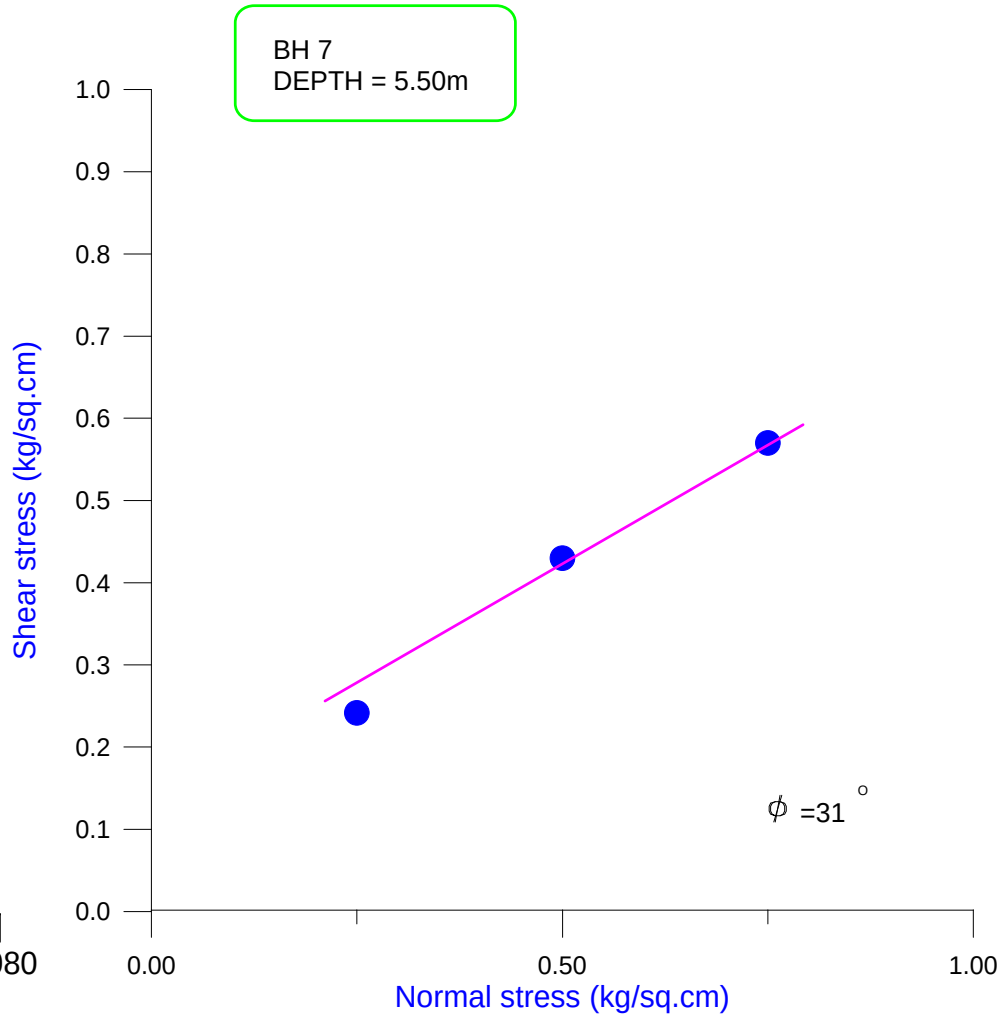
FIG- DS 7-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



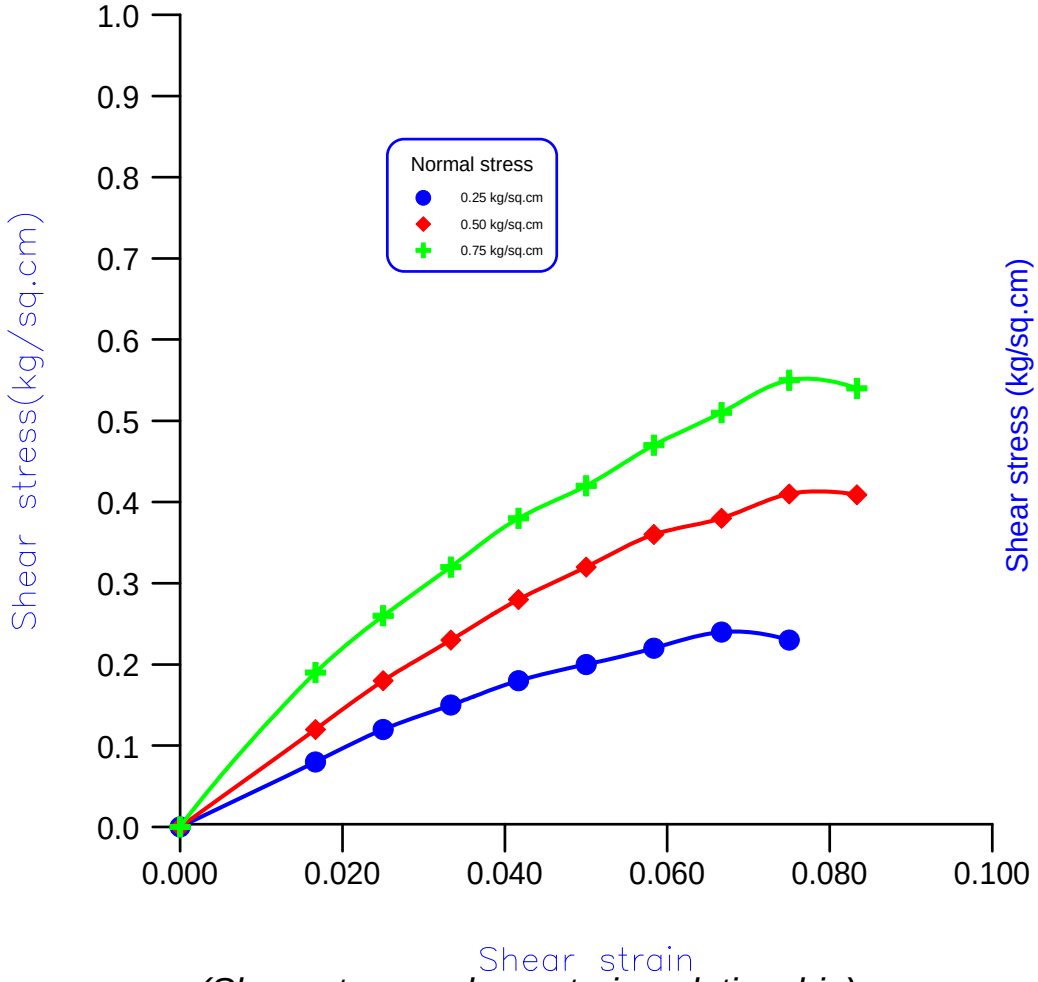
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

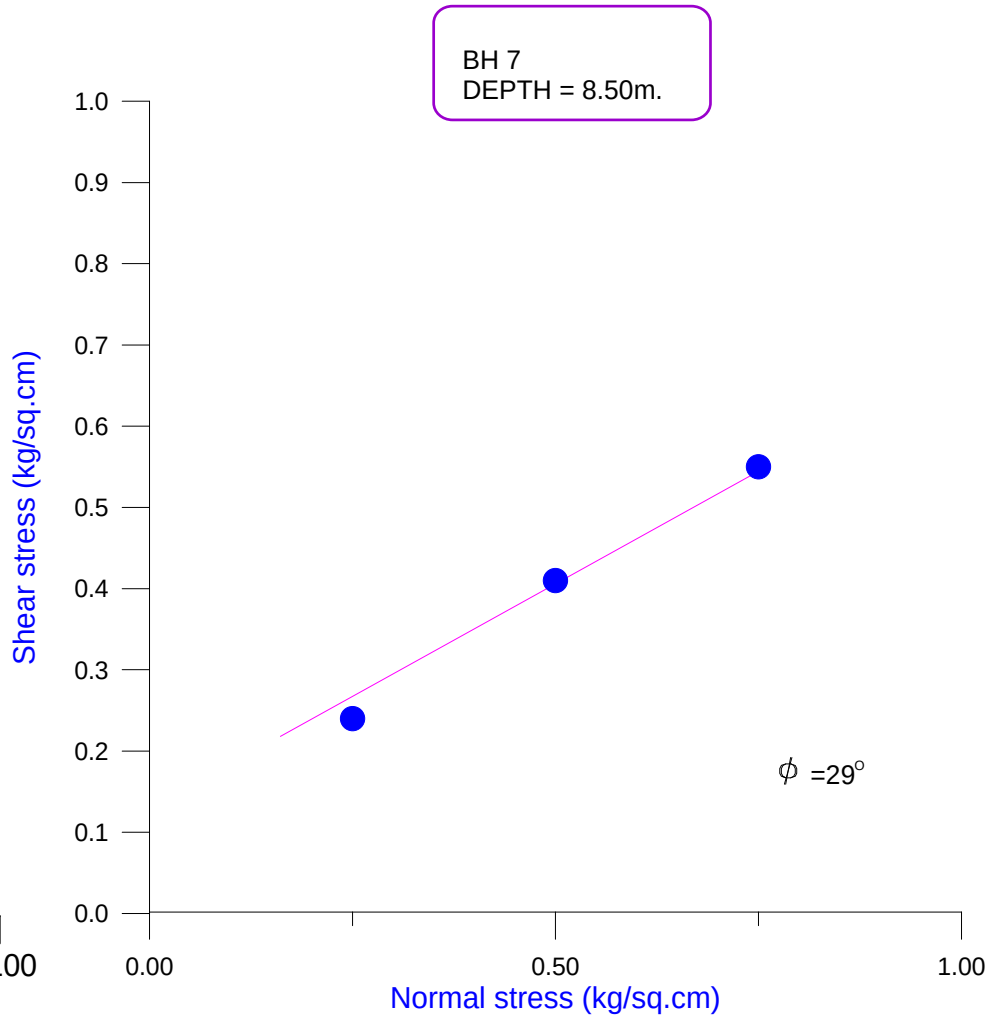
FIG- DS 7-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



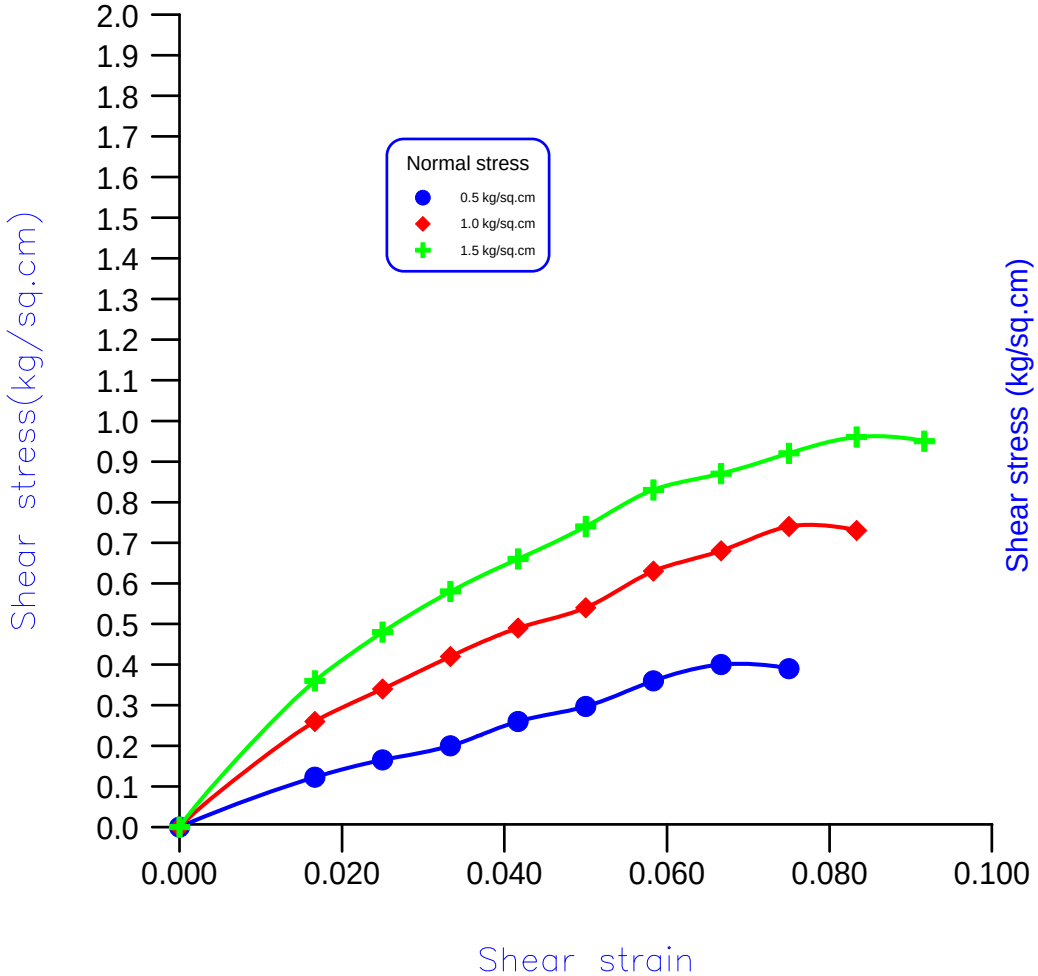
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

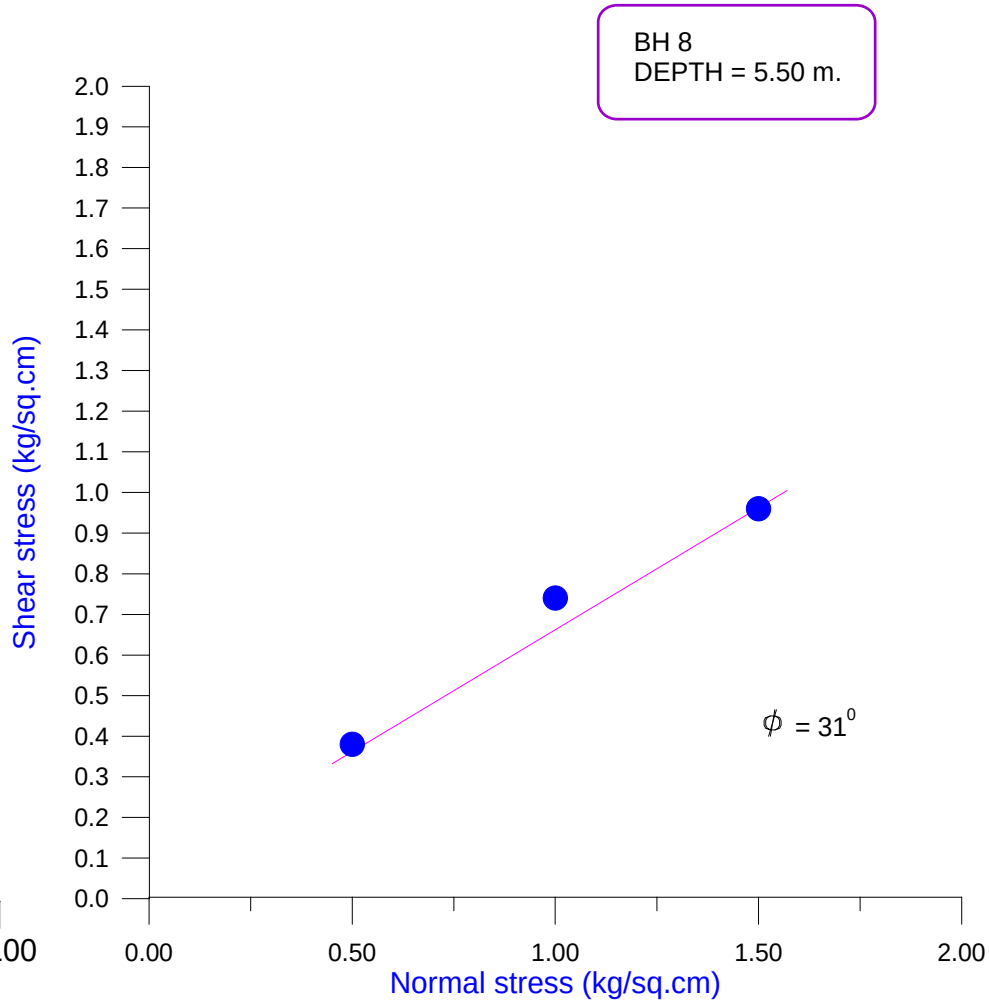
FIG- DS 7-3

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



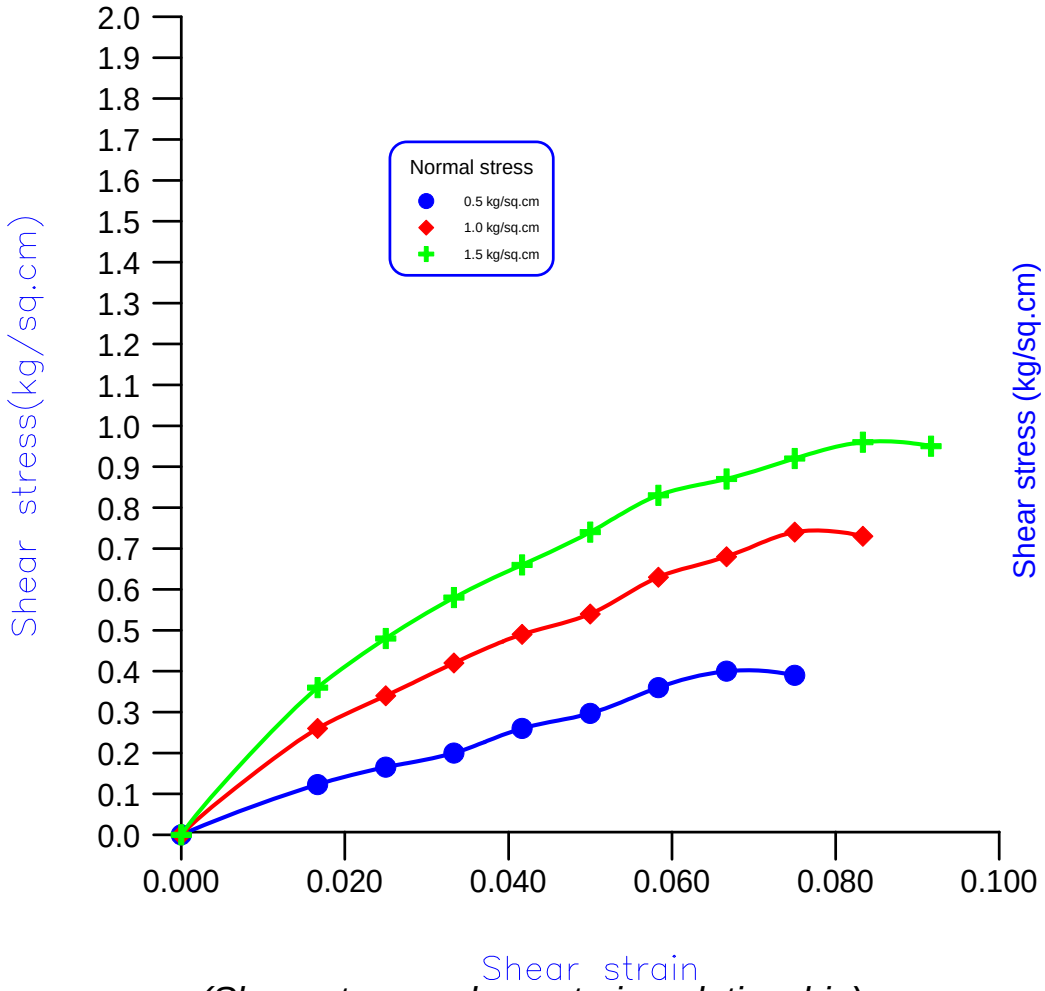
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

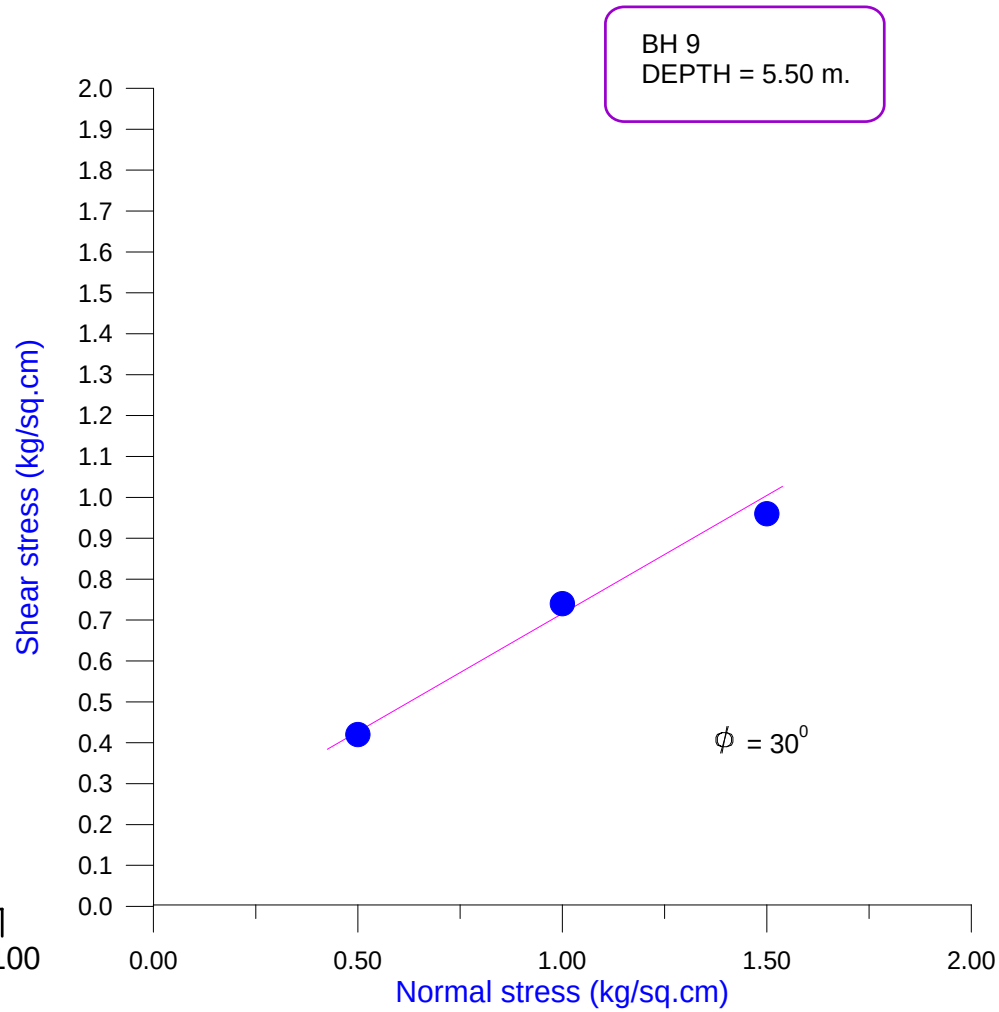
FIG- 8-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



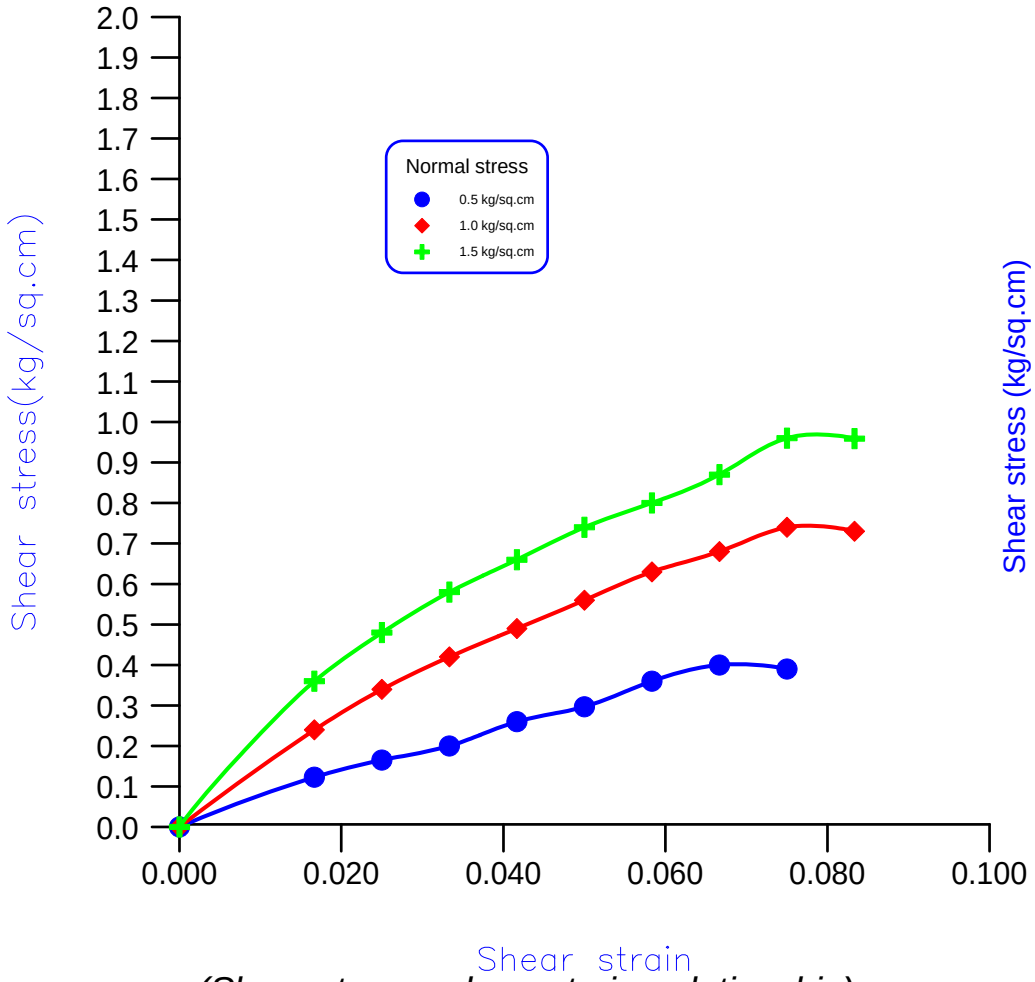
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

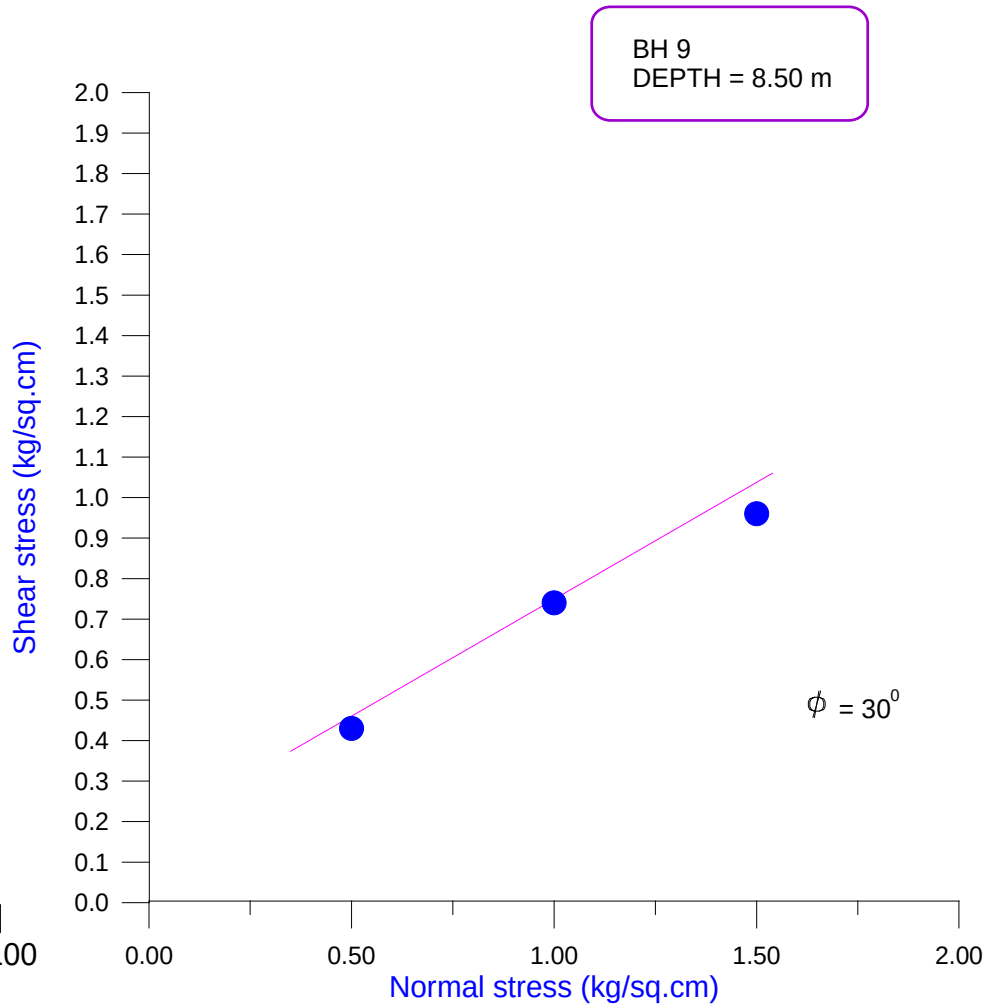
FIG- 9-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



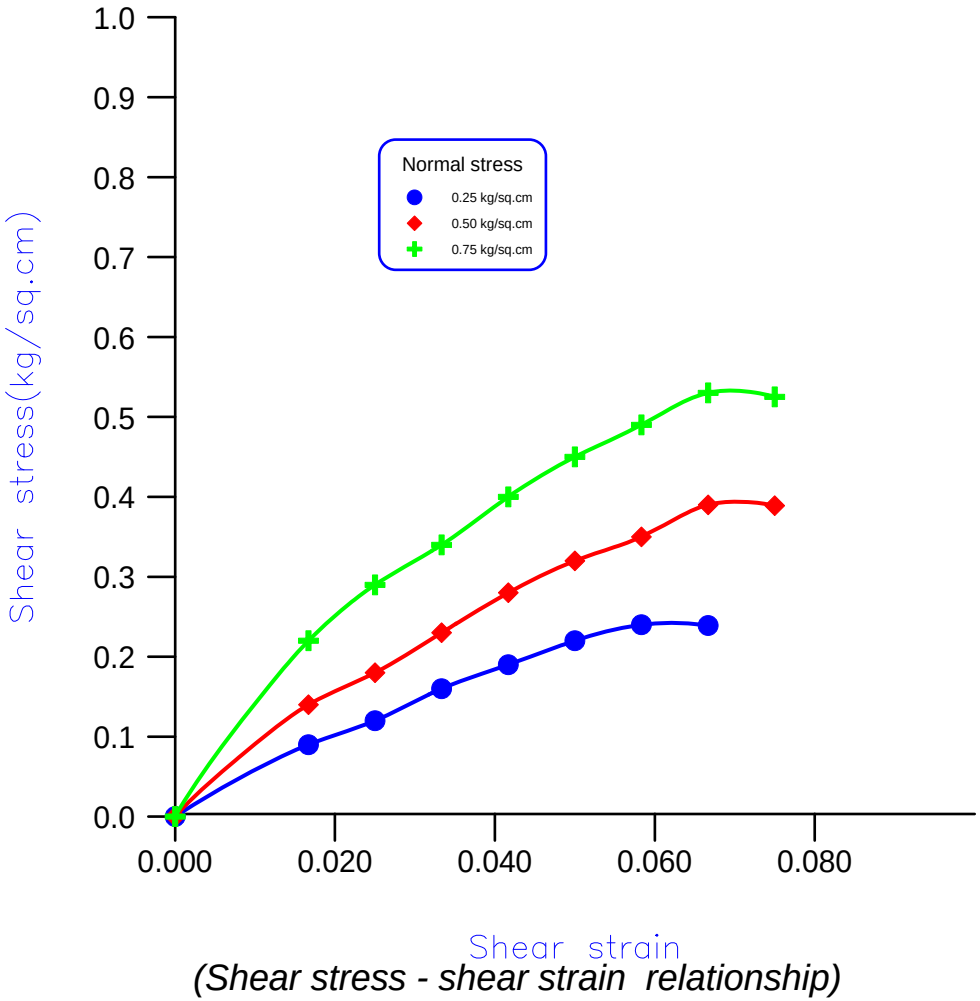
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

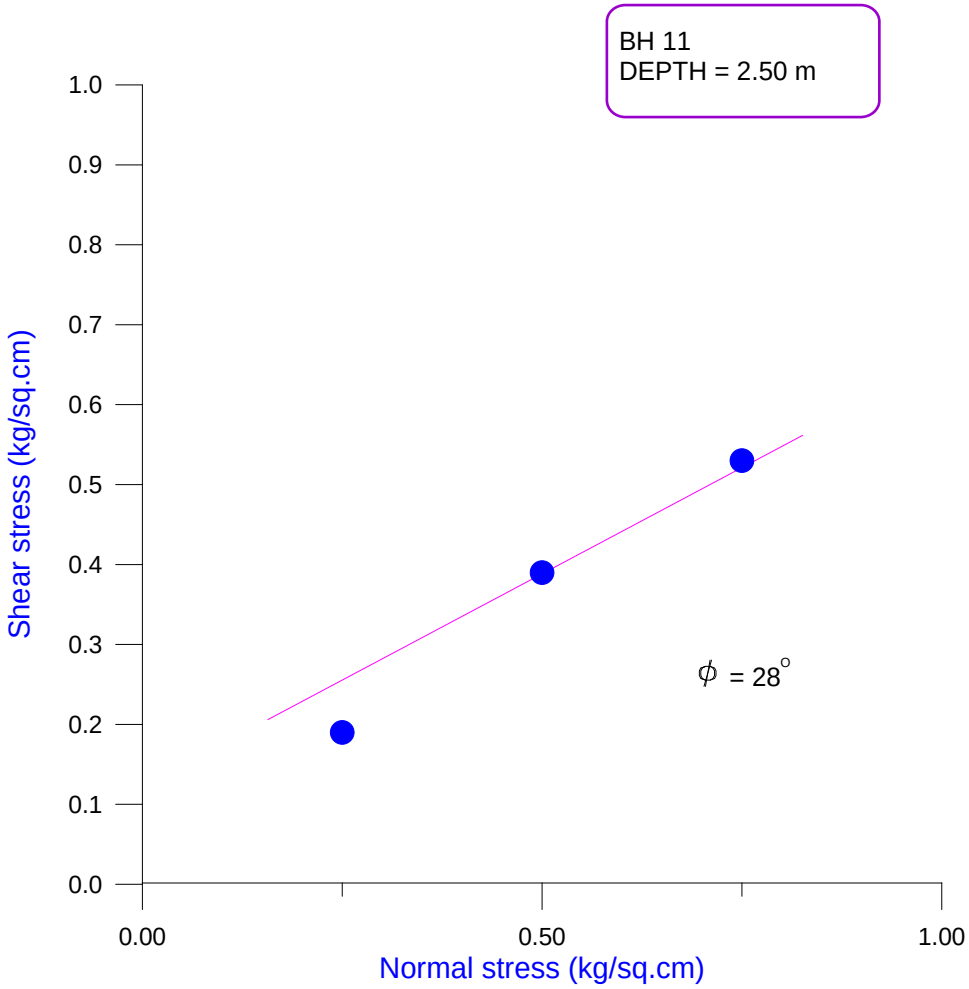
FIG- 9-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



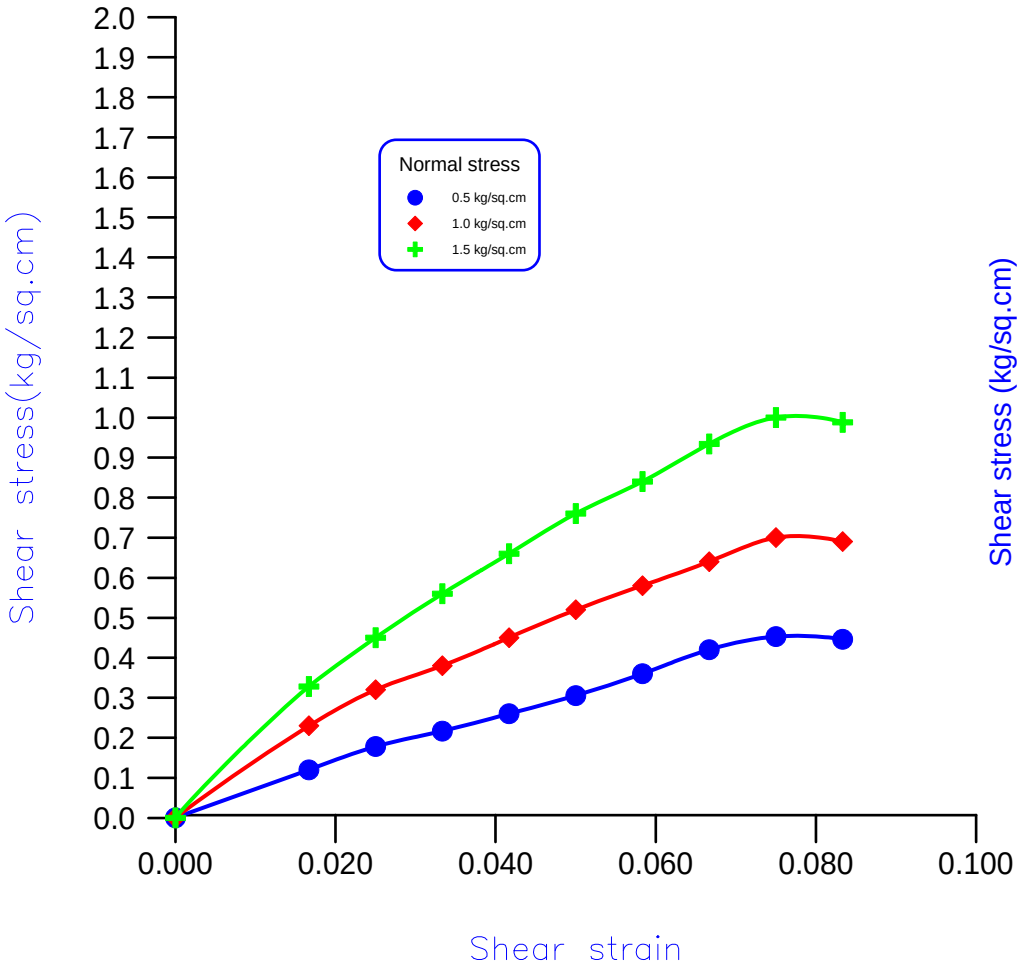
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

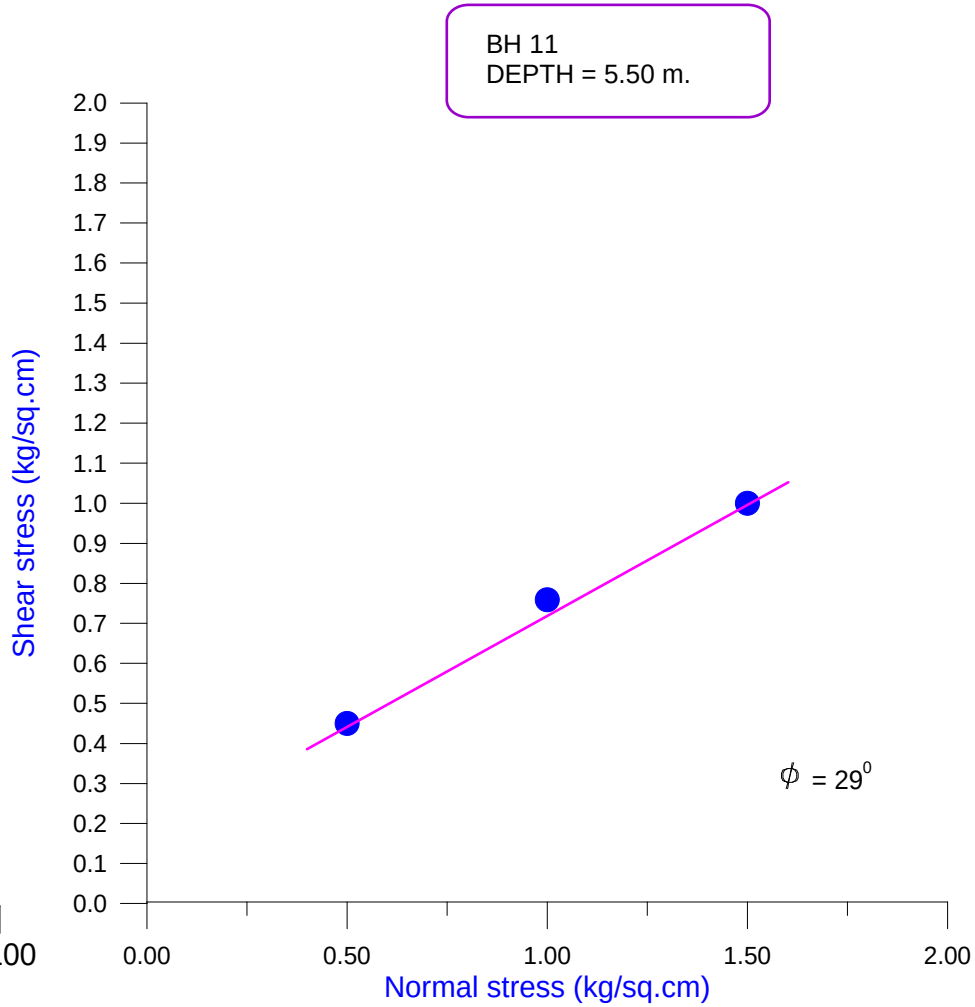
FIG- DS 11-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



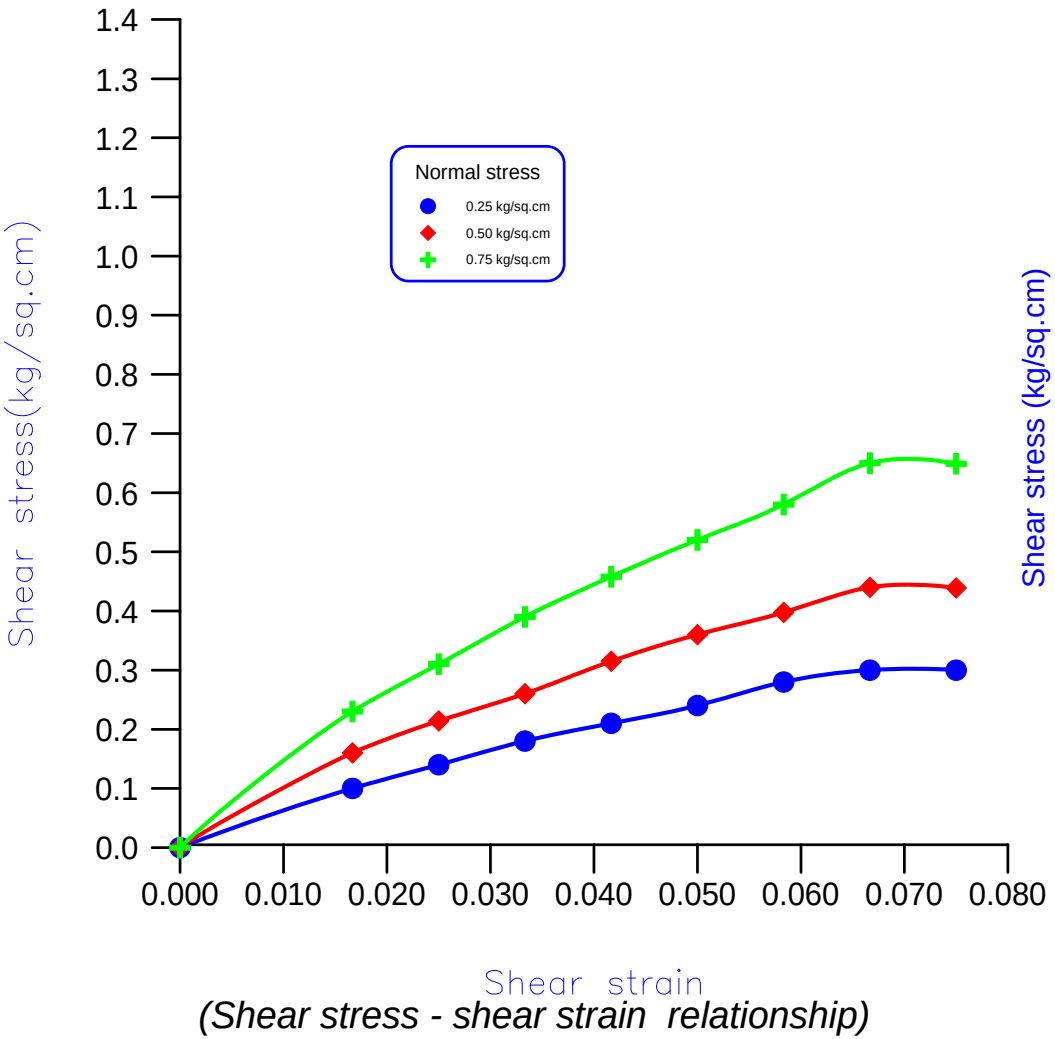
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

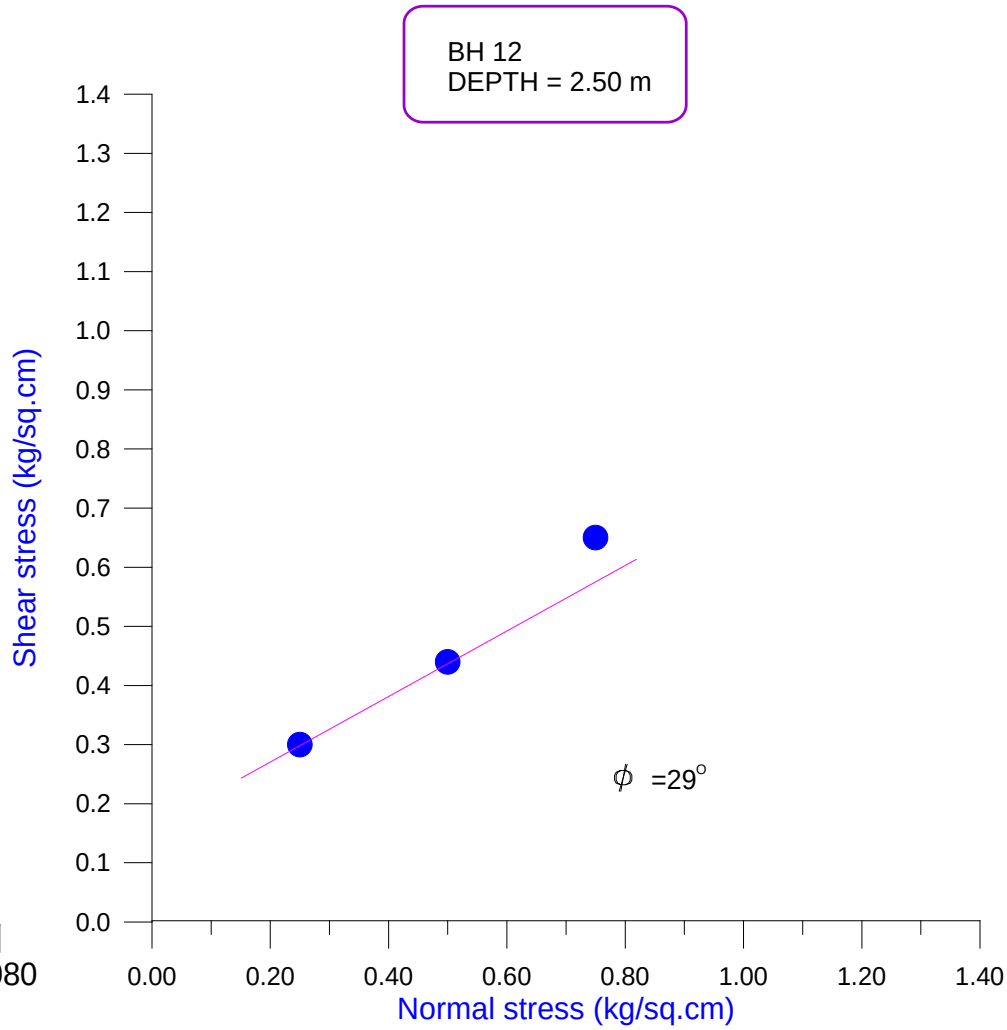
FIG- DS 11-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



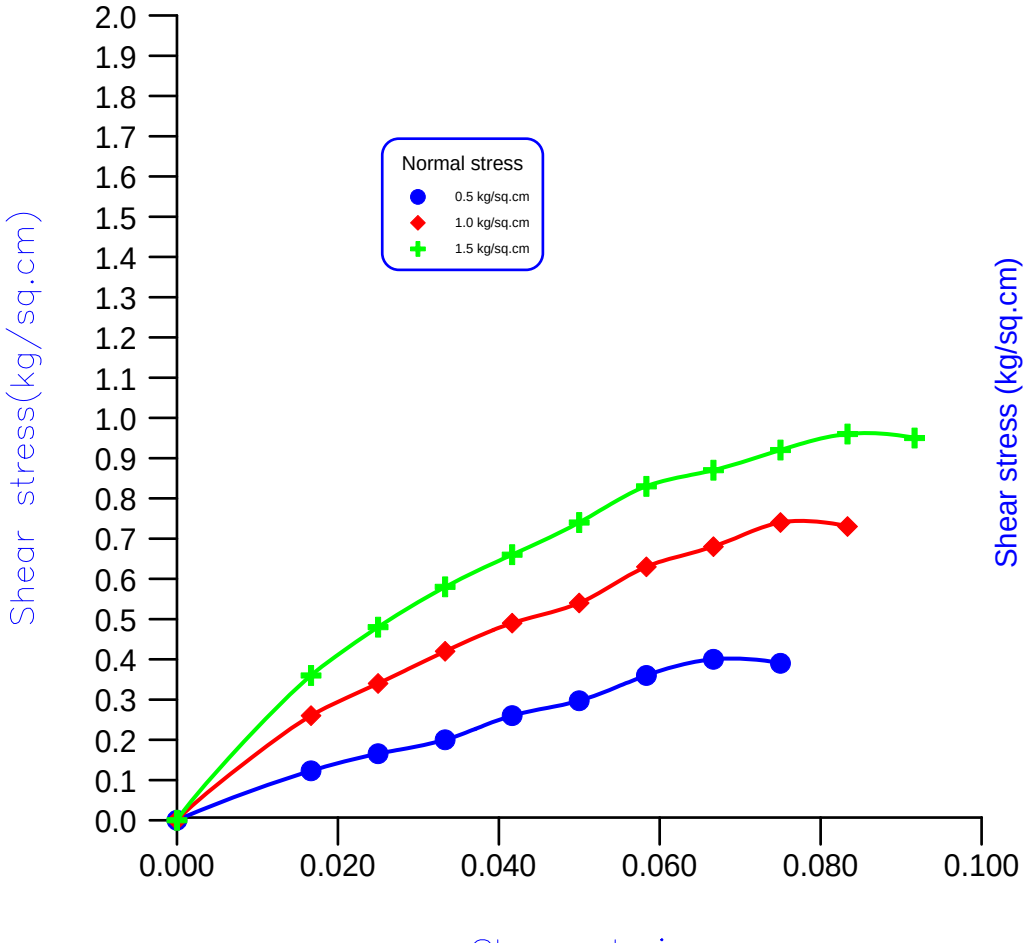
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

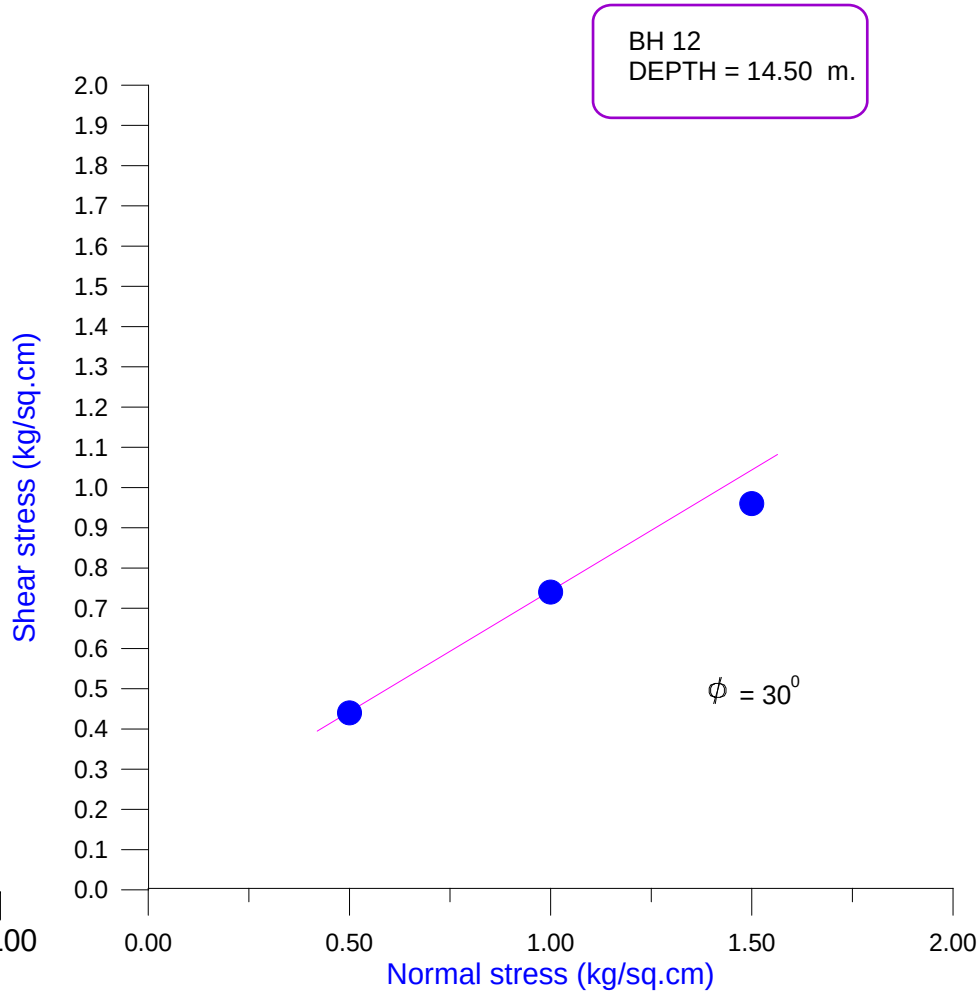
FIG- DS 12-1

Soil Engineering Conslants

Job. 2152



(Shear stress - shear strain relationship)



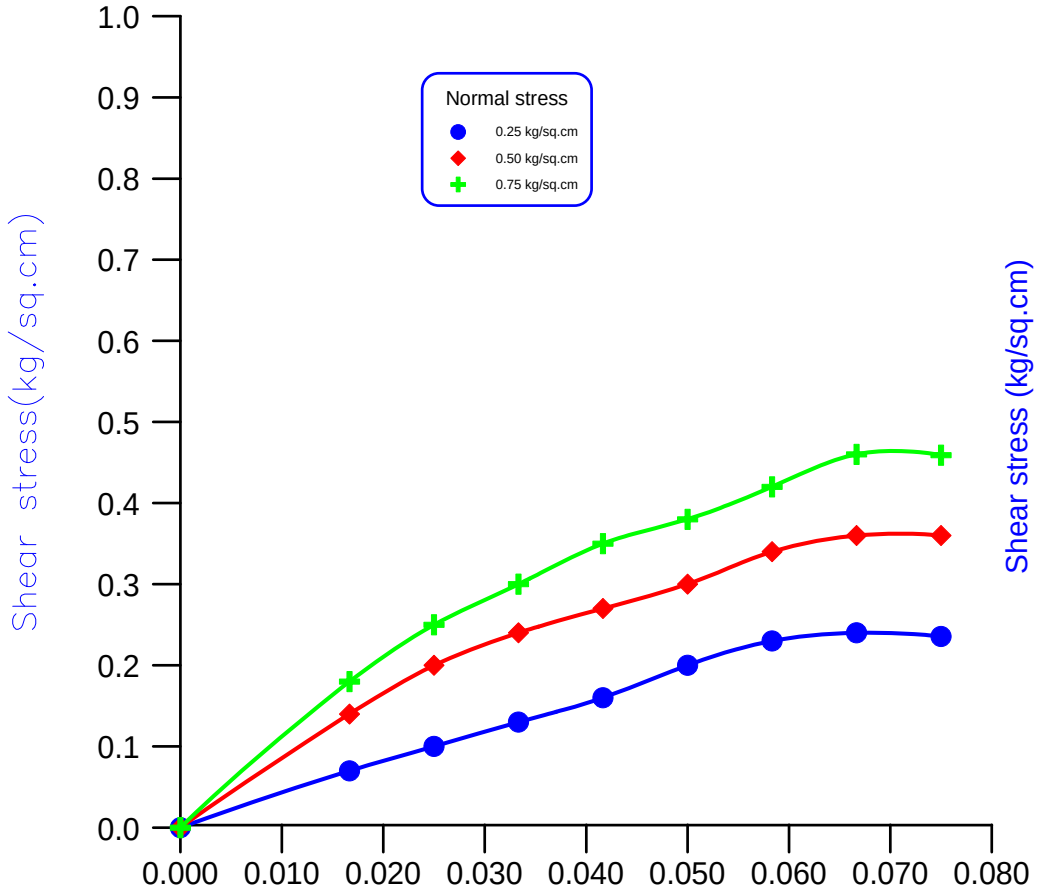
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

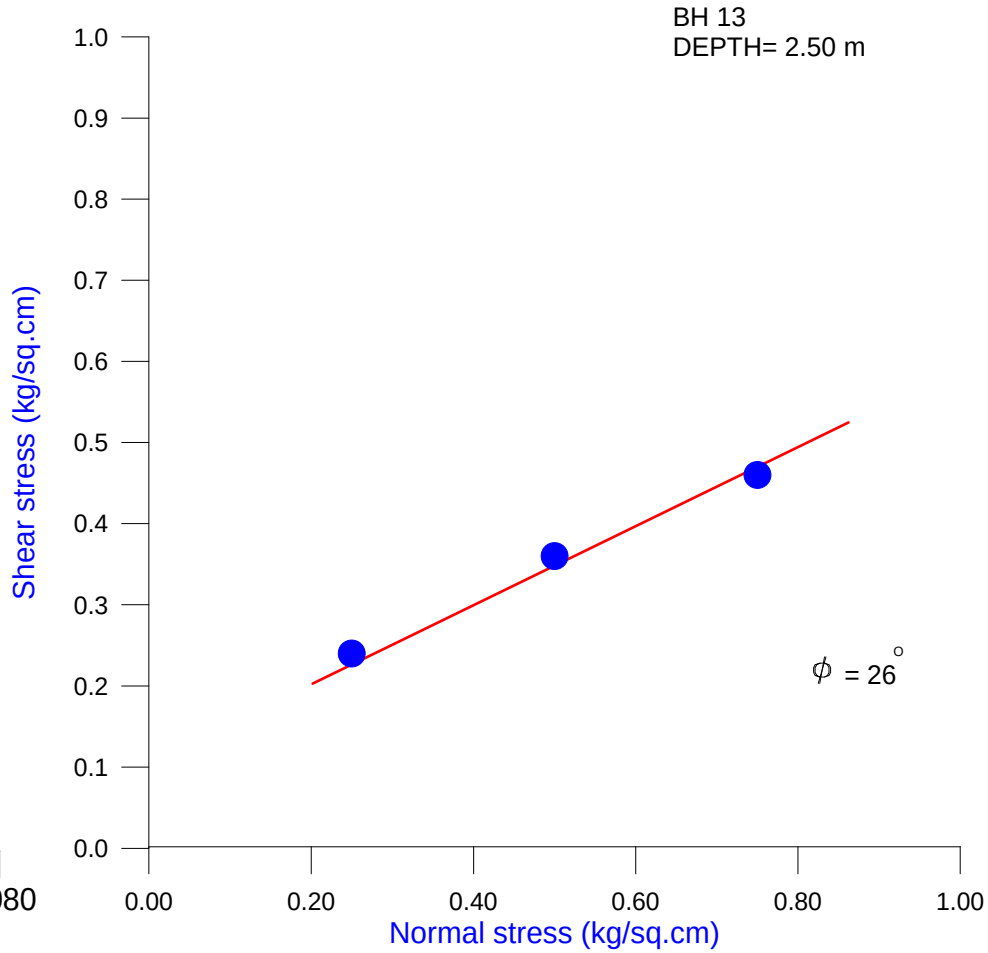
FIG- 12-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



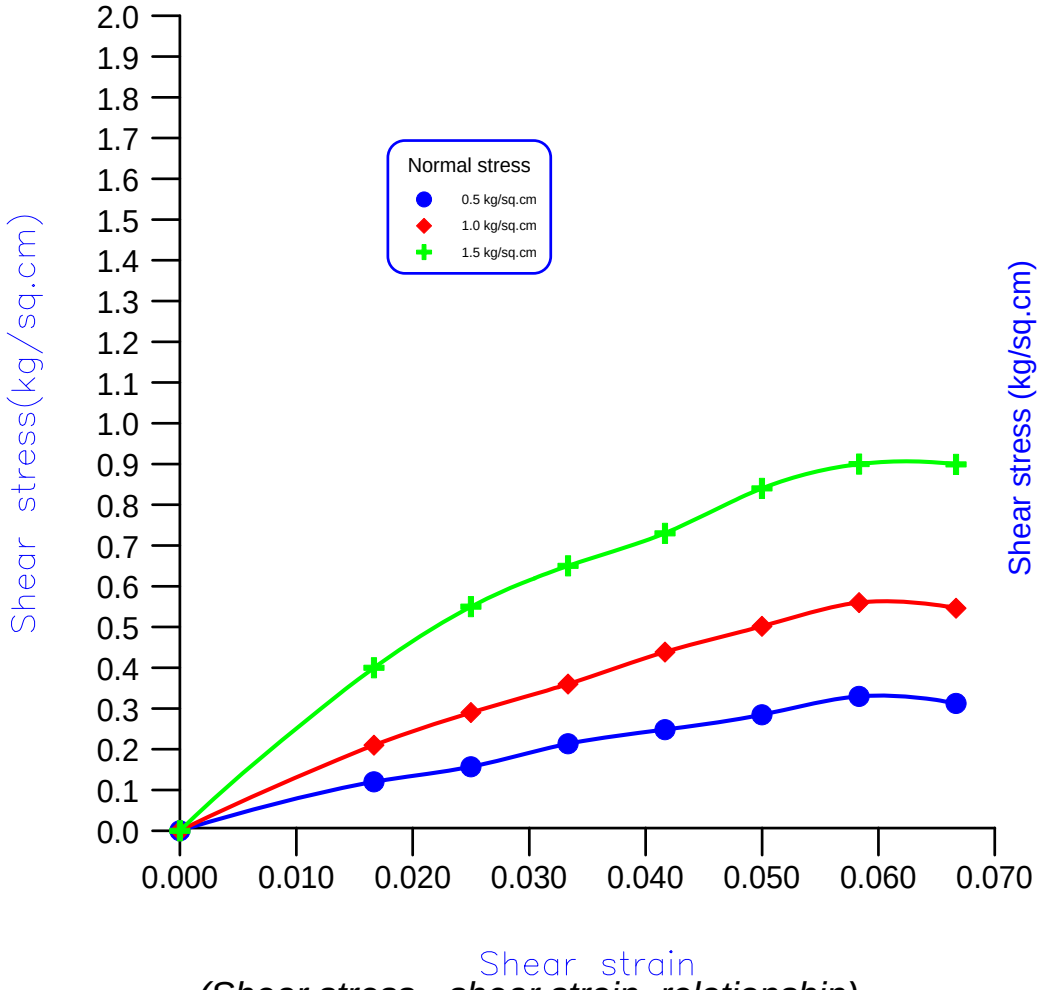
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

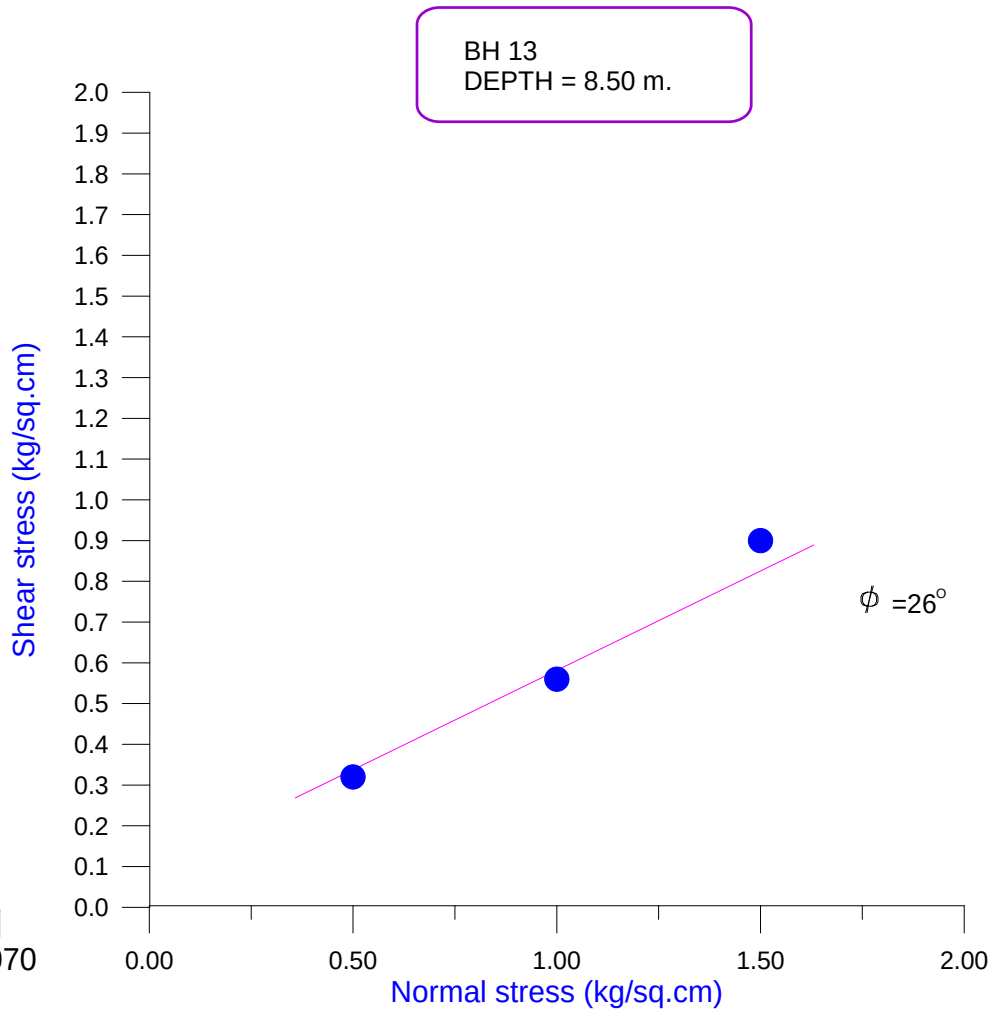
FIG- DS 13-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



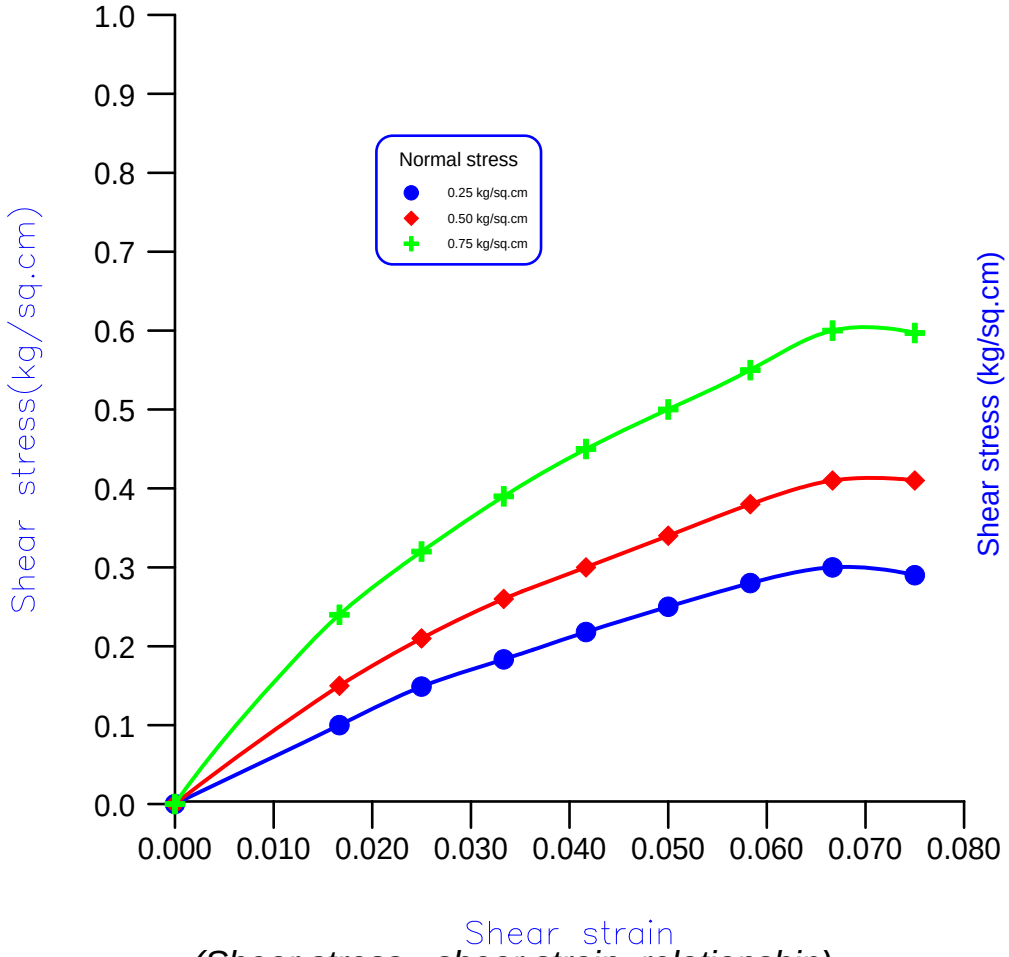
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

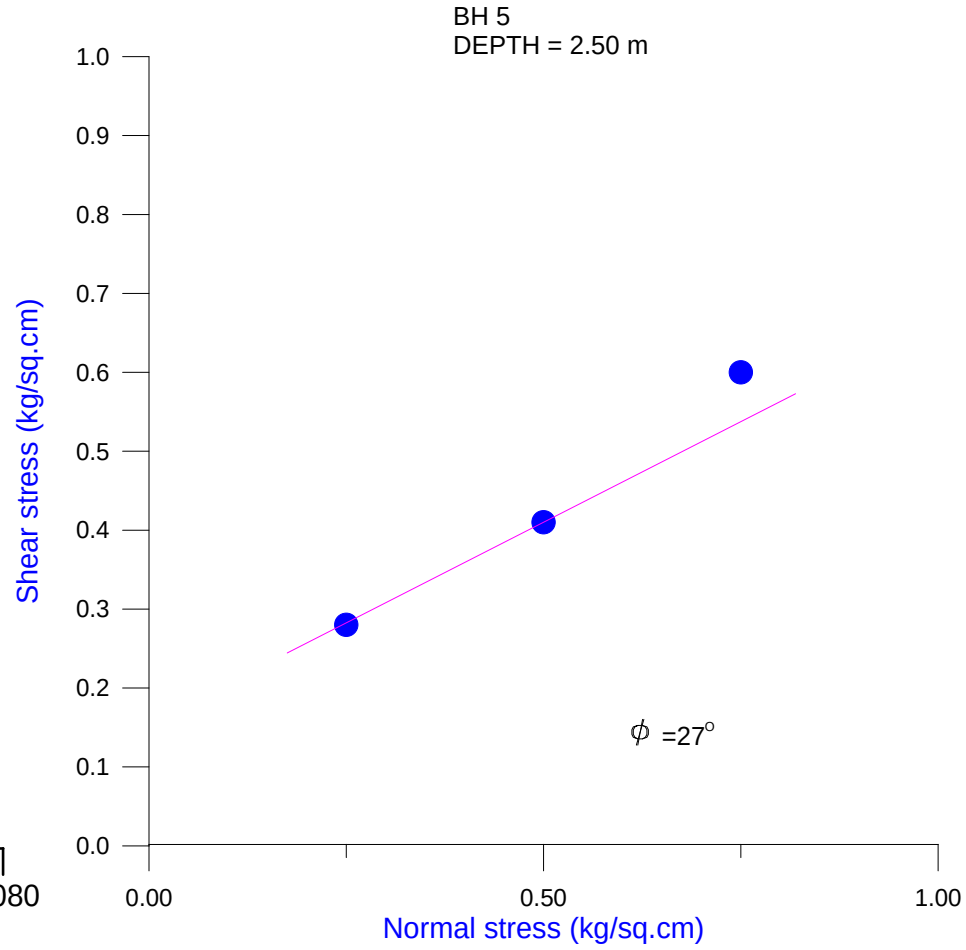
FIG- DS 13-2

Soil Engineering Consltants

Job. 2137



(Shear stress - shear strain relationship)



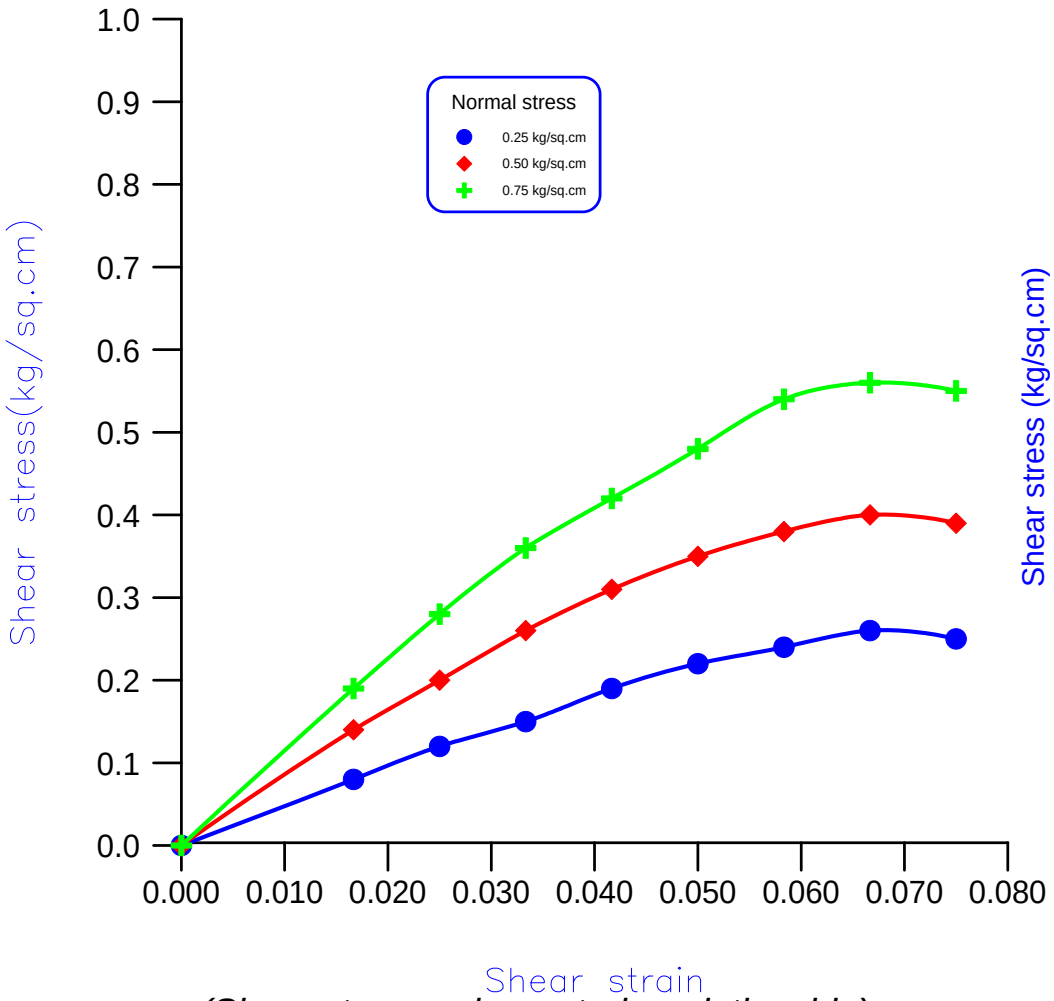
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

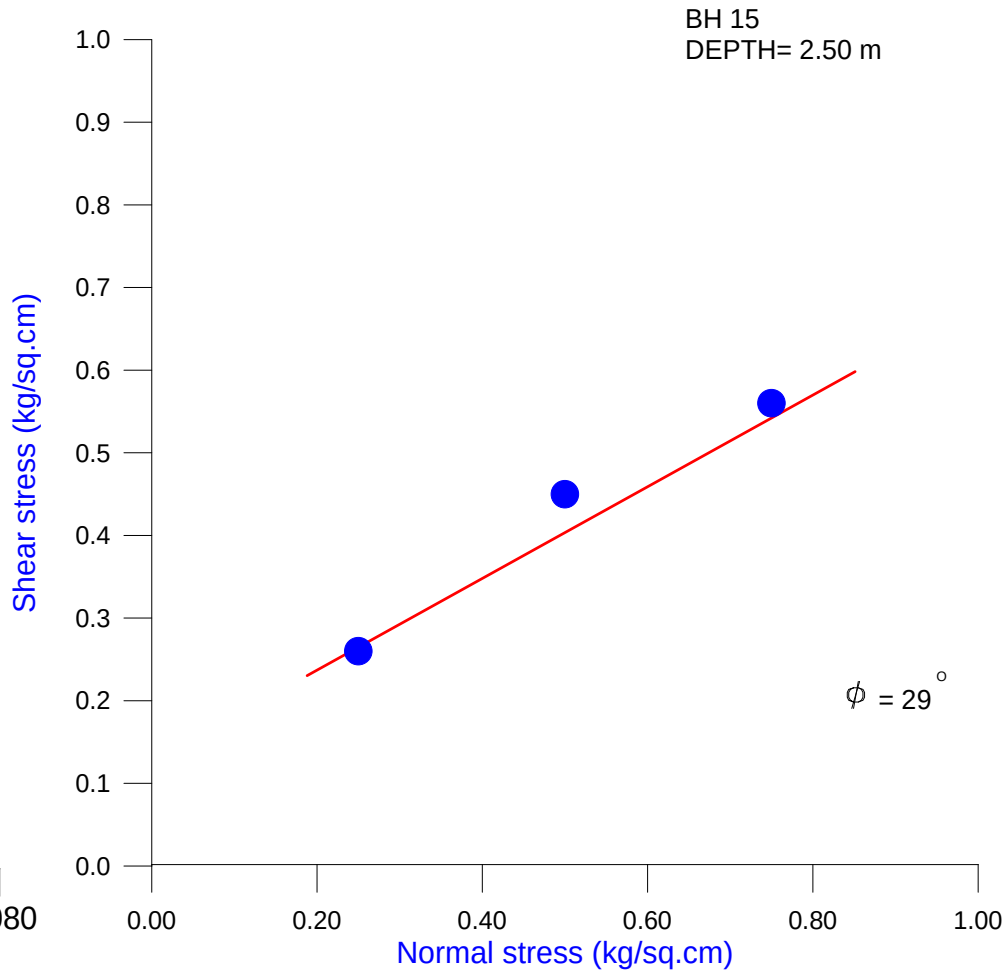
FIG- DS 14-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



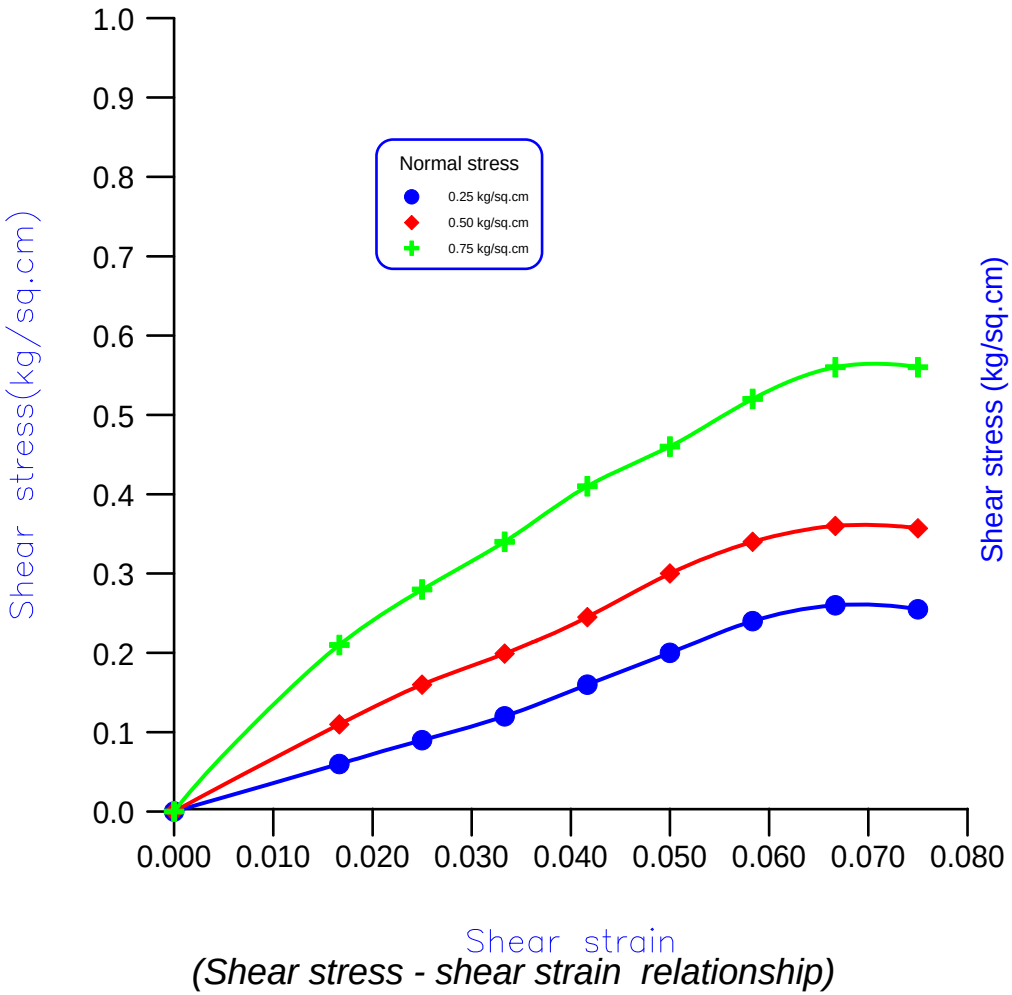
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

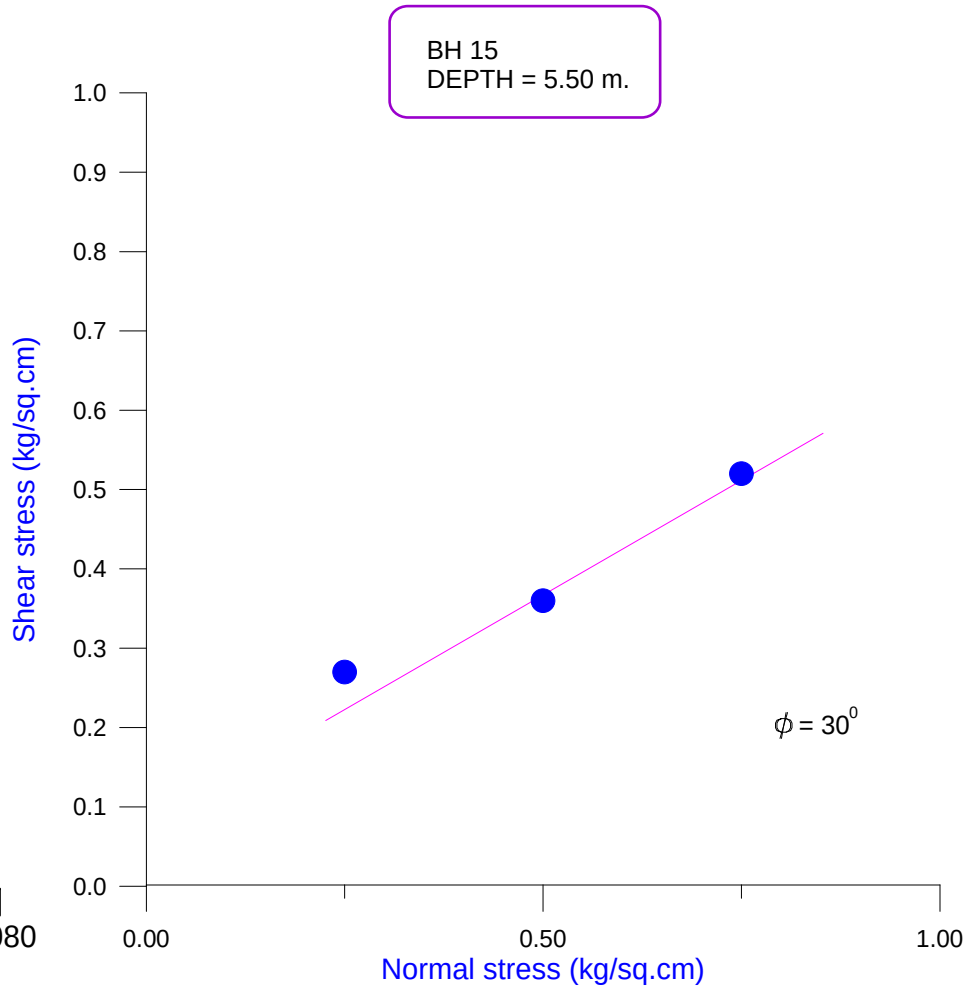
FIG- DS 15-1

Soil Engineering Conslants

Job. 2152



(Shear stress - shear strain relationship)



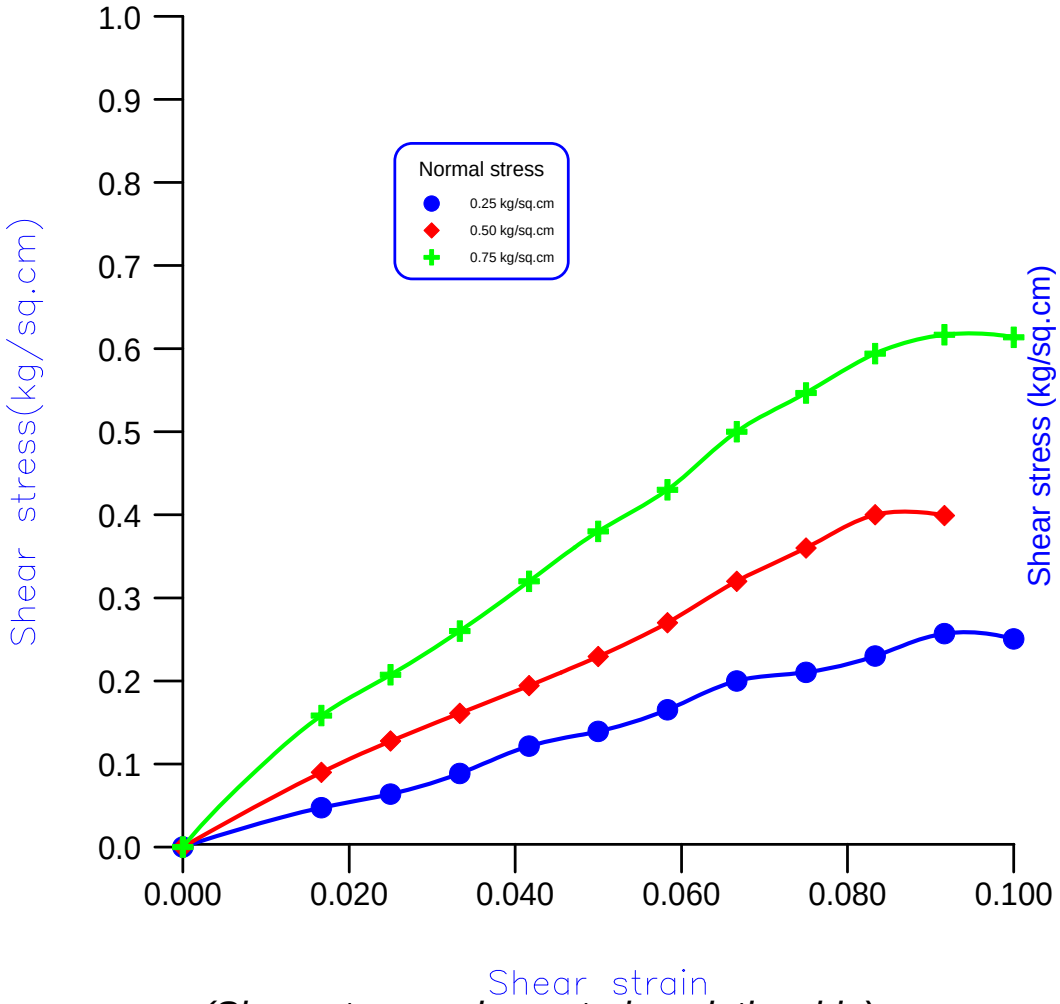
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

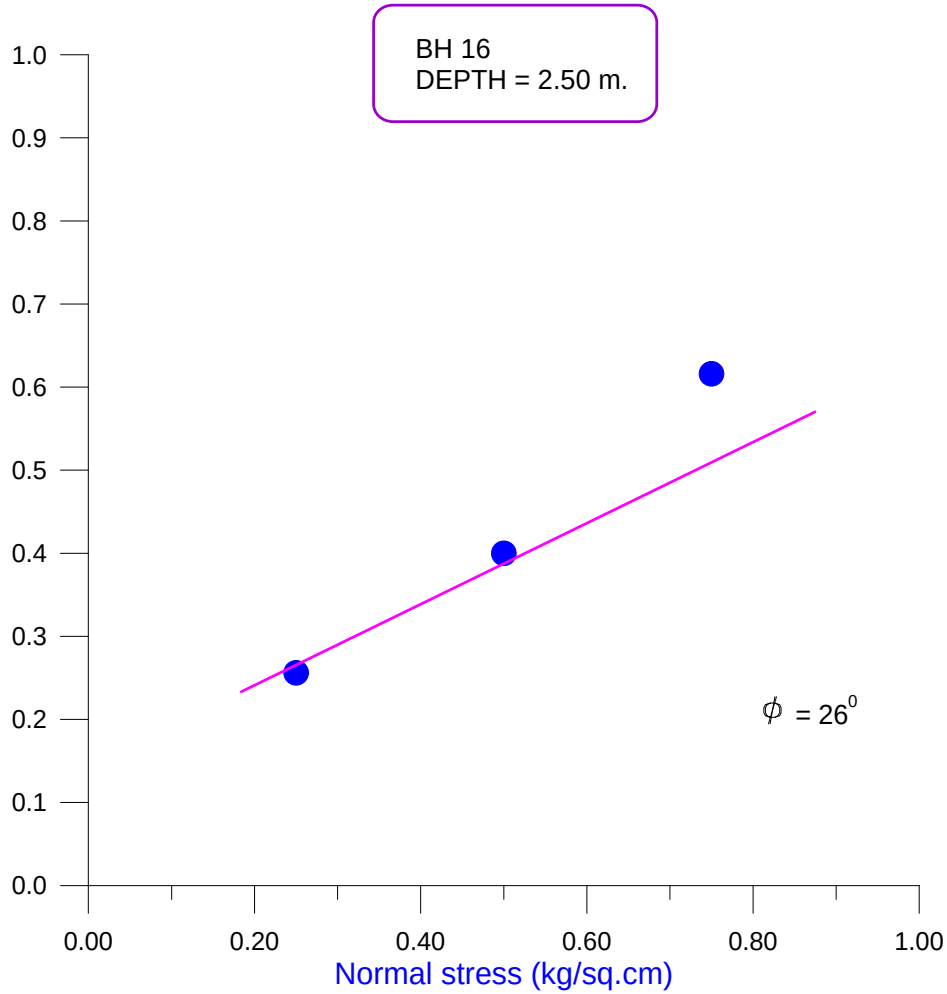
FIG- DS 15-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



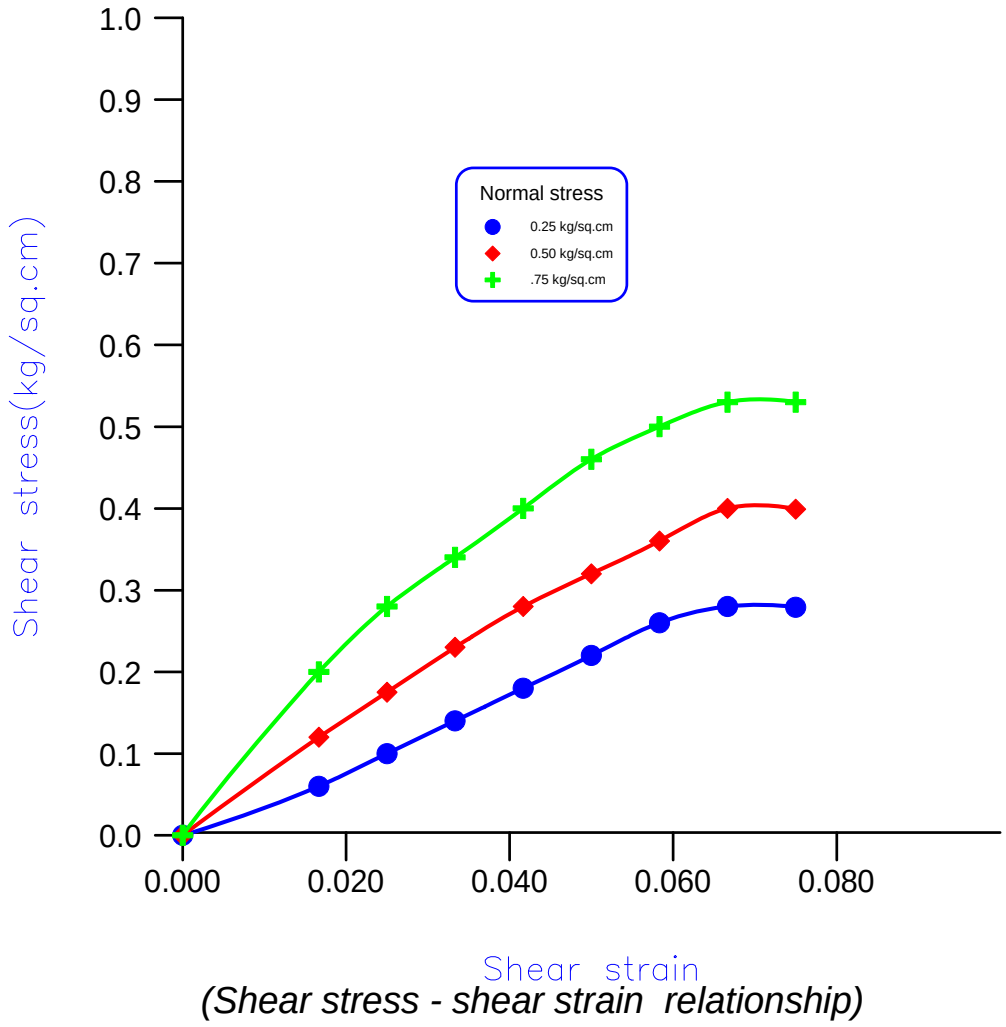
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

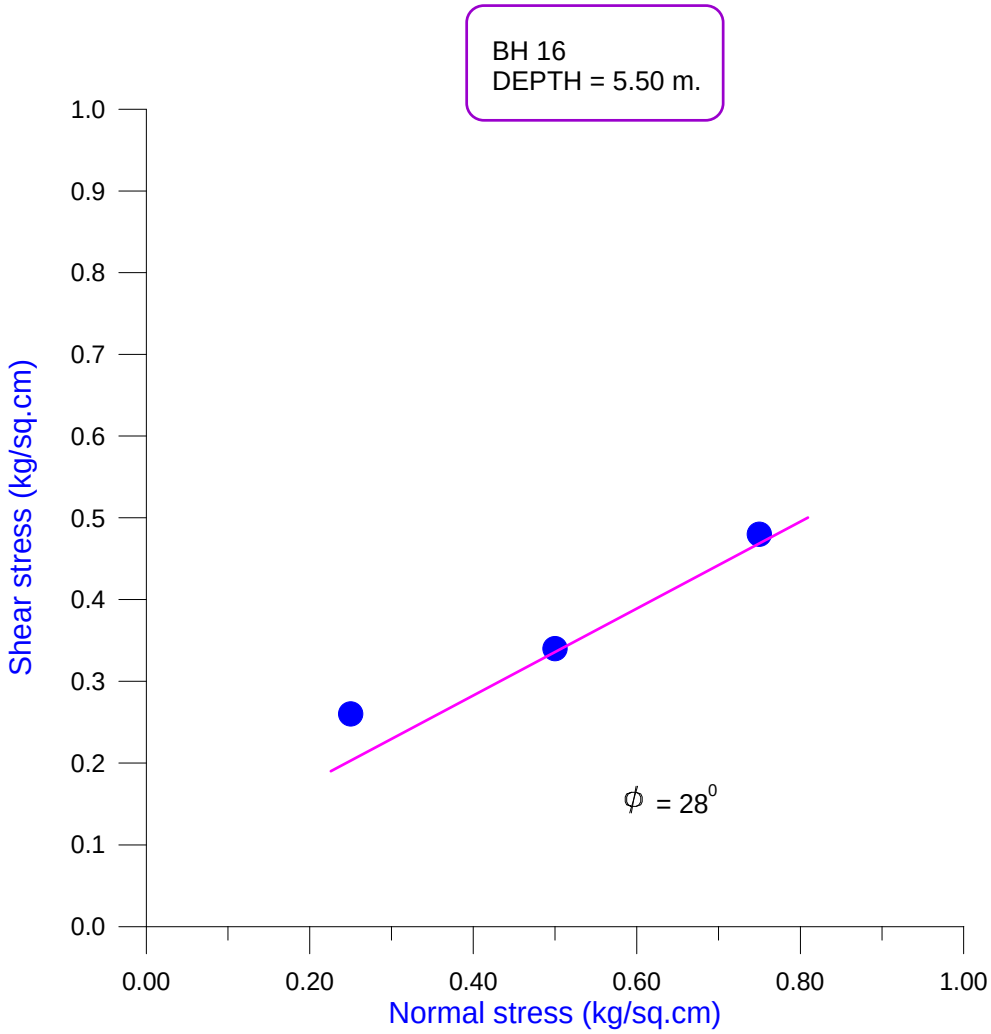
FIG- DS 16-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



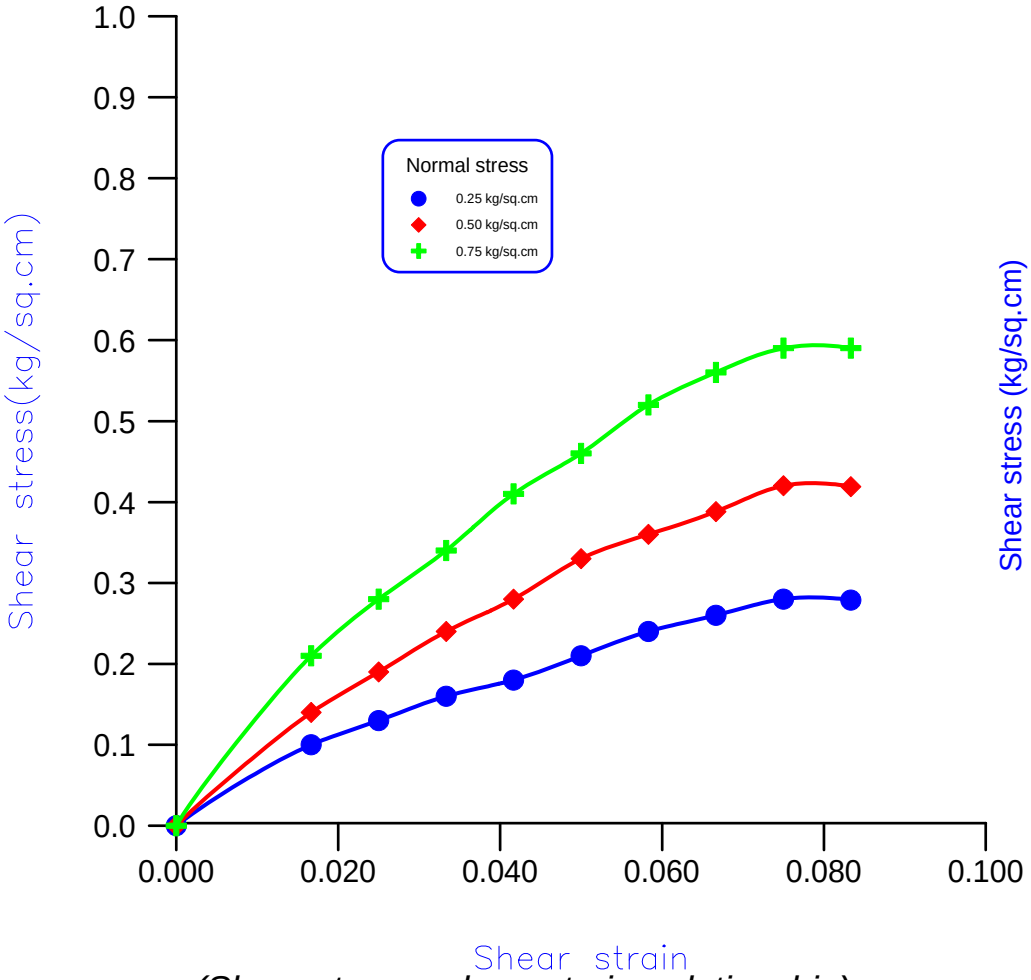
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

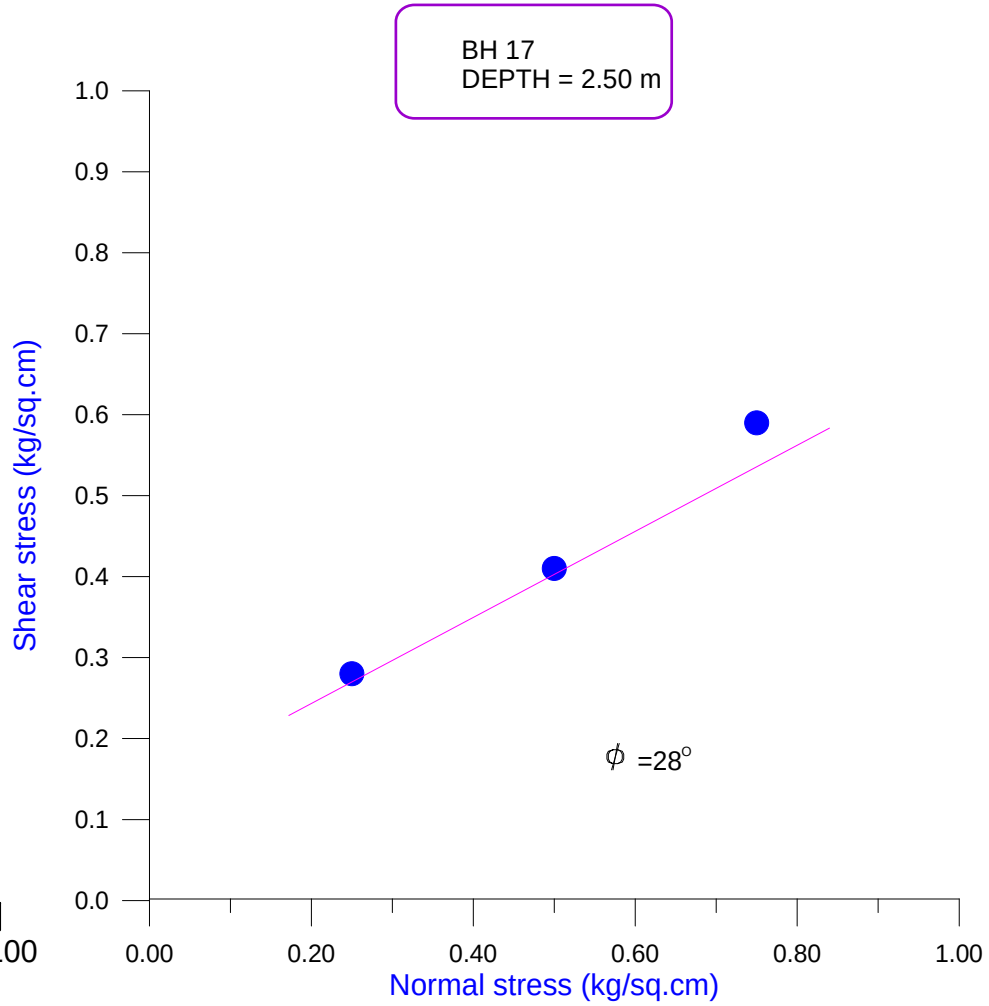
FIG- DS 16-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



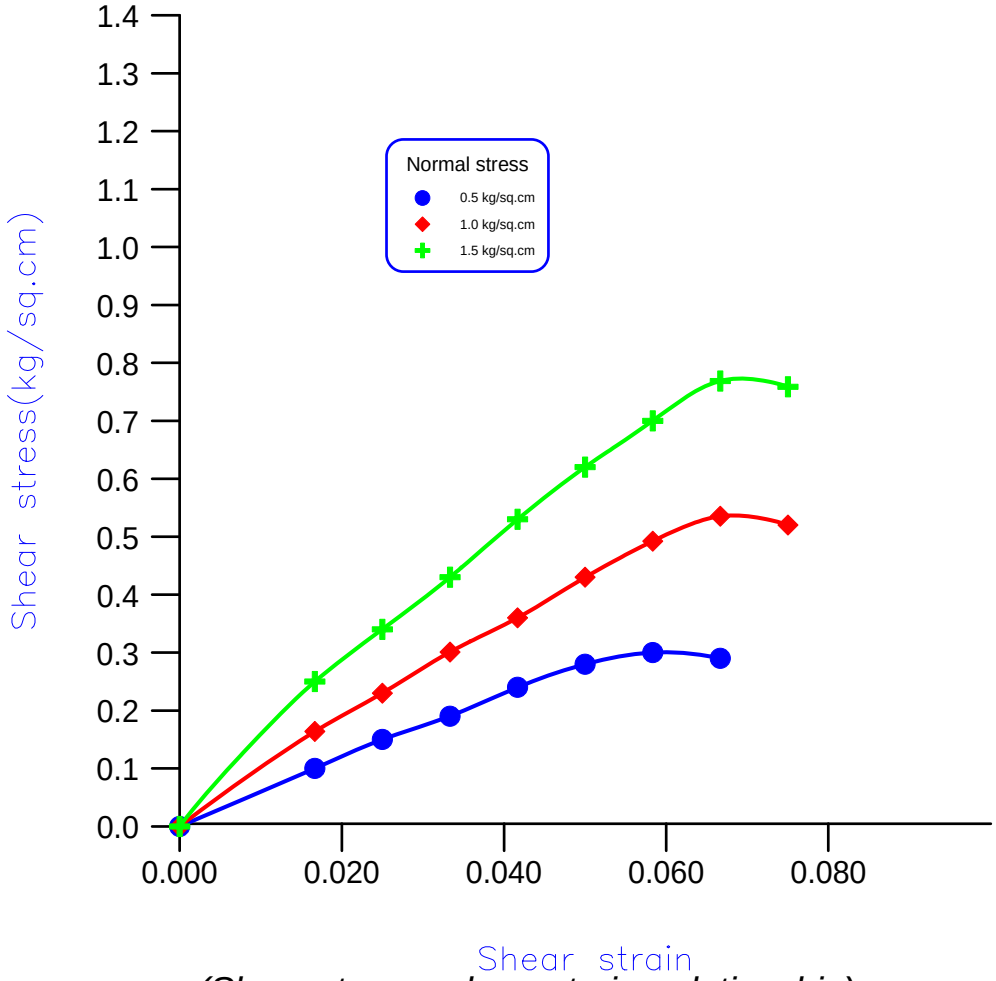
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

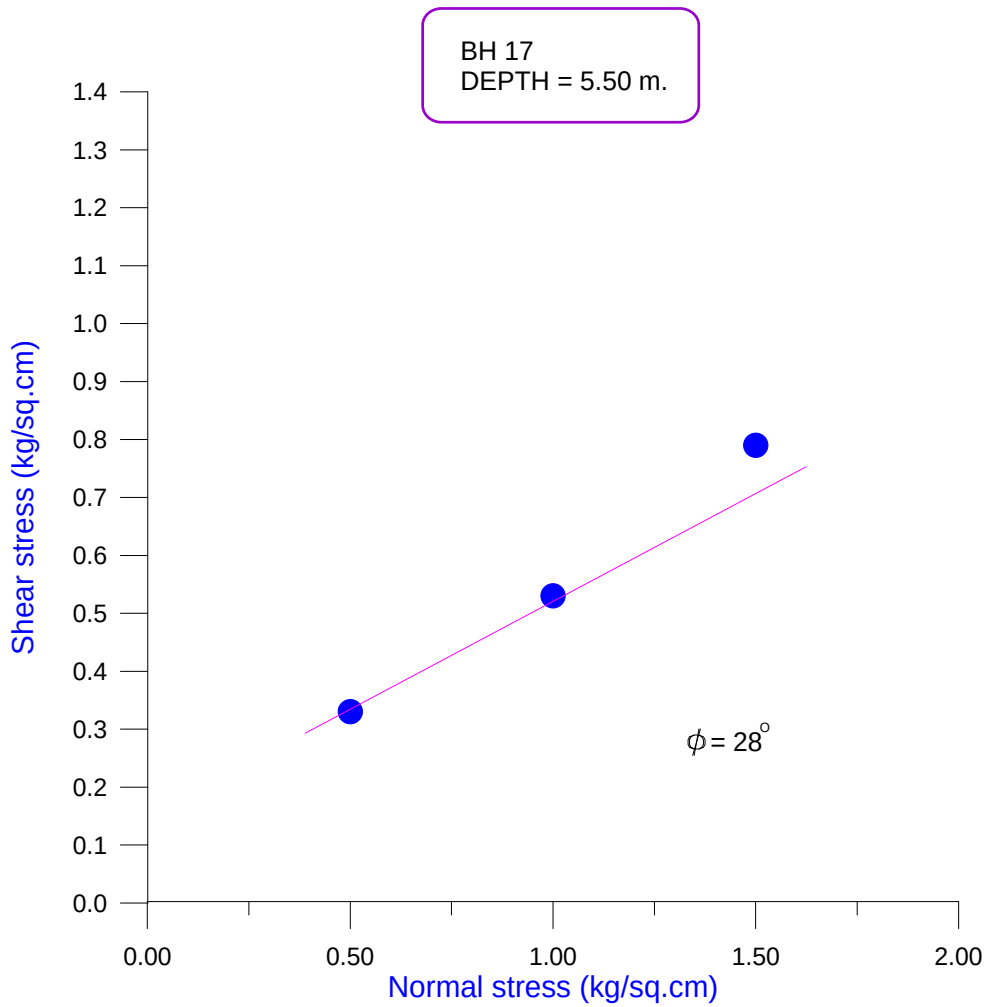
FIG- DS 17-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



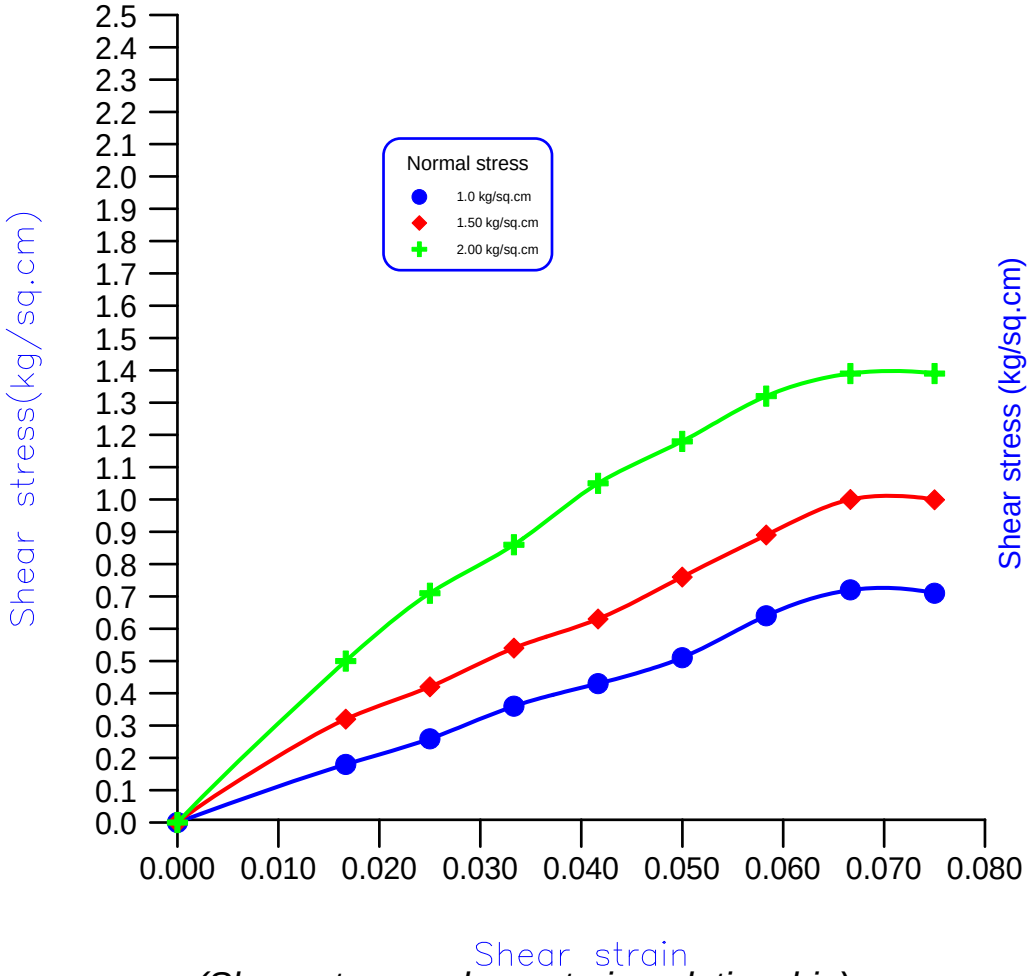
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

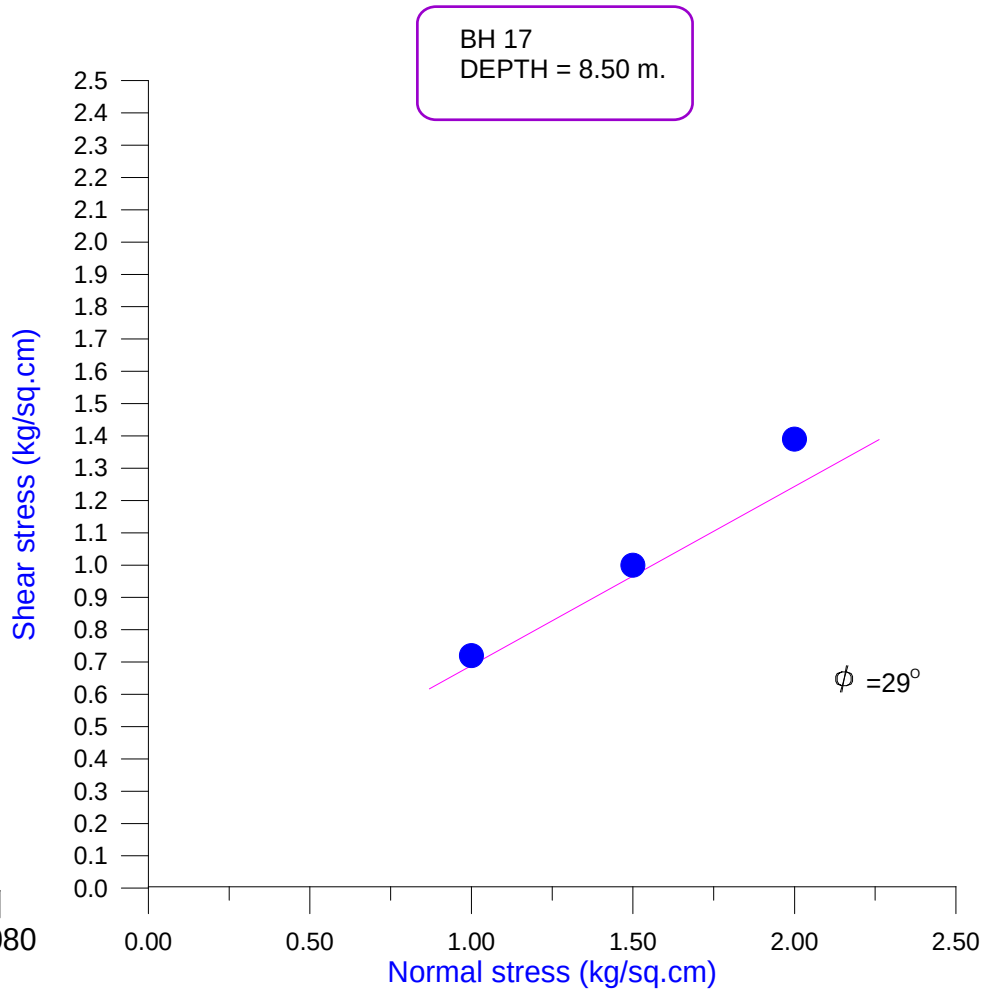
FIG- DS 17-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



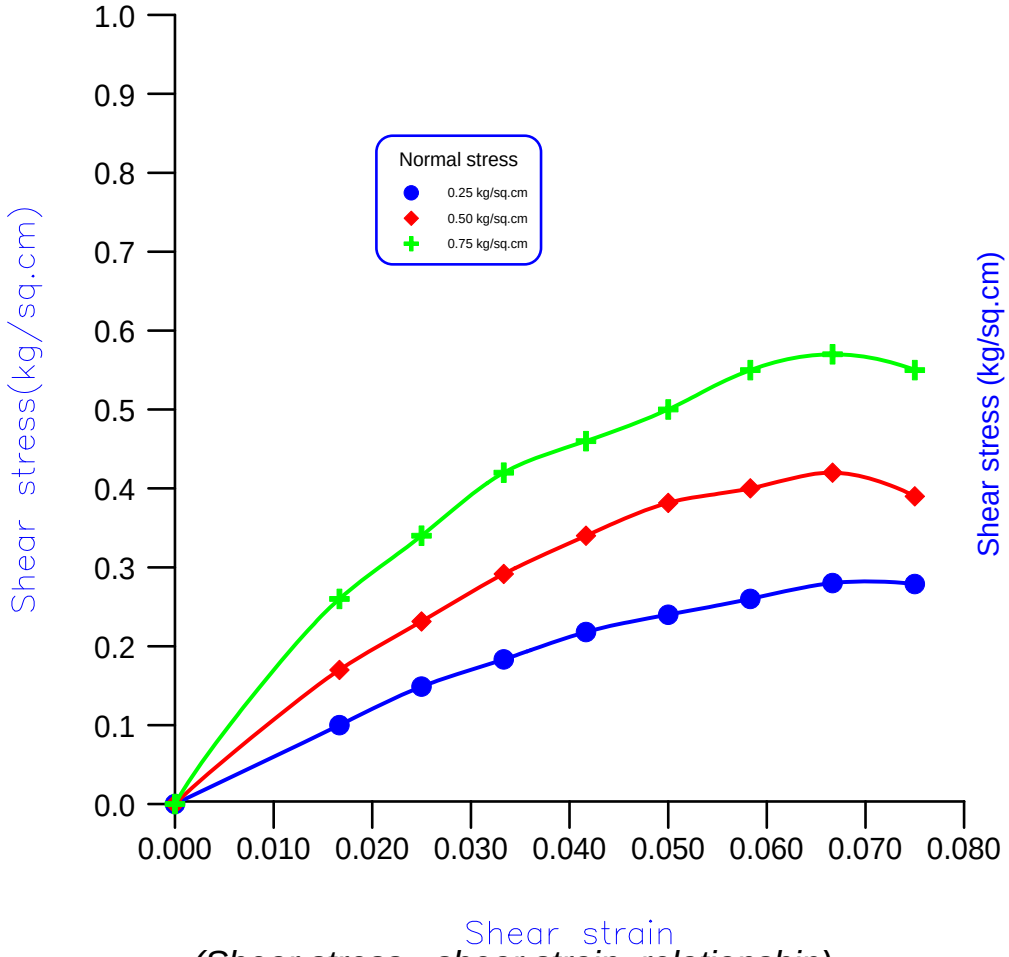
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

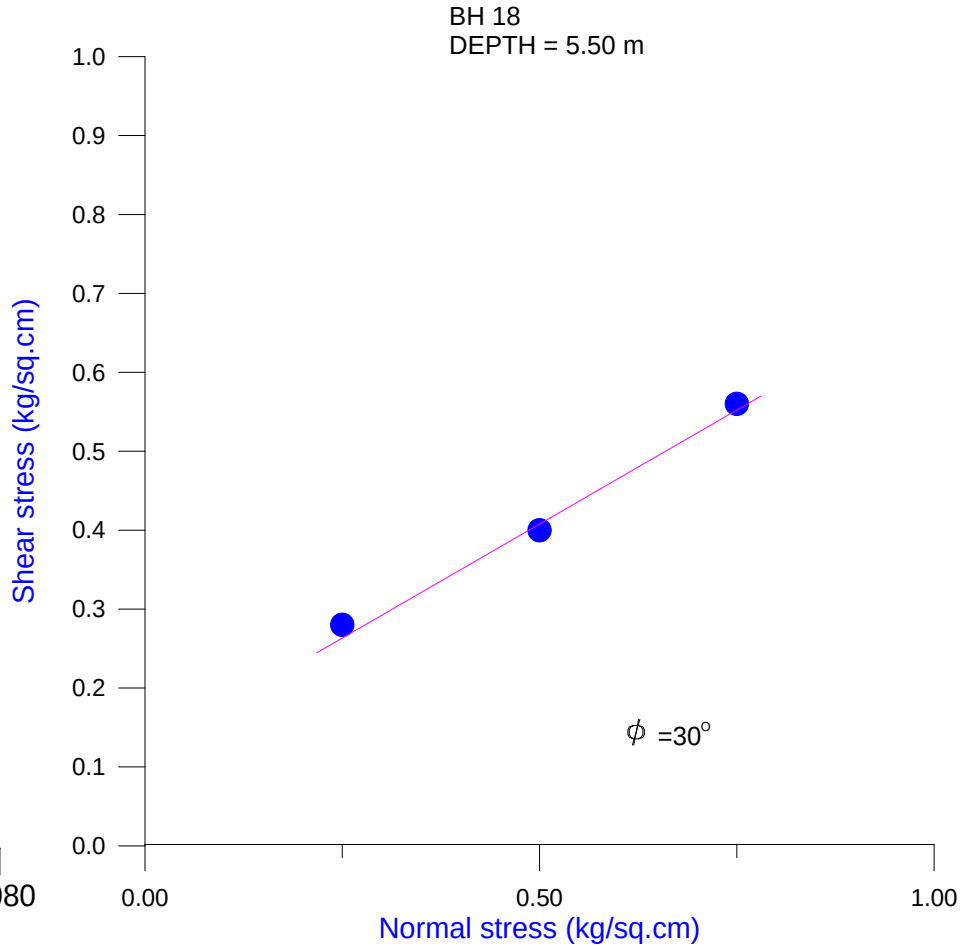
FIG- DS 17-3

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



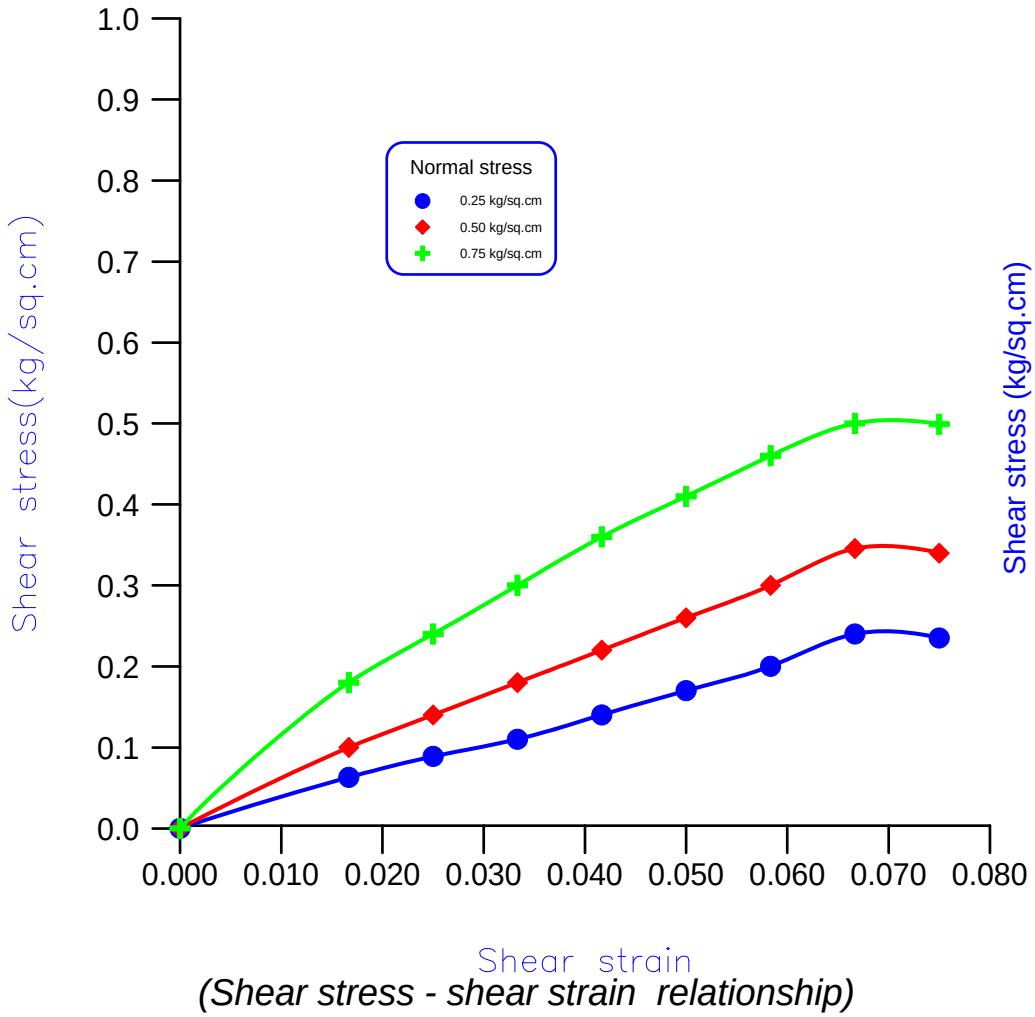
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

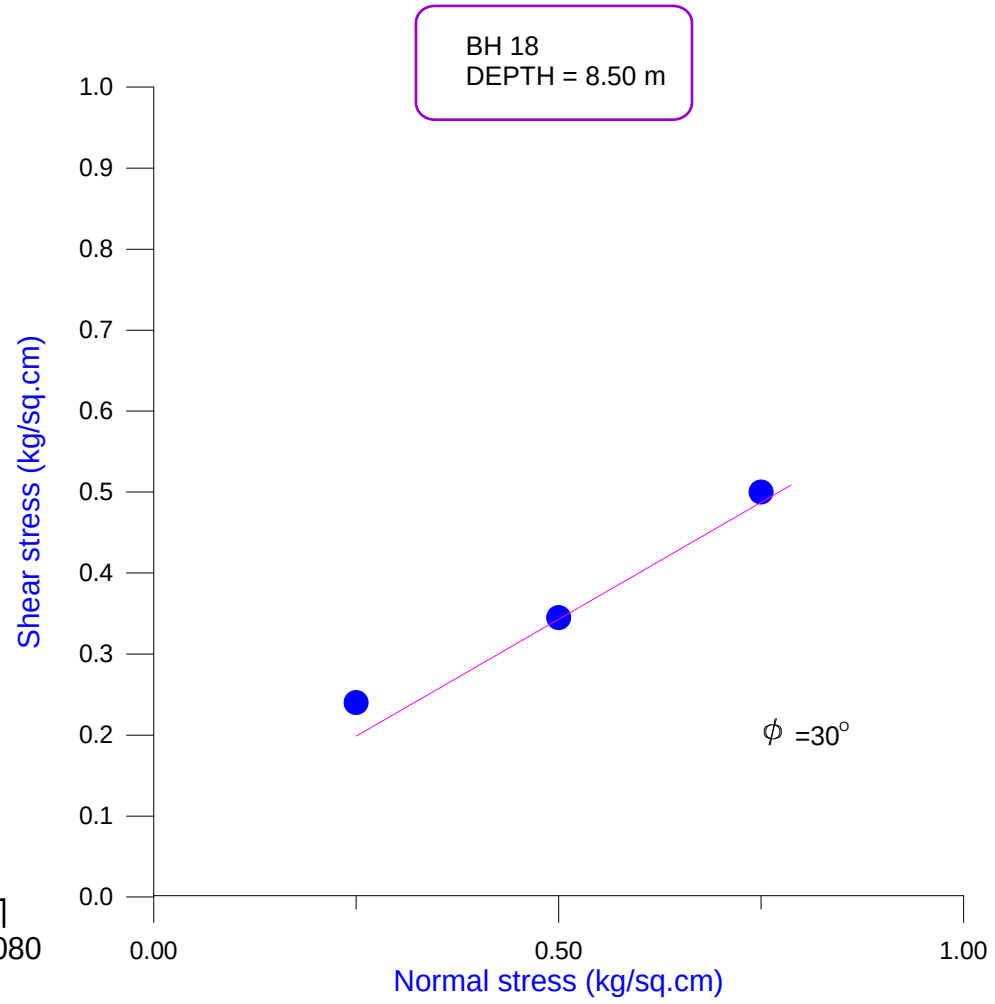
FIG- DS 18-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



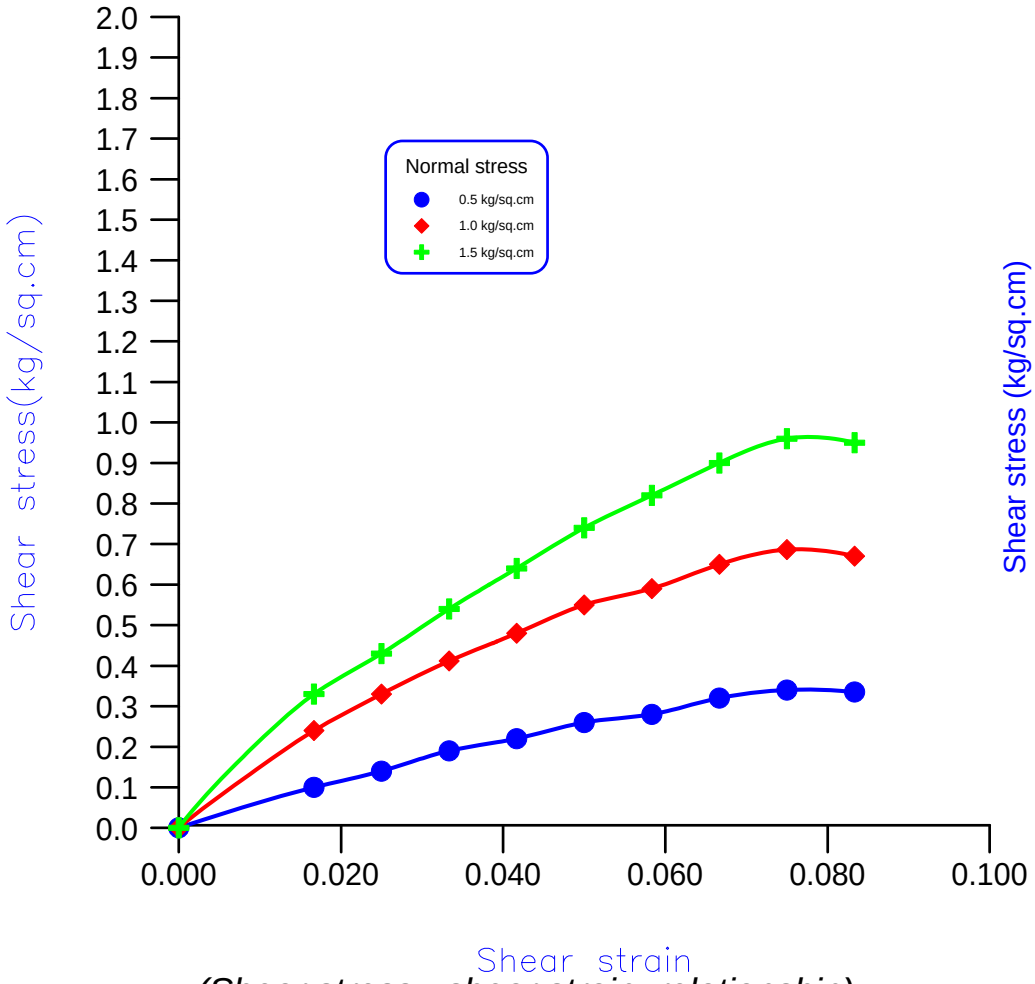
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

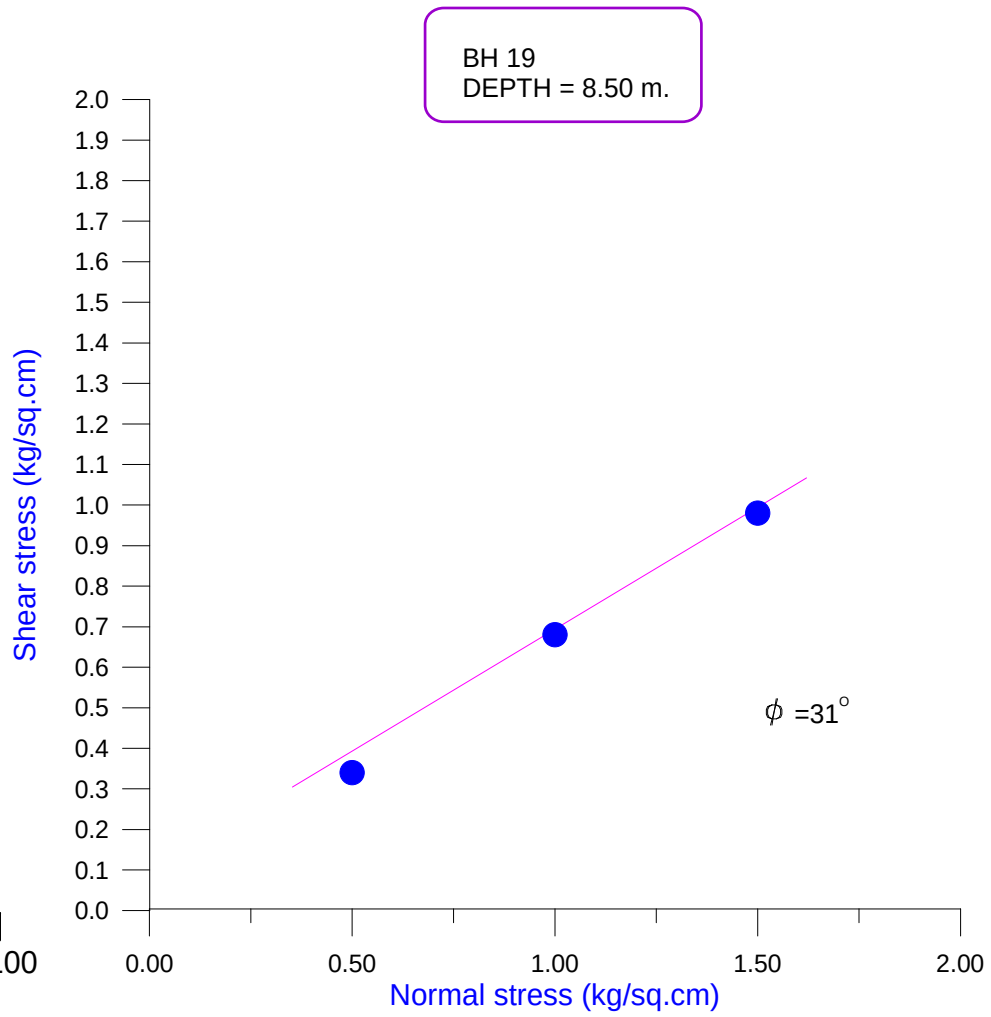
FIG- DS 18-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



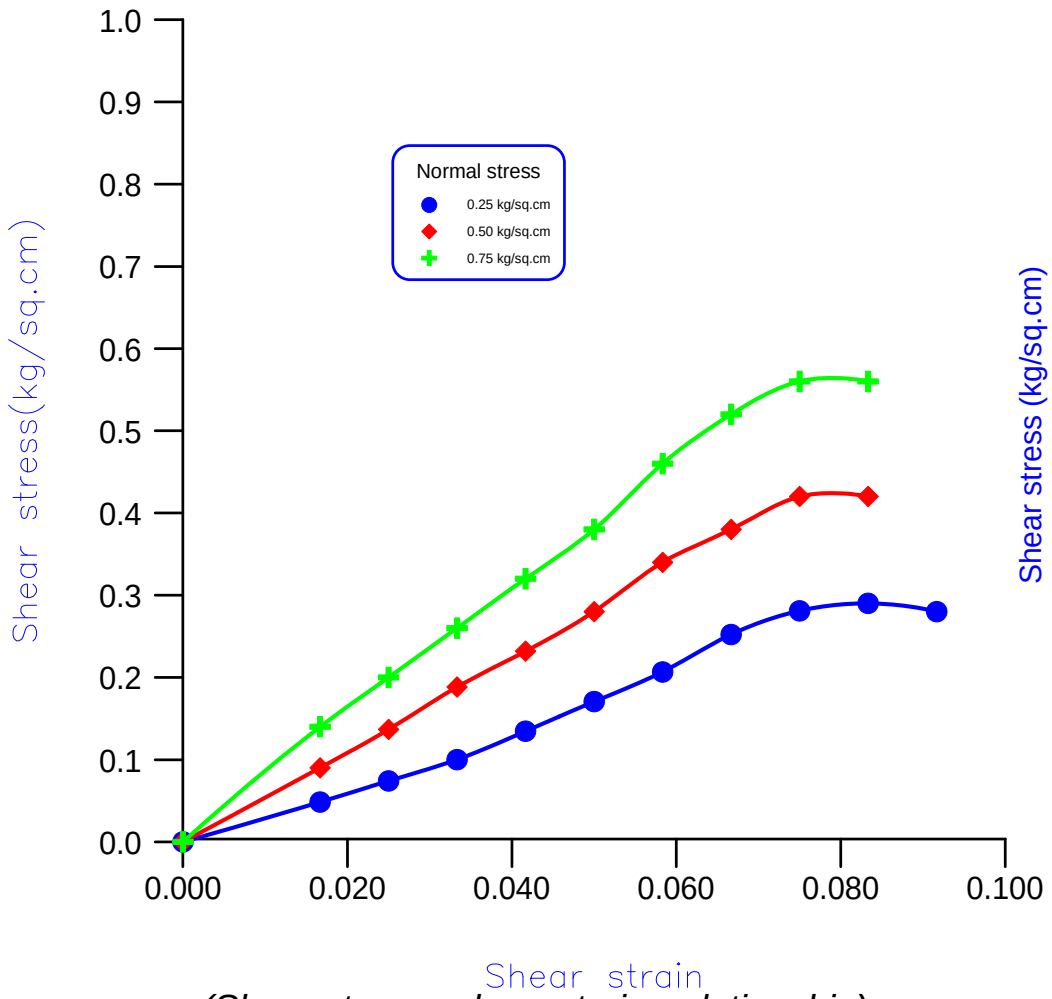
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

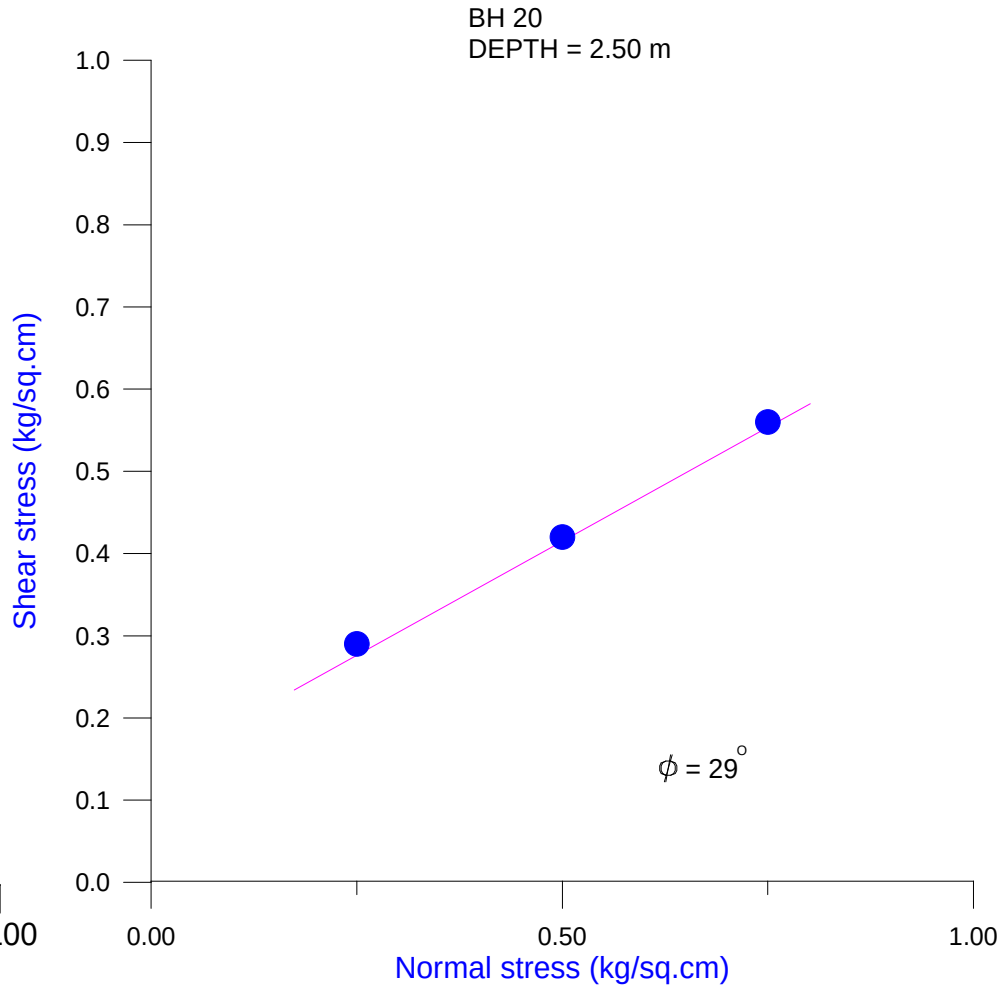
FIG- DS 19-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



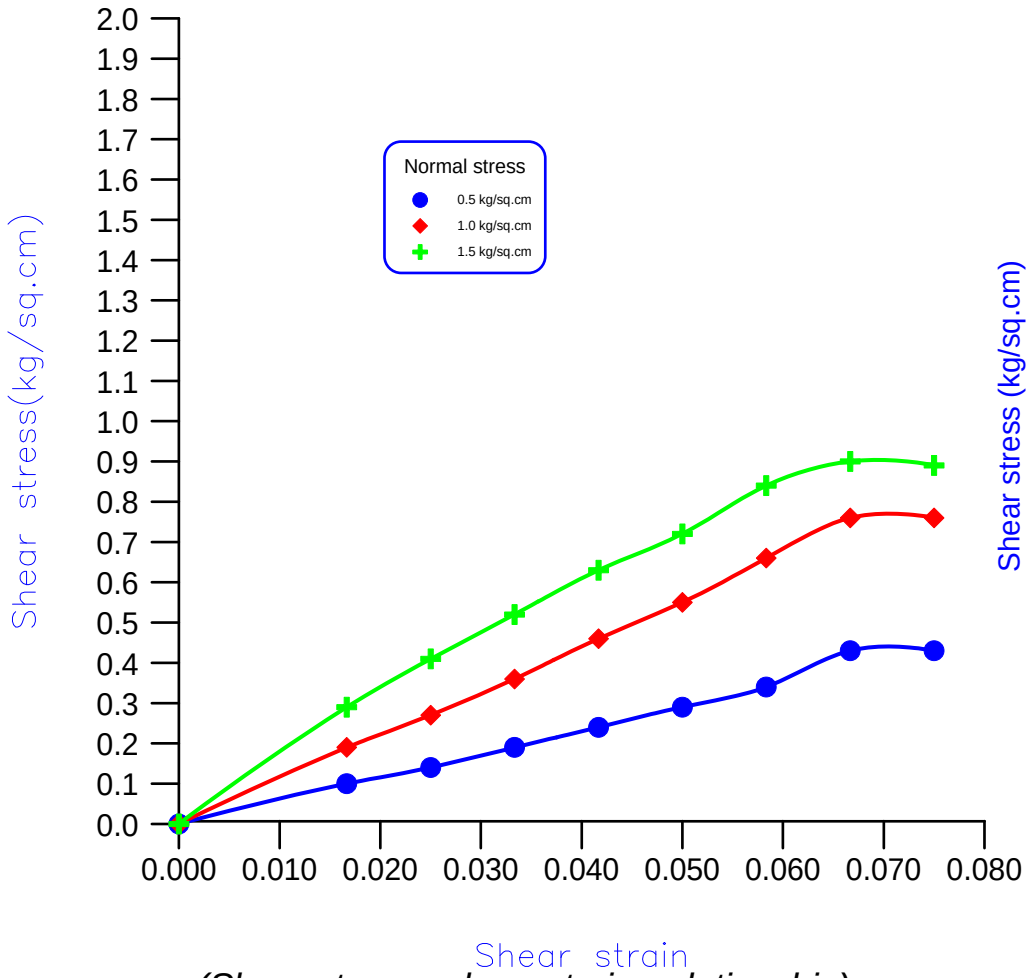
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

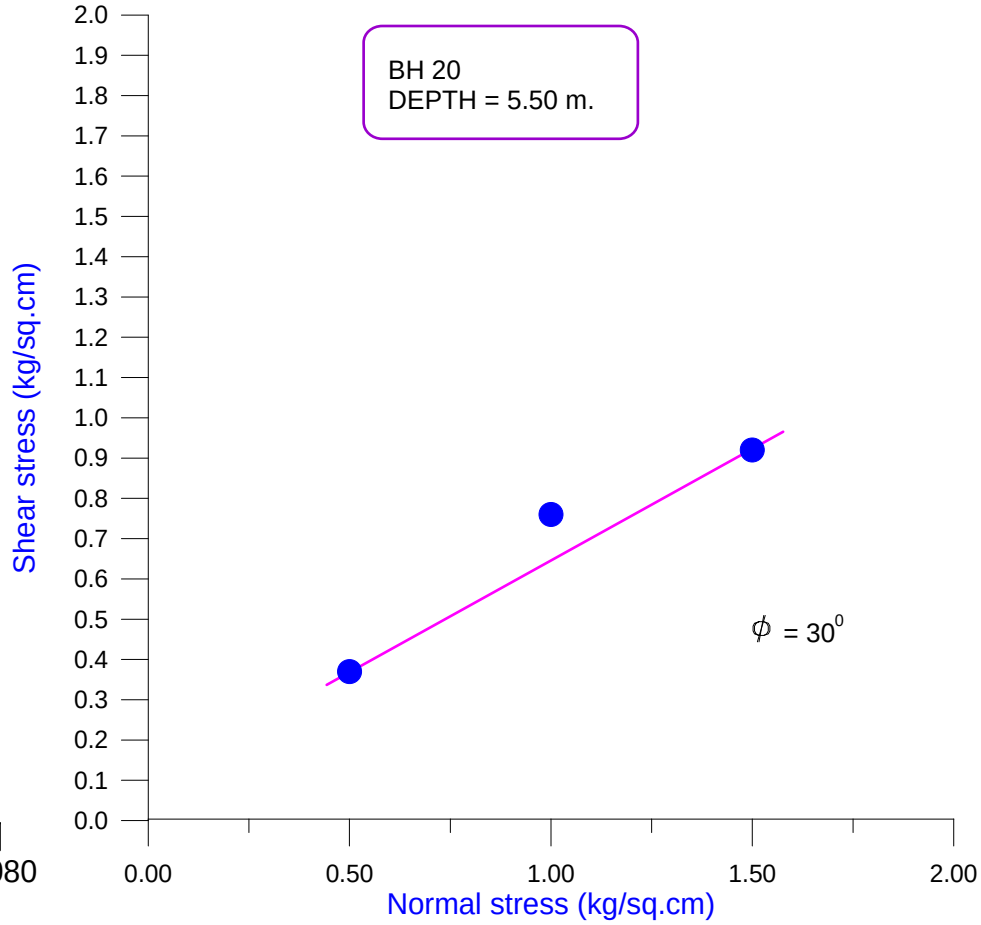
FIG- DS 20-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



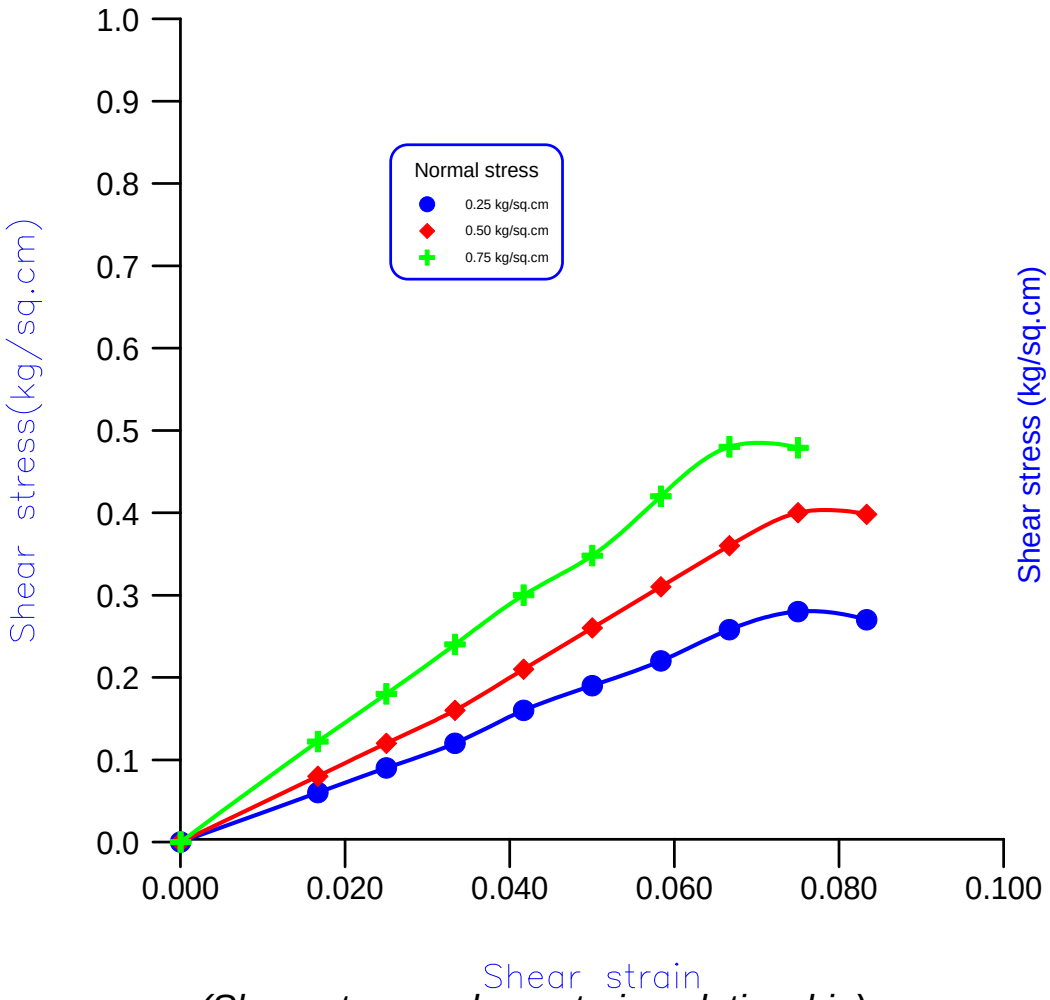
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

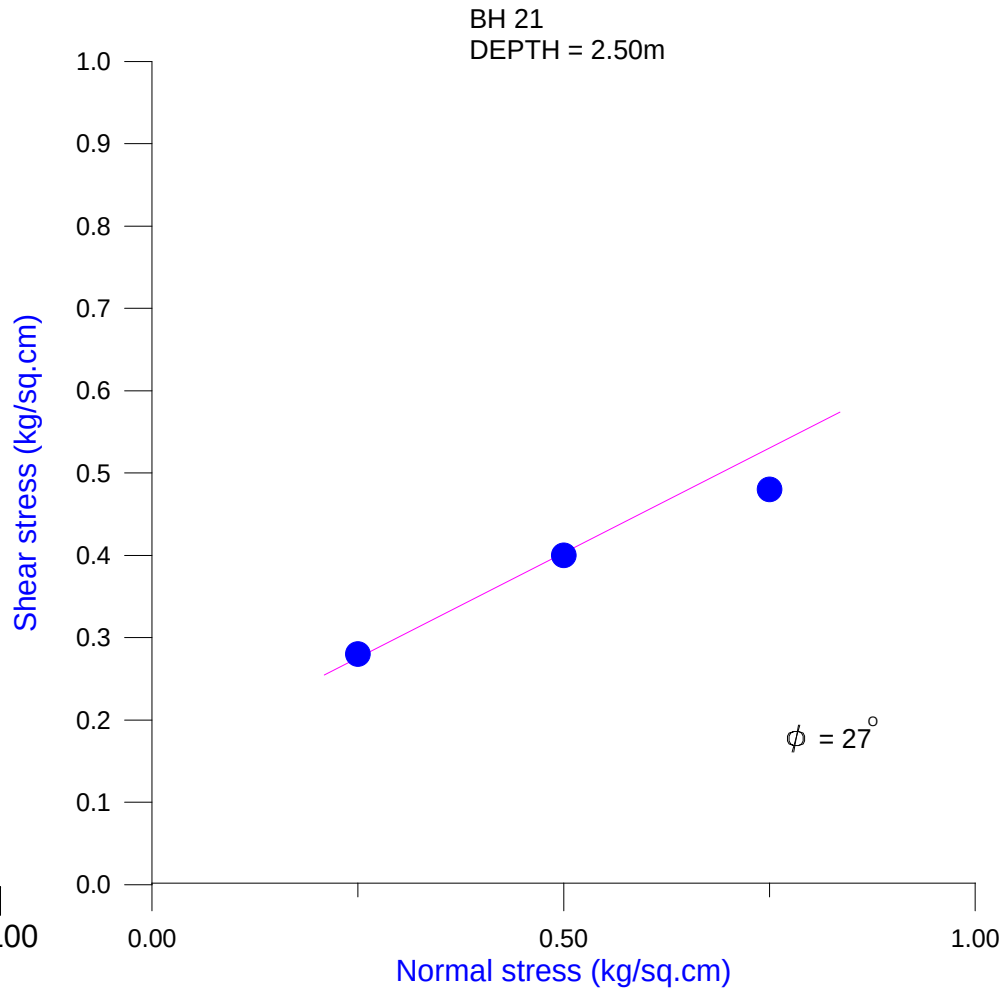
FIG- DS 20-2

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



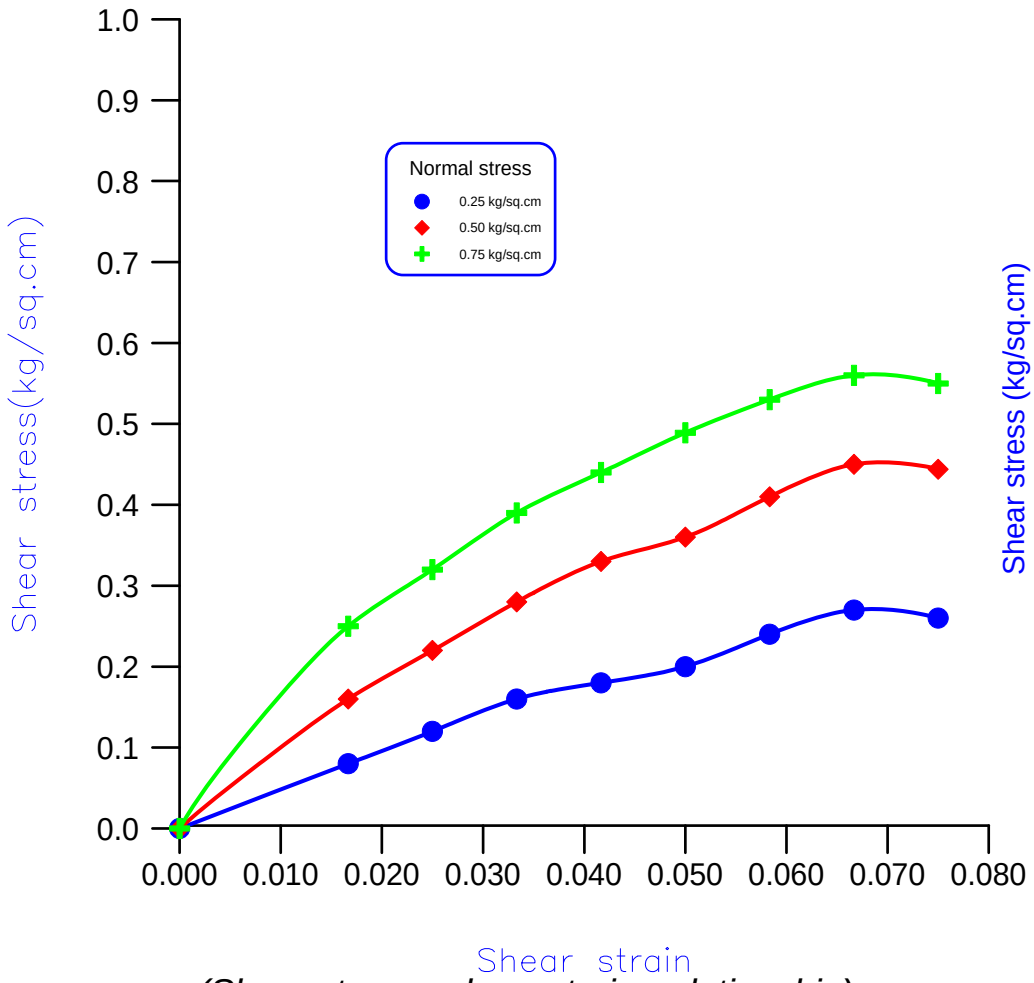
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

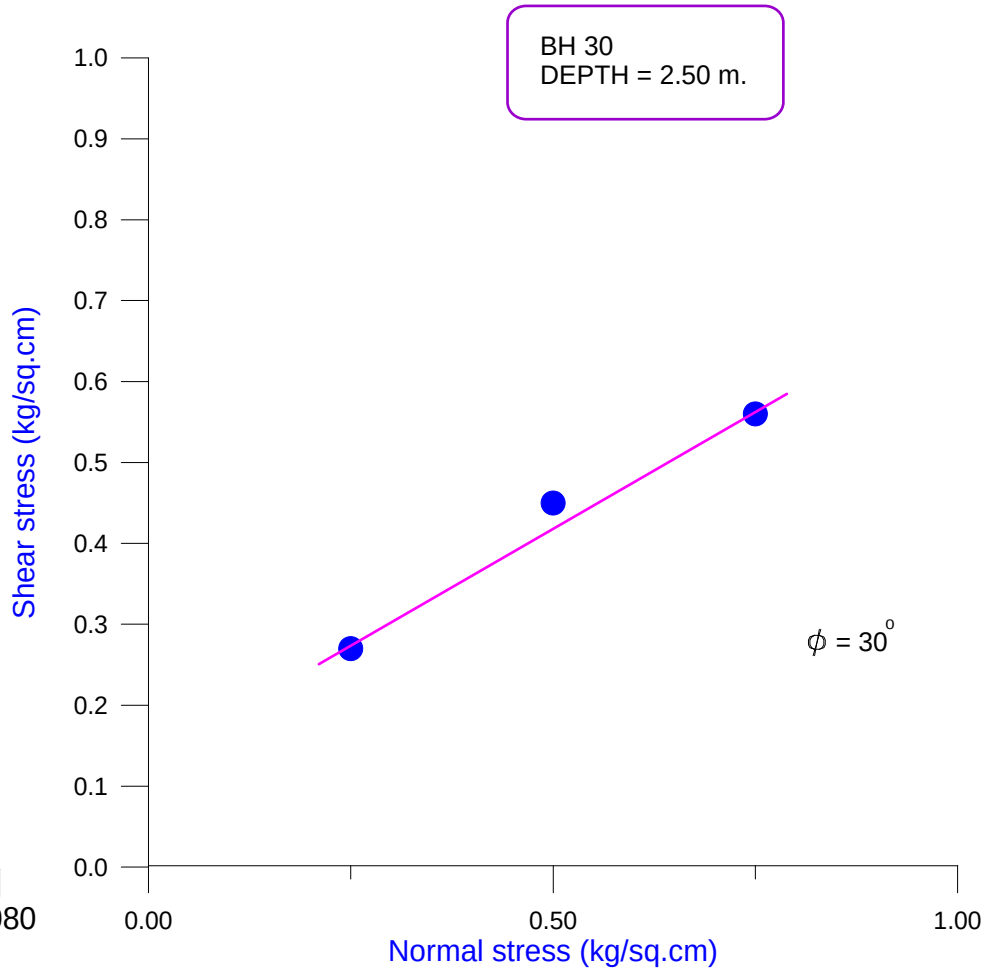
FIG- DS 21-1

Soil Engineering Conslants

Job. 2152



(Shear stress - shear strain relationship)



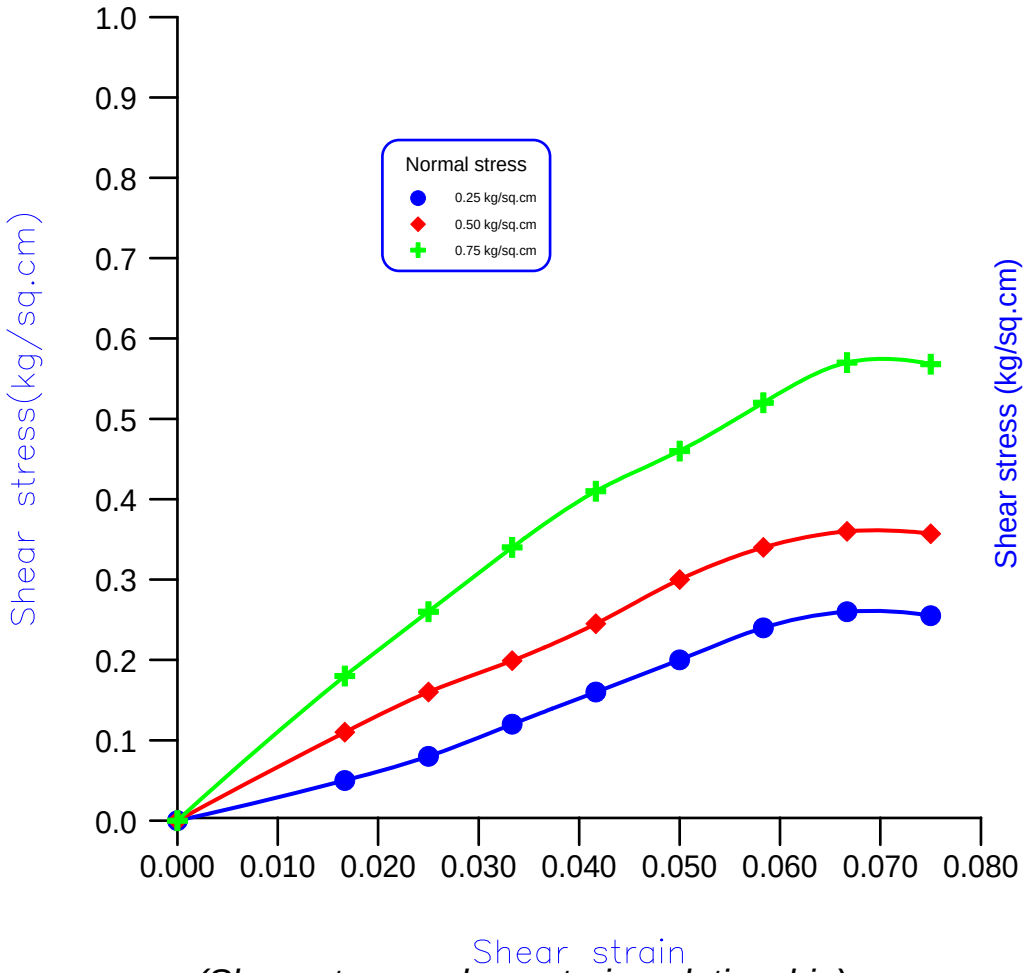
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

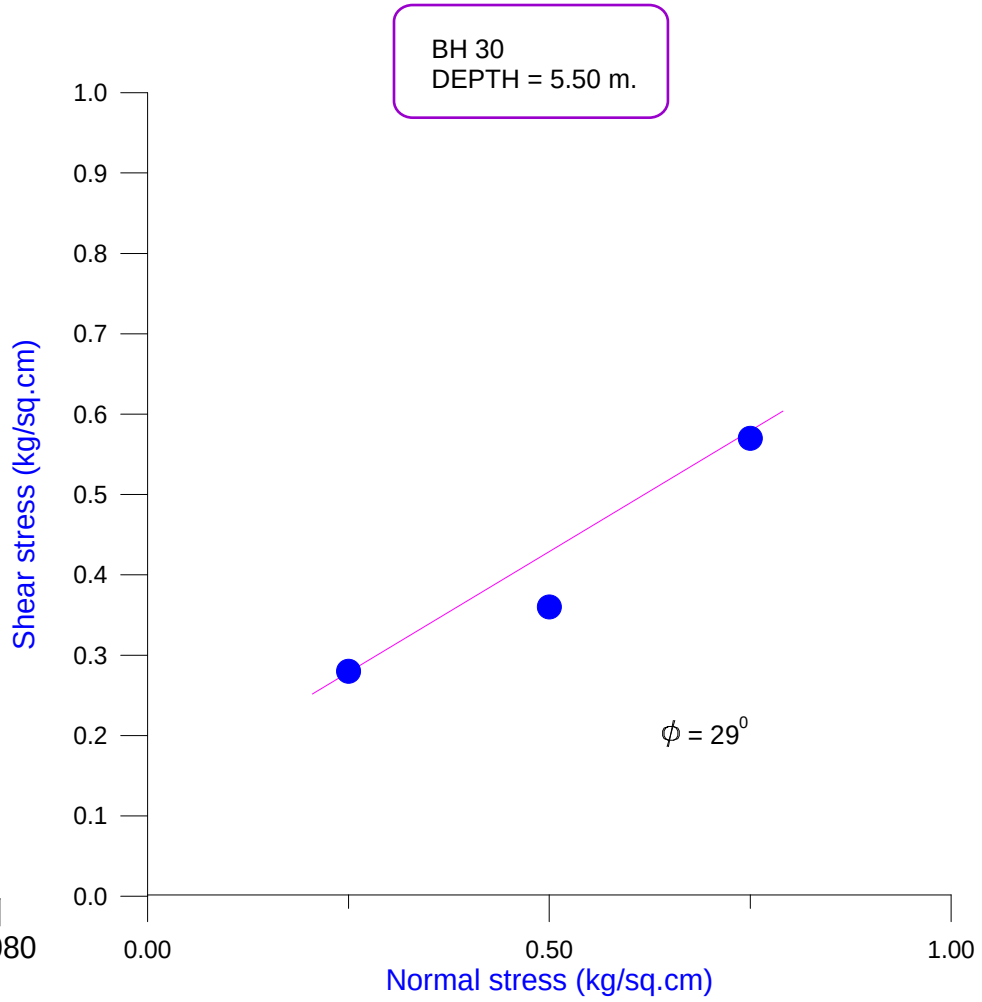
FIG- DS 30-1

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



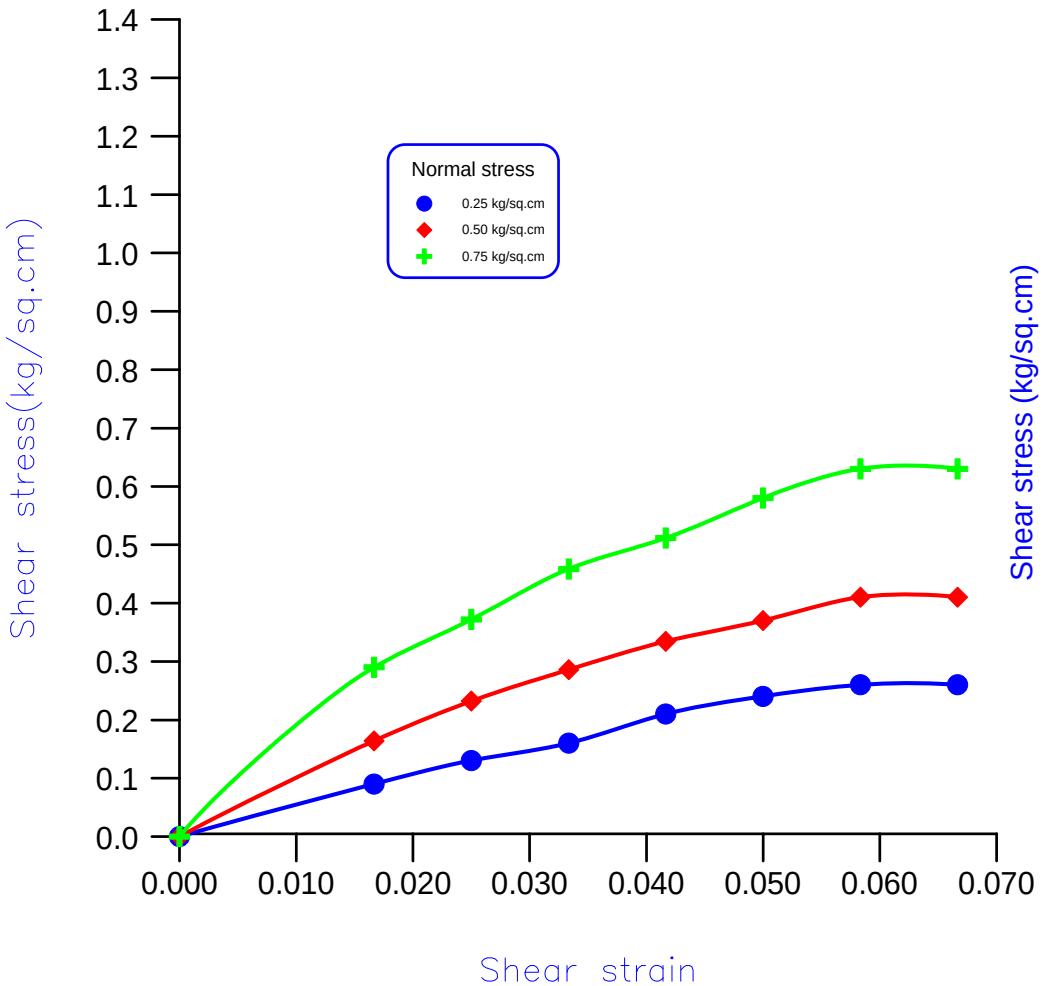
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

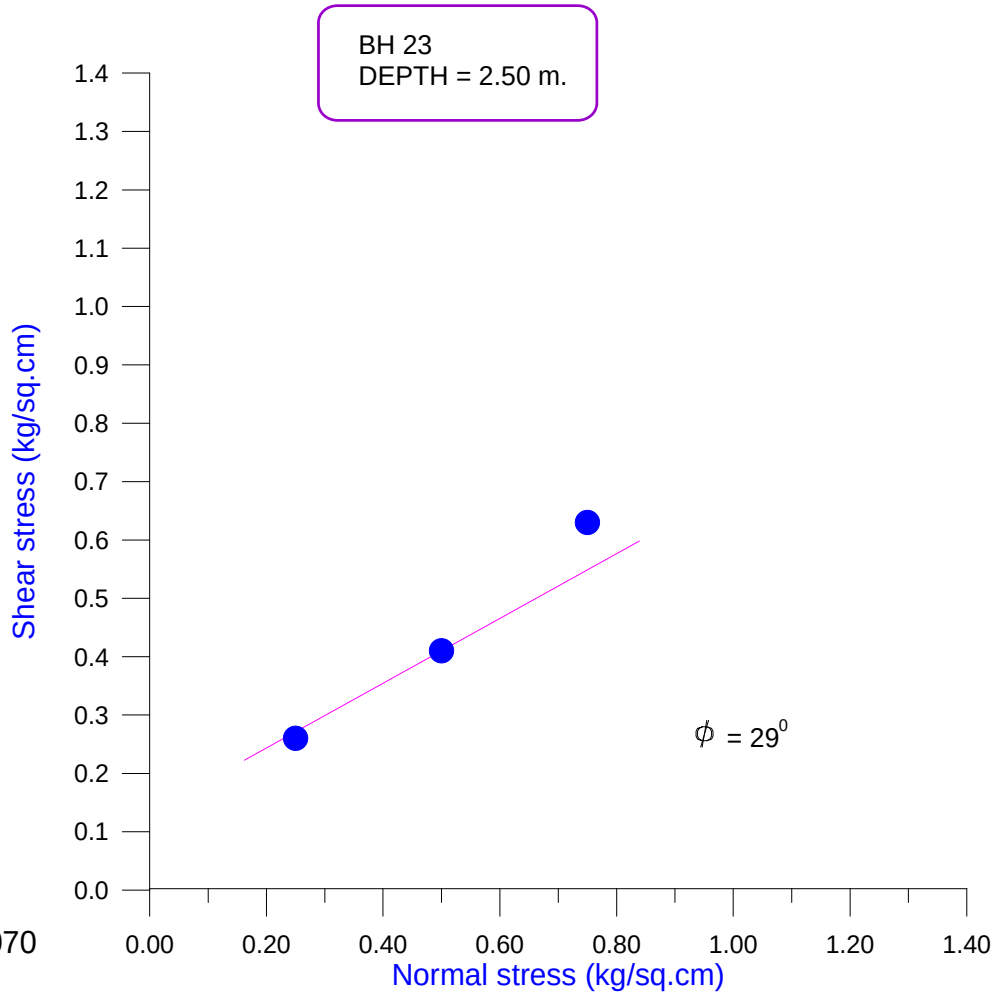
FIG- DS 30-2

Soil Engineering Consltants

Job 2152



(Shear stress - shear strain relationship)



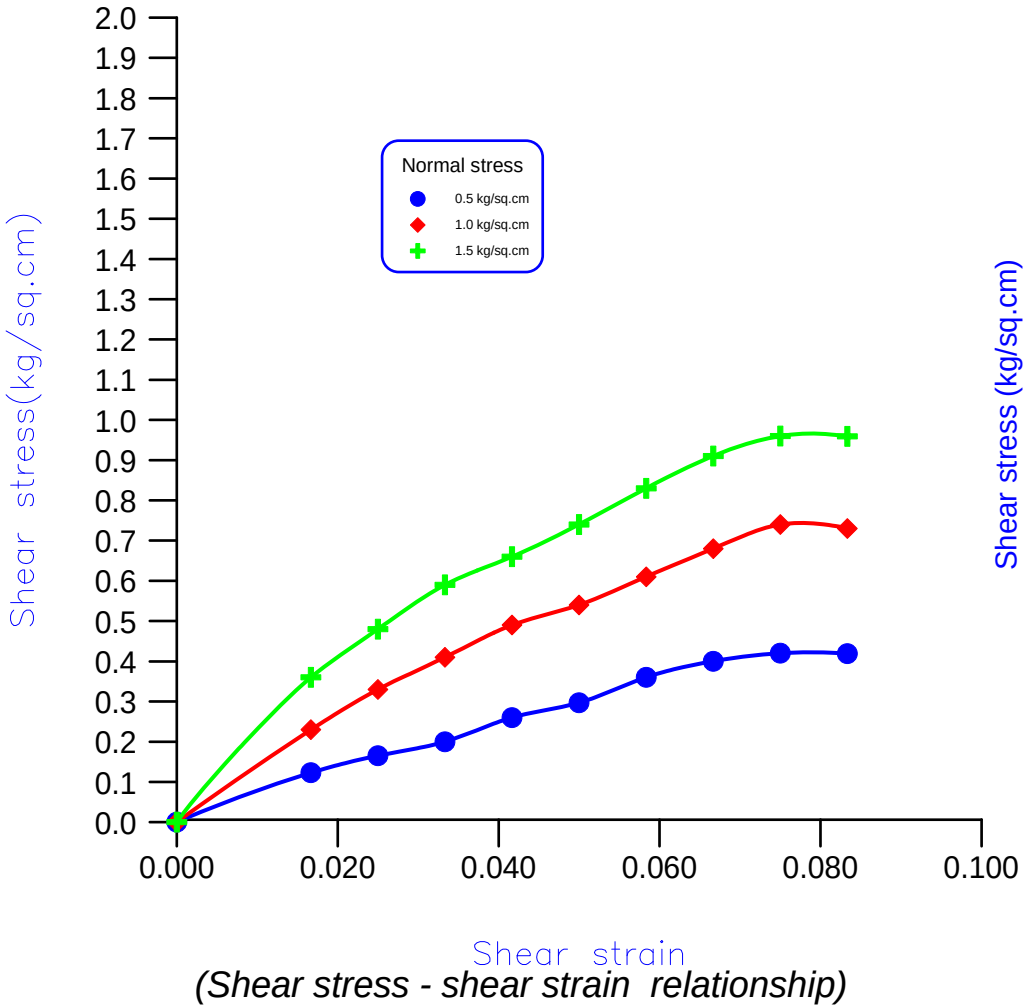
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

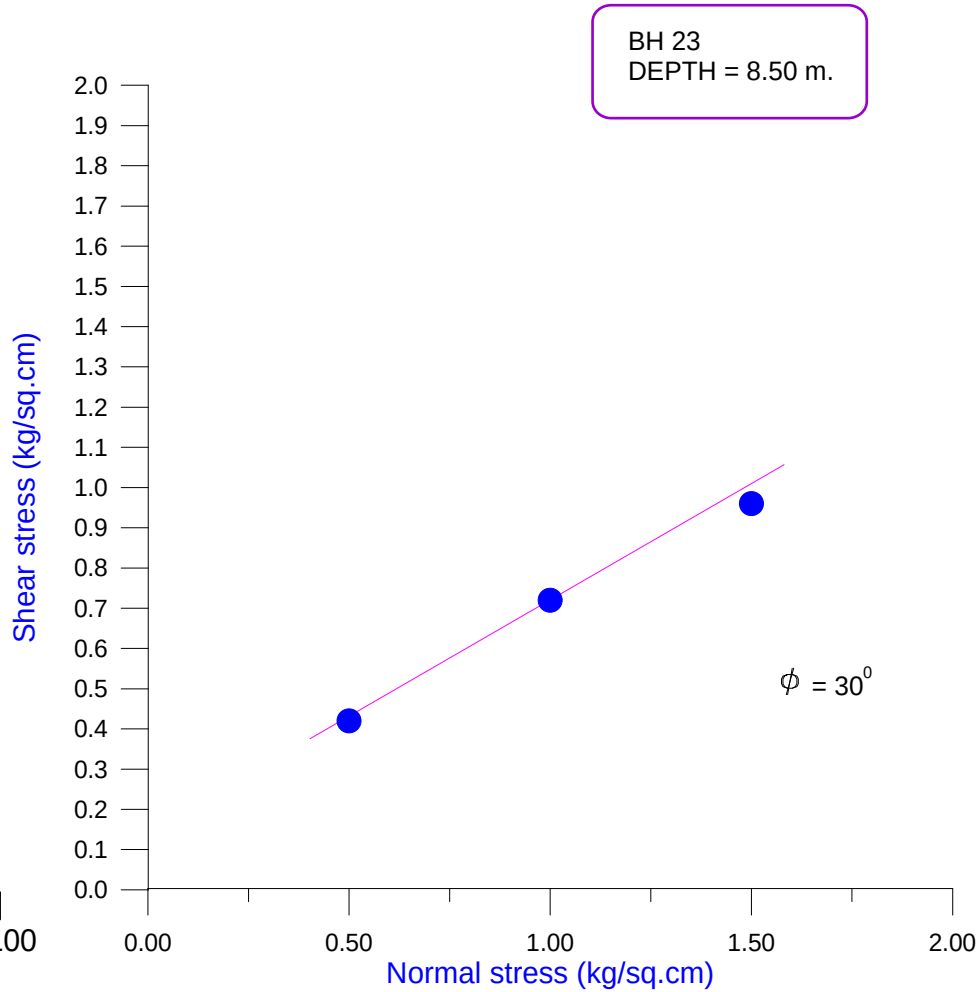
FIG- DS 23-1

Soil Engineering Conslants

Job. 2152



(Shear stress - shear strain relationship)



(Shear stress - Normal stress relationship)

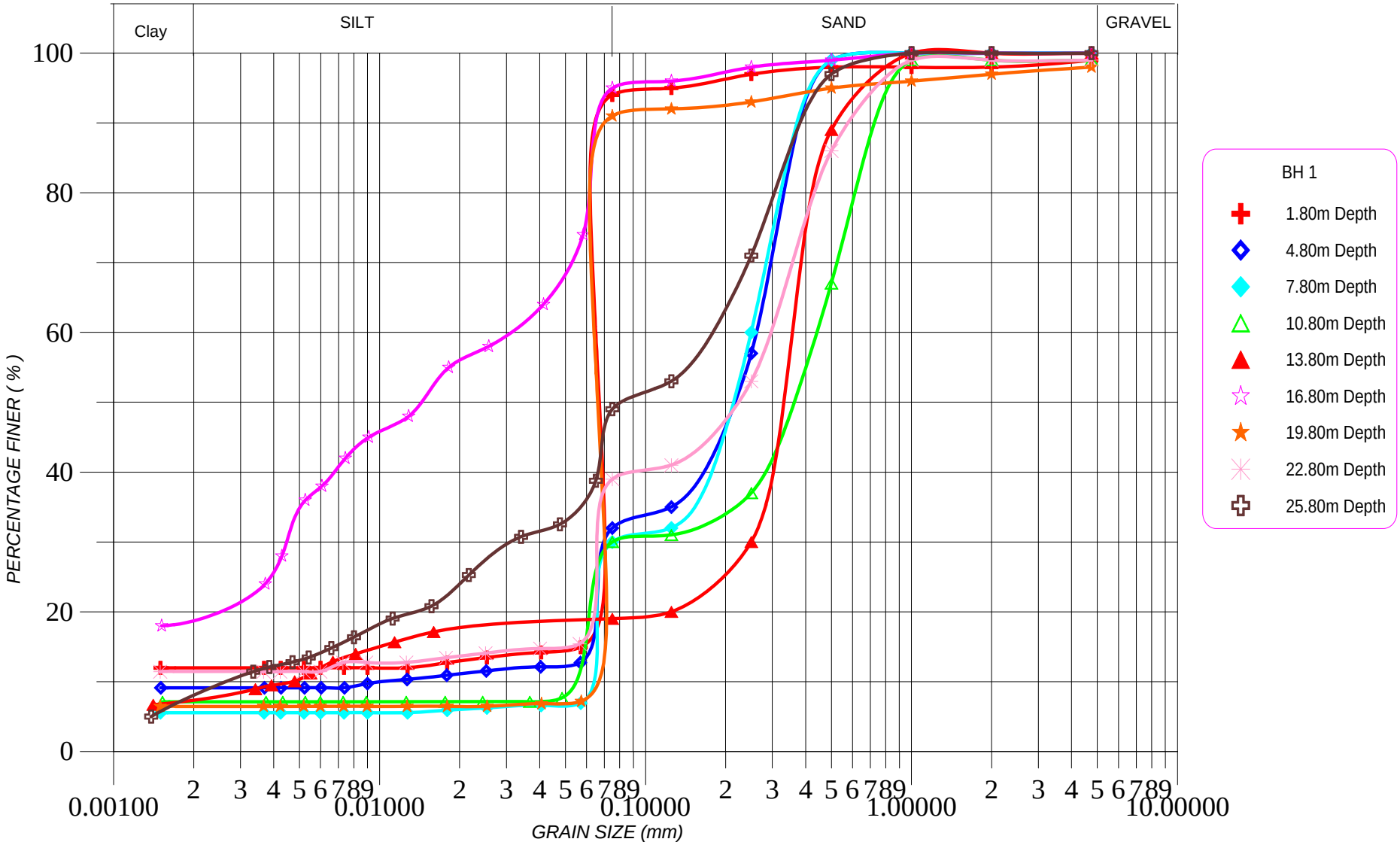
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

FIG- DS 23-2

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



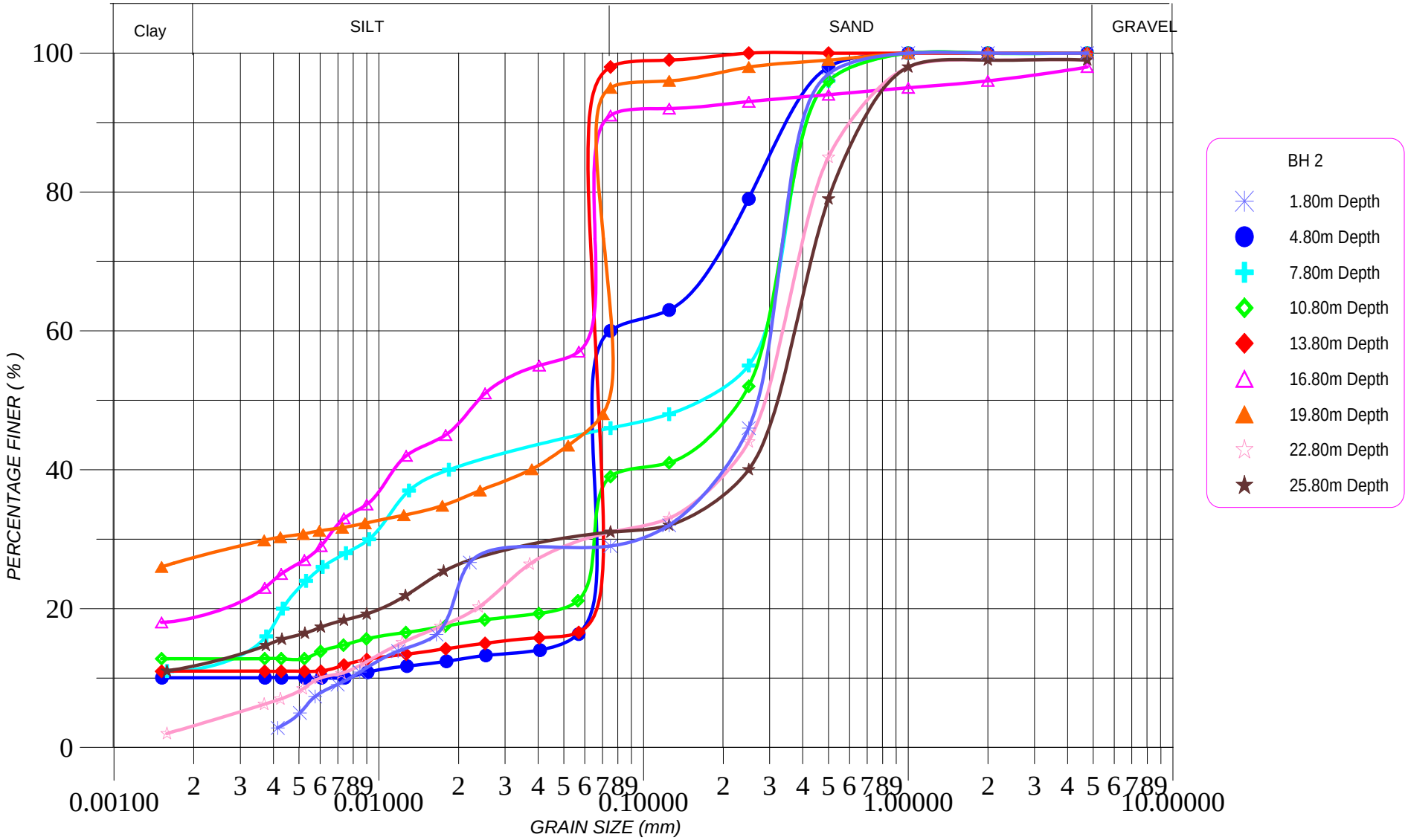
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 1

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



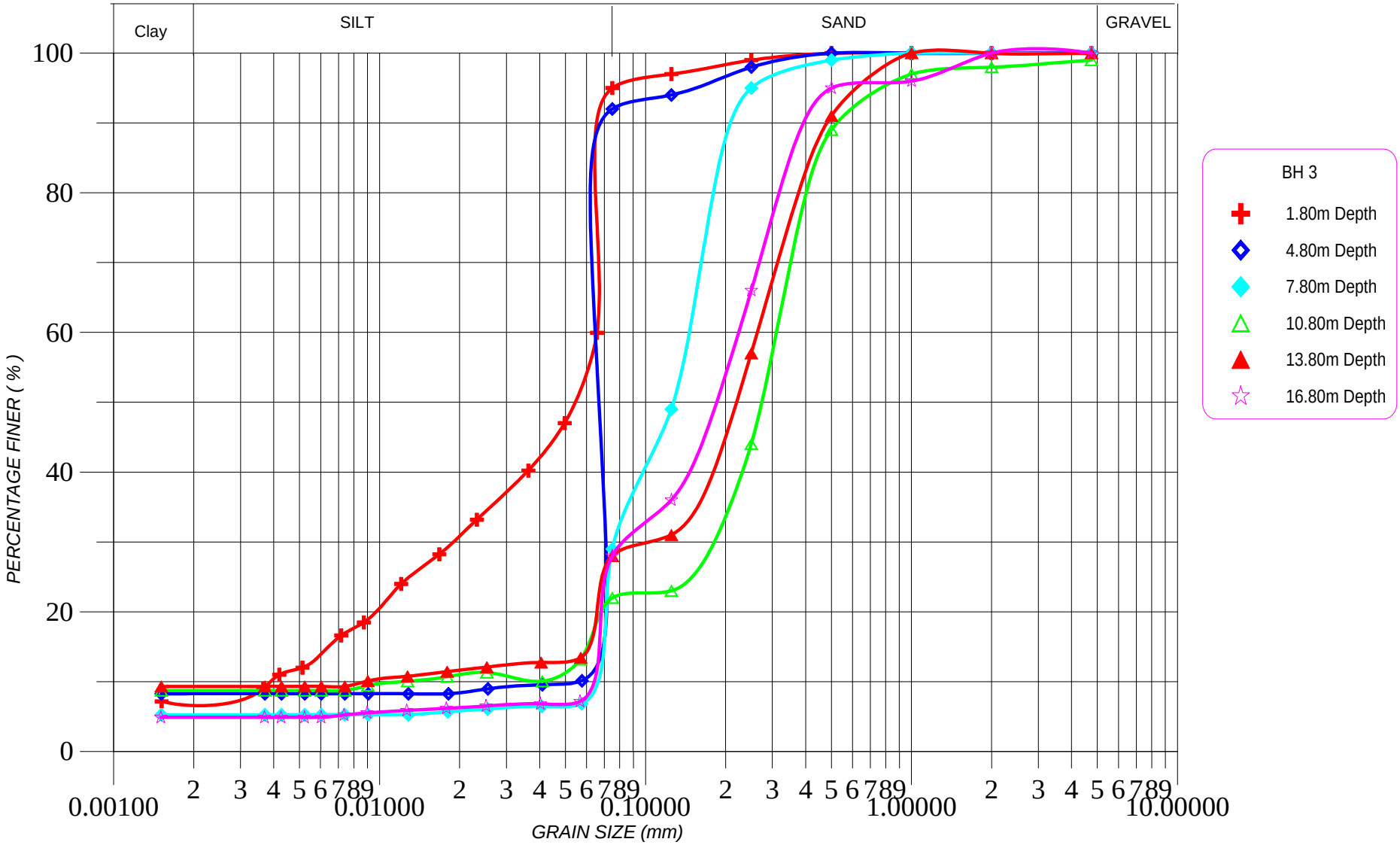
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD-2

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



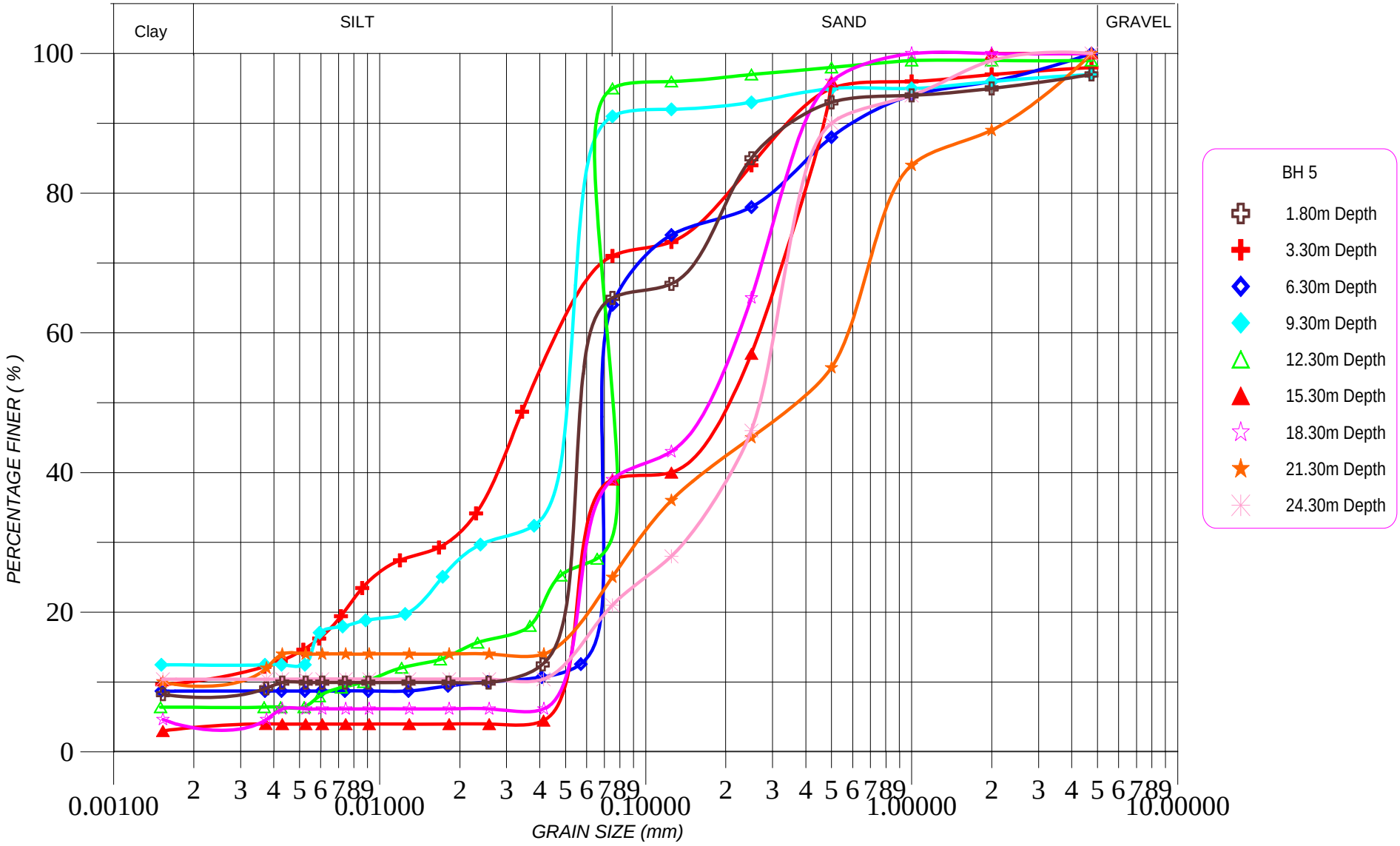
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 2

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 5

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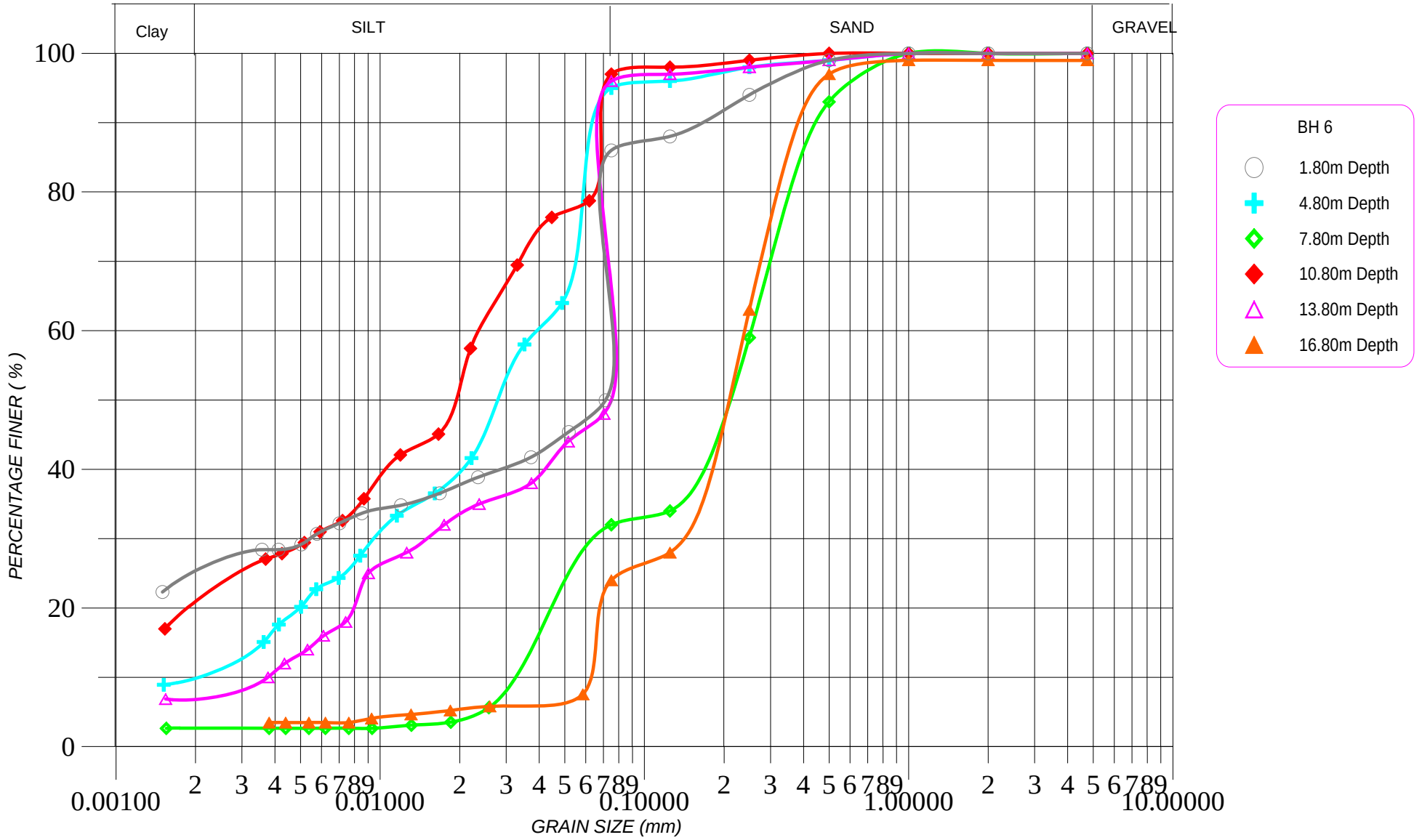
GRAIN SIZE DRISTRIBUTION CURVE



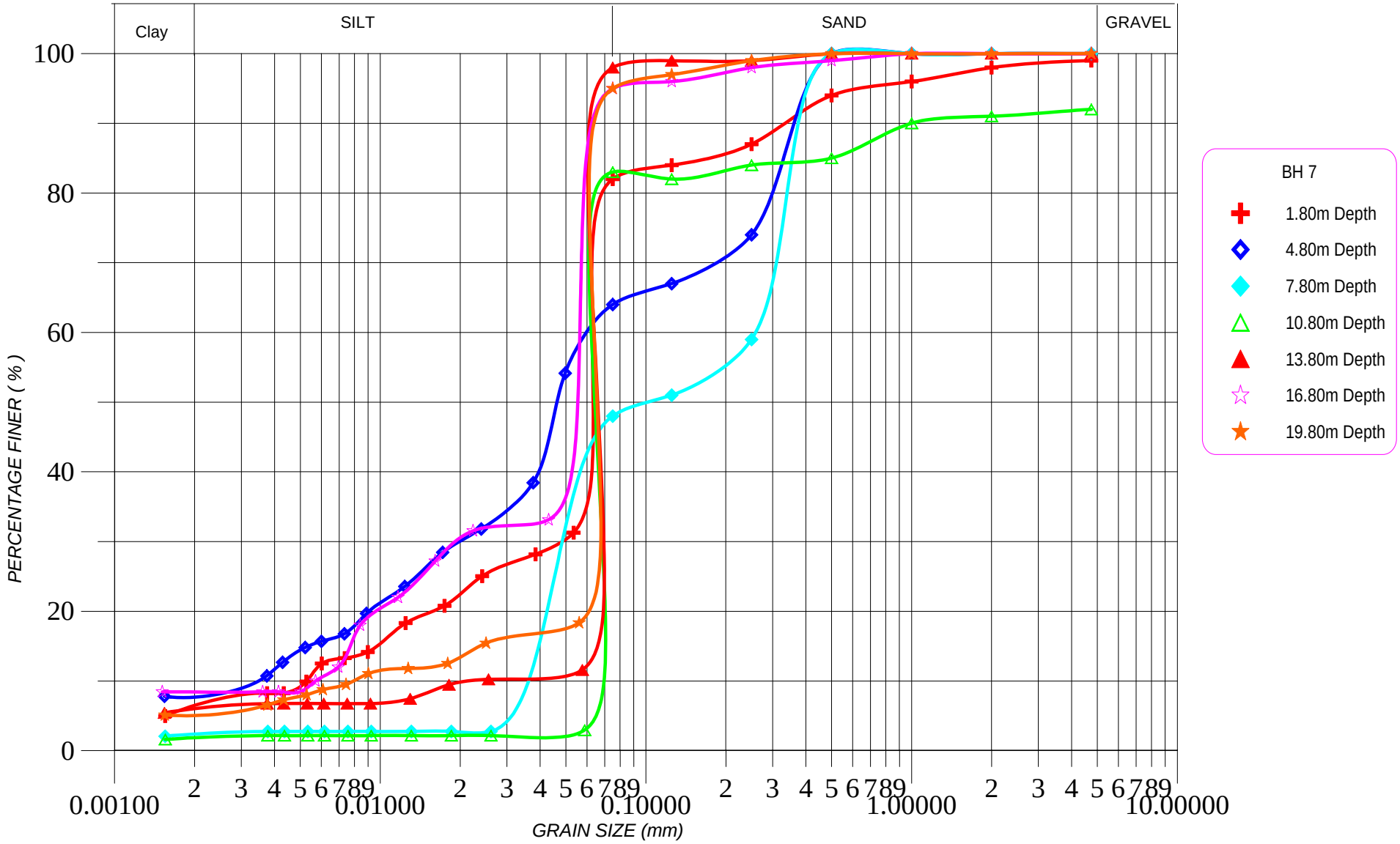
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD-6

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



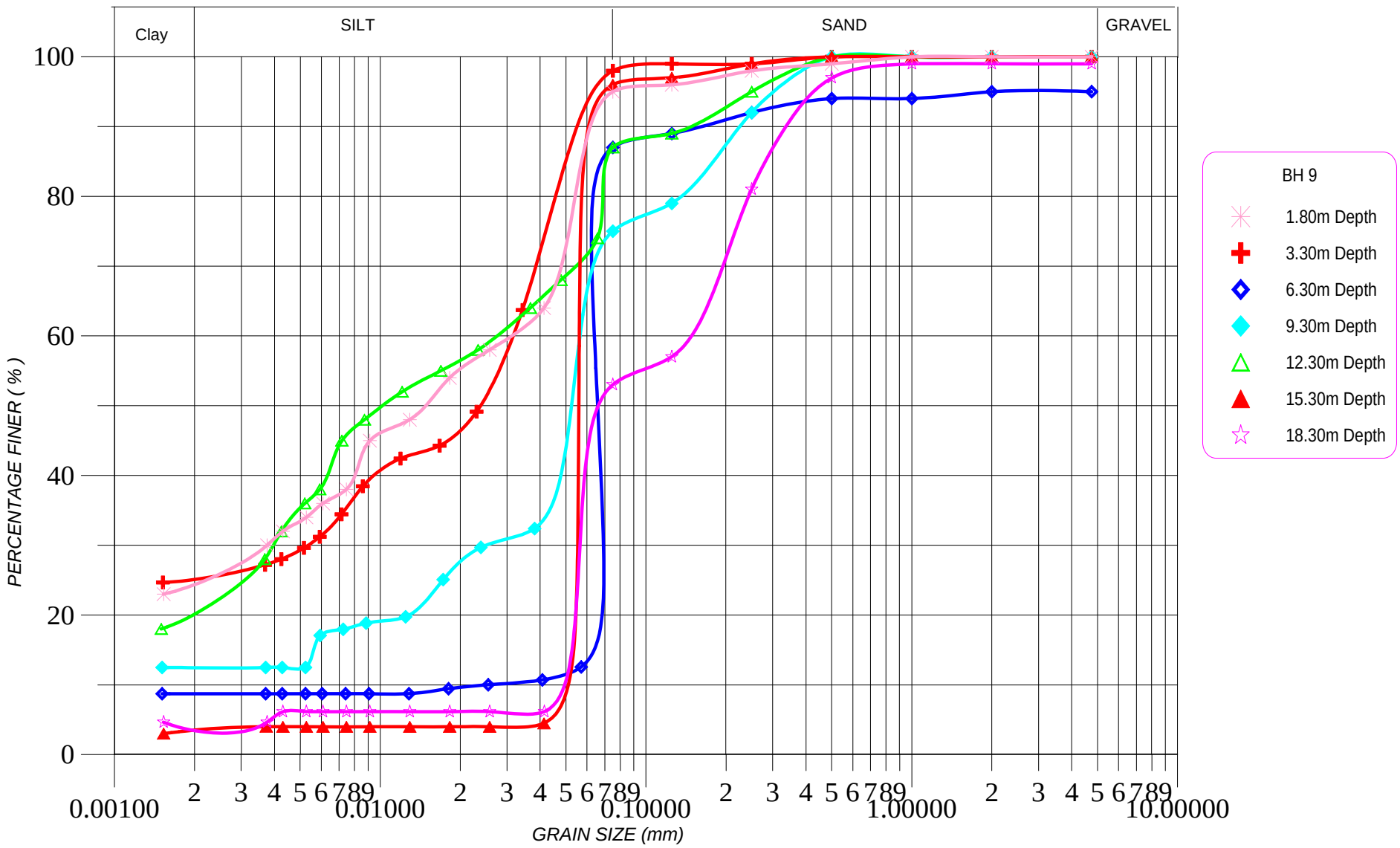
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 7

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



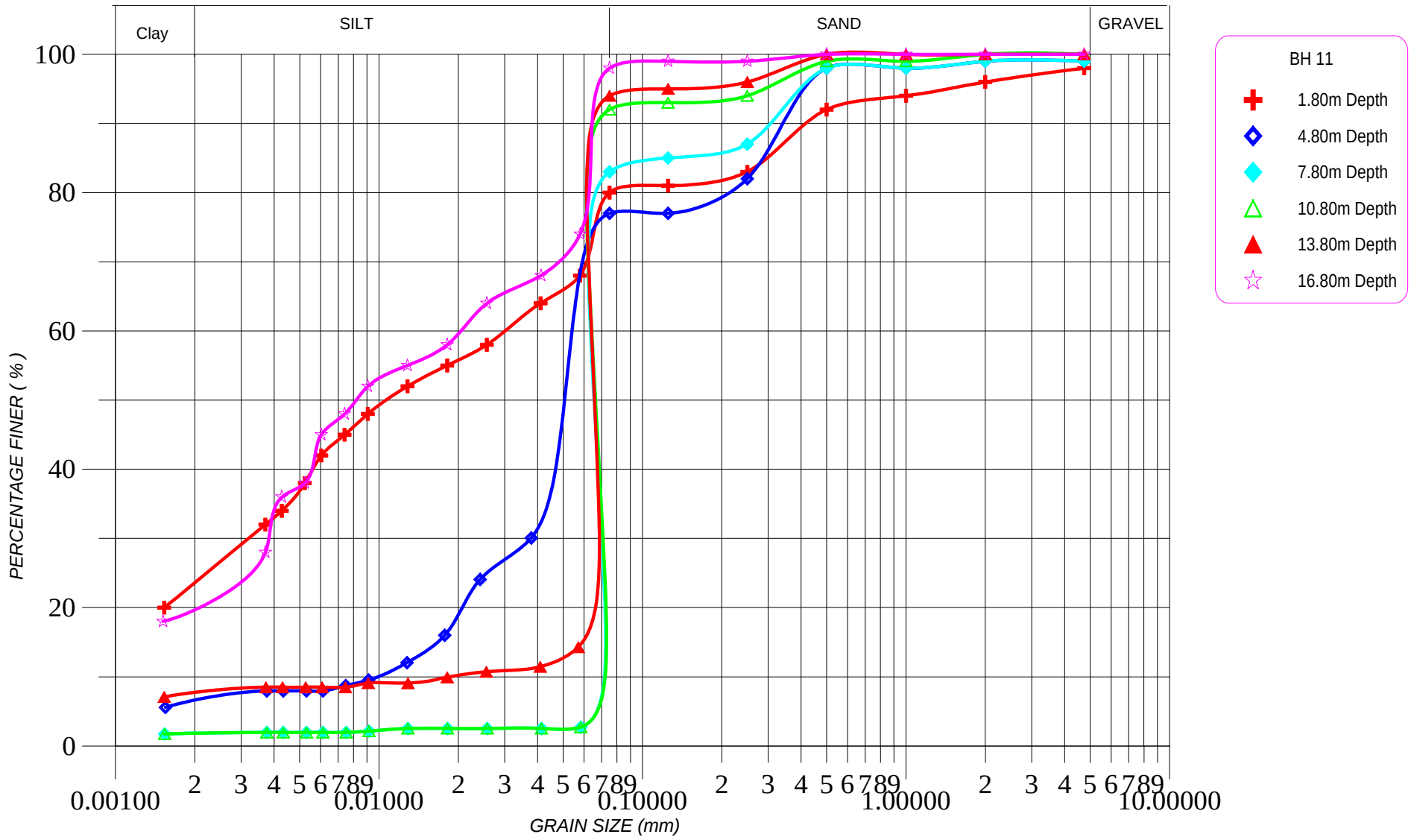
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 9

Soil Engineering Consultants

Job: 2152

GRAIN SIZE DRISTRIBUTION CURVE



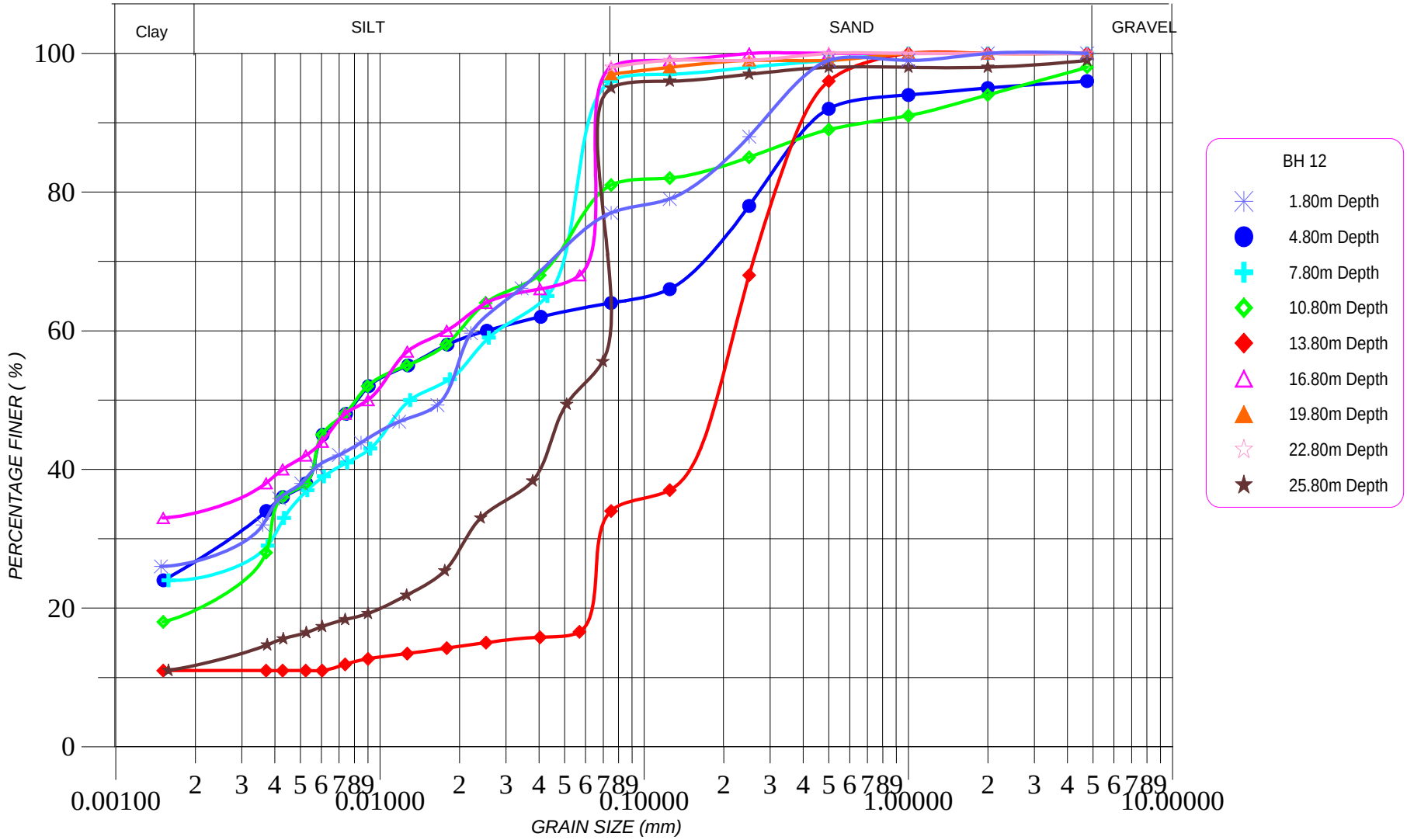
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD- 11

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD-12

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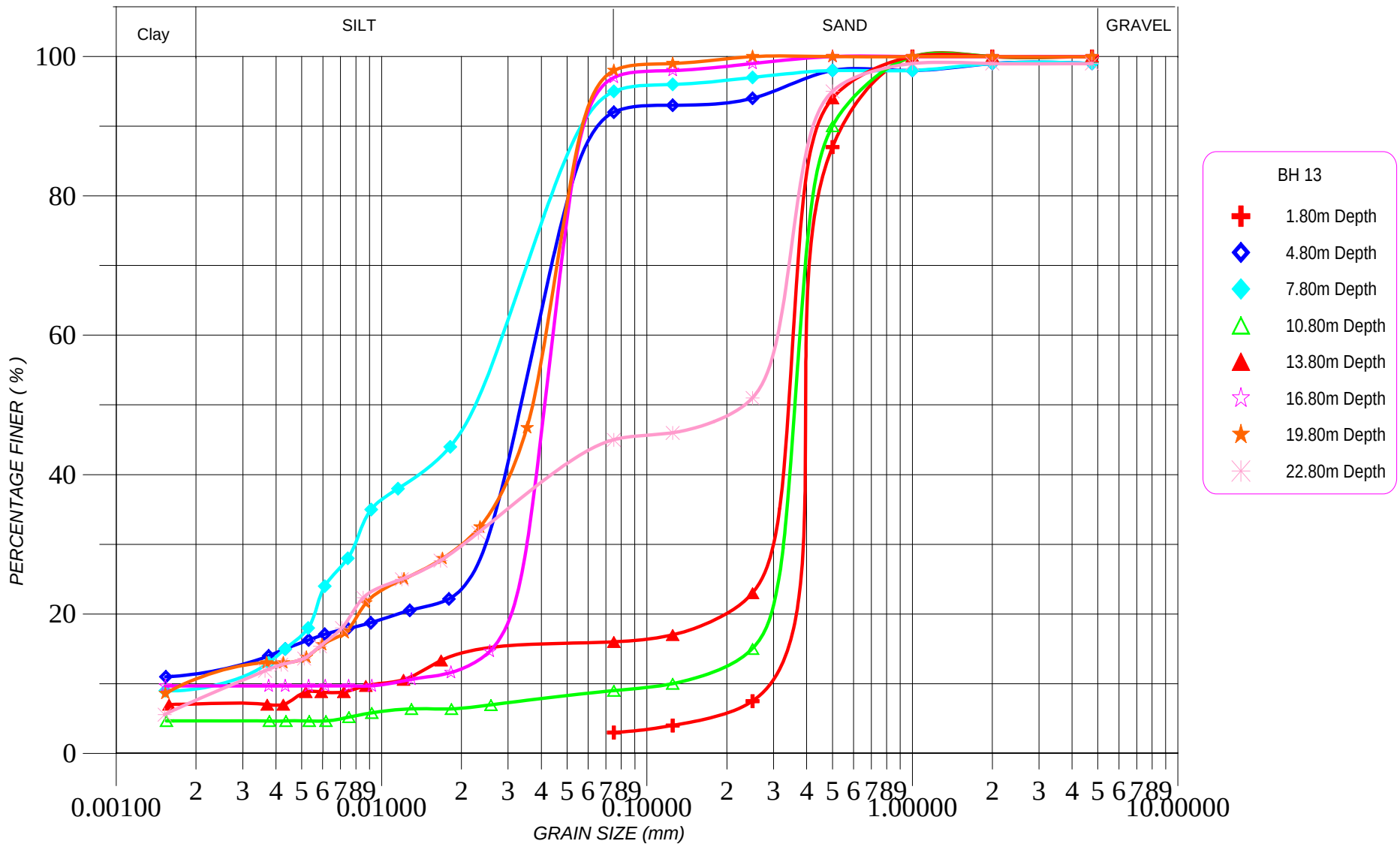

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 13

Soil Engineering Consultants

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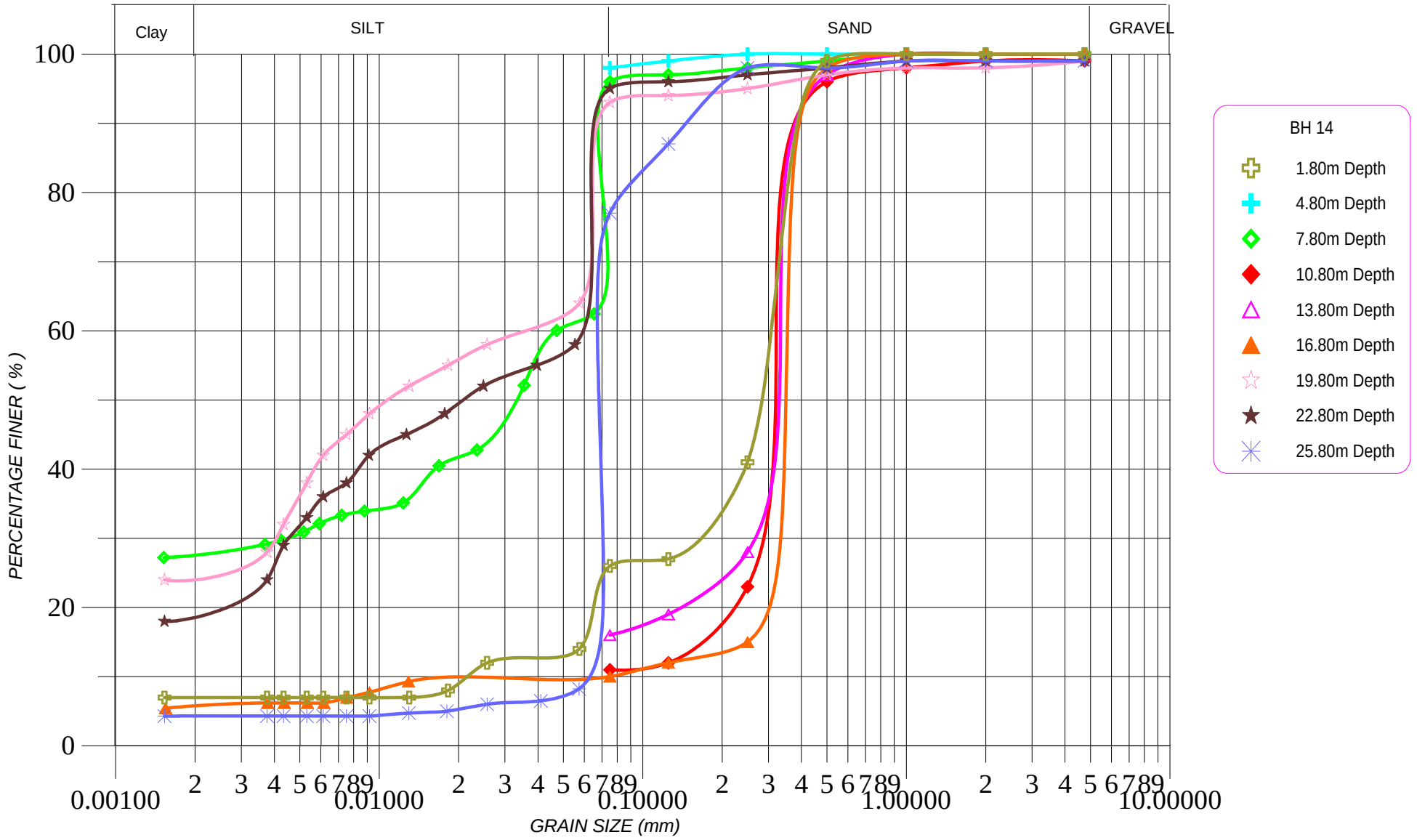
GRAIN SIZE DRISTRIBUTION CURVE

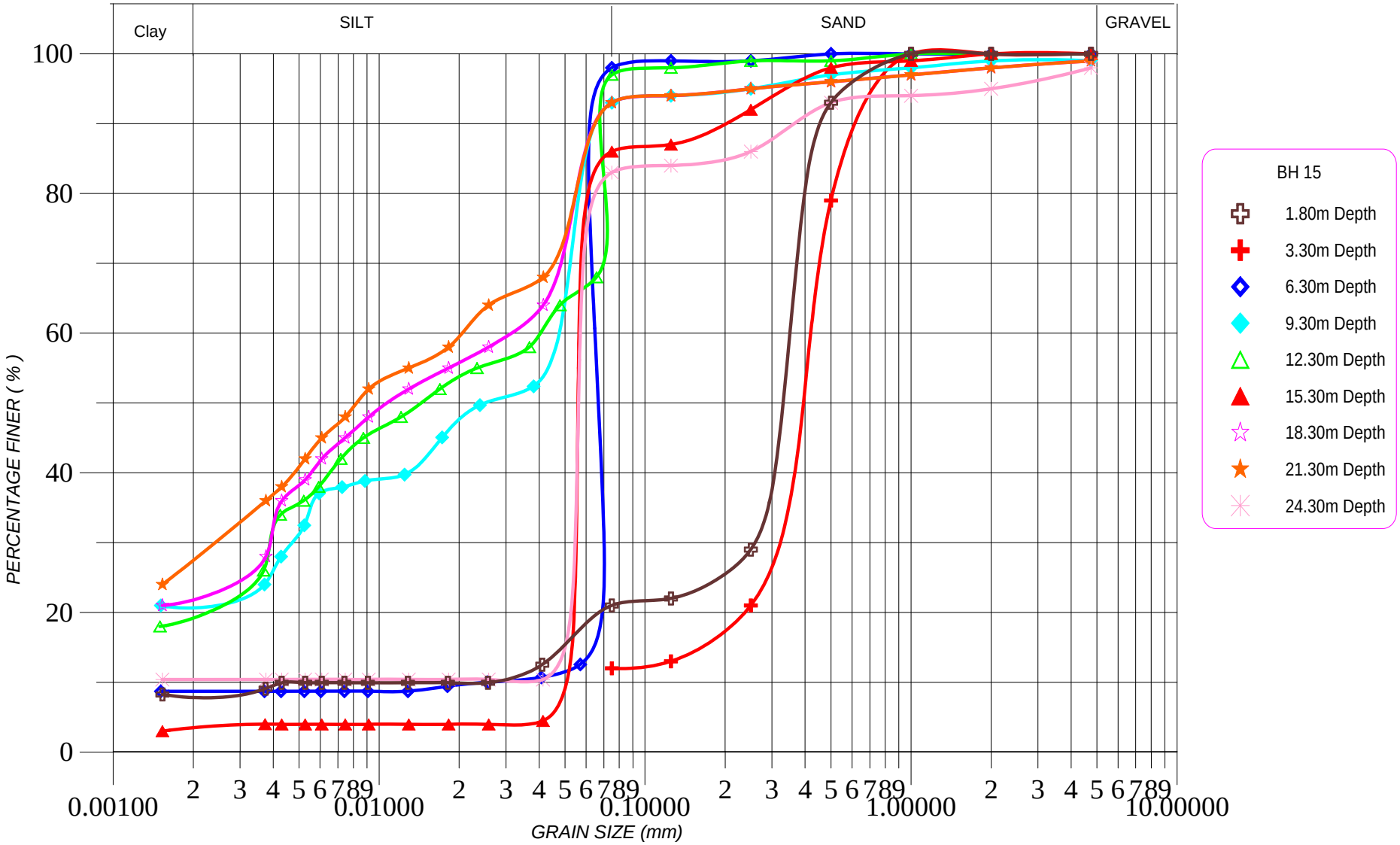


PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD-14

Soil Engineering Consultants

Job No 2152



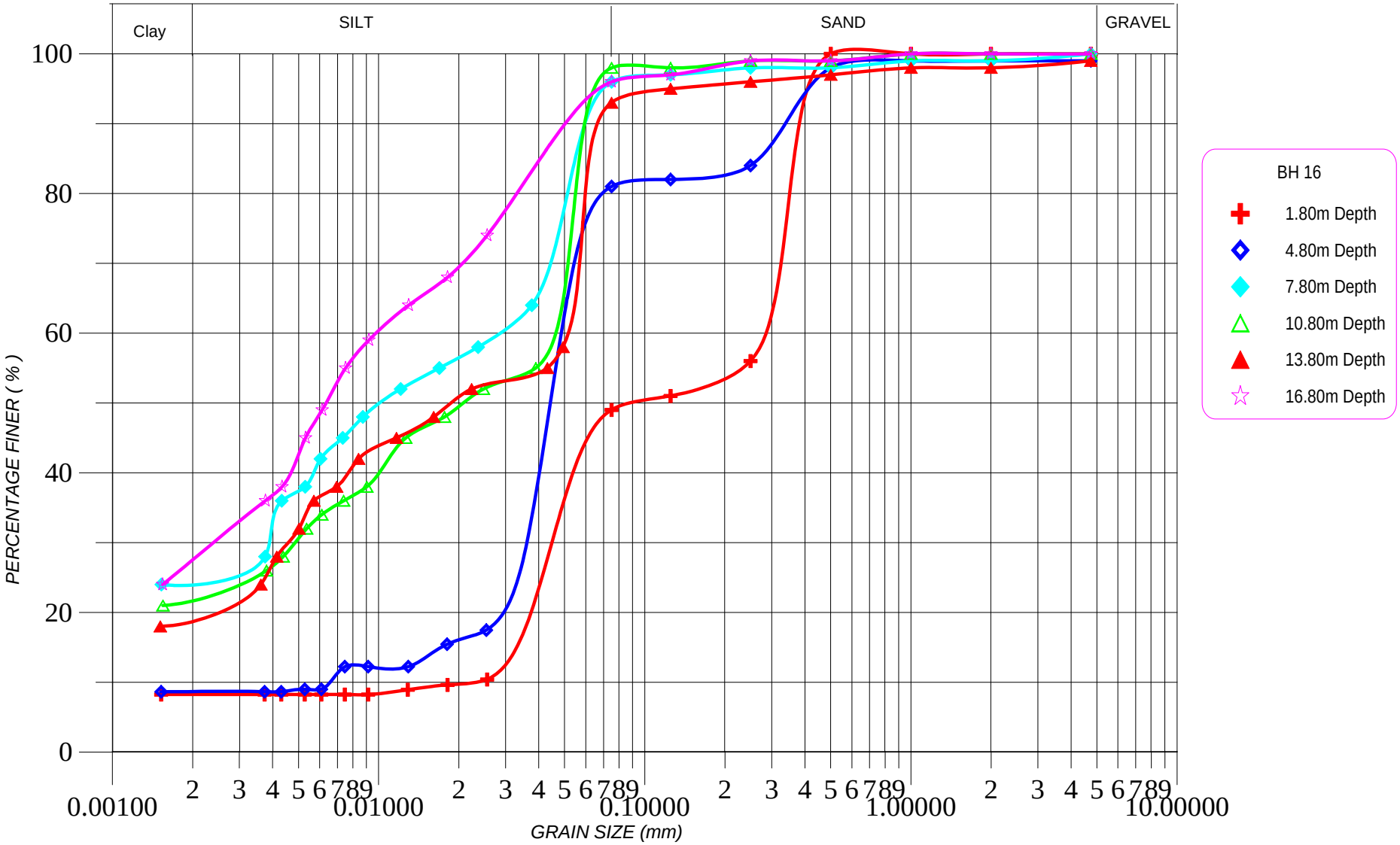
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 15

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 16

Soil Engineering Consultants

Job No 2152

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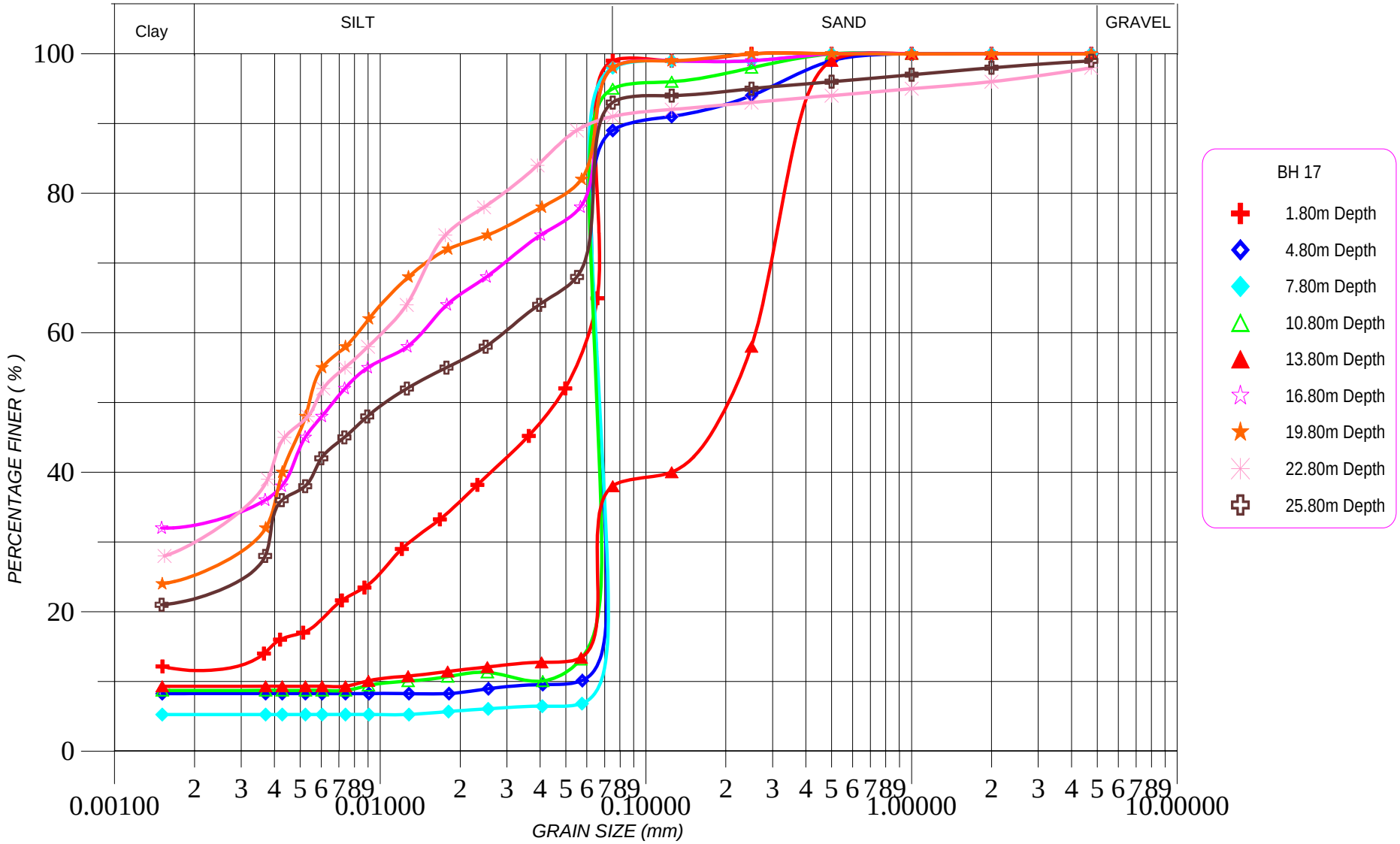


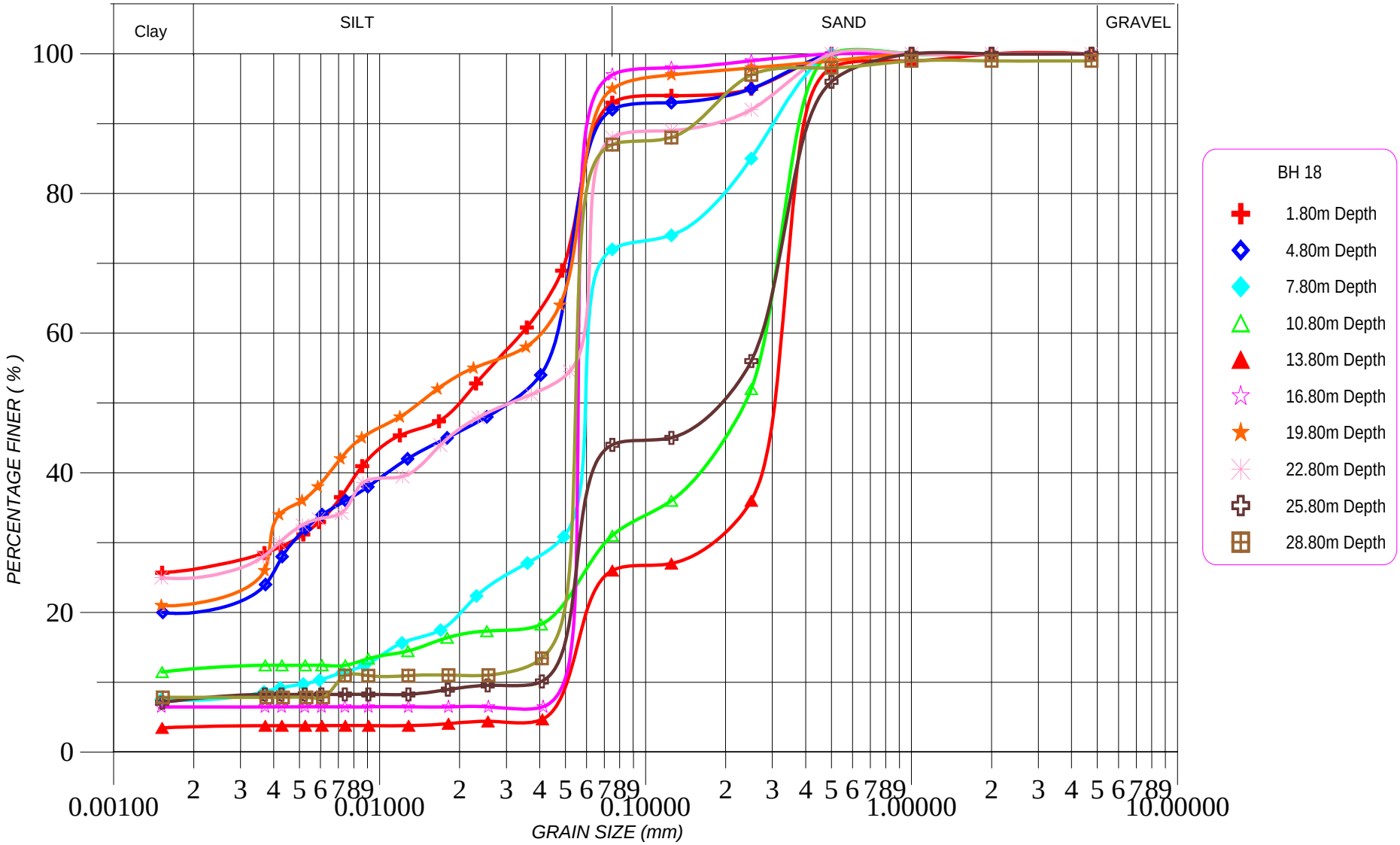
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 17

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



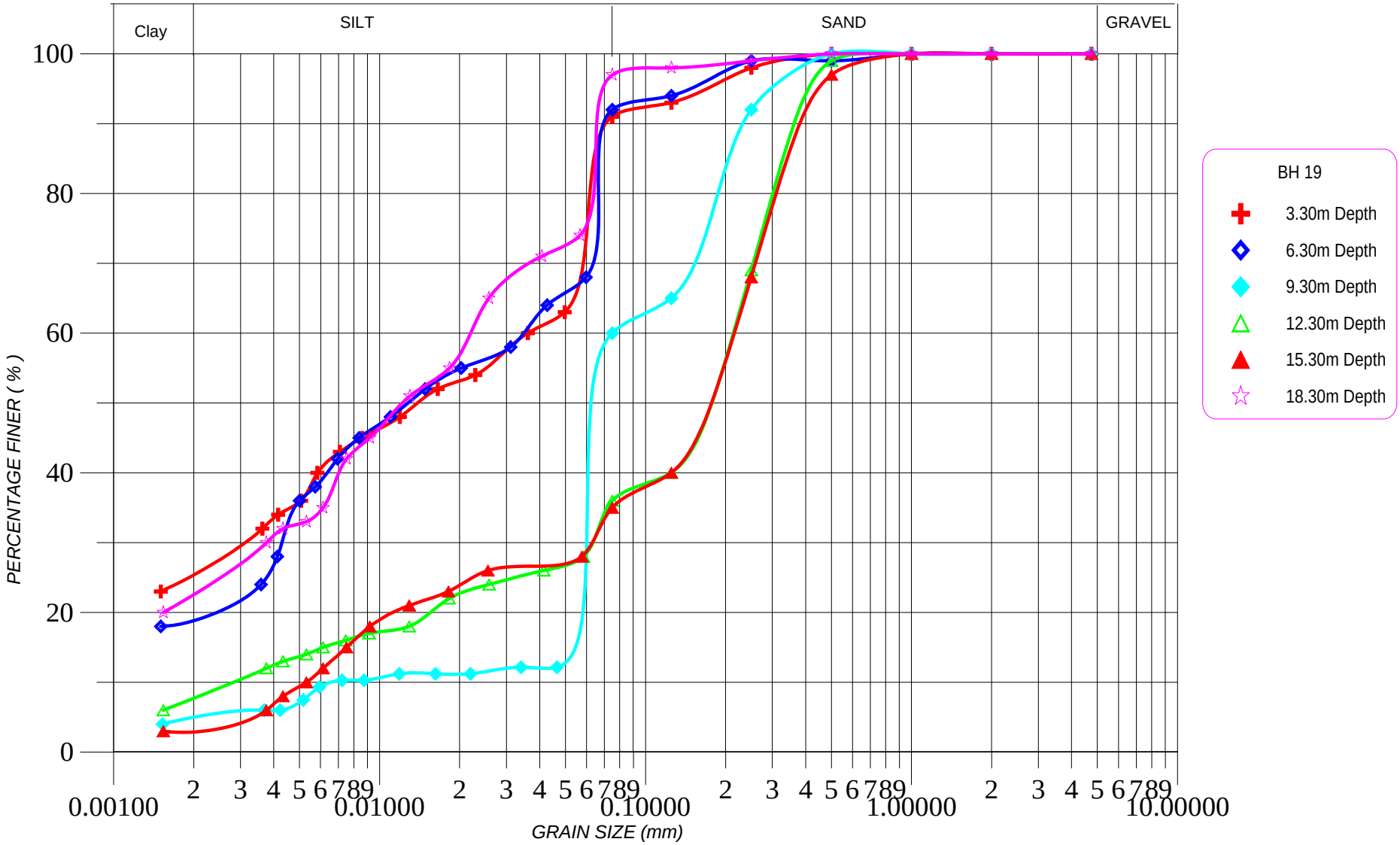
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 18

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



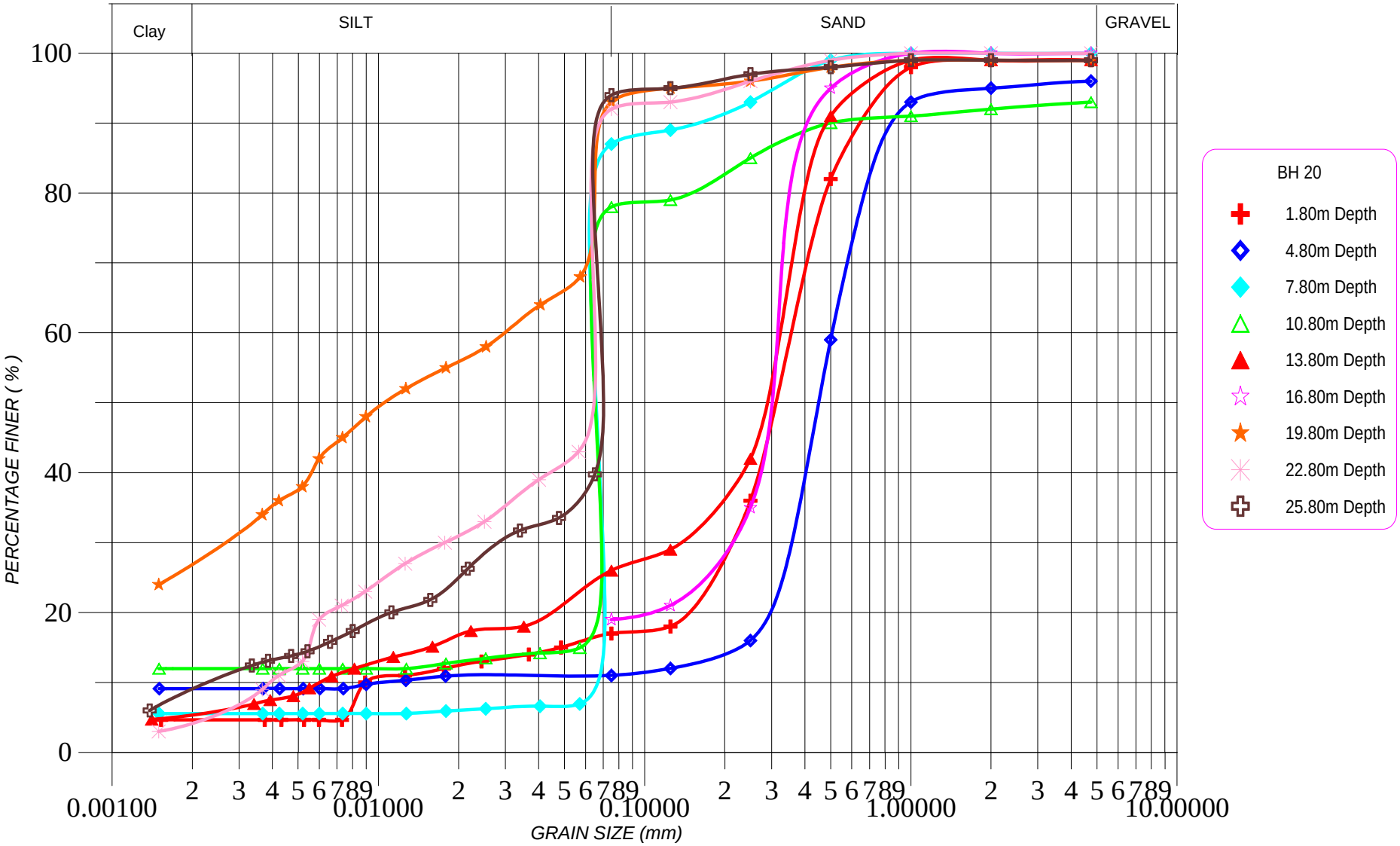
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 19

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



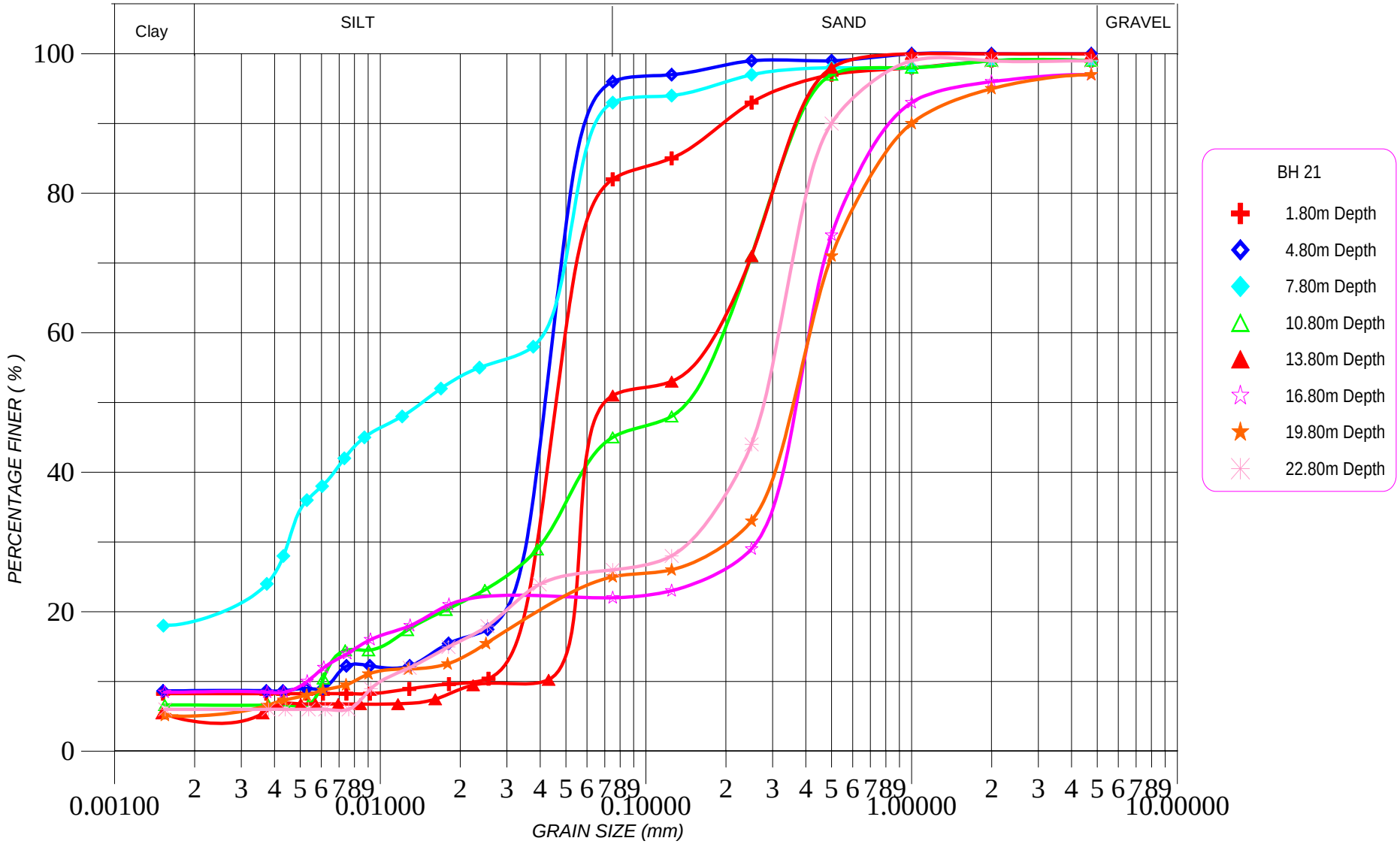
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 20

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



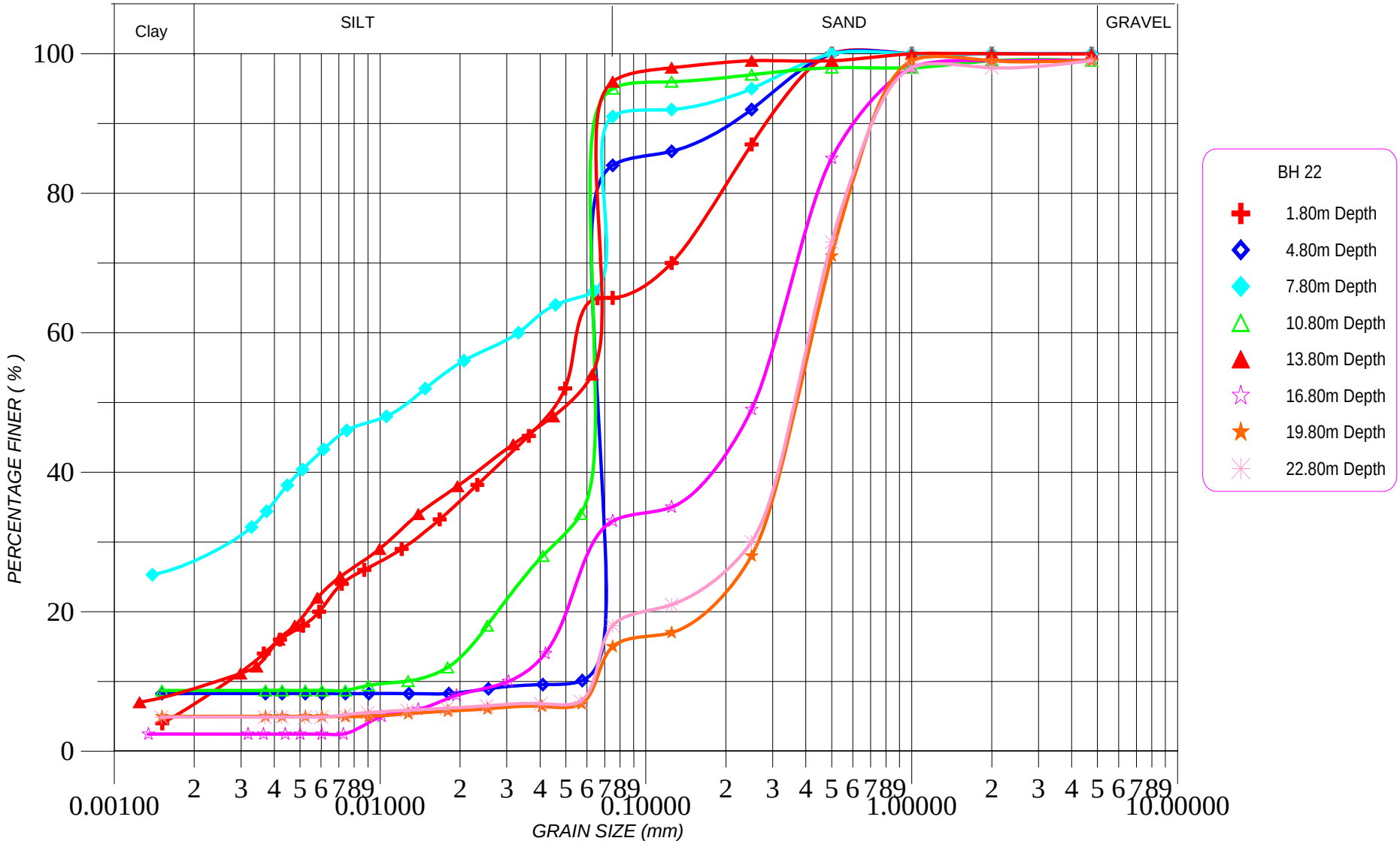
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 21

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



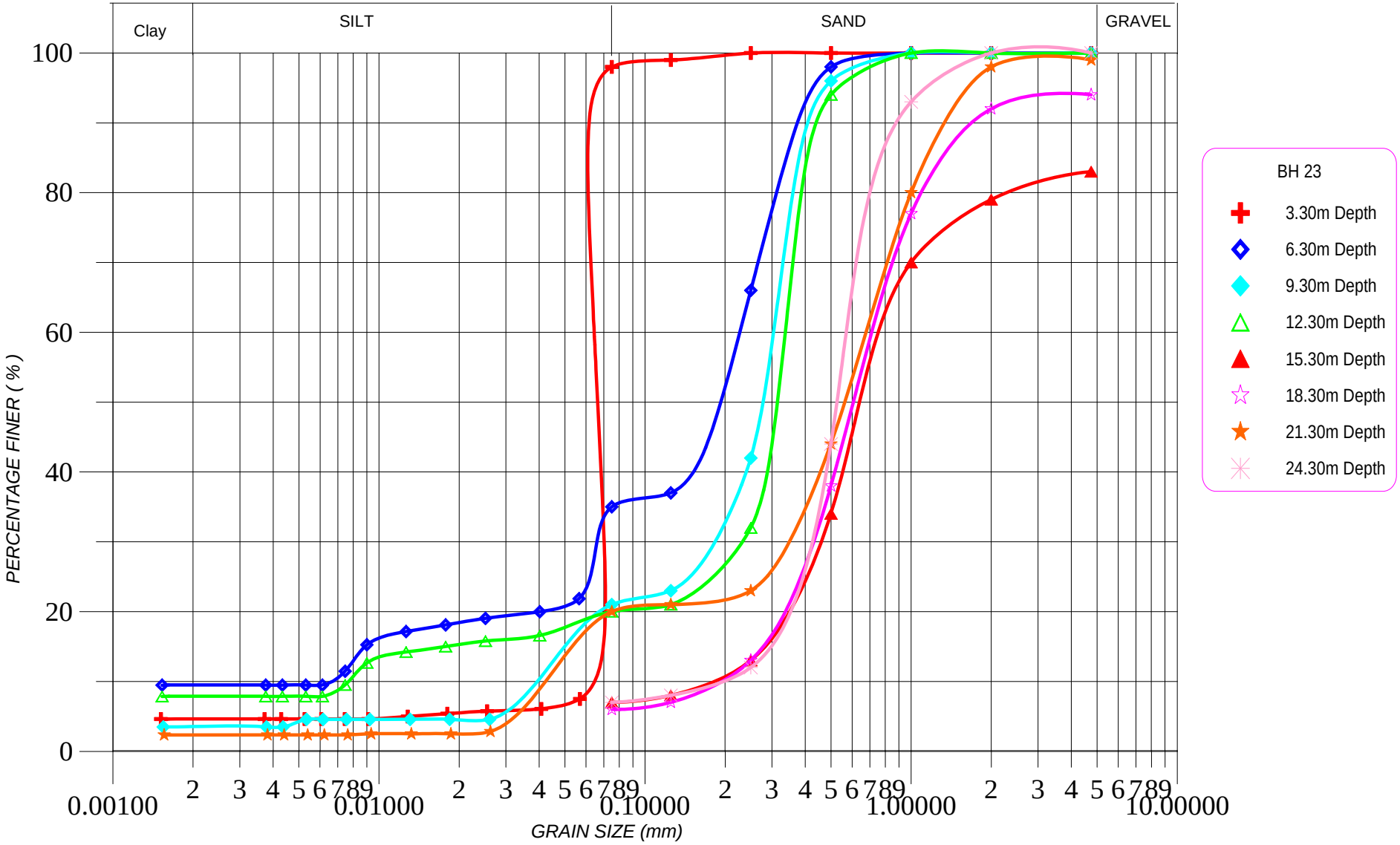
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 22

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE

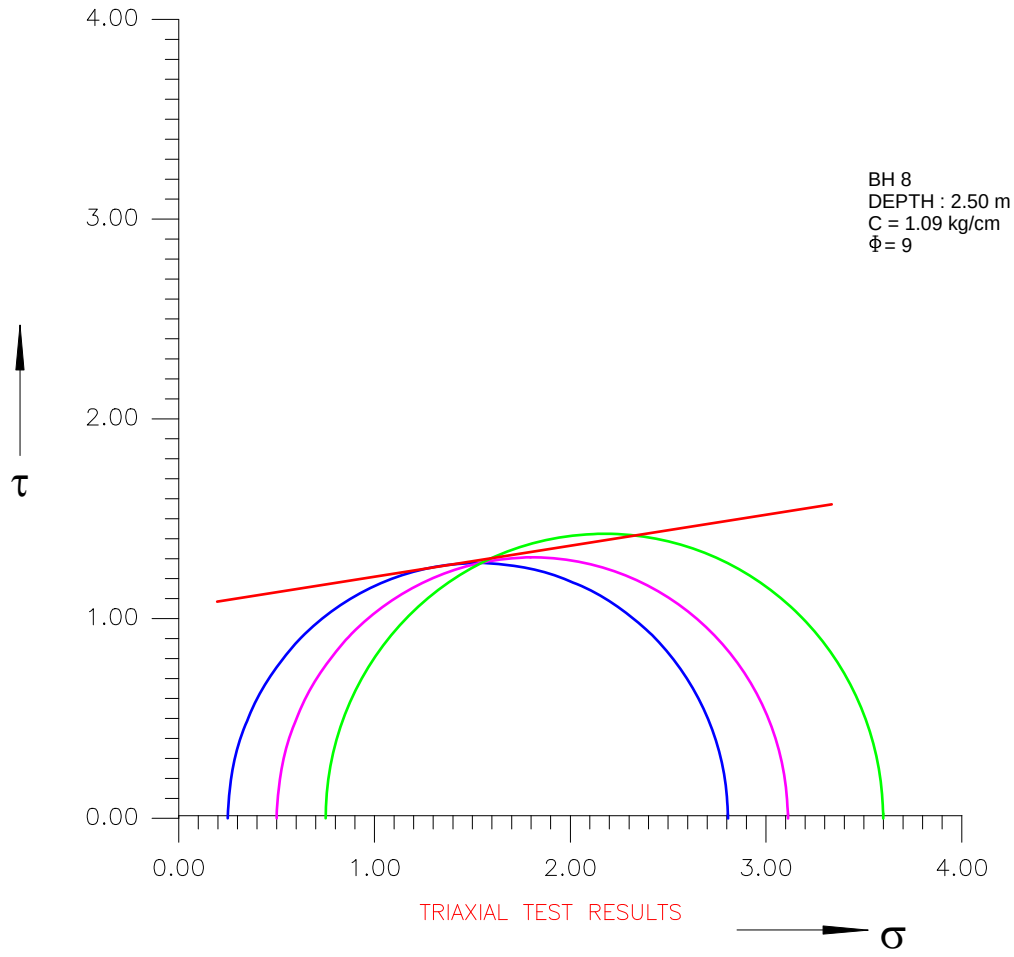


PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 23

SOIL ENGINEERING CONSULTANTS

Job No: 2152

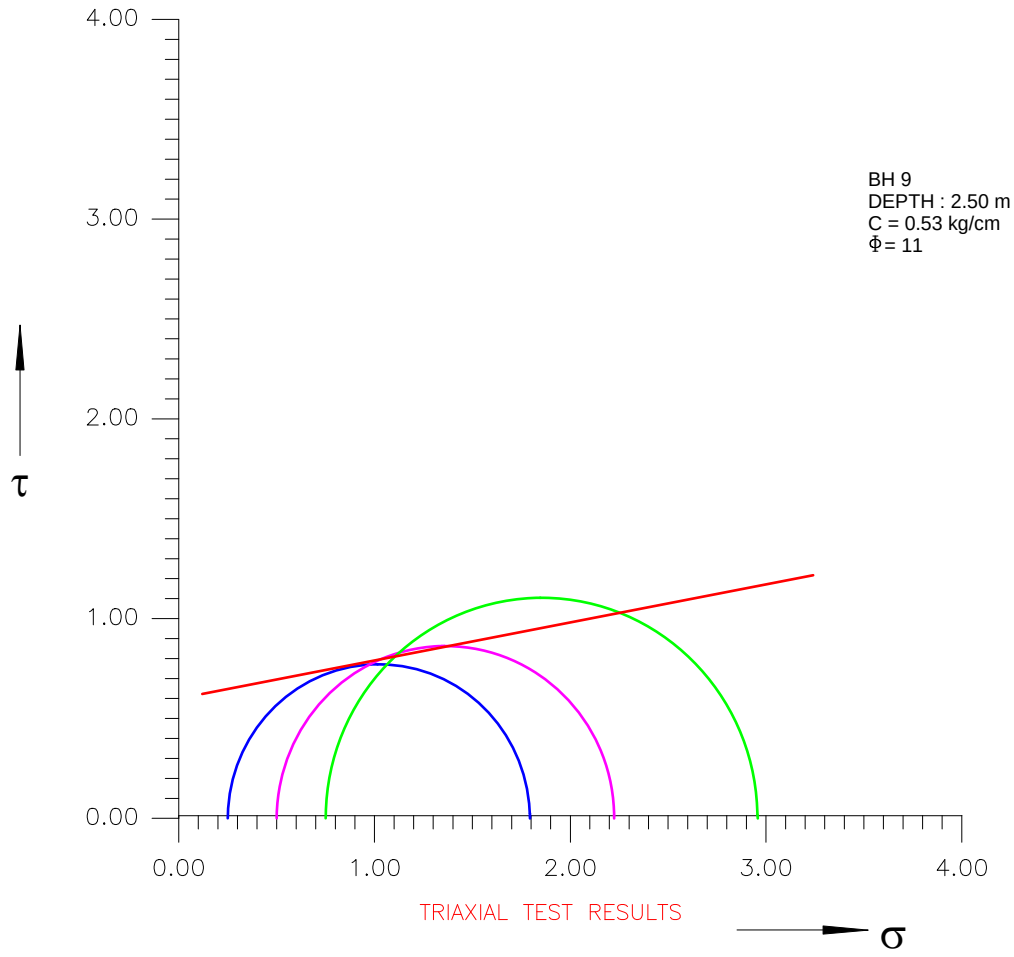


PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Figure : T8-1

SOIL ENGINEERING CONSULTANTS

Job No: 2152

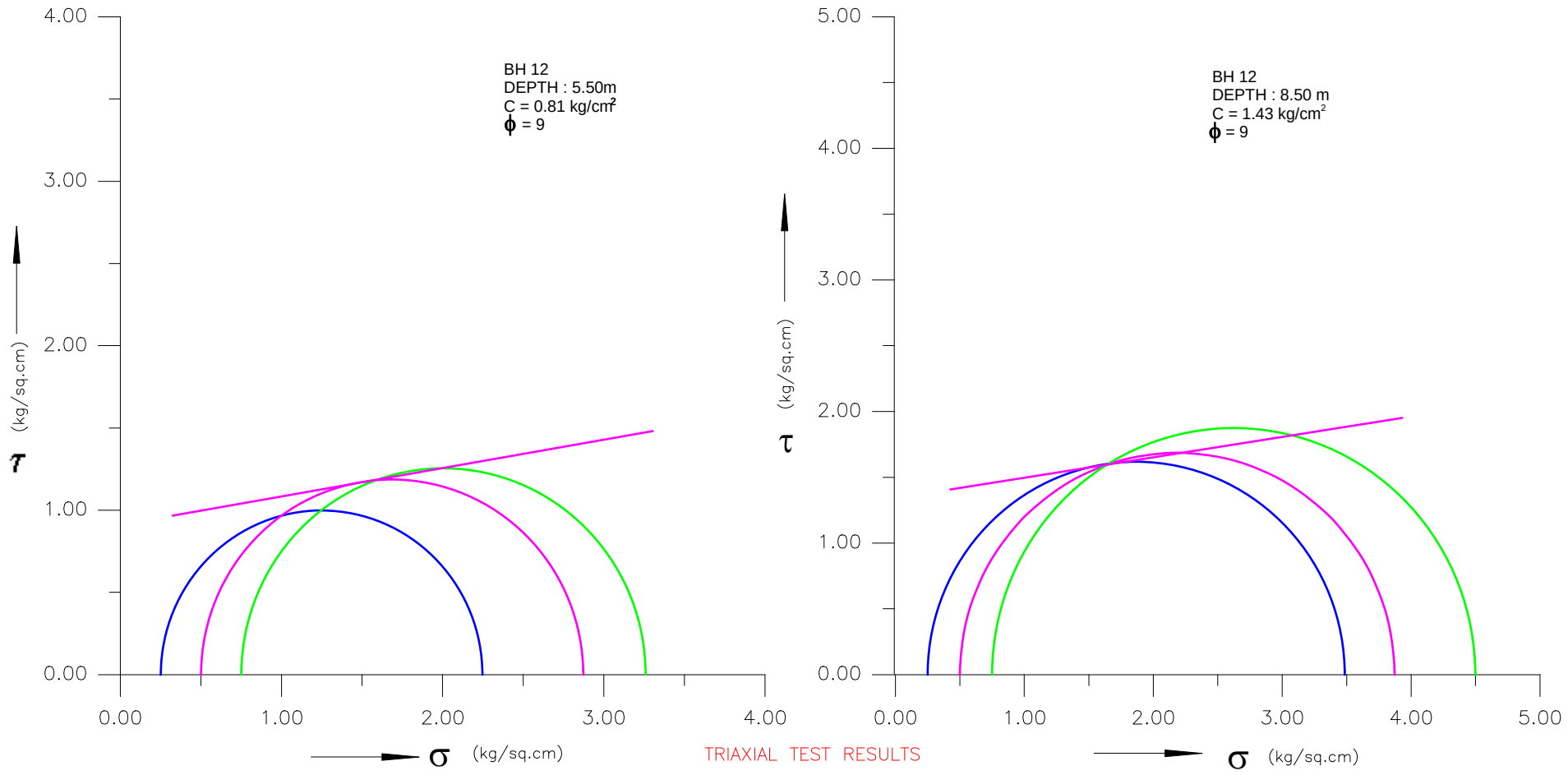


PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Figure : T9-1

SOIL ENGINEERING CONSULTANTS

Job No: 2152



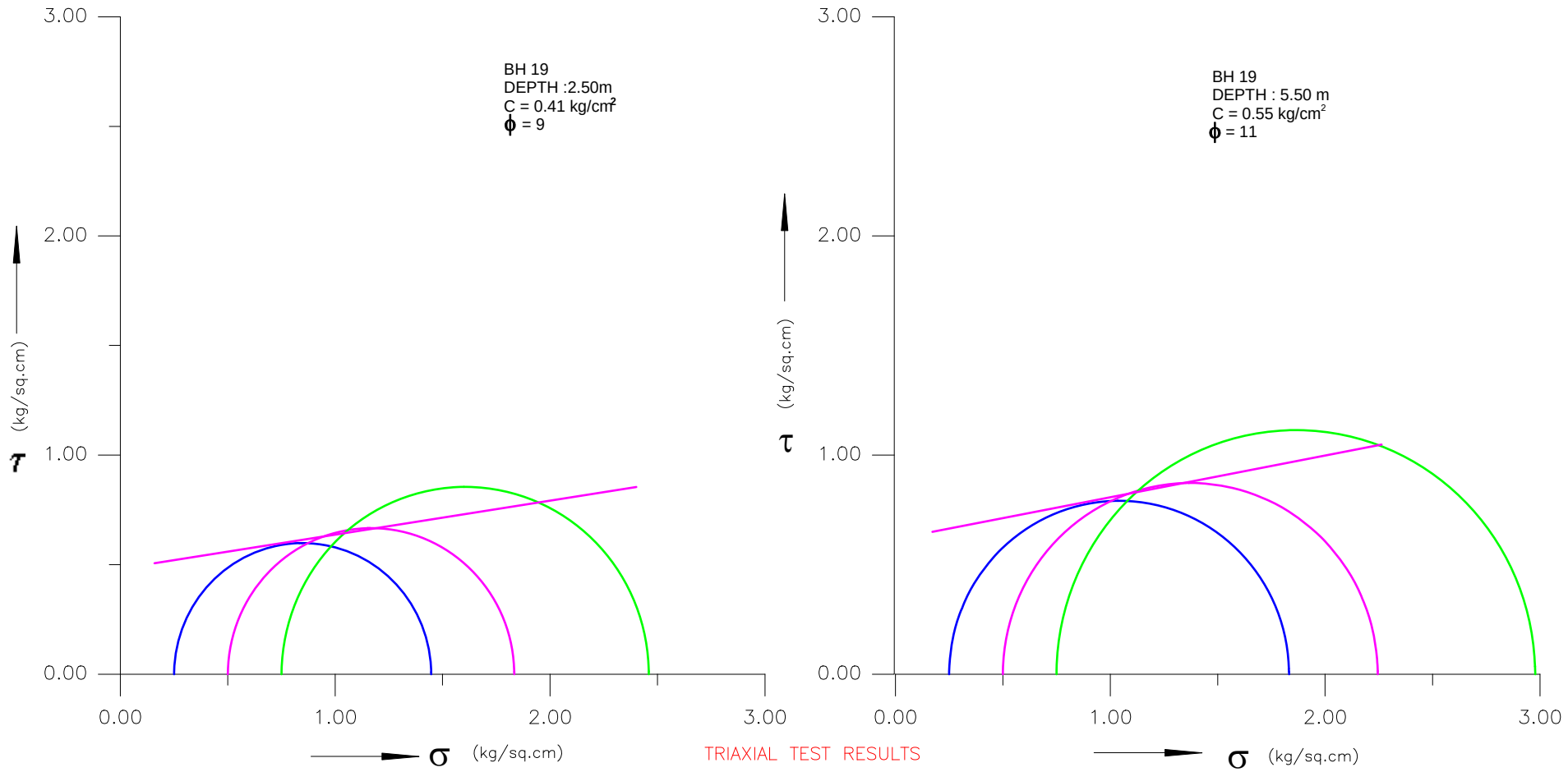
TRIAXIAL TEST RESULTS

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Figure : T 12-1

SOIL ENGINEERING CONSULTANTS

Job No: 2152



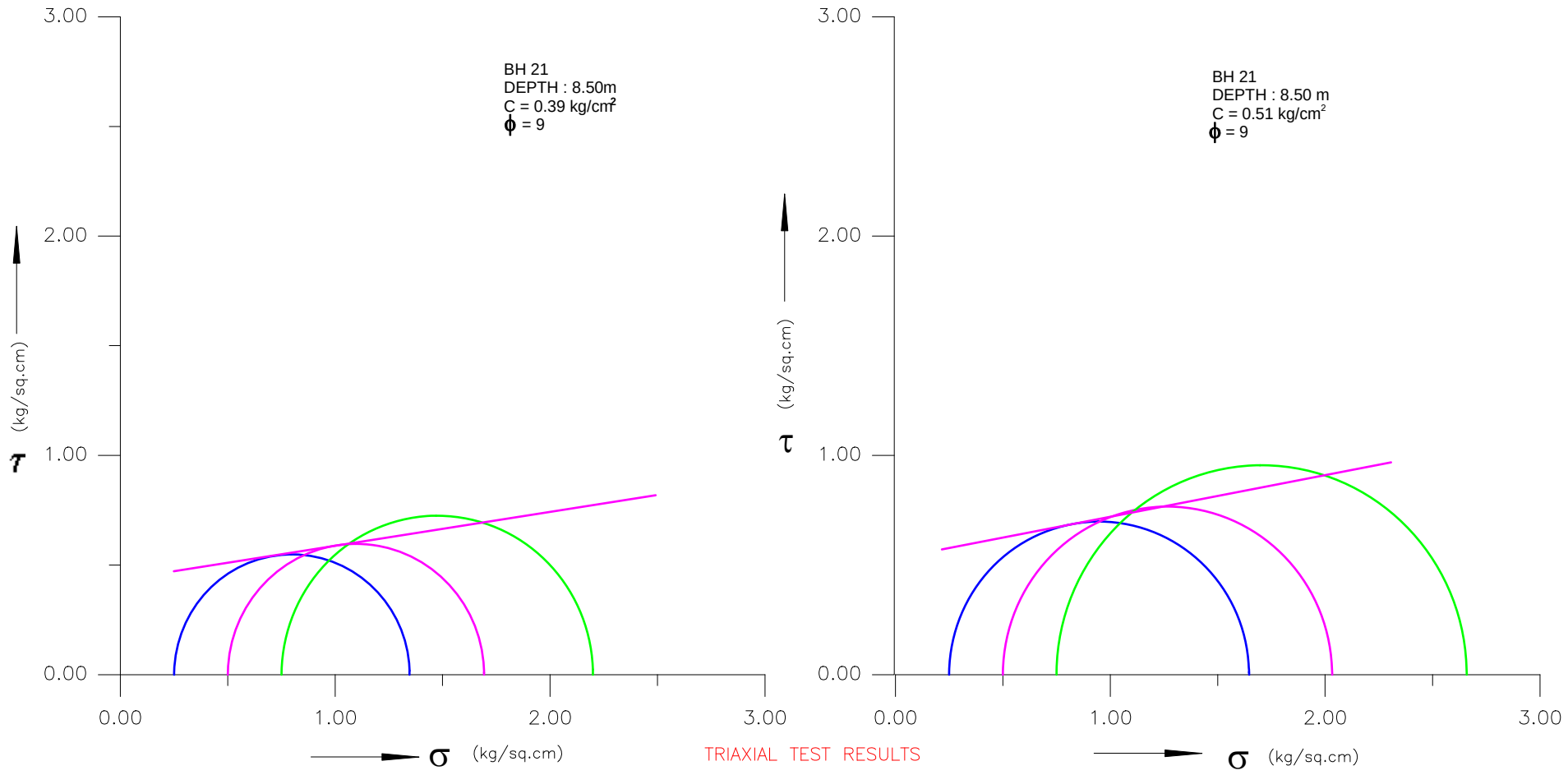
TRIAXIAL TEST RESULTS

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Figure : T 19-1

SOIL ENGINEERING CONSULTANTS

Job No: 2152



TRIAXIAL TEST RESULTS

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Figure : T 21-1

Annexure VI
Site Photograph's

Flyover @ 0+800

MJB @ CH 1+530

VUP @ CH 6+280

Flyover @ CH 8+020

VUP @ CH 16+690

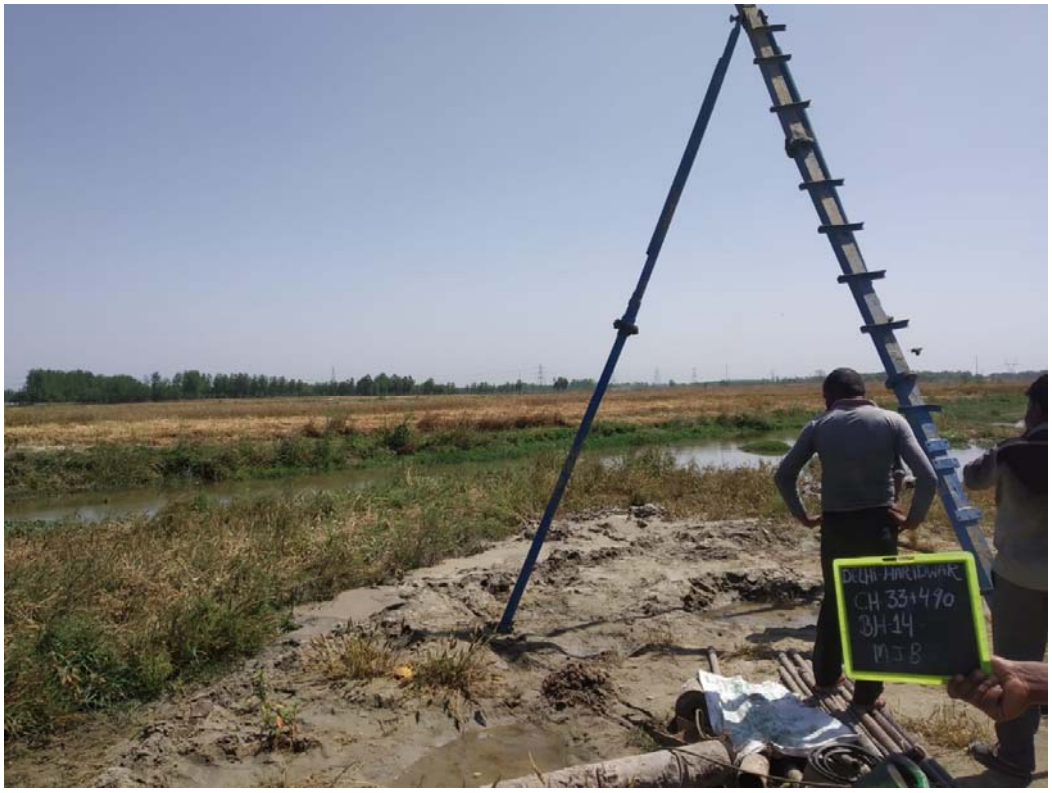
VUP@ CH 22+980

VUP @ CH 25+430

MNB @ CH 29+260

Flyover @ CH 32+170

MJB @ CH 33+420



MJB @ CH 33+490

MJB @ CH 35+860

MNB @ CH 38+010

MJB @ CH 39+580

MJB @ CH 39+690

VUP @ CH 40+960

MJB @ CH 42+550

Flyover @ CH 43+910

MJB @ CH 47+950

Flyover @ CH 49+900

Transys Consulting Pvt. Ltd

Geotechnical Investigation work for Proposed Greenfield project from Spur to Haridwar.

Job No 2152

Report
ROB @ 7+530 & 27+120-R0

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Sno	Date of submission	Revison No.
1	12-07-2021	R0

Table of Contents

1.0 INTRODUCTION

M/s Transys Consulting Pvt Ltd has awarded the work of Geo technical Investigation for the proposed Greenfield project from Spur to Haridwar to M/s Soil Engineering Consultants, New Delhi.

Geotechnical investigation was conducted to characterize and assess the subsurface conditions at the locations of various Structures viz. proposed ROB's. The overall objectives of the exploration were to study and evaluate the stratigraphy of the said project corridor and to obtain geotechnical / geological parameters of the subsurface formations for design and construction of various foundations.

This report presents the details of Geotechnical investigations carried out and data obtained from various field and laboratory tests, their presentation in graphical form, and their compilation for the proposed Structures.

2.0 SCOPE OF WORK

a) Drilling bore holes upto the maximum depth of 30.0 m as per IS code of practice and as per the direction of the Engineer-in-Charge.

b) Conducting Standard Penetration tests in the bore holes at regular intervals of 1.50m or wherever possible as per IS Code of Practice.

c) Collecting undisturbed soil samples / core samples from the bore holes at regular intervals or change of strata or wherever possible as per IS Code of Practice.

d) Recording of water table level in the bore holes after completion of borehole.

e) Preparation of report summarizing the details of soil classification, analysis of test data, type of foundation etc.

3.0 FIELD WORK

3.1 Boring

Bore holes of 150 mm dia. were drilled as per IS code of practice (IS 1892-1979) and as per the directions of the Engineer in charge. The details of Bore holes drilled, Depth of bore hole and the depth of water table are as given below:

Table 1 : Detail of the Boreholes.

Chainge	BH No.	Structure	Depth of Borehole (m)	Water Table (m)
7+530	BH 7	ROB	30.00	15.30
27+120	BH 11	ROB	30.00	15.70

3.2 Standard Penetration Test (SPT)

These tests were conducted at every 1.50m intervals and every change of strata or wherever possible. The tests were performed by driving into the soil (bore holes cleaned of any loose material) a standard split spoon sampler with the help of a standard hammer with a free fall of 75 cms on a driving head as described in IS: 2131. This head was attached to "A" drill rod to the other end of which the sampler was fitted. The number of blows needed to penetrate the first, second and third stages (each of 15 cms) depth of the sampler length, were noted. The number of blows (N - value) as given in the bore hole data sheets is the numerical sum of blows counted during the second & third stage only i.e. for a depth of 30 cms.

3.3 Collection of Samples

Disturbed and Undisturbed soil samples were collected from the boreholes at regular intervals as per IS Code of practice.

3.4 Recording of water table

Water table was met at varying depth in the boreholes at the time of Soil investigation which was carried out during the month of April 2021. The details are given at Table I above. Fluctuations may occur in measured

water levels due to seasonal variation in rainfall and surface evaporation rates as well as flow of water.

4.0 LABORATORY TESTS

A visual and discrete examination of all the soil samples collected was carried out for deciding the number and type of tests to be tested from each bore hole. Based on the strata met at site the following tests were conducted on samples to classify them and to evaluate their index and Engineering properties.

4.1 SOIL SAMPLES & BIS CODES

a) Grain size distribution as per IS: 2720(Part IV).
b) Hydrometer Analysis as per IS: 2720(Part IV).
c) Specific gravity as per IS: 2720(Part III).
d) Bulk density and dry density as per IS: 2720(Part II).
e) Moisture content as per IS: 2720(Part II).
f) Liquid and plastic limits as per IS: 2720(Part V).
g) Direct Shear Tests as per IS: 2720 (Part XIII).

5.0 General Geology of the Area

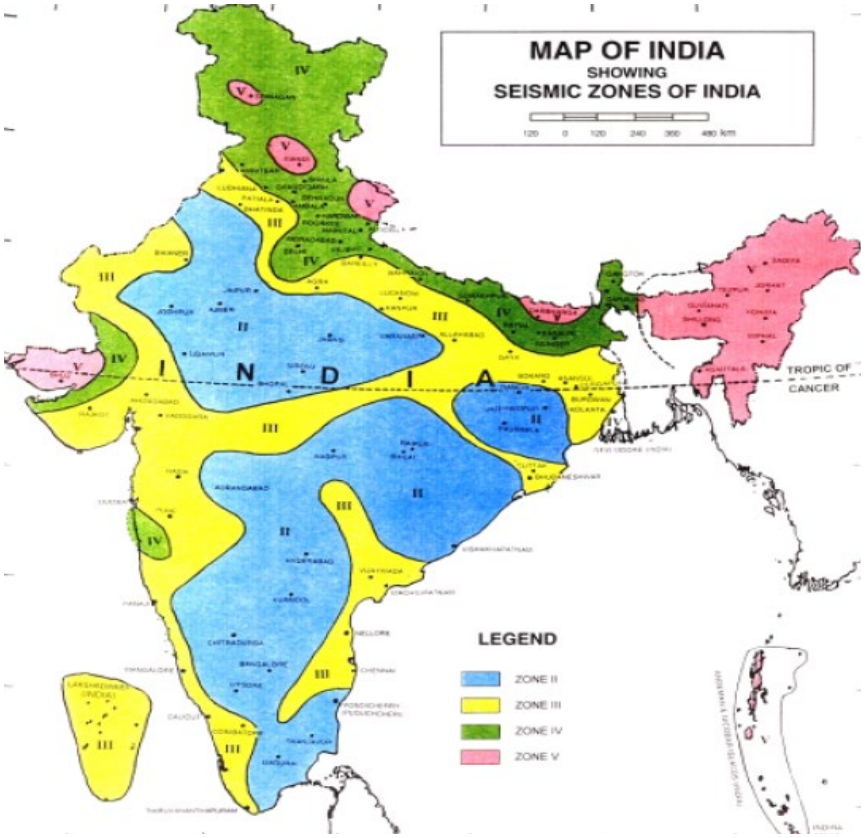
The present location is in the state of Uttarakhand situated on the northern Gangetic plains of India. Most of the state of Uttarakhand lies in the Gangetic Plain. This is a fore-deep, a downwarp of the Himalayan foreland, of variable depth, converted into flat plains by long-vigorous sedimentation. This is known as a geosyncline and the Gangetic Plain is the Indo-Gangetic Geosyncline. This has shown considerable amounts of flexure and dislocation at the northern end and is bounded on the north by the Himalayan Frontal Thrust. The floor of the Gangetic trough (if see without all the sediments) is not an even plain, but shows corrugated inequalities and buried ridges (shelf faults). Beneath Uttar Pradesh, run the Delhi-Haridwar Ridge (DHR), trending NNE-SSW along New Delhi to the Gharwal region. The Delhi-Muzaffarnagar Ridge (DMR), which trends east

to west, running from New Delhi to Kathgodam, in Nepal. The last ridge is the Faizabad ridge (FR), which runs in a curved manner, first east to west from Allahabad to Kanpur and then starts to bend towards the north-east towards Lucknow and carries on in this direction towards the Himalayas in Nepal. The depression that forms between the DMR and the FR, forms the West Uttar Pradesh shelf in the west and the Sharda Depression in the east. The region to the south of the FR, forms the East Uttar Pradesh shelf. There are several faults in the region, among them the Moradabad Fault which trends NE-SW and the Bhairwan Fault in the vicinity of Allahabad. Apart from these there are east-west running tear faults in the region that control the courses of the main rivers. Earthquakes have occurred in mostly all parts of Uttarakhand. Major earthquakes in the neighbouring states of New Delhi, Uttaranchal, Bihar and from across the Indo-Nepal border have also shaken many parts of Uttar Pradesh.However, it must be stated that proximity to faults does not necessarily translate into a higher hazard as compared to areas located further away, as damage from earthquakes depends on numerous factors such as subsurface geology as well as adherence to the building codes.

6.0 SEISMICITY

The seismic hazard map of India was updated in 2016 by the Bureau of Indian Standard (BIS). The project site lies in Zone IV. The tectonic elements of the area are considered capable of generating an earthquake of intensity MSK 7.0. In Seismic design Zone factor, Z of 0.24 is recommended.

Seismic Map



7.0 LIQUEFACTION

Liquefaction is a process in which a saturated soil loose strength during an earthquake and acquires a degree of mobility sufficient to permit significant movements. In general, fine uniform sands are found to be most susceptible for liquefaction in terms of grain size. It can be stated that soils containing less than 10% fines, D_{60} between 0.20 mm to 1.0mm, uniformity coefficient between 2 to 5 are most susceptible to liquefaction for given relative density of soil and intensity of earthquake. Thus, uniformly graded materials are more susceptible to liquefaction than well graded materials. Also fine sands are more susceptible than gravelly soils, silty sands, silts or clays.

Assessment of liquefaction potential of foundation strata is made by simplified approach proposed by Seed & Idriss (1983 - 1985) from the SPT data and peak ground acceleration likely to occur at the site. In this method, cyclic shear stress likely to be induced in the foundation strata is

first evaluated. Next threshold cyclic shear stress, which is good enough to cause liquefaction, is determined from SPT data and the empirical relations. Finally, comparison of these two stresses is used in the estimation of liquefaction susceptibility of the foundation strata

7.1 Liquefaction Analysis:

Cyclic Stress Ratio under Earth Quake (CSR)

Stress ratio under earth quake (CSR)

$$= (\tau / \sigma_o)_{earthquake} = 0.65 (\gamma h\, a_{max} / \sigma_o\, g)\lambda$$

σ_o= Effective overburden pressure at depth h

γ = Bulk density of soil

a_{max}= Max. Ground acceleration = 0.24g

Evaluation of Liquefaction Resistance (CRR)

$CRR_{7.50} = 1/ \{(34-(N_1)_{60CS}\} + (N_1)_{60CS} / 135 + 50/ \{10*(N_1)_{60CS} + 45\}^2 - 1/ 200$

$(N_1)_{60} = NC_{60}C_N$

N= Uncorrected SPT count

C_N= factor to normalize N_m to a common reference effective overburden stress = $(p_o / \sigma_o)^{0.5}$

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

C_{HT} =Correction for Hammer Energy Ratio

C_{BD}= Correction factor for the borehole diameter

C_{RL}= correction factor for rod length

C_{SS}= Correction for samples with or without liners

Correction for Fineness content

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

$CRR_L = CRR_{7.50} * k_m$

k_m Correction factor

For earthquake magnitude other than 7.5 = $10_{2.24} / (M_{7.5})^{2.56}$

Liquefaction occurs if $CSR_L \geq$ CRR

Data considered for Liquefaction:

Magnitude of Earth quake = 7.0.

a_{max}/g = 0.24

Water table assumed for Calculation = considered 3.0m rise water table encounter at the time investigation.

The Liquefaction analysis has been calculated and given at **Annexure II**.

8.0 SUB SOIL PROFILE & STRENGTH CHARACTERISTICS OF SOIL

ROB @ 7+ 530

At this structure One Borehole namely (BH 4) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. However from 22.0m to 22.50m depth a layer of Silty Clay of Medium Plasticity (CI) was observed. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However, at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and High water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 9 to 40 upto the depth drilled. For evaluating the shear parameters Direct shear Tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

ROB @ 27+120

At this structure One Borehole namely (BH 11) was drilled upto 30.0m depth. While advancing the bore holes SPT tests were conducted at regular intervals of 1.5m and representative samples were collected. These representative samples were analysed for soil classification by conducting sieve analysis, Hydrometer analysis & Atterberg Limits. From the classification it is revealed that the strata predominately consists of medium dense Sandy Silt with Gravel (SM-ML)/ Silty Sand with Gravel (SM) upto the depth drilled. However from 23.0m to 26.5m depth a layer of Silty Clay of High Plasticity (CH) was observed. Attempts were made to collect Undisturbed soil samples at regular intervals of 3.0m depth. However, at greater depth some of the samples could not be collected due to presence of very dense/ Hard strata and water table. The SPT values has been corrected for Overburden strata and dilatancy in non- plastic strata. These corrected values have been plotted against depth and are shown in the respective borelogs. It can be seen from the plot that the SPT values are generally varying from 9 to 40 upto the depth drilled. However at greater depths SPT values above 40 were observed this might be due to the presence of Hard/Very dense strata. For evaluating the shear parameters Direct shear Tests/Unconsolidated undrained shear tests were conducted on the UDS samples collected. The results are given in the respective borelog. Liquefaction analysis has been carried out and the details are given at Annexure **II**. It can be seen from the results that the strata is not susceptible to liquefaction.

9.0 DESIGN CRITERIA

Any foundation is to be safe against possible failure against

a) Excessive Shear failure (the bearing pressure should be within permissible limits) and
b) Excessive settlement.

The latter depends upon not only on the type of soil in the foundation but also on the type of foundation, material used for construction and functionality of the structure.

9.1 Design Methodology

ROB @ 7+530 & 27+120

Bored - Cast - in situ Piles of 1.0m and 1.20m diameter are analyzed.

9.1.1 Bored cast in-situ concrete pile

The ultimate load carrying capacity (P_u) of piles is given by the following formula:

$P_u = A_p (N_c.C_p + ½ D \gamma N_r + P_d N_q) + \sum K P_{di} \tan \delta A_{si} + \alpha c.As$

$P_u = P_{pu} + P_{su}$

P_{pu} = Ultimate bearing resistance

$= A_p (N_c. C_p + ½ D \gamma N_r + P_d N_q)$

P_{Su}= Ultimate shaft resistance

$\sum K P_{di} \tan \delta A_{si} + \alpha c.As$

A_p = Cross sectional area of the pile toe m^2

D = Stem diameter in mm

γ = Effective unit weight of soil at pile toe in t/m^3

P_d = Effective overburden pressure at pile toe in t/m^2

i.e 20 X diameter (as per IRC 78-2014).

N_r & N_q = Bearing capacity factors depending upon the angle of internal friction ∅ at toe

$\sum$ = Summation of n layers in which pile is installed

K = Coefficient of earth pressure

= Taken 1.5 (as per IRC 78- 2014 Appendix 5)

P_{di} = Effective overburden pressure in t/m^2 for the i^{th} layer where i varies from i to n

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

A_{si} = Surface area of pile stem in m^2 in i^{th} layer where i varies from 1 to n.

FOS= Factor of Safety considered as 2.5 (as per IS 2911 part 1 sec 2)

For vertical Capacity of pile, weight of pile has not been considered.

10.0 COMPUTATIONS

The Vertical, Uplift and lateral carrying capacities of the Bored Cast in Situ Piles of 1.0m and 1.20m dia are calculated and are given at **Annexure I.**

11.0 RECOMMENDATIONS

ROB @ 7+530 & 27+120

Bored Cast in-situ Pile Foundation of 1.0 m and 1.20m dia are recommended at cut off level of 2.0m and 2.30m respectively. The Length of pile and Safe load carrying capacity of the pile can be taken as given below:

Chainage	BH No.	Pile Dia (cms)	Length of Pile (m)	Safe Load carrying capacity of Pile (t)		
				Vertical	Uplift	Lateral
7+530	BH 7	100	25.0	340.0	180.0	30.0
		120	25.0	450.0	200.0	50.0
27+120	BH 10	100	25.0	400.0	210.0	30.0
		120	25.0	500.0	270.0	50.0

For Soil Engineering Consultants

(A.V.S. RANGA RAO)
Consultant

Annexure I

(Calculation)

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	**Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.**	Structure @ Chainage	7+530	Location	ROB	Based on Bore Hole No	**BH 4**	Pile Cut -off level (m)	2.0
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = Ap^* (cN_c+P_dN_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s $P_{di}\tan\delta$).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	2	0.00	0	29	29	1.82	1.03	2.06	0	18.1	19.3	0.79	0	37.24	9.000	36.29	1.03	6.28	5.37	0	0	0	36.29	2.19	14.51	2.19	2
2	SM-ML / SM	2	0.00	0	31	31	1.86	1.01	4.08	0	23.9	26	0.79	0	97.61	13.120	86.92	3.07	6.28	17.37	0	0	17.37	104.29	4.38	41.71	9.24	4
3	SM-ML / SM	3	0.00	0	32	32	1.9	0.99	7.05	0	28.9	30.2	0.79	0	203.6	14.950	171.56	5.56	9.42	49.09	0	0	66.46	238.02	7.67	95.2	26.27	7
4	SM-ML / SM	4	0.00	0	32	32	1.9	0.99	11.01	0	28.9	30.2	0.79	0	317.96	14.950	261.33	9.03	12.6	106.3	0	0	172.8	434.09	12.06	173.63	60.43	11
5	SM-ML / SM	2	0.00	0	30	30	1.9	0.99	12.99	0	20.9	22.4	0.79	0	272.12	11.080	191.64	12	6.28	65.26	0	0	238	429.66	14.25	171.86	80.89	13
6	SM-ML / SM	3	0.00	0	29	29	1.9	0.99	15.96	0	18.1	19.3	0.79	0	288.52	9.570	165.66	14.47	9.42	113.33	0	0	351.4	517.01	17.54	206.8	115.91	16
7	SM-ML / SM	2	0.00	0	29	29	1.9	0.99	17.94	0	18.1	19.3	0.79	0	324.31	9.570	148.49	16.95	6.28	88.5	0	0	439.9	588.34	19.73	235.33	142.88	18
8	SM-ML / SM	2	0.00	0	29	0	1.9	0.99	19.92	0	18.1	19.3	0.79	0	360.1	9.570	120.1	18.93	6.28	0	0	0	439.9	559.95	21.92	223.98	145.07	20
9	CI	1	0.00	17	0	0	1.9	1.02	19.92	9	0	0	0.79	153	0	0.000	120.1	19.92	3.14	0	0.3	16.01	455.9	575.96	23.01	230.38	150.65	21
10	CI	2	0.00	17	0	0	1.9	1.02	19.92	9	0	0	0.79	153	0	0.000	120	19.92	6.28	0	0.3	32.02	487.9	607.88	25.2	243.15	161.8	23
11	SM-ML	2	0.00	0	29	29	1.9	0.99	19.92	0	18.1	19.3	0.79	0	360.1	9.570	290	19.92	6.28	104.01	0	0	591.9	881.89	27.39	352.75	193.11	25

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	25.0
d) Vertical Pile Capacity (tonnes)	340.0
e) Uplift pile capacity (Tonnes)	180.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	Structure @ Chainage	7+530	Location	ROB	Based on Bore Hole No	BH 4	Pile Cut -off level (m)	2.3		
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	2.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion , C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	γ (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5.\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{su} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_u=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	$c.N_C$	PdN_q	$0.5.\gamma.D.N_\gamma$	P_{pu} (tonnes)	Effective over burden Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	(K_s $P_{di}.\tan\delta$).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	1.7	0.00	0	29	29	1.82	1.03	1.75	0	18.1	19.3	1.13	0	31.63	11.000	48.17	0.87	6.4	4.62	0	0	0	48.17	2.68	19.26	2.68	1.7
2	SM-ML / SM	2	0.00	0	31	31	1.86	1.01	3.77	0	23.9	26	1.13	0	90.19	15.750	119.71	2.76	7.53	18.73	0	0	18.73	138.44	5.84	55.37	11.08	3.7
3	SM-ML / SM	3	0.00	0	32	32	1.9	0.99	6.74	0	28.9	30.2	1.13	0	194.64	17.940	240.21	5.25	11.3	55.6	0	0	74.33	314.54	10.58	125.81	31.39	6.7
4	SM-ML / SM	4	0.00	0	32	32	1.9	0.99	10.7	0	28.9	30.2	1.13	0	309.01	17.940	369.45	8.72	15.1	123.17	0	0	197.5	566.95	16.9	226.78	72.2	10.7
5	SM-ML / SM	2	0.00	0	30	30	1.9	0.99	12.68	0	20.9	22.4	1.13	0	265.63	13.300	255.89	11.69	7.53	76.23	0	0	273.7	529.62	20.06	211.84	96.7	12.7
6	SM-ML / SM	3	0.00	0	29	29	1.9	0.99	15.65	0	18.1	19.3	1.13	0	282.91	11.480	226.14	14.16	11.3	133.04	0	0	406.8	632.91	24.8	253.16	138.69	15.7
7	SM-ML / SM	2	0.00	0	29	29	1.9	0.99	17.63	0	18.1	19.3	1.13	0	318.71	11.480	206.26	16.64	7.53	104.18	0	0	511	717.21	27.96	286.88	171.02	17.7
8	SM-ML / SM	2	0.00	0	29	0	1.9	0.99	19.61	0	18.1	19.3	1.13	0	354.5	11.480	172.89	18.62	7.53	0	0	0	511	683.84	31.12	273.53	174.18	19.7
9	CI	2	0.00	17	0	0	1.9	1.02	21.65	9	0	0	1.13	153	0	0.000	172.89	20.63	7.53	0	0.3	38.4	549.4	722.24	34.28	288.89	188.09	21.7
10	CI	1	0.00	17	0	0	1.9	1.02	22.67	9	0	0	1.13	153	0	0.000	172	22.16	3.76	0	0.3	19.17	568.5	740.52	35.86	296.2	195.04	22.7
11	SM-ML	2.3	0.00	0	29	29	1.9	0.99	22.67	0	18.1	19.3	1.13	0	409.82	11.480	476	22.67	8.66	163.23	0	0	731.8	1207.75	39.49	483.1	244.38	25

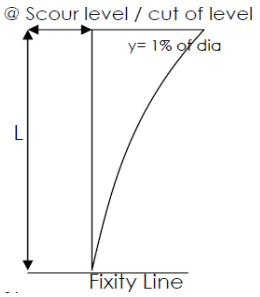
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	25.0
d) Vertical Pile Capacity (tonnes)	450.0
e) Uplift pile capacity (Tonnes)	200.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C	
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.	

Structure @ Chainage :	ROB @ 7+530	
Borehole no :	BH 4	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" **:**	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	25.0	25.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	21.00	21.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.98E+03	2.98E+03
Stiffness factor for Cohesionless soil (T) in m :	3.43	3.97
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (**L_1**) in "m"**:**	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	25.00	25.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	7.51	8.69
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	7.51	8.69
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	41.10	65.97
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	35.00	50.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Appendix-4.3: Geotechnical Investigation Data

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.		Structure @ Chainage	27+120	Location	ROB	Based on Bore Hole No	BH 10	Pile Cut -off level (m)	2.0	
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	15.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1000	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m)	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion, C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors N_C	N_q	N_γ	Ultimate Base Resistance $P_{pu} = A_p^*(cN_C+P_dN_q+0.5\gamma.D.N_\gamma)$ A_p (m²)	$c.N_C$	PdN_q	$0.5\gamma.D.N_\gamma$	P_{pu} (tonnes)	Ultimate Shaft Friction $P_{SU}=(\sum(K_s P_{di}\tan\delta).A_{si}+a.c.A_s)$ Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	$(K_s P_{di}\tan\delta).A_{si}$	Adhesion Factor, a	a.c.A_{si}	P_{su}	Total Ultimate Capacity, $P_U=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s=\frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
1	SM-ML / SM	2	0.00	0	30	30	1.84	1.03	2.06	0	20.9	22.4	0.79	0	43.15	11.000	42.5	1.03	6.28	5.6	0	0	0	42.5	2.19	17	2.19	2
2	SM-ML / SM	2	0.00	0	30	30	1.83	1.01	4.08	0	20.9	22.4	0.79	0	85.47	11.310	75.97	3.07	6.28	16.69	0	0	16.69	92.66	4.38	37.06	9.05	4
3	SM-ML / SM	3	0.00	0	30	30	1.83	0.99	7.05	0	20.9	22.4	0.79	0	147.68	11.080	124.62	5.56	9.42	45.35	0	0	62.04	186.66	7.67	74.66	25.04	7
4	SM-ML / SM	4	0.00	0	30	30	1.93	0.99	11.01	0	20.9	22.4	0.79	0	230.64	11.080	194.52	9.03	12.6	98.22	0	0	160.3	354.78	12.06	141.91	56.93	11
5	SM-ML / SM	3	0.00	0	30	30	1.9	0.99	13.98	0	20.9	22.4	0.79	0	292.86	11.080	226.09	12.49	9.42	101.89	0	0	262.2	488.24	15.35	195.29	88.75	14
6	SM-ML / SM	3	0.00	0	30	30	1.9	0.99	16.95	0	20.9	22.4	0.79	0	355.08	11.080	228.36	15.46	9.42	126.12	0	0	388.3	616.63	18.64	246.65	127.35	17
7	SM-ML / SM	2	0.00	0	30	30	1.9	0.99	18.93	0	20.9	22.4	0.79	0	396.56	11.080	213.6	17.94	6.28	97.56	0	0	485.8	699.43	20.83	279.77	156.86	19
8	CH	1	0.00	21	0	0	1.9	0.99	19.92	9	0	0	0.79	189	0	0.000	148.36	19.42	3.14	0	0.3	19.78	505.6	653.97	21.92	261.58	163.49	20
9	CH	2.5	0.00	21	0	0	1.9	1.02	19.92	9	0	0	0.79	189	0	0.000	148.36	19.92	7.85	0	0.3	49.45	555.1	703.42	24.66	281.36	180.07	22.5
10	SM-ML / SM	2.5	0.00	0	30	30	1.9	1.02	19.92	0	20.9	22.4	0.79	0	417.3	11.420	336	19.92	7.85	135.42	0	0	690.5	1026.48	27.4	410.59	220.73	25

Recommendation :

a) Pile Diameter (mm)	1000
b) Pile cut off level (m)	**2.0**
c) Pile Shaft Length from Cut off Level (m)	25.0
d) Vertical Pile Capacity (tonnes)	400.0
e) Uplift pile capacity (Tonnes)	210.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Appendix-4.3: Geotechnical Investigation Data

Design of Pile Foundation
Estimation of Safe Vertical Load carrying Capacity of "Bored Cast in situ Concrete Pile"as per IRC 78-2014

Name of Project	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.		Structure @ Chainage	27+120	Location	ROB	Based on Bore Hole No	BH 10	Pile Cut -off level (m)	2.3
Type of Pile Foundation	Bored Cast-in-situ Concrete Pile	Inclination of pile with Vertical Axis (deg)	0	Factor of Safety for base Resitance	2.5	Actual Water table (m)	15.70	water Level considered (m)	0.00	Scour Level @ RL(m)	
Pile Diameter (mm)	1200	Earth Presure Coefficient Ks	1.5	Factor of Safety for Shaft Friction	2.5	Scour Level below the cut off level (m)	0.00	Liqefaction depth below Ground level (m)	0.00	RL of the Borehole (m)	

Maximum effective overburden pressure= 20*Diameter of pile.
Assuming the strata @ 30 m and below to be same.

Scour level below cut-off level(m) : **0.000**

Layer No.	Type of Sub Soil Layer	Thickness of Layer (m)	Water table (W.T) m	Cohesion, C (t/m^2)	Angle of Shearing Resistance, φ (deg)	Angle of Wall Friction δ(deg)	r (density of soil) t/m^3	Total/ Submerged Unit Weight of Soil (t/m^3)	Effective over-burden Pressure at pile tip "q_{tip}" (t/m^2)	Bearing Capacity Factors			Ultimate Base Resistance $P_{pu} = A_p^* (cN_c+P_dN_q+0.5\gamma.D.N_\gamma)$					Ultimate Shaft Friction $P_{SU} = (\sum(K_s P_{di} \tan\delta).A_{si}+a.c.A_s)$						Total Ultimate Capacity, $P_U=P_{pu}+P_{su}$ (tonnes)	Weight of pile, W_p (Tonnes)	Total Safe Capacity, P_s (Tonnes) $P_s = \frac{Ps}{2.5}$	Total safe uplift capactiy (Tonnes)	Pile Length (meters)
										N_C	N_q	N_γ	A_p (m²)	c.N_C	PdN$_q$	0.5.γ.D.N$_\gamma$	P_{pu} (tonnes)	Effective over burder Pressure at c.g of the layer 'P_{di}' (t/m²)	A_{si} (m²)	($K_s P_{di} \tan\delta$).A_{si}	Adhesion Factor, a	a.c.A_{si}	P_{su}					
1	SM-ML / SM	1.7	0.00	0	30	30	1.84	1.03	1.75	0	20.9	22.4	1.13	0	36.66	13.000	56.11	0.87	6.4	4.82	0	0	0	56.11	2.68	22.44	2.68	1.7
2	SM-ML / SM	2	0.00	0	30	30	1.83	1.01	3.77	0	20.9	22.4	1.13	0	78.97	13.570	104.57	2.76	7.53	17.99	0	0	17.99	122.56	5.84	49.02	10.87	3.7
3	SM-ML / SM	3	0.00	0	30	30	1.83	0.99	6.74	0	20.9	22.4	1.13	0	141.19	13.300	174.57	5.25	11.3	51.37	0	0	69.36	243.93	10.58	97.57	30	6.7
4	SM-ML / SM	4	0.00	0	30	30	1.93	0.99	10.7	0	20.9	22.4	1.13	0	224.15	13.300	250.07	8.72	15.1	113.8	0	0	183.2	433.23	16.9	173.29	68.18	10.7
5	SM-ML / SM	3	0.00	0	30	30	1.9	0.99	13.67	0	20.9	22.4	1.13	0	286.37	13.300	265.69	12.18	11.3	119.19	0	0	302.4	568.04	21.64	227.21	106.29	13.7
6	SM-ML / SM	3	0.00	0	30	30	1.9	0.99	16.64	0	20.9	22.4	1.13	0	348.58	13.300	246.15	15.15	11.3	148.25	0	0	450.6	696.75	26.38	278.7	152.54	16.7
7	SM-ML / SM	2	0.00	0	30	30	1.9	0.99	18.62	0	20.9	22.4	1.13	0	390.06	13.300	213.6	17.63	7.53	114.96	0	0	565.6	779.16	29.54	311.66	187.89	18.7
8	CH	2	0.00	21	0	0	1.9	0.99	20.6	9	0	0	1.13	189	0	0.000	213.57	19.61	7.53	0	0.3	47.43	613	826.56	32.7	330.62	204.33	20.7
9	CH	1.5	0.00	21	0	0	1.9	1.02	22.13	9	0	0	1.13	189	0	0.000	213.57	21.36	5.65	0	0.3	35.59	648.6	862.15	35.07	344.86	216.67	22.2
10	SM-ML / SM	2.8	0.00	0	30	30	1.9	1.02	22.13	0	20.9	22.4	1.13	0	463.59	13.710	539	22.13	10.6	202.19	0	0	850.8	1389.77	39.49	555.9	277.7	25

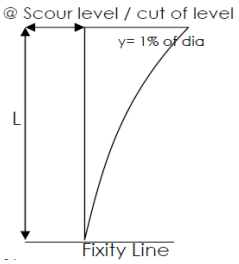
Recommendation :

a) Pile Diameter (mm)	1200
b) Pile cut off level (m)	**2.3**
c) Pile Shaft Length from Cut off Level (m)	25.0
d) Vertical Pile Capacity (tonnes)	500.0
e) Uplift pile capacity (Tonnes)	270.0

*** For vertical Capacity of Pile weight of the pile has not been considered.**

Project no : 2152	Lateral Load Capacity of pile [As per IS 2911-2010 Part 1Section-2] Annex-C
Project :	Geotechnical Investigation Work for the Proposed Greenfield Project from Spur to Haridwar.

Structure @ Chainage :	ROB @ 27+120	
Borehole no :	BH 10	
Type of pile :	Bored cast in situ	Bored cast in situ
Diameter of the pile in "mm" **:**	1000	1200
Cut off Level of the Pile in "m" :	2.000	2.300
Length of the Pile below the cut off level in "m" :	25.0	25.0
Type of Pile Head :	fixed	fixed
Crossection of the Pile :	Circle	Circle
Gade of the concrete **(M):**	35.0	35.0
Type of Soil :	Granular	Granular
Condition of Soil with w.r.t Ground water :	Submerged	Submerged
No. of Blow (N)	15.00	15.00
Moment of Inertia , **I** in "cm^4" :	4.909E+06	1.018E+07
Modulus of elasticity of the Pile , **E** (Kg/cm^2) **:**	2.96E+05	2.96E+05
Modulus of subgrade reaction for granular soil (K1) in Kn/m3 :	2.12E+03	2.12E+03
Stiffness factor for Cohesionless soil (T) in m :	3.67	4.25
Free standing length of pile or length of the pile below cut off level not contributing substantially to lateral capacities (L_1) in "m"**:**	0.000	0.000
therefore L_1/T or L_1/R :	0.00	0.00
Embedded Length of the Pile (L_e) in "m" :	25.00	25.00
Reading from the graph **L_f/T** or **L_f/R** (As per Appendix C,Clause 5.5.2 Fig 2):	2.19	2.19
Depth of Fixidity **L_F** in "m":	8.04	9.31
Depth of Fixity + free standing length **($L_{xx}=L_1+L_f$)** in "m"	8.04	9.31
Type of Pile Behavviour :	Long Flexible Pile	Long Flexible Pile
Considering 1% of dia for Horizontal Deflection :		
Permissible Horizontal Deflection pile (Y) " in mm" :	**10.00**	**12.00**
Lateral capcity of pile ,**Q** (Tonnes) for 1% dia. deflection :	33.56	53.77
Recommended Lateral Capacity of Pile (T) for 1% dia deflection :	30.00	50.00



Equations :

$T=(EI/n_h)^{1/5}$; $R=(EI/K_1)^{1/4}$

For Free Head (Y) =$[QLxx^3]/3EI$; For Fixed head (Y)=$[QLxx^3]/12EI$

Annexure II
Liquefaction Analysis

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details		**Seimsmic Parameters**		**Parameters from SPT Boring**	
Location		Magnitude of Earthquake	7.0	Efficiency in SPT Boring (for C_E factor) "%" :	60
Structure @ Chainage	MNB @ 21+810	Design PGA	0.24 g	Borehole diameter (mm)	150
Borehole no :	BH 7	Importance Factor of the Structure	1	Was liner used in SPT boring	No
Water Table Depth (m)	11.30				
Water Table Depth considered (m)	7.00				

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o) at site, kN/m^2	Effective overburden (s_o) considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	6	17.90	7.90	82	0.99	32.22	32.22	32.22	0.15	1.70	1.06	10.81	5.00	1.20	17.97	0.19	0.23	1.48	Non Liquefiable
3.3	SM-ML	10	17.90	7.90	70	0.97	59.07	59.07	59.07	0.15	1.30	1.06	13.79	5.00	1.20	21.55	0.24	0.28	1.85	Non Liquefiable
4.8	SM-ML	28	17.90	7.90	64	0.96	85.92	85.92	85.92	0.15	1.08	1.06	32.02	5.00	1.20	43.42	NA	NA	>1	Non Liquefiable
6.3	SM-ML	31	18.70	8.70	58	0.95	113.97	113.97	113.97	0.15	0.94	1.06	30.78	5.00	1.20	41.94	NA	NA	>1	Non Liquefiable
7.80	SM	18	18.70	8.70	48	0.94	142.02	142.02	134.02	0.16	0.84	1.06	16.01	5.00	1.20	24.21	0.28	0.33	2.13	Non Liquefiable
9.30	SM-ML	13	18.70	8.70	87	0.93	170.07	170.07	147.07	0.17	0.77	1.06	10.57	5.00	1.20	17.68	0.19	0.22	1.34	Non Liquefiable
10.80	SM-ML	11	18.20	8.20	83	0.89	197.37	197.37	159.37	0.17	0.71	1.06	8.30	5.00	1.20	14.96	0.16	0.19	1.11	Non Liquefiable
12.30	SM-ML	18	18.20	8.20	91	0.85	224.67	214.67	171.67	0.17	0.66	1.06	12.54	5.00	1.20	20.05	0.22	0.26	1.49	Non Liquefiable
13.80	SM-ML	19	18.20	8.20	98	0.81	251.97	226.97	183.97	0.17	0.63	1.06	12.77	5.00	1.20	20.32	0.22	0.26	1.52	Non Liquefiable
15.30	SM-ML	24	18.20	8.20	82	0.77	279.27	239.27	196.27	0.17	0.61	1.06	15.58	5.00	1.20	23.69	0.27	0.32	1.88	Non Liquefiable

Liquefaction Potential Evaluation as per IRC SP 114-2018

Computation Sheet

Project : **Geotechnical Investigation Work for Proposed Greenfield project from Spur to Haridwar.**

Borehole Details		**Seismsic Parameters**		**Parameters from SPT Boring**	
Location		Magnitude of Earthquake	7	Efficiency in SPT Boring (for C_E factor) "%"	60
Structure @ Chainage	ROB @ 27+120	Design PGA	0.24 g	Borehole diameter (mm)	150
Borehole no :	BH 10	Importance Factor of the Structure	1	Was liner used in SPT boring	No
Water Table Depth (m)	15.70				
Water Table Depth considered (m)	11.00				

Depth below EGL, m	Type of Strata	Field SPT N_{Field}	Bulk unit weight (kN/m^3)	Submerged unit weight (kN/m^3)	Fines Content (%)	Stress reduction coefficient (r_d)	Total overburden pressure (s_o), kN/m^2	Effective overburden (s_o) at site, kN/m^2	Effective overburden (s_o) at considered, kN/m^2	Cyclic Stress ratio (CSR)	C_N	C_{s60}	SPT $(N_1)_{60}$	α	β	SPT $(N_1)_{60cs}$	$CRR_{M=7.5}$	CRR	FOS	Conclusion
1.8	SM-ML	14	18.30	8.30	71	0.99	32.94	32.94	32.94	0.15	1.70	1.06	25.23	5.00	1.20	35.27	NA	NA	>1	Non Liquefiable
3.3	SM-ML	15	18.30	8.30	70	0.97	60.39	60.39	60.39	0.15	1.29	1.06	20.46	5.00	1.20	29.55	0.44	0.52	3.44	Non Liquefiable
4.8	SM-ML	18	18.30	8.30	74	0.96	87.84	87.84	87.84	0.15	1.07	1.06	20.36	5.00	1.20	29.43	0.43	0.52	3.43	Non Liquefiable
6.3	SM-ML	10	18.30	8.30	86	0.95	115.29	115.29	115.29	0.15	0.93	1.06	9.87	5.00	1.20	16.85	0.18	0.21	1.44	Non Liquefiable
7.80	SM-ML	13	18.30	8.30	87	0.94	142.74	142.74	142.74	0.15	0.84	1.06	11.53	5.00	1.20	18.84	0.20	0.24	1.64	Non Liquefiable
9.30	SM-ML	26	18.60	8.60	90	0.93	170.64	170.64	170.64	0.14	0.77	1.06	21.10	5.00	1.20	30.32	NA	NA	>1	Non Liquefiable
10.80	SM-ML	30	18.60	8.60	89	0.89	198.54	198.54	198.54	0.14	0.71	1.06	22.57	5.00	1.20	32.08	NA	NA	>1	Non Liquefiable
12.30	SM-ML	29	18.60	8.60	96	0.85	226.44	211.44	213.44	0.14	0.66	1.06	20.40	5.00	1.20	29.49	0.44	0.52	3.71	Non Liquefiable
13.80	SM-ML	26	18.60	8.60	76	0.81	254.34	224.34	226.34	0.14	0.64	1.06	17.61	5.00	1.20	26.13	0.32	0.38	2.67	Non Liquefiable
15.30	SM-ML	27	19.80	9.80	92	0.77	284.04	239.04	241.04	0.14	0.61	1.06	17.54	5.00	1.20	26.04	0.31	0.37	2.66	Non Liquefiable

Borelogs and Figures

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

ROB @ CH 7+530
BH :4
Depth : 30.00m
Depth of Water table : 15.30 m

Date of start : 24/03/2021

Date of finish : 26/03/2021

Project No. 2152

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	7 / 9	2	13	85				Non	Plastic					
	2.50	UDS						1.82	1.63	11.58				DST	0.14	29	
	3.30	SPT		10 / 11	12	6	82				Non	Plastic					
	4.80	SPT		18 / 18	2	34	64				Non	Plastic					
	5.50	UDS						1.86	1.64	13.41			2.61	DST	0.14	31	
	6.30	SPT		27 / 25	5	21	74				Non	Plastic					
	7.80	SPT		36 / 31	0	12	88				Non	Plastic					
	8.50	UDS						1.90	1.63	16.79				DST	0.1	32	
	9.30	SPT		35 / 29	0	5	95				Non	Plastic					
	10.80	SPT	Silty Sand with Gravel (SM)	44 / 34	0	35	65				Non	Plastic					
	12.30	SPT		52 / 38	0	85	15				Non	Plastic					
	13.80	SPT		33 / 23	0	82	18				Non	Plastic					
	15.30	SPT		37 / 24	0	84	16				Non	Plastic					
	16.80	SPT		35 / 18	1	77	22				Non	Plastic					
	18.30	SPT		37 / 19	0	68	32				Non	Plastic				29 *	
	19.80	SPT		42 / 20	0	70	30				Non	Plastic					
	21.30	SPT		37 / 18	0	5	95				Non	Plastic					
	22.80	SPT	Silty Clay of Medium Plasticity (CI)	40 / 40	0	5	95				40	22					
	24.30	SPT		36 / 36	10	11	79								1.70 *		
	25.80	SPT	Sandy Silt with Gravel (SM-ML)	44 / 20	0	26	74				Non	Plastic					
	27.30	SPT		49 / 21	2	30	68				Non	Plastic					
	28.80	SPT		57 / 23	2	7	91				Non	Plastic				29 *	
	30.30	SPT		36 / 17	0	6	94				Non	Plastic					

* Based on SPT values

BORE LOG

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Project No. 2152

ROB @ CH 27+120
BH : 10
Depth : 30.00m
Depth of Water table : 15.70 m

Date of start : 03/04/2021

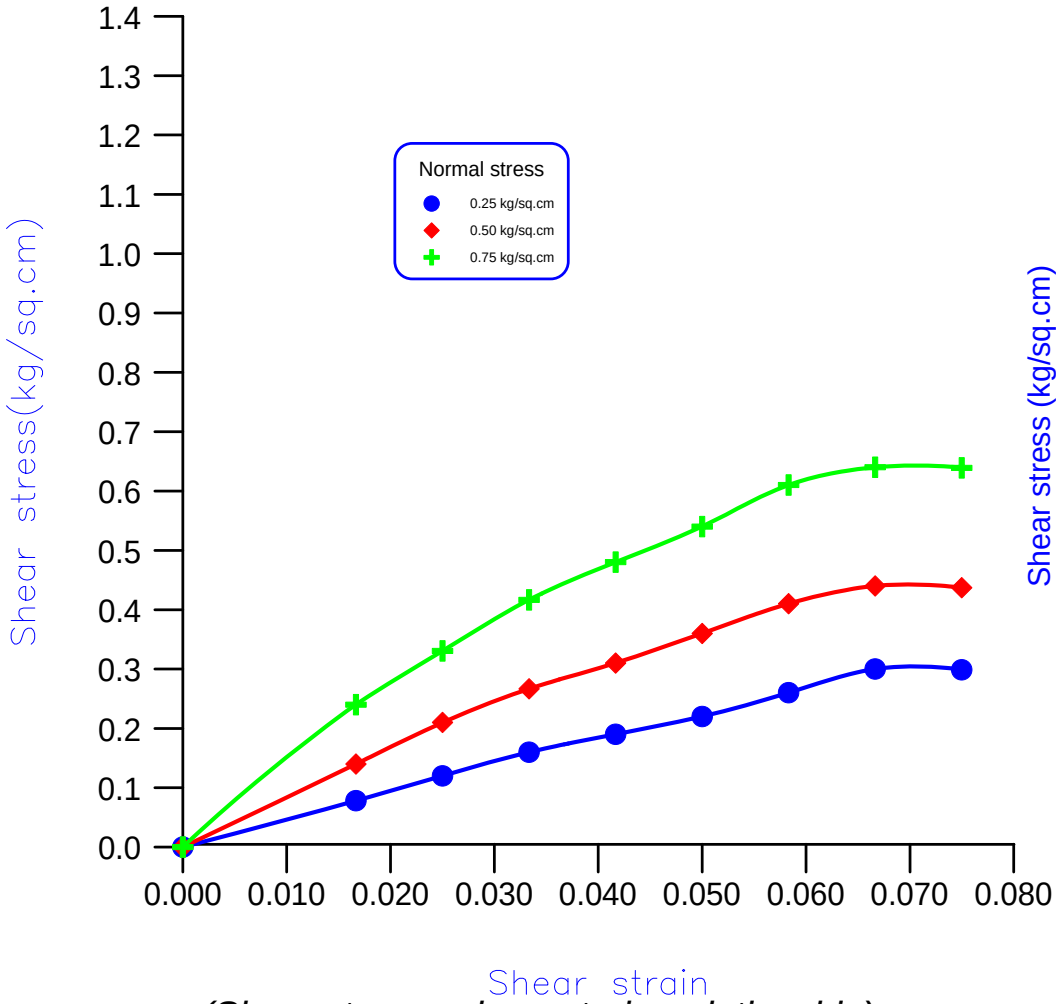
Date of finish : 05/04/2021

Reduced Level	Depth (m)	Type of sample	Soil Classification	S.P.T Plot (Observed / Corrected)	Grain size (%) Gravel	Sand	Silt/Clay	Density (gm/cc) r(wet)	r(dry)	W/C W(%)	Limits (%) L.L	P . L	Sp.Gr	Shear Parameters Type of test	C(kg/sq.cm)	phi(degrees)	Cc
	1.80	SPT	Sandy Silt with Gravel (SM-ML)	14 / 19	0	29	71				Non	Plastic					
	2.50	UDS						1.84	1.67	10.45				DST	0.14	30	
	3.30	SPT		15 / 17	0	30	70				Non	Plastic					
	4.80	SPT		18 / 18	0	26	74				Non	Plastic					
	5.50	UDS						1.83	1.64	11.57			2.61	DST	0.14	31	
	6.30	SPT		10 / 9	4	10	86				Non	Plastic					
	7.80	SPT		13 / 11	2	11	87				Non	Plastic					
	8.50	UDS						1.83	1.62	12.65				DST	0.12	30	
	9.30	SPT		26 / 21	0	10	90				Non	Plastic					
	10.80	SPT		30 / 23	1	10	89				Non	Plastic					
	11.50	UDS						1.85	1.62	14.44				DST	0.12	30	
	12.30	SPT		29 / 21	0	4	96				Non	Plastic					
	13.80	SPT		26 / 18	0	24	76				Non	Plastic				30	
	15.30	SPT		27 / 17	0	8	92				Non	Plastic					
	16.80	SPT		44 / 21	0	7	93				Non	Plastic					
	18.30	SPT		45 / 21	0	48	52				Non	Plastic					
	19.80	SPT	Silty Sand with Gravel (SM)	46 / 21	0	72	28				Non	Plastic					
	21.30	SPT		38 / 18	0	82	18				Non	Plastic				30 *	
	22.80	SPT		42 / 19	0	44	56				Non	Plastic					
	24.30	SPT	Silty Clay of High Plasticity (CH)	46 / 46	0	2	98				55	28					
	25.80	SPT		49 / 49	1	4	95								2.10 *		
	27.30	SPT	Sandy Silt with Gravel (SM-ML)	36 / 17	4	7	89				Non	Plastic					
	28.80	SPT		45 / 19	0	6	94				Non	Plastic				30 *	
	30.30	SPT	Silty Sand with Gravel (SM)	71 / 26	1	78	21				Non	Plastic		*			

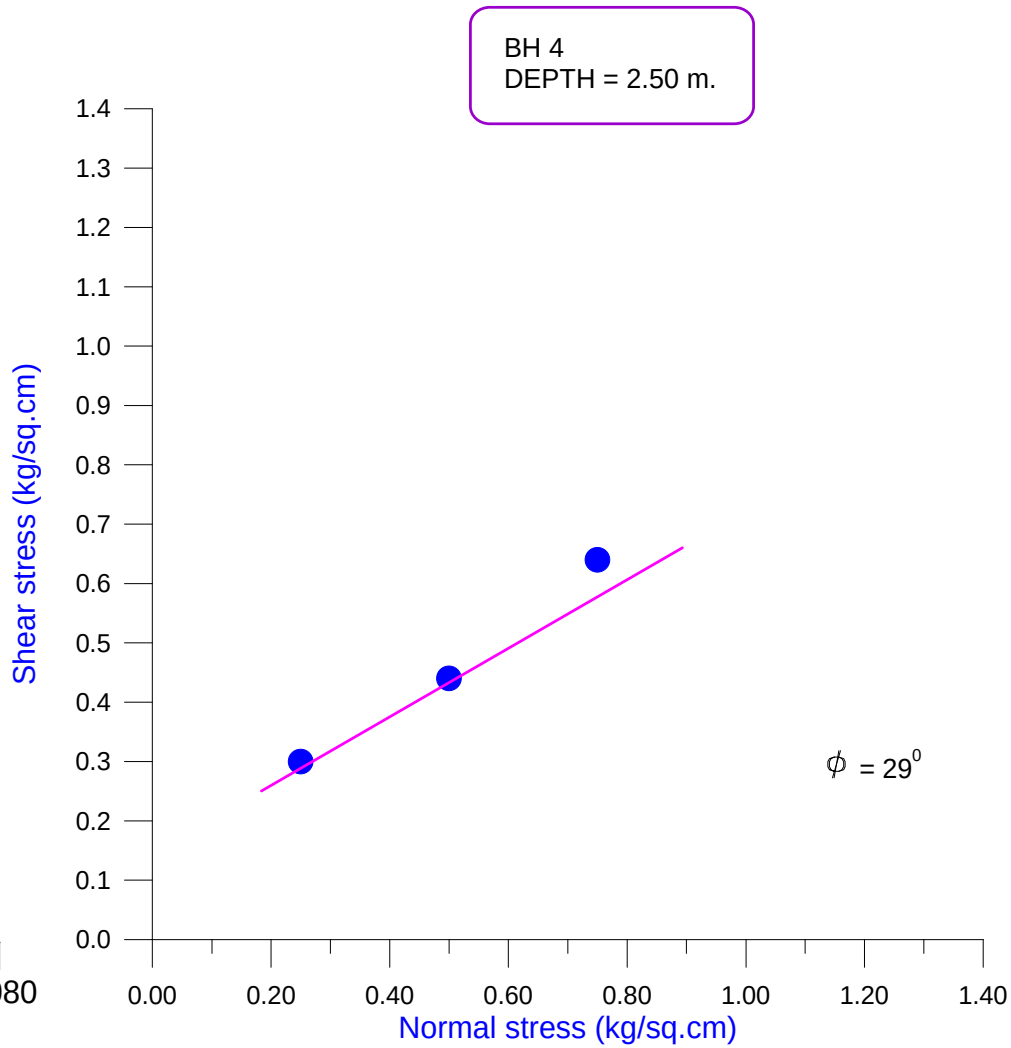
Based on SPT values

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



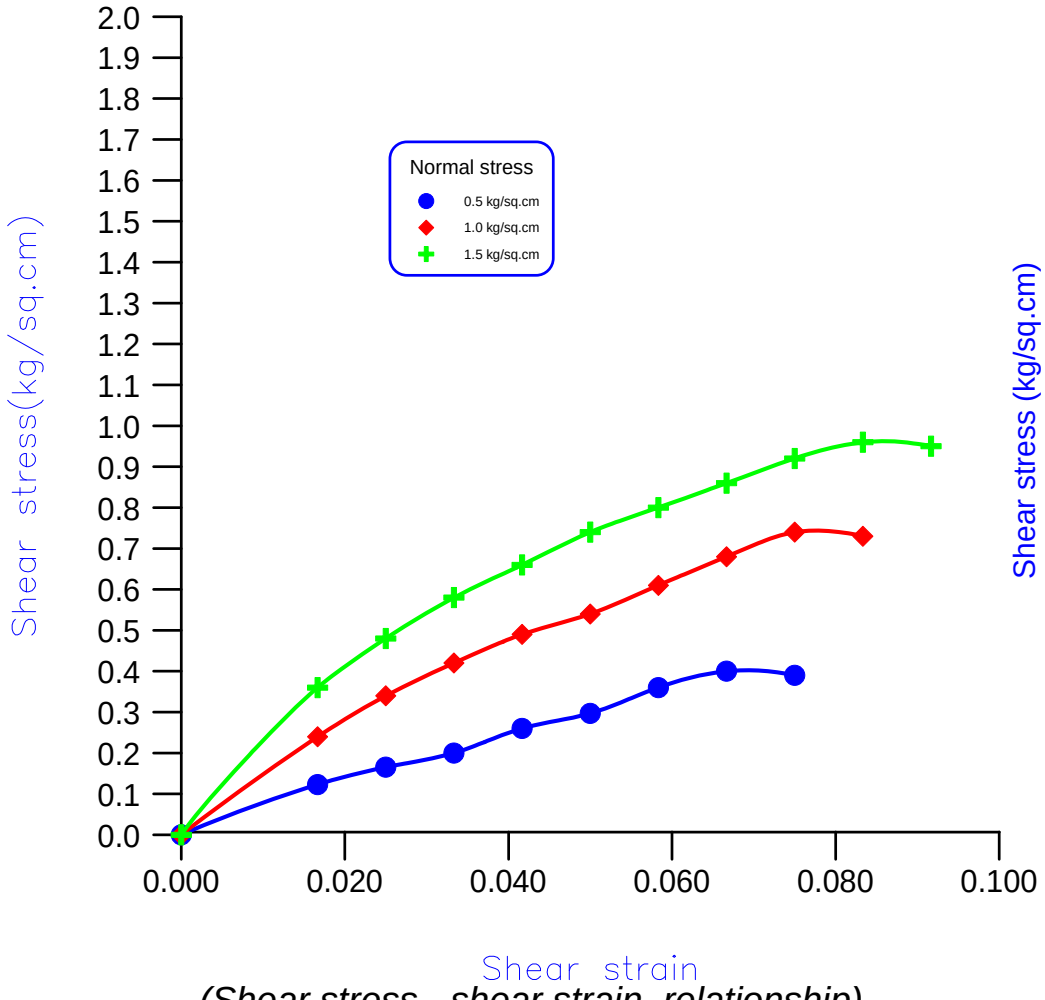
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

FIG- DS 4-1

Soil Engineering Consltants

Job. 2152



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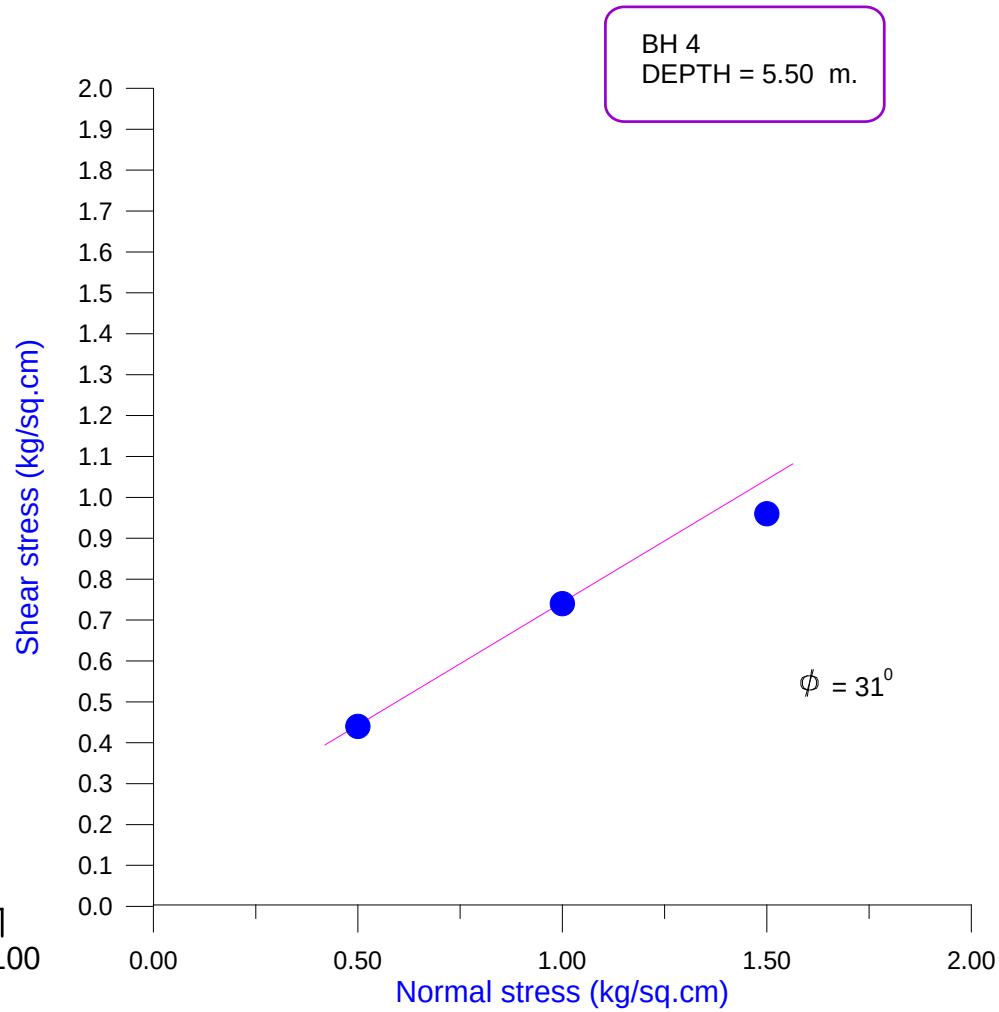
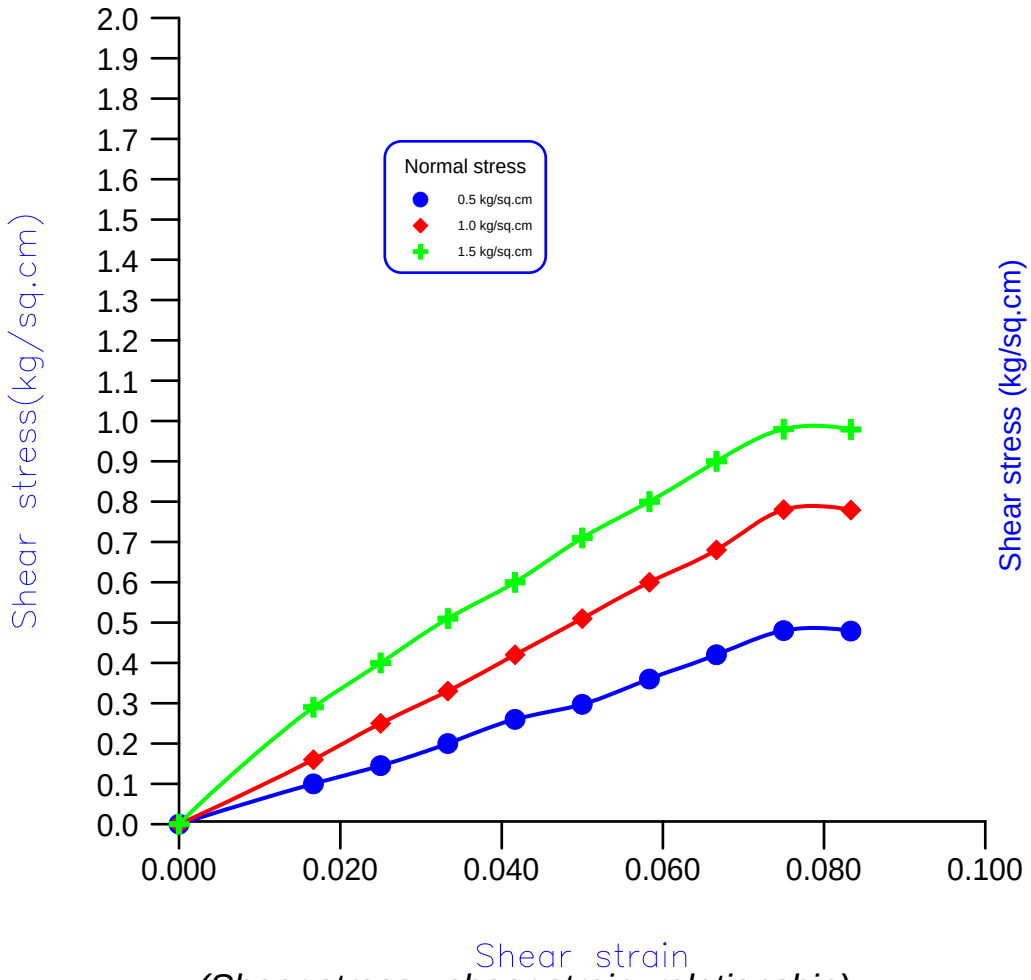


(Shear stress - Normal stress relationship)

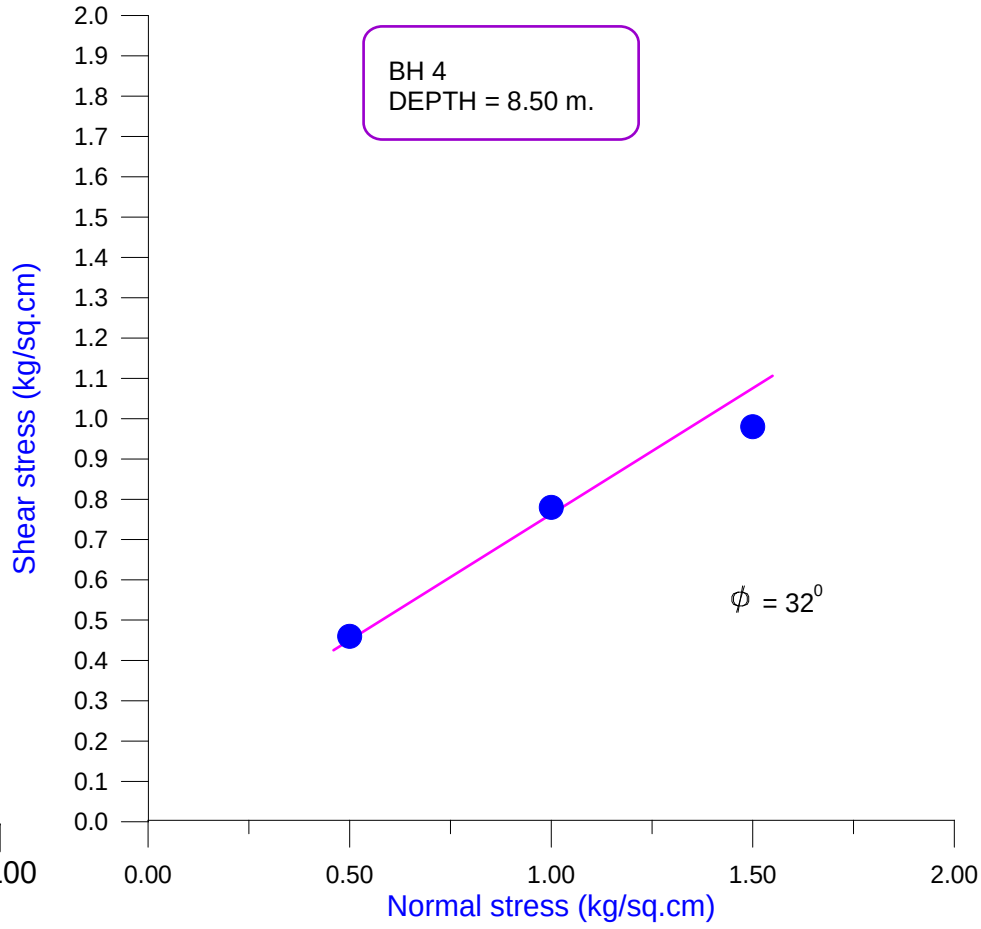
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

FIG- 4-2

Soil Engineering Consltants *Job. 2152*



(Shear stress - shear strain relationship)



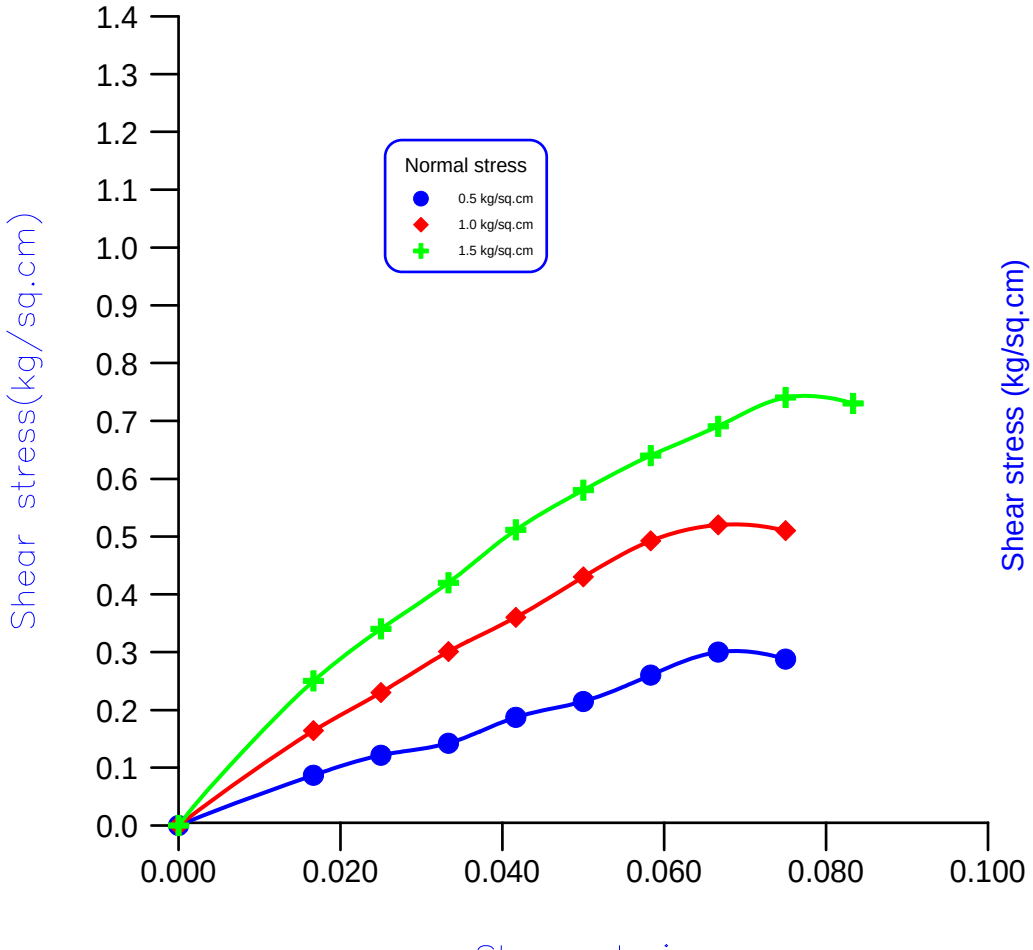
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

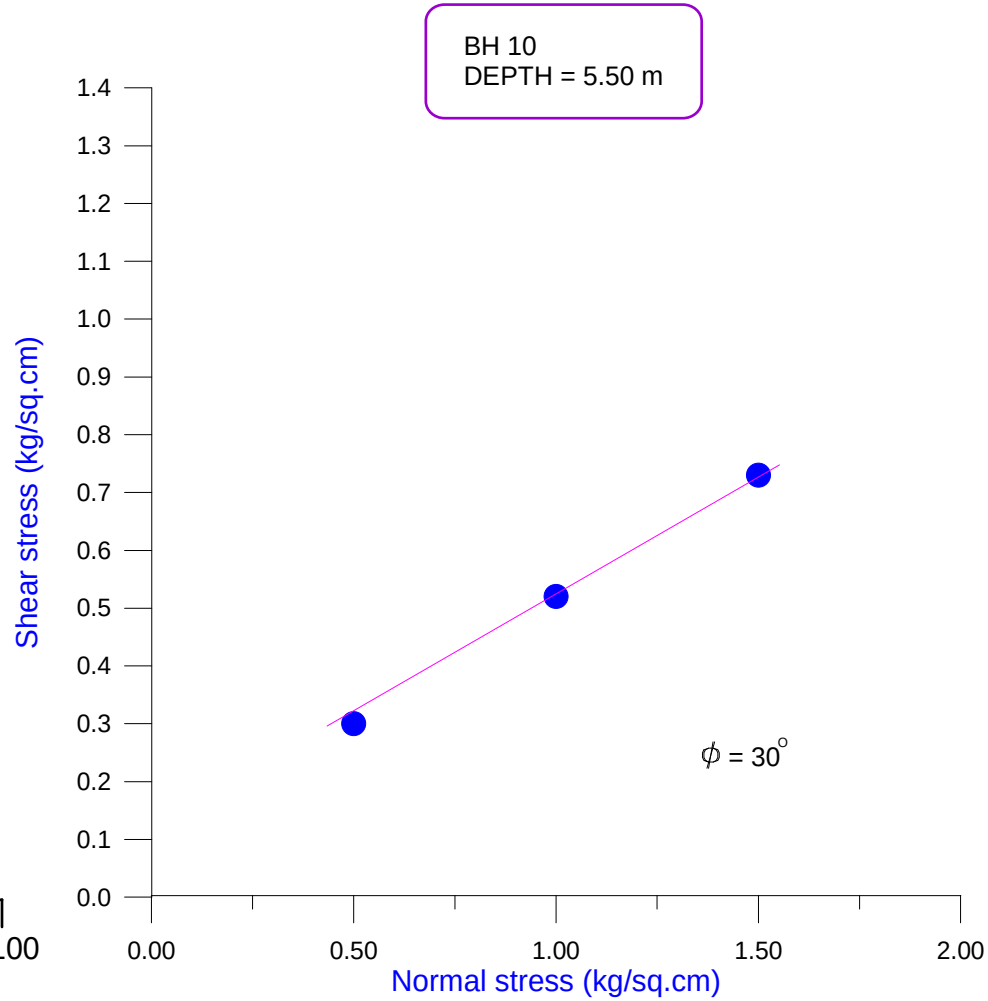
FIG- DS 4-3

Soil Engineering Consltants

Job. 2152



(Shear stress - shear strain relationship)



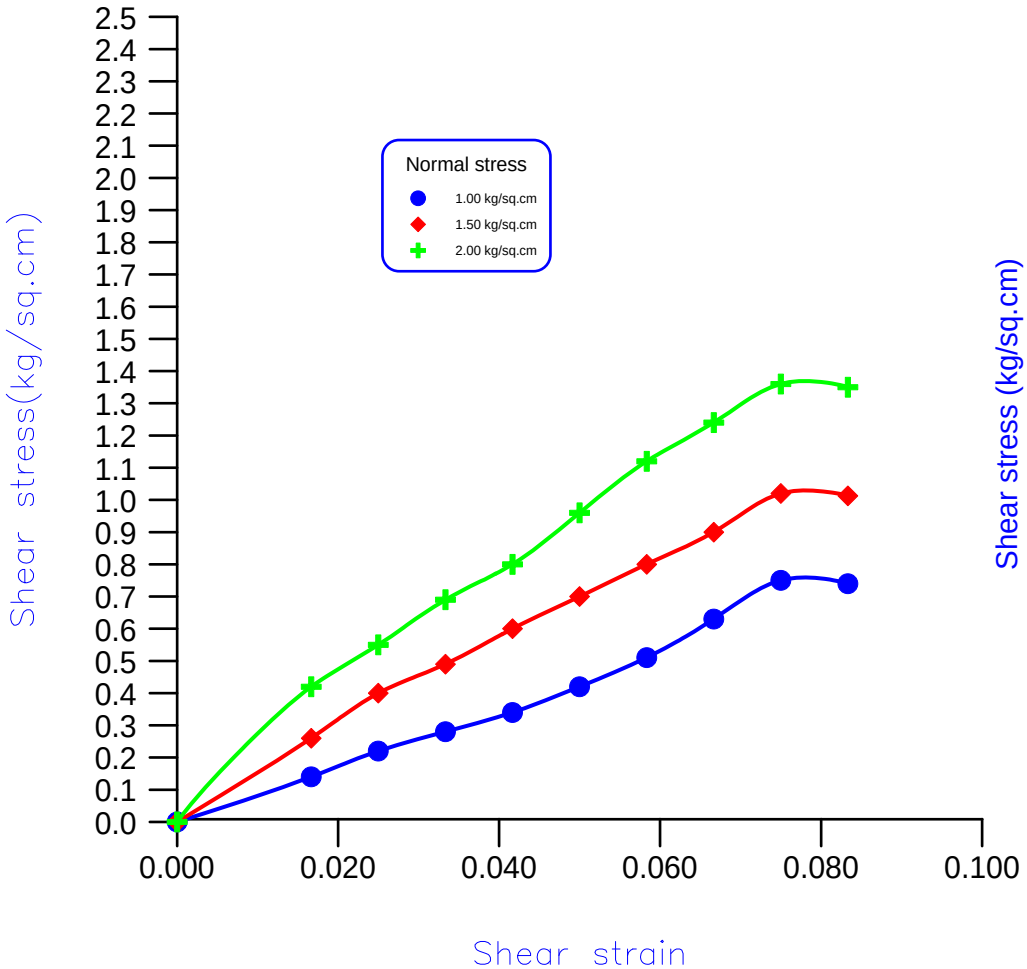
(Shear stress - Normal stress relationship)

PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

FIG- DS 10-1

Soil Engineering Consltants

Job. 2152



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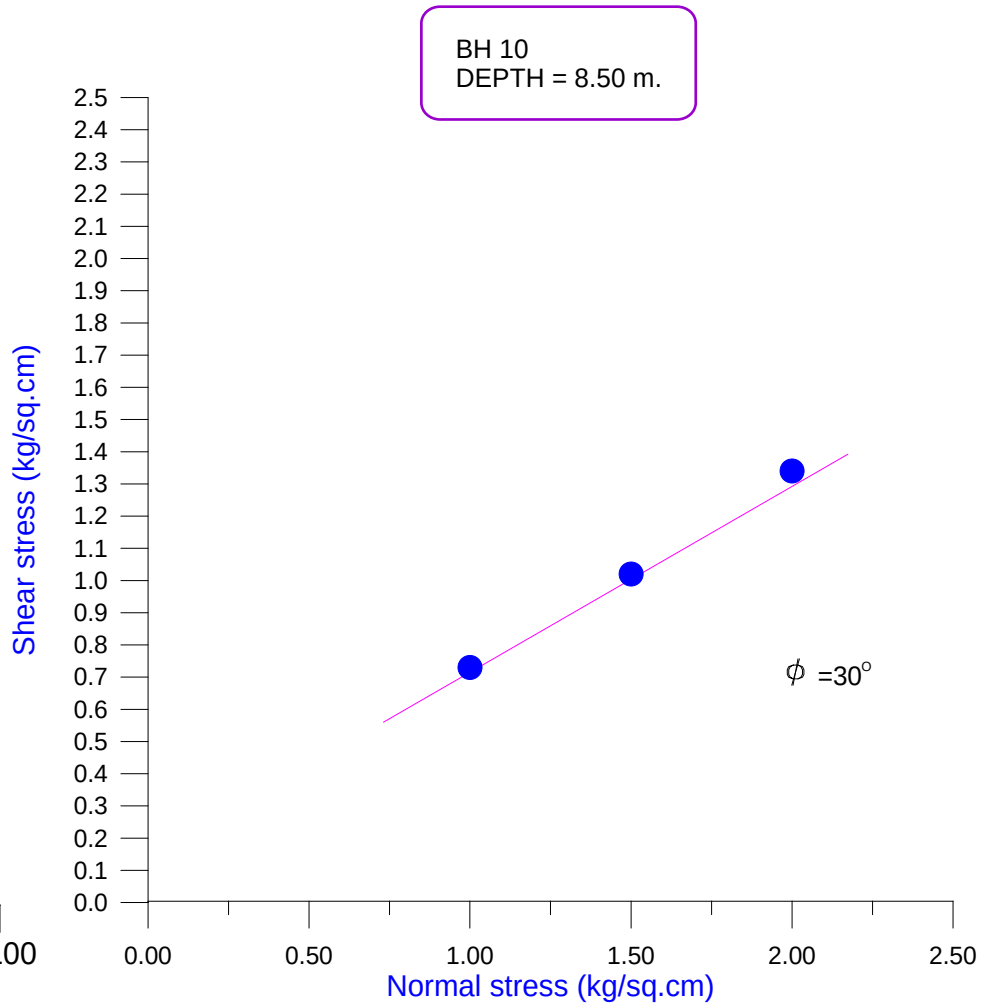


(Shear stress - Normal stress relationship)

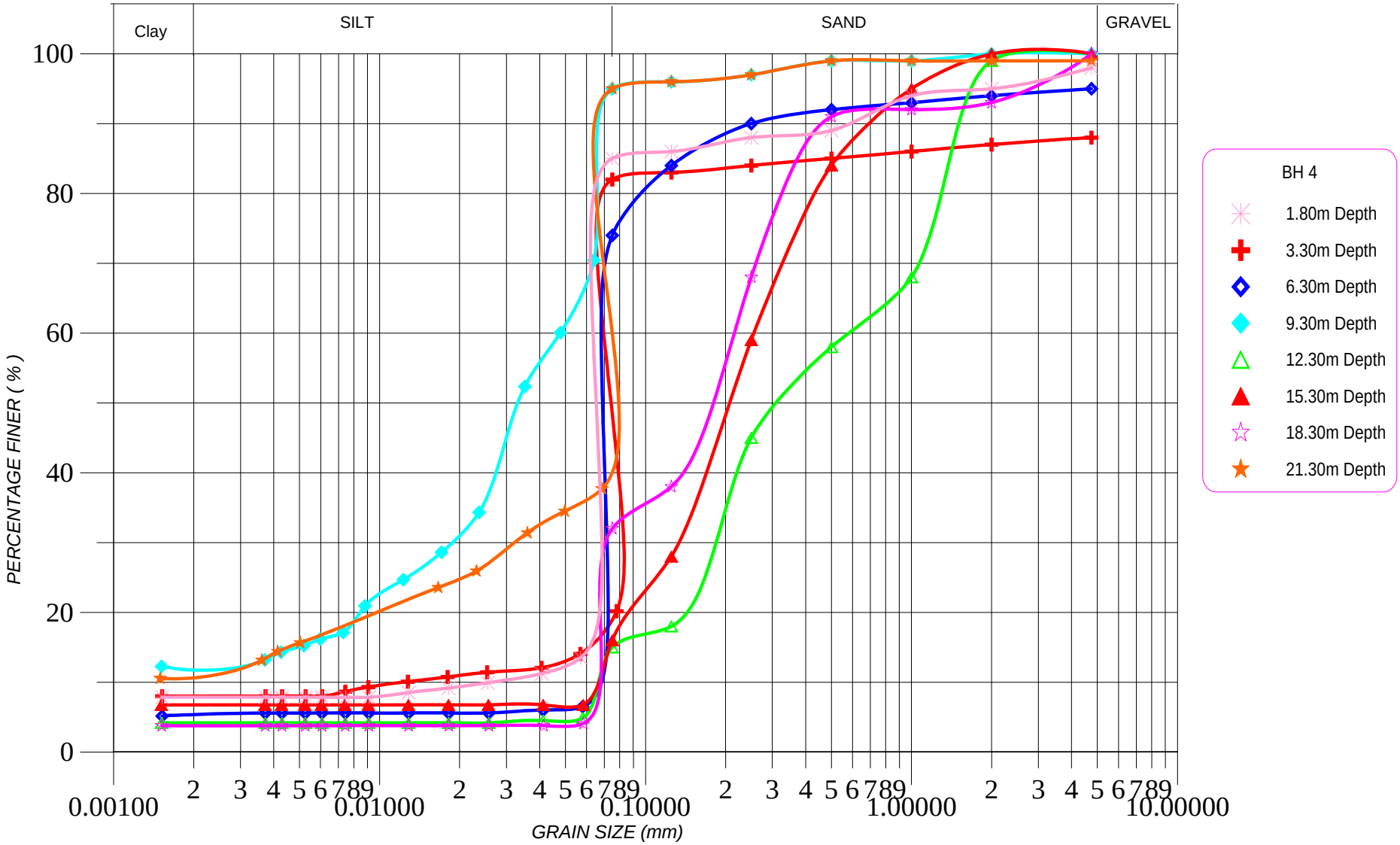
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

FIG- DS 10-2

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



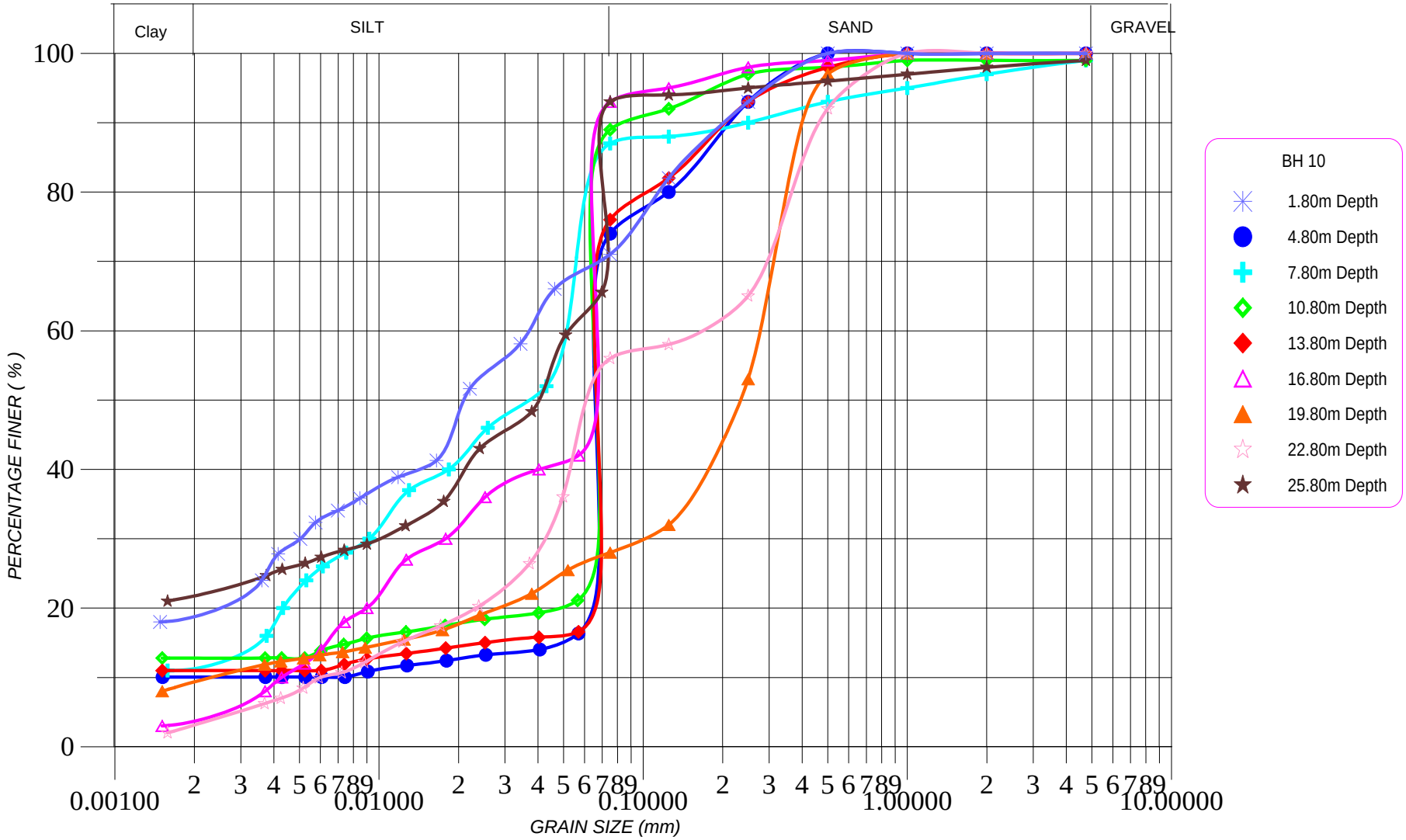
PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD 4

Soil Engineering Consultants

Job No 2152

GRAIN SIZE DRISTRIBUTION CURVE



PROJECT: Geotechnical Investigation work for the proposed Greenfield project from Spur to Haridwar

Fig : GSD-10

Annexure VI
Site Photograph's

ROB @ CH 7+530 BH 4

ROB @ CH 27+120 BH 10