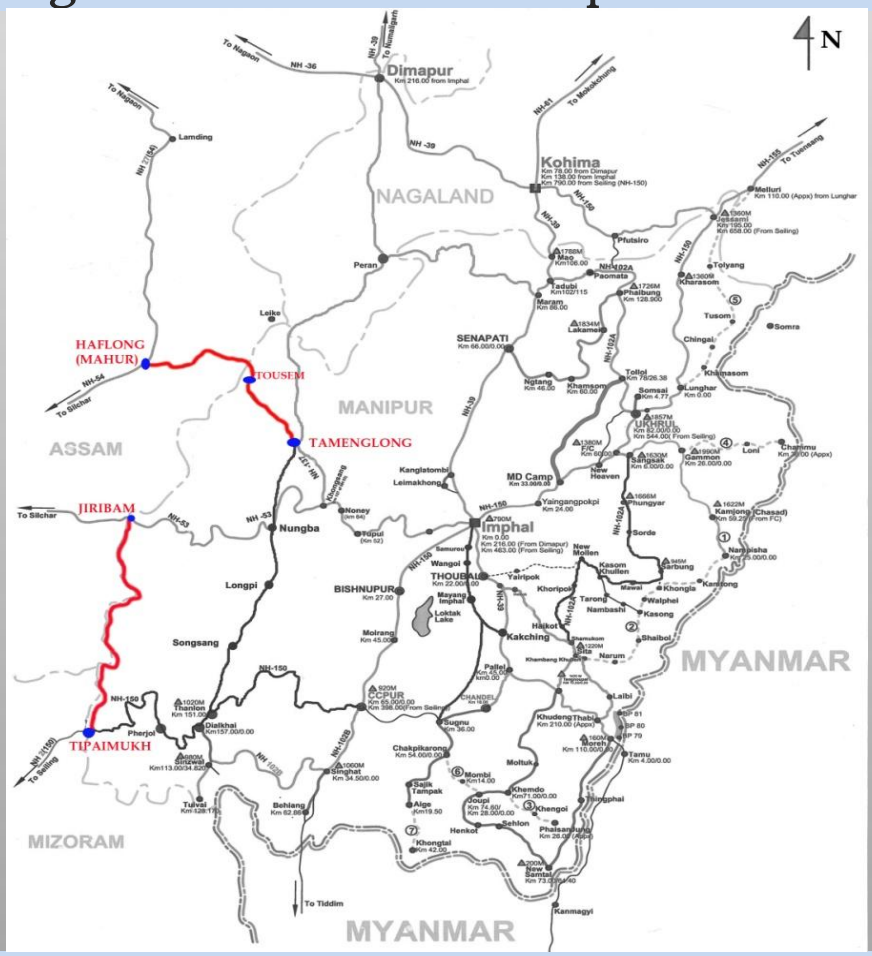
NATIONAL HIGHWAY INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

Consultancy Services for preparation of Feasibility Study and Detailed Project Report for Two Lane with Paved Shoulders of Tamenglong-Tousem-Haflong Road in the State of Manipur and Assam.



DRAFT DETAILED PROJECT REPORT
VOL-III MATERIAL REPORT
PKG-1
TAMENGLONG-DIALONG SECTION
(FROM KM 0+000 TO KM 10+000) LENGTH-10.0KM

M/s L.N Malviya Infra Projects PVT. LTD. Bhopal.
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CHAPTER 1
INTRODUCTION

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1.1 INTRODUCTION

- GENERAL

The selected National Highway serve as lifeline for population living in rural areas scattered in vast geographical span of districts. In Manipur the geographical rough & Hilly terrain demands for an effective road network in order to provide population proper connectivity. The condition of highways has quite improved in past years, however still lot of scope still remains for improvement in road infrastructure network across Manipur.

- PROJECT BACKGROUND

National Highways and Infrastructure Development Corporation Limited.,(NHIDCL) have been constituted by the Government of India in the year 2014 with the purpose of up-gradation and development of National Highways and Strategic Roads including interconnecting roads in parts of the country which share international boundaries with neighboring countries. Private consultants will provide consultancy service to establish the technical, economical and financial viability of the projects with due consideration to environmental and social safeguards and to prepare Detailed Project Reports for widening, relaying and / or reconstruction of roads. LN Malviya Infra Projects Pvt. Ltd., BHOPAL as consultants to provide the Consultancy Services for Preparation of Detailed Project Report for Tamenglong-Tousem-Haflong Road in the State of Manipur.

1.2 PURPOSE OF MATERIAL INVESTIGATION

The investigation for the soil and other construction material has been carried out to :-

- Determine the natural and physical characteristics of soil and soil profile for design of

embankment and pavement.

- Identify and locate borrow areas for their availability and suitability for use.
- Locate sources for aggregate require for pavement and structures and to ascertain their vitality and suitability for use.
- Locate sources of water suitable for construction.
- Gather general information regarding sub -soil, water level and flooding.
- Identify sources for other construction material such as cement, Sand, Aggregate, bitumen and steel.

1.3 DETAIL OF INVESTIGATION

The detailed investigation included both field and laboratory work. Samples of borrow soils, sand and crushed rock for use in embankment, pavement and in other structure were collected from the existing as well as proposed borrow sources / quarries within reasonable short haulage distance from the project corridor. Auger holes and test pits were excavated where necessary to obtain samples for testing.

The following **Table 1.1** Summarizes the investigation and testing accomplished by the consultant to archive the objective

Table 1.1 Quantum of investigation and Testing

S. No.	Description	Interval	Number
1.	Test pit excavation penetrating pavement structure down to sub-grade to record (a) pavement (b) field density and compaction and (c) collection of sub-grade sample	Min 1 per 1 kms. (Both Sides)	20
2.	Investigation of (I) Quarry sources (ii) Sand sources	 ------- -------	 1 1

1.4 TEST PROCEDURE

The standard test procedure followed for soil sampling and laboratory testing is given in Table 1.2. All laboratory tests have been performed at in house Laboratory, Indore (M.P.) and the results are compiled in Annexure.

Table 1.2 Standard Test Procedures

S. No.	Type of Test	Method
1.	Sieve analysis - Natural Soils - Selected Soil	IS: 2720 Part 4 IS: 2386 Part 1
2.	Field Density Test	
3.	Modified Proctor Compaction Tests - OMC - MDD	 IS :2720 Part 2 (Section l) IS :2720
4.	Atterberg Limits	IS :2720 Part 5
5.	CBR Soaked & Unsoaked & Swell Test	IS :2720 Part 16

CHAPTER 2
SOIL PROFILE ALONG THE PROJECT ROAD

CHAPTER 2
SOIL PROFILE ALONG THE PROJECT ROAD

2.1 FIELD AND LABORATORY TESTING

Test pits were excavated on an average at an interval of about 1 kms and at the location where the soil strata changes to perform field density and to collect samples for laboratory tests. They were carefully dug from the pavement surface up to sub grade level, after this they were manually leveled and prepared for field density tests. Field density tests on the sub-grade soil were conducted using the sand replenishment method at each test location and small quantity was collected in airtight containers for deterring the field moisture from each test pit.

Upon completion of field density test, respective sample of sub – grade soil was collected in bulk in gunny bag from each test pit for laboratory tasting. Finally holes were drilled using hand auger from the bottom of the test pit to collect soil samples for identification and laboratory classification test. Respective samples of soil and materials collected from the test pit and auger holes were subjected to various laboratory and field tests as listed below.

The tests performed were

- Grain size distribution
- Atterberg limit
- OMC & Maximum Dry Density for modified proctor Compaction
- CBR tests Soaked and Unsoaked

2.2 TEST RESULTS

The tests results of soil and soil field density are exhibited in Appendix 1 Summary of laboratory soil test result and field test result are given in Tables 2.1 and 2.2 respectively.

Table 2.1 Laboratory Soil test Results

S. No.	Chainage Km	Modified Proctor Compaction Test		Grain Size Analysis				Atterberg Limit			CBR
		OMC %	MDD gm/cc	Gravel %	Sand %	Silt %	Clay %	L.L. %	P.L. %	P.I. %	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	0.000(L)	11.80	1.932	1.02	51.42	27.45	20.11	31.25	23.45	7.8	13.90
2	5.000(L)	13.90	1.877	1.26	51.88	28.14	18.72	31.5	22.84	8.66	9.50
3	10.000(L)	12.60	1.899	0	52.64	28.13	19.23	35.65	27.56	8.09	10.80

2.3 CONCLUSIONS

Along the entire corridor mainly one type of soil were encountered, Reddish Clayey Silty Sand with high compressibility (CH) and granular properly and well graded soil. Field density measurements on the existing sub – grade reveals that they are within the acceptable range.

To evaluate the sub-grade strength in it existing condition, the CBR strength of the sub - grade were determine by compacting the samples in soaked (for four days) and unsoaked condition.

The soaked CBR of soil varies from 9.9% to 13.60% out of which 100 % of the results are above 8% CBR. Therefore CBR strength is quite good reflection of their potential strength.

CHAPTER 3
CONSTRUCTION MATERIALS

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CONSTRUCTION MATERIALS

3.1 OBJECTIVE

The objective of the construction material survey was to :

(I) Locate potential sources of soil borrow areas, gravel, rock quarries, water sources and other construction materials with in the project vicinity.

(II) Examine the engineering properties of materials relevant to the project as per MOSRTH specifications.

As a first step, material surveys were identified with the help of existing data, local enquiry and field assessment. Thereafter soil and aggregate samples were collected from the identified sources for testing.

3.2 BORROW AREAS

3.2.1 Identification

Investigation has been done to locate the potential borrow areas for sub – grade / embankment fill and granular sub- base along the project corridor with economic hauling distance. To achieve the objective the offices of NHIDCL and local people were connected. Based on the information collected, field surveys carried out and personal experience, potential burrow areas have been identified which either existing old borrow areas or new ones are lying in the Existing Road land belonging to government or people.

borrow areas have been identified in existing road side hill portion. These are spread between overall length of the project corridor. The soil from these borrow areas (or existing) is generally of hard moorum type with high CBR Value. The details of these areas i.e. , location, distance from the project road, is given Table 3.1 below.

Table 3.1: Borrow Areas Location

Sr. No.	Location	Villages	Distance from project corridor
1.	From Km 0 To Km 10	-	On Corridor Both Side

All the borrow areas have sufficient quantity of material and can be used in the road. Some of borrow areas are pre-approved by the NHIDCL. Burrowing soil from these areas would require prior notice to the local authorities' private people and permission obtained from them with or without royalties.

Soil samples from these borrow areas were collected by excavating pits down to 1.0 m. depth from the existing surface The top organic layer of 100 mm was removed before sampling.

3.2.2 Sampling and Laboratory Testing

3 borrow areas identified. The following tests were carried out on borrow soil samples

- Grain Size Analysis
- Atterberg Limits
- Proctor Compaction Test
- CBR Test

3.3 AGGREGATES

3.3.1 Quarries for Aggregates

Aggregates for sub- base, base and surface courses are proposed to be utilized from the crusher or quarries under operation within economical haulage distance of the project corridor. Some of these quarries have been leased by Manipur Government and the lessees have installed crusher and sell aggregates. The allotted area is a small fraction of the total area of each quarry. It is learnt that further area can be leased out by the Manipur Government for this purpose.

Table 3.2 : Location of Aggregate Quarries

Sr. No.	Location	Chainage (km.)
1.	At Barak River	At 20km Lead
2.	At Km 28.00 on Project Road	At 30km Lead

Table 3.3: Location of Sand Quarries

Sr. No.	Location	Chainage (km.)
1.	Barak River	At 20km Lead

3.3.2 Sampling and Testing

The following tests were conducted

3.3.2.1 For Aggregate

- Impact Value
- Specific Gravity
- Water Absorption
- Flakiness index

3.3.2.2 For Sand

- Grading
- Fineness Modules

Four samples each of aggregates and sand collected from the identified quarries have been tested. The test report is exhibited in Appendix -1. Summary of test results of Aggregates and sand is given in Table 3.4.

Table 3.4 Test Result of Aggregates at Location-1

S. No.	Name of Test	Sample Details / Result
1.	% Impact Value	25.89%
2.	% Specific Gravity	2.58
3.	% Water Absorption	1.40%
4.	CBR	31.46%

Table 3.5 Test Result of Aggregates at Location-2

S. No.	Name of Test	Sample Details / Result
1.	% Impact Value	34.95%
2.	% Specific Gravity	2.47
3.	% Water Absorption	1.83%
4.	CBR	26.16%

3.3.2.3 Aggregates

For the Aggregates tested, the impact value is 25.89 % which is within the permissible limit. The specific gravity varies from 2.58% to which is acceptable. The water absorption varies from 1.4% and less then the permissible limit of 2%. On the basis of this property; all the samples are suitable as aggregate for any of the pavement layers. However it may be pointed out that a change in type of crusher can result in lower flakiness and elongation index. It is therefore expected that with the use of integrated crushing plants (cone crusher as secondary unit), this property will get satisfied.

It therefore reveals that aggregate from the tested quarries, which are with reasonable reach of the projected corridor, after meeting all the engineering requirement and specifications can be used for construction.

3.3.2.4 SAND

The grading and fineness modules of sand samples tested are generally within the permissible limits and as such material from such quarries is fit for use.

3.4 WATER

The potable water from tube well, opens wells, water supply schemes is considered suitable for construction and available in plenty.

3.5 OTHER CONSTRUCTION MATERIALS

Bitumen is to be brought reputed oil refinery or from Distributor of Imphal, Guwahati or near by places . Manufacturer's test / quality certificate is required for each consignment received. Steel of various grade including HYSD steel as per IS specification is available in Imphal, Guwahati & other cities of Assam and can be bought from there or can be arranged from the Manufacturers. Manufacturer's test / quality certificate is needed for each consignment received.

CHAPTER 4
PROCUREMENT OF CONSTRUCTION MATERIALS

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PROCUREMENT OF CONSTRUCTION MATERIALS

4.1 BORROW AREA SOILS

To get the soil, the contractor

- Shall have to meet the owner (Private Person or Government Department) of the borrow area.
- Negotiate the price of the land (for Government area as per notified rules).
- Specifically mentioning the area required, depth of cut, exact time and duration of operation.
- Should make a proper agreement on the stamp paper with all terms and condition mentioned in it.
- Replace the top soil of the borrow area at the time of handing over the borrow pit to the owner, which was removed in the beginning of the operation, of excavation.

4.2 AGGREGATES

To get aggregates, the contractor

- Can purchase the aggregates. from the market as long as the aggregate meet the specification requirements.
- Can set up his own crusher in the quarry area, after taking the quarry area on lease from the revenue / mining department of the state.
- Take NOC from various Government Departments such as Police, Mining, Revenue etc. for new quarries.

4.3 SAND

Sand can be obtained from the natural stream or quarries by paying royalty to the Government.

4.4 WATER

To get Water, the contractor

- Can have it by installing pumps on the existing open well / bore holes along the road and payments may be paid to the owner of the wells / bore holes or
- Can dig his own tube well after taking approval from the state Ground Water Board.

4.5 GRANULAR SUB-BASE

To obtain GSB, the contractor

- Can have it from his own crusher as 'Direct Crusher Run'

4.6 OTHER CONSTRUCTION MATERIALS

To arrange other construction materials like cement, steel etc., the Contractor

- Can buy it directly from the sources / manufacturing unit or
- Can purchase from the local suppliers of nearby cities.

APPENDICES TO CHAPTER 1

Analysis Report

I. SAND

a.Source: Barak River

S. No.	Tests	Test Values
1.	**Sieve Analysis**	
2.	**Sieve size mm**	**% Passing**
3.	10	97.86
4.	4.75	95.58
5.	2.36	95.42
6.	1.18	94.51
7.	600	92.88
8.	300	35.00
9.	150	7.59
10.	75	0.00
11.	Deleterious Material	-
12.	Deleterious Material-Coal & Lignite	-
13.	Deleterious Material-Clay & Lumps	-
14.	Silt & Clay	0.48%
15.	Fineness Modulus	0.55%

IS Codes Followed: 2720(Various parts),2386(Various parts),383

II. Sub Soil Investigation Detail(LHS)

Chainage	Side	Type of Soil	CBR	OMC	MDD	LL %	PL %	PI %	Gravel %	Sand %	Silt %	Clay %	IS Classification
0+000	LHS	Reddish Clayey Silty Sand	11.60	12.20	1.891	32.15	22.65	9.5	11.23	38.13	31.12	19.52	SM-SC
1+000	LHS	Reddish Clayey Silty Sand	13.10	12.80	1.902	32.5	23.54	8.96	11.45	37.12	32.11	19.32	SM-SC
2+000	LHS	Reddish Clayey Silty Sand	10.40	13.00	1.888	32.2	23.77	8.43	12.36	36.87	32.12	18.65	SM-SC
3+000	LHS	Reddish Clayey Silty Sand	9.90	11.50	1.875	32.3	23.62	8.68	10.89	38.12	31.86	19.13	SM-SC

4+000	LHS	Reddish Clayey Silty Sand	13.50	12.40	1.912	32.4	23.33	9.07	10.67	38.95	31.61	18.77	SM-SC
5+000	LHS	Reddish Clayey Silty Sand	12.20	11.80	1.892	33.1	23.64	9.46	2.31	42.32	33.56	21.81	SM-SC
6+000	LHS	Reddish Clayey Silty Sand	13.60	12.70	1.911	33.00	23.75	9.25	2.01	43.12	32.75	22.12	SM-SC
7+000	LHS	Reddish Clayey Silty Sand	11.30	12.80	1.884	33.5	23.58	9.92	2.11	43.58	33.11	21.2	SM-SC
8+000	LHS	Reddish Clayey Silty Sand	11.60	12.40	1.889	33.15	24.6	8.55	2.16	44.12	32.56	21.16	SM-SC

9+000	LHS	Reddish Clayey Silty Sand	8.70	13.30	1.865	33.65	24.45	9.2	2.2	43.1	33.18	21.52	SM-SC
10+000	LHS	Reddish Clayey Silty Sand	12.80	11.95	1.894	33.2	24.31	8.89	2.23	44.88	33.78	19.11	SM-SC

III. Sub Soil Investigation Detail(RHS)

Chainage	Side	Type of Soil	CBR	OMC	MDD	LL %	PL %	PI %	Gravel %	Sand %	Silt %	Clay %	IS Classification
0+000	RHS	Reddish Clayey Silty Sand	11.55	12.95	1.894	32.55	23.45	9.1	10.92	38.45	31.02	19.61	SM-SC
1+000	RHS	Reddish Clayey Silty Sand	12.90	12.60	1.898	32.25	23.61	8.64	11.35	37.94	32.12	18.59	SM-SC
2+000	RHS	Reddish Clayey Silty Sand	10.50	12.00	1.886	32.1	22.78	9.32	10.88	38.23	31.22	19.67	SM-SC
3+000	RHS	Reddish Clayey Silty Sand	10.00	11.20	1.900	32.75	23.46	9.29	11.78	38.79	30.56	18.87	SM-SC

4+000	RHS	Reddish Clayey Silty Sand	13.20	12.60	1.908	32.5	22.89	9.61	11.23	38.12	31.11	19.54	SM-SC
5+000	RHS	Reddish Clayey Silty Sand	12.00	11.40	1.882	32.45	23.54	8.91	2.32	43.98	32.66	21.04	SM-SC
6+000	RHS	Reddish Clayey Silty Sand	13.40	12.90	1.915	32.65	23.94	8.71	2.12	44.22	33.43	20.23	SM-SC
7+000	RHS	Reddish Clayey Silty Sand	11.25	13.10	1.886	32.7	24.02	8.68	2.44	43.55	32.87	21.14	SM-SC
8+000	RHS	Reddish Clayey Silty Sand	11.65	12.75	1.887	33.75	23.49	10.26	2.62	44.11	33.55	19.72	SM-SC

9+000	RHS	Reddish Clayey Silty Sand	8.90	13.10	1.859	32.5	23.46	9.04	2.74	43.75	33.74	19.77	SM-SC
10+000	RHS	Reddish Clayey Silty Sand	12.65	12.40	1.895	33.45	23.67	9.78	2.36	43.12	32.82	21.7	SM-SC

GEOTECHNICAL INVESTIGATION REPORT

JOB NO: NEST/2020/ B-865 **DATED: 10/11/2020**

REPORT ON

Sub-surface Investigation work for Preparation of Detailed Project Report of Tamenglong – Dailong section of Tamenlong Halflong road.

Chainage: *2+220 km,* ***ID:*** *BH-01*

Job Entrusted by:

The Project Manager,

LN Malviya Infra Projects Private Limited

NORTH EAST SOIL TESTING

[A FULL FLEDGED TESTING LABORATORY FOR QUALITY CONTROL OF CONSTRUCTION MATERIALS; GEOTECHNICAL INVESTIGATION; DIGITAL SURVEY; STRUCTURAL DETAILINGS; PROJECT MANAGEMENT CONSULTANCY & DPR]

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LIST OF CONTENTS

1. INTRODUCTION

1.1 PROJECT:-

A detailed geotechnical investigation including field & laboratory testing was carried out for the construction of Bridge section. The objective of this investigation was to evaluate the soil parameters for design of foundation for proposed structure with particular reference to safe bearing capacity and Permissible settlements.

The investigation work for this project was started on the instruction of Client. The fieldwork was commenced on 26th October, 2020 and the report is finalized on 10th November, 2020.

The report has been prepared after careful study of all data collected during fieldwork and laboratory testing and it deals with geotechnical properties of the sub-soil.

1.2 LABORATORY DESCRIPTION:-

"North East Soil Testing" was established in the year 2004 with an aim of testing the construction related materials accurately, unambiguously & objectively as per IS/CPWD/MORD specifications and methods registered as per Govt. of Tripura rules & regulations.

Our laboratory is well established with all modern equipment, which are calibrated every year. Testing the supplied materials & reporting the results are performed by well experienced & qualified engineers in this field.

The team of third party quality monitoring (TPQM) for any type of construction projects is having sufficient exposure under various kinds of state & central Govt.Dept., Govt. undertaking & private organizations. The survey & structural drawing & analysis team is fulfilling the requirements of Detailed Project Report (DPR).

It is our firm belief that the accurate & reliable results received from actual tests will make Civil Engineering design & Construction more perfect. Our attempts will lead development of society along the correct path.

1.3 UNITS:-

SI & CGS units are used at & wherever it requires.

2. FIELD INVESTIGATION

The aim and objective of the present study is to bring out the soil stratification, strength and settlement characteristics with suitability of different types of foundation could be analyzed. This is accomplished by borehole studies and site reconnaissance as per IS: 1892-1979 including field & laboratory tests followed by the necessary interpretation and analysis.

The soil exploration programme is drawn to find out the general stratification of soil and related parameters, which when put to analysis would provide the best possible knowledge of foundation behavior at this site. The programme included:

i) Sinking borehole at predetermined location. The termination depth of borehole is 18.00m. Conducting Standard penetration Tests [SPT] at suitable interval.

ii) Collection of disturbed/representative samples at suitable intervals.

iii) Collection of Undisturbed Samples at and from cohesive deposits only.

iv) Conducting necessary laboratory testing on collected soil samples.

2.1 BORING:

The scope of this soil investigation is limited to one borehole in the location as suggested (site plan enclosed). Boring through the soil was carried out by Auger and Wash method to sink nominal 150 mm diameter borehole by using manually operated winch. Suitable casings have been used upto 5.0 m below the existing ground level to prevent cavity inside the borehole. During the process of boring, both undisturbed and disturbed soil samples were collected either at suitable intervals or at the change of strata whichever was encountered earlier by open drive sampling method. S.P.T. Tests were also conducted at suitable intervals and recorded.

2.2 SAMPLING:

Representative soil samples were collected frequently from auger, split spoon sampler of standard Penetrometer and cutting shoe of undisturbed sampling assembly to maintain a continuous record of strata encountered. Nominal 100 mm diameter undisturbed samples were recovered. The sampling equipment used consists of two tier assembly of sample tube 450 mm in length fitted at its lower end. The sampling assembly was driven by means of jarring link to its full length or as far down as was found practicable. The ends of the tubes were sealed with wax & capped before onwards transmission to the laboratory.

2.3 STANDARD PENETRATION TESTS:

Standard Penetration Tests were conducted in each exploratory borehole at suitable intervals. The number of blows required for middle 30 cm penetration of the split spoon sampler out of a total penetration of 45 cm driven by a 63.5 Kg hammer falling freely through a height of 75 cm was recorded as N – values. The test procedure conformed to IS 2131-1981.

2.4 MEASUREMENT OF GROUND WATER TABLE:

During the field investigation, ground water observation was made. The standing water level was measured in the borehole after 24 hours of removal of casings. These levels of ground water are likely to change with normal seasonal variations.

2.5 SUMMARY OF FIELD WORK:

Design km	BH No	Termination Depth from EGL in m	No. of SPT	No. of D.S.	GWT in m After 24 hr's
2+220	01	18.00	11	02	NF

ISO 9001: 2015 Certified

3. LABORATORY RESULTS

Date of Boring Commenced: *26.10.2020*	***Date of Boring Completed:*** *26.10.2020*	***Name of Work :*** *Soil Investigation for Bridge Section*	***Bore Hole No.:*** *01*
Design km : *2+220*	***Termination Depth from EGL in m:*** *18.00*	***WaterTable in m After 24 hr's:*** *NF*	

Soil Details								Atterberg Limits			Grain Size Distribution				Density (T/m^3)		Shear Parameters	
																	UU	
Layer (M)	Sample Nos. & type	IS Classification	Description of layer	N - Value (Observed)	N - Value (Corrected)	Natural Moisture Content(%)	Specific Gravity	Liquid Limit(%)	Plastic Limit(%)	Plasticity Index(%)	Organic (%)	Sand(%)	Silt(%)	Clay(%)	saturated Density	Submerged Density	Cohesion (T/m^2)	Angle of Internal Friction(
I (0.00 - 2.80)	DS-01	SM-SC	Reddish Loose Clayey Silty Sand	NA	NA	20.12	2.69	_	_	_	_	79	14	7	1.84	0.84	_	19 Direct Shear
	DS-02			NA	NA													
	SPT-01			9	10													
II (2.80 - 4.20)	SPT-02	CI-MI	Greyish Soft Silty Clay	3	2	36.12	2.72	39	21	18	_	17	25	58	1.64	0.64	1.30	5 Tri-axial
III (4.20 - 18.00)	SPT-03	SP	Greyish Medium to Dense Silty Sand	8	8	20.18	2.66	_	_	_	_	97	3	_	2.02	1.02	_	34 (Direct Shear)
	SPT-04			11	10													
	SPT-05			19	17													
	SPT-06			26	21													
	SPT-07			33	26													
	SPT-08			39	30													
	SPT-09			54	39													
	SPT-10			88	61													
	SPT-11			N>100	N>50													

4. LAB INVESTIGATION

The following laboratory tests are conducted on selected soil samples.

- Unit Weight(T/m^3)
- Natural Moisture Content (%)
- Sieve & Hydrometer Analysis
- Specific gravity
- Liquid & Plastic Limit [Atterberg Limits](%)
- Direct Shear Test
- Triaxial Test(UU)

UNIT WEIGHT

It is the ratio of the weight [moist] and volume of the sample.

NATURAL MOISTURE CONTENT

It is the percentage loss of weight of sample on oven drying at or at 105 -110^{0}c. As per IS: 2720 (Part2)1973.

SIEVE & HYDROMETER ANALYSIS

The percent content of gravel, sand, silt & clay of a sample are determined with the help of sieves and principles of falling velocity of particles in a liquid, As per IS:2720 (Part4)1985.

SPECIFIC GRAVITY

Ratio of mass of a given volume of soil to mass of equal volume of water at 4^{o}c, As per IS: 2720 (Part3/Sec1)1980.

ATTERBERG LIMITS [LL &PL]

It is the moisture content at transition when soil starts behaving like liquid [LL] & plastic [PL], As per IS: 2720 (Part5)1985.

DIRECT SHEAR TEST

3 Samples are taken in order to determine the C-Φ value of soil. C-Φ value is obtained from a curve where Normal stress is plotted along X-axis and Shear Stress is plotted along Y-axis, As per IS: 2720(Part13) 1986.

TRIAXIAL TEST-UU

Determination of shear strength parameters of saturated soils, As per IS: 2720(Part11) 1993.

APPENDIX - I

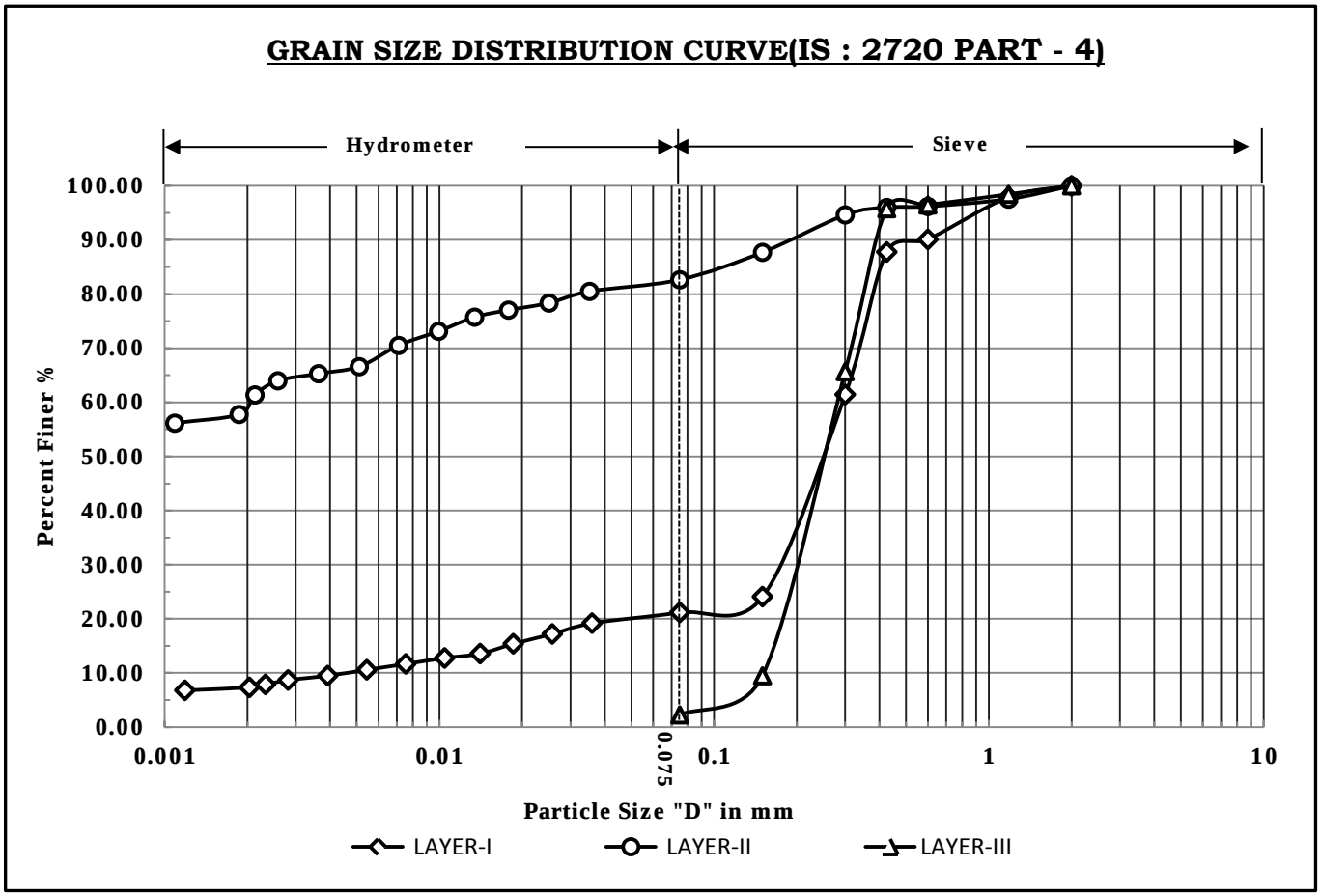

Fig No. 4.1: Grain size distribution graph

Bore Hole No.	Layer	Symbol	Description of Soil	Gravel in %	Sand in %	Silt in %	Clay in %
Grain Size in mm				**>4.75**	**0.075-4.75**	**0.002-0.075**	**<0.002**
01	I	◇	Reddish Loose Clayey Silty Sand	–	79	14	7
	II	○	Greyish Soft Silty Clay	–	17	25	58
	III	△	Greyish Medium to Dense Silty Sand	–	97	3	–

APPENDIX-III

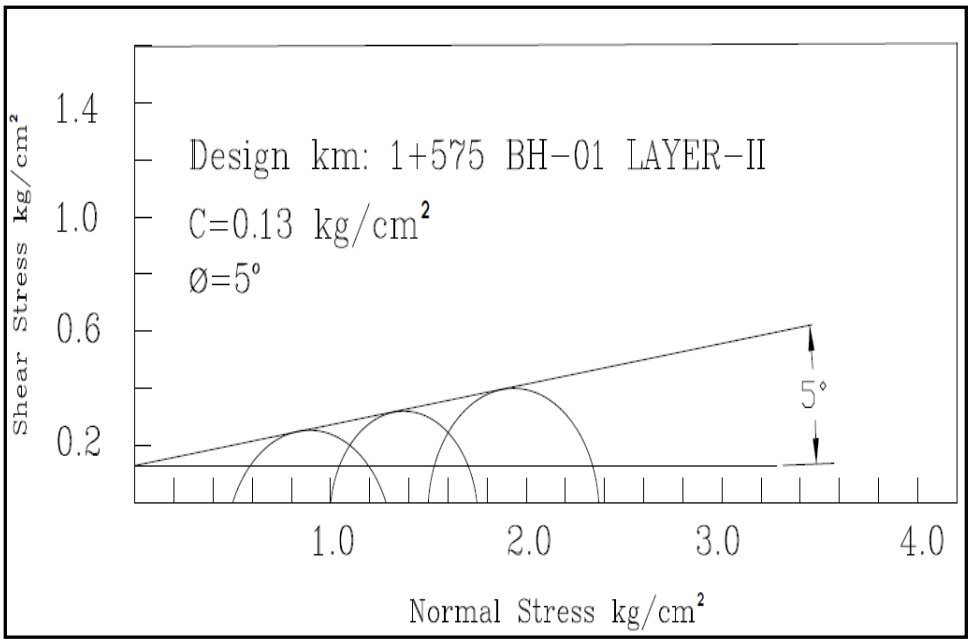

Fig No.4.2: - Stress condition @ failure by Tri-axial (UU) Test

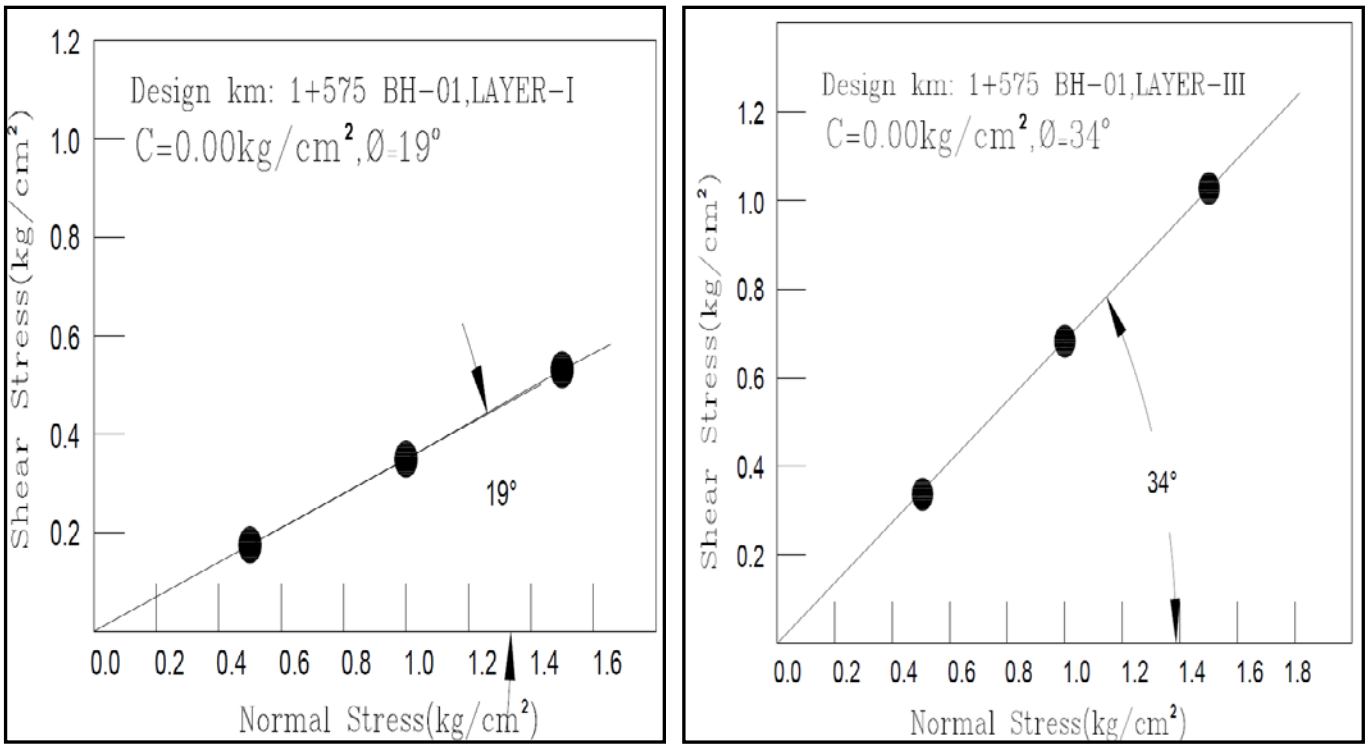

Fig No.4.3: - Stress condition @ failure by Direct shear (UU) Test

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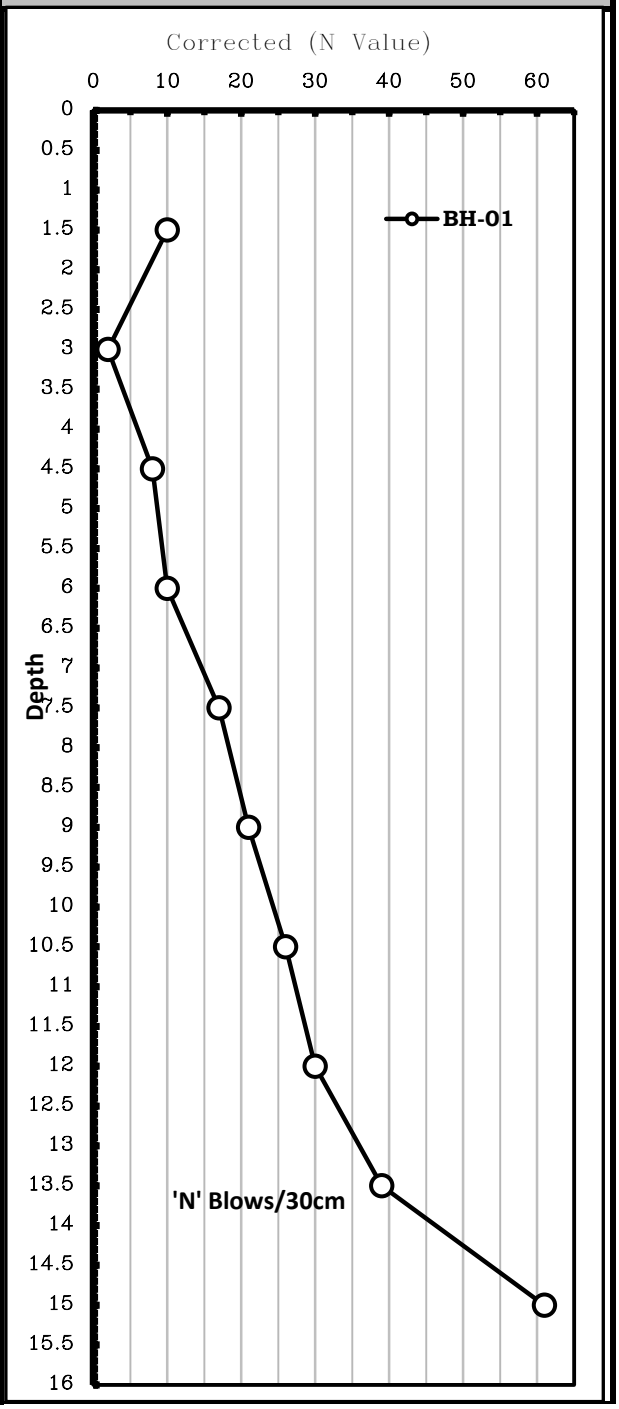
5. FIELD BORELOG SHEET

Sampling Type:- Standard split spoon sampler for disturbed samples and UDS samples by Shelby tubes for SPT.

Design km	2+220	**Sample BH No:-**01	**Depth of Water Table:-** NF
Boring Type	Auger/Wash	**Boring Diammeter:-**150mm	

Depth from EGL in m	Symbol	Visual Classification (IS: 1498-1970)	S.P.T. (N.Value) 0 to 15 cm	15 to 30 cm	30 to 45 cm	SPT Value (N)	ID No.
0.5		Reddish Loose Clayey Silty Sand	–	–	–	–	DS01
1.0			–	–	–	–	DS02
1.5			2	3	5	8	SPT01
3.00		2.80 m	1	1	2	3	SPT02
		Greyish Soft Silty Clay					
4.50		4.20 m	2	2	6	8	SPT03
6.00			2	4	7	11	SPT04
7.50			4	7	12	19	SPT05
9.00			6	9	17	26	SPT06
10.50		Greyish Medium to Dense Silty Sand	9	12	21	33	SPT07
12.00			11	15	24	39	SPT08
13.50			16	21	33	54	SPT09
15.00			22	39	49	88	SPT10
16.50			31	49	50+	N>100	SPT11
		Same Strata					
18.00		18.00 m					

Penetration Resistance Chart



6. SOIL PROFILE:

6.1 GENERAL

Soil profiles were drawn on the basis of analysis of samples obtained from 1 borehole and presented in bore log, which may not be conclusive over the entire area. The characteristics parameters of each individual stratum as obtained from laboratory tests are also presented against the strata. The results of the Standard Penetration Tests (S.P.T.) of each possible layer has also been recorded and shown against each respective layer. A sub soil profile across the borehole representing physical characteristics, strata-wise is shown. The 'N' values are also shown in the profiles as well as in the bore log data sheet.

6.2 SUB-SURFACE LAYER AND THEIR PROPERTIES

Stratification:

Upto the full depth of boring i.e. 18.00 m from the existing ground level (EGL), the soil consists of 3 distinct layers in BH-01. The water table has been not found below EGL in case of BH-01.

BH-01: The first layer consists of Reddish Loose Clayey Silty Sand which continues upto a depth of 2.90 m below EGL. The second layer consists of Greyish Soft Silty Clay which continues upto a depth of 4.20 m below EGL. The third layer consists of Greyish Medium to Dense Silty Sand which continues upto a depth of 18.00 m below EGL.

6.2.1 Layer Stratification of BH-01

A) Layer – I [EGL – 2.80m]

This layer is constituted of Reddish Loose Clayey Silty Sand. The average properties of this layer are presented as follows,

Moisture Content (%)-	20.12	Sand (%)-	79
Saturated Density(T/m^3)-	1.84	Silt (%)-	14
Specific Gravity-	2.69	Clay (%)-	7
Average "N"-	10	Void ratio-	0.54
Direct Shear Test (UU)			
Cohesion(T/m^2)-	_	Angle of Friction-	19^0

B) Layer – II [2.80 m – 4.20 m]

This layer is constituted of Greyish Soft Silty Clay. The average properties of this layer are presented as follows,

Moisture Content (%)-	36.12	Sand (%)-	17
Saturated Density(T/m³)-	1.64	Silt (%)-	25
Specific Gravity-	2.72	Clay (%)-	58
Average "N"-	02	Void ratio-	0.99
Liquid Limit (%)-	39	Plastic Limit (%)-	21
Plasticity Index (%)*-	18		
Tri Axial Test (UU)			
Cohesion(T/m²)-	1.30	Angle of Friction-	5^0

C) Layer – III [4.20m – 18.00m]

This layer is constituted of Greyish Medium to Dense Silty Sand. The average properties of this layer are presented as follows,

Moisture Content (%)-	20.18	Sand (%)-	97
Saturated Density(T/m³)-	2.02	Silt (%)-	3
Specific Gravity-	2.66	Clay (%)-	_
Average "N"-	26	Void ratio-	0.54
Direct Shear Test (UU)			
Cohesion(T/m²)-	_	Angle of Friction-	34^0

7. DETERMINATION OF PILE CAPACITY

Based on the study of field borehole data, field data and laboratory tests results, following average design profile was considered:

Deep foundation in the form of the pile may be adopted. Considering the Pile Capacity values are derived based on the following assumptions,

a) Diameter of pile = 1000 and 1200 mm.
b) Cut off level is considered as 1.50 meters.
c) The length of the pile below the cut-off level is 15.00 meters.
d) Applying a factor of safety, F = 2.50 (Ref: IS: 2911:2010)

Calculation for the Borehole: (IS: 2911(Part 1/Sec 2):2010

PILES IN GRANULAR SOIL

$$Q_u = A_p (0.5\, D\, \gamma\, N_\gamma + P_d\, N_q) + \Sigma^n_{i=1}\ K \tan\delta\ P_{di}\ A_{si}$$

Where,

A_p = Cross-Sectional Area of Pile tip, in m^2

D = Diameter of the Pile Shaft, in m^2

γ = Effective unit Weight of Soil at Pile tip, in T/m^2

Nγ & Nq = Bearing Capacity factors

PD = Effective Overburden pressure at Pile tip in T/m^2

Ki = Coefficient of earth pressure applicable to the i^{th} layer

P_{Di} = effective overburden pressure for the i^{th} layer, in T/m^2

δ = Angle of Wall friction between pile and soil,

Asi = Surface area of the pile shaft

PILES IN COHESIVE SOIL

$$Q_u = A_p\, C_u\, N_c + a\, C_u\, A_{si}$$

Where,

Ap = Cross-Sectional Area of Pile tip, in m^2

Nc = Bearing Capacity factor

Cp = average cohesion at Pile tip, in t/m^2

α_I = adhesion factor for the ith layer depending on the consistency of soil

Ci = average cohesion for the ith layer in $/m^2$, Asi = Surface area of the pile shaft

REFERENCE CALCULATION: (DIA- 1000mm, 15.00m length below 1.50m Cut-Off) BH-01

- **Skin Friction, Q_{sf} = K_i x P_{Di} x tanδ x A_{si}**

  Ist Stratum, Q_{sf} = 0.60 x 0.59 x tan19 x π x 1.00 x 1.40 = 0.54 T

- **Skin Friction, Q_{sf} = α x C_u x A_{si}**

  IInd Stratum, Q_{sf} = 1.00 x 1.30 x π x 1.00 x 1.40 = 5.72 T

  Skin Friction, Q_{sf} = K_i x P_{Di} x tanδ x A_{si}

  IInd Stratum, Q_{sf} = 0.50 x 1.63 x tan5 x π x 1.00 x 1.40 = 0.31 T

- **Skin Friction, Q_{sf} = K_i x P_{Di} x tanδ x A_{si}**

  IIIrd Stratum, Q_{sf} = 0.75 x 8.89 x tan34 x π x 1.00 x 12.20 = 172.37 T

- **Pile tip resistance, Q_{tip} = π /4x d^2 x [(q x N_q) + (.5 x D x γ x N_γ)] (*IS 2911*)**

  = π/4 x $(1.00)^2$ x [(8.89 x 48.00) + (0.5 x 1.00 x 1.02 x 48.03)]

  = 354.38 T

Ultimate Load Capacity, Q_u= End Bearing + Skin Friction

Q_u = 533.32 T

ALLOWABLE LOAD

$Q_a = Q_u/F$

Q_a= 213.33 T

Where, F= Factor of Safety, 2.5

Lateral Load of Pile Capacity (Refer IS: 2911 Part I, Section 2; 2010)

- Stiffness factor = Stiffness factor, T in m = $(EI/\eta_h)^{1/5}$

Where,

E= Young's modulus of Pile material

I= Moment of Inertia

η_h = Modulas of Subgrade Reaction

Hence,

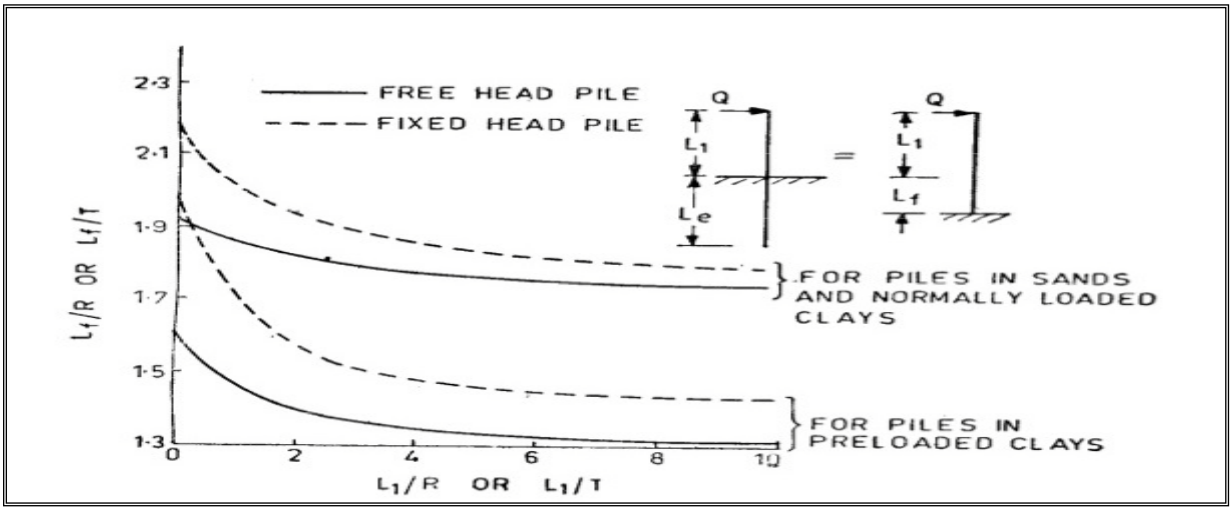
E pile= 250000 kg/cm^2 for M 25

I= πd^4/64= 4908738.521 cm^4

η_h = 0.14 kg/cm^2 (IS: 2911(Part 1/Sec 2):2010)

T= 387.80 cm (IS: 2911(Part 1/Sec 2):2010)

- **Deflections & Moments**



Le: Embedded Length	= 15.00 m
Le: Actual Embedment Available	= 15.00 m
L_1: Free Length	= 0 m
L_f: Length of fixity below MSL	= 853.06 cm
From graph (Fig-4), L_f/ R	= 2.20 (IS -2911 PART 1 SEC 2)
Length of Fixity below Cut off Level	= $L_f + L_1$ = 8.50 m
Pile head deflection as per IS-2911, Part IV	= 0.5 cm (5 mm allowed during load test)
Considering fixed head pile, displacement, Y	= H $(e+z_f)^3 \times 10^3$ / 12 EI
So, Lateral load, H = 12EIY/ (L_1+L_f) 3 x 10^3	= 11.86 T

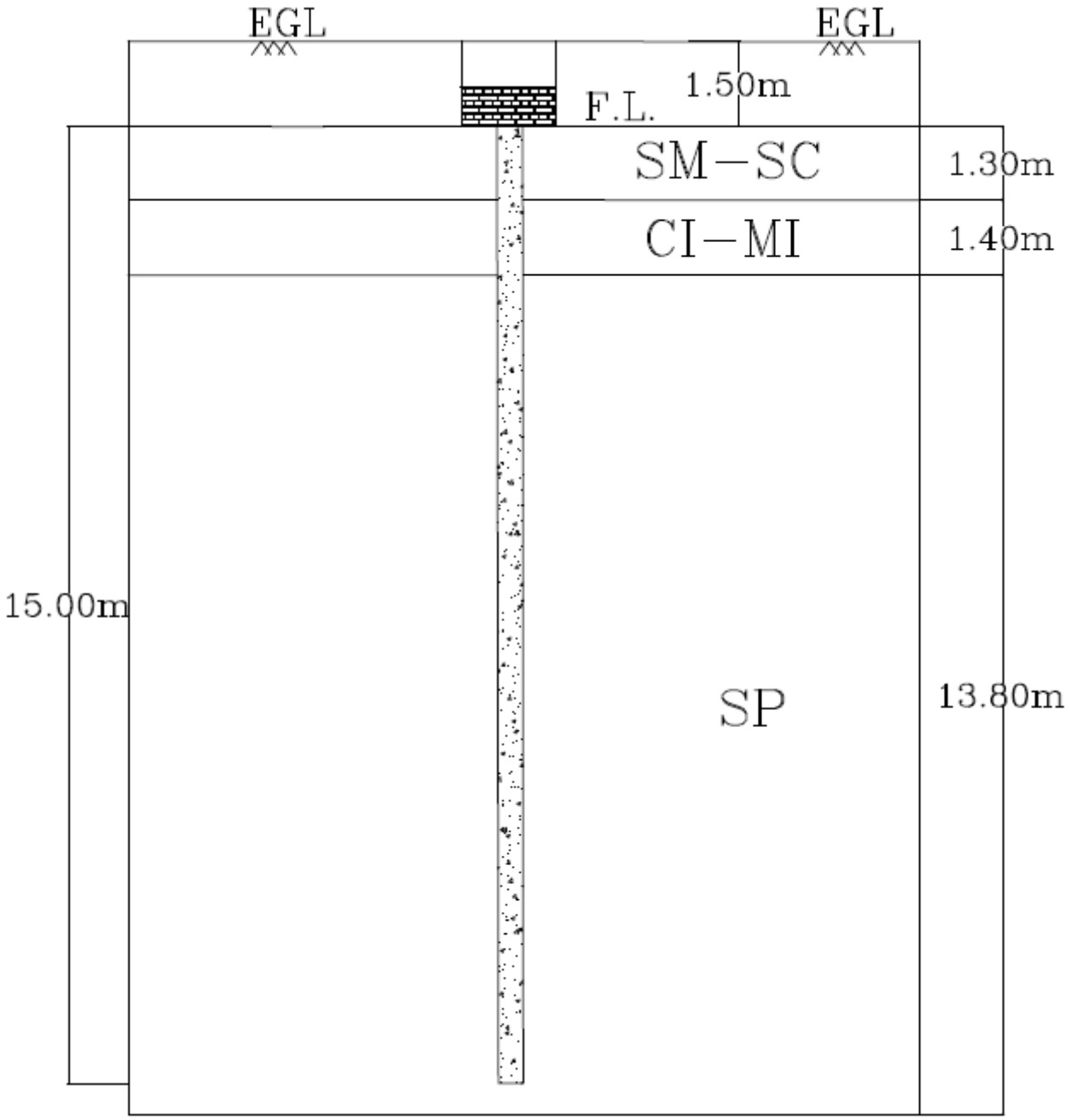


Fig.No.7.1:- Pile foundation at the cut off 1.50 m below EGL

7.2 SUMMARIZED RECOMMENDATION

Based on the above discussion, the following are summarized below:

1. **BH-01:** The first layer consists of Reddish Loose Clayey Silty Sand which continues upto a depth of 2.80 m below EGL. The second layer consists of Greyish Soft Silty Clay which continues upto a depth of 4.20 m below EGL. The third layer consists of Greyish Medium to Dense Silty Sand which continues upto a depth of 18.00 m below EGL.

2. The diameter of the pile has been taken into consideration as per IS: 2911(Part1/Sec2).

3. It is proposed to design and construct R.C.C. Bored Cast-in-situ piles (as per IS 2911, Part I - Sec – 2) may be considered as foundation system for the proposed structure. The recommended values of safe Vertical Capacity of various nominal diameters R.C.C. Bored Cast-in-situ Piles having a cut-off level and tip level as indicated in the following **Table-7.1**. Regarding the 'diameter and configuration' of the pile thereof shall be taken by the designer depending upon the magnitude of load transfer.

4. The recommended pile capacity values are presented below:

Table 7.1: Recommended Pile capacity and Lateral Load

Borehole Number	1.50m Cut-Off Level (m)	Diameter of Pile (mm)	Safe Pile Capacity (Ton)	Recommended Safe Pile Capacity (Ton)	Uplift Load (Ton)	Lateral Load (Ton) (5 mm)
1	15.00	1000	213.33	213.00	65.54	11.86
		1200	292.23	292.00	80.06	15.88

5. As per clause 6.9 of IS-2911 (Part 1-Sec 2), a maximum permissible safe load of a pile as arising out of wind loading is 25%. In case of loads arising out of earthquake effects, the increase of safe load on a single pile shall be limited to the provisions contained in IS 1893 (Part 1). For transient loading arising out of superimposed loads, no increase is permitted and shall be taken care of by the Structural Engineer and seismic forces are not being taken into consideration.

6. The decision regarding the 'configuration of the pile' shall be taken by the Structural designer depending upon the magnitude of load transfer envisaged. It may be noted that pile capacity depends on piling methodology, equipment used and experience of piling agency. Therefore, care should be taken to ensure quality control and provisions of relevant BIS codes should be followed. Pile capacity should be verified by the load test following the BIS code.
7. Initial and Routine Pile load tests shall be carried out as per IS-2911 (Part IV) for confirmation of pile capacity prior to installation of actual piles for the proposed structure and after pile installation. The maximum test load should be two and a half times and one and half times the safe lo for initial and routine pile load tests respectively.
8. Choice of foundation as discussed above depends on the superstructure loading and hence it lies with the Structural Designer.

Reviewed by

8. CODES & REFFERENCES

a. *IS 2131:1981, RA-2016- Method for standard penetration test.*

b. *IS 2720(Part2):1973, RA-2015- Determination of water content.*

c. *IS 2720(Part3/Sec 1):1980, RA-2016- Determination of specific gravity.*

d. *IS 2720(Part4):1985, RA-2015- Determination of Grain size analysis.*

e. *IS 2720(Part5):1985, RA-2015- Determination of liquid and plastic limit.*

f. *IS2720 (Part13):1986, RA-2016- Determination of Direct shear test.*

g. *IS2720 (Part11):1993, RA-2016- Determination of the shear strength parameters of a specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure.*

h. *IS2911 (Part1/Sec 2):2010, RA-2015- Determination of Bored Cast In-situ Concrete Piles.*