डेडीकेटेड फ्रेट कोरीडोर

DESIGN AND CONSTRUCTION OF CIVIL, STRUCTURES AND TRACK WORKS, INVOLVING FORMATION IN EMBANKMENT /CUTTING, BALLAST ON FORMATION, TRACK WORKS, BRIDGES, STRUCTURES, BUILDINGS, YARDS & INTEGRATION WITH INDIAN RAILWAY'S EXISTING RAILWAY SYSTEM AND TESTING & COMMISSIONING ON DESIGN-BUILD LUMP SUM BASIS OF KHURJA-PILKHANI SECTION (APPROXIMATELY 222 ROUTE KM OF SINGLE LINE) OF EASTERN DEDICATED FREIGHT CORRIDOR

CIVIL, STRUCTURES AND TRACK WORKS

CONTRACT PACKAGE NO: 303

ICB No.: **HQ/EN/EC/D-B/Khurja-Pilkhani Section**

PART-4 – REFERENCE DOCUMENT

GEOTECH DATA – VOLUME 3

KHURJA TO PILKHANI

From Km. 1367.0 (ALJN-GZB) to Km 187.5 (SRE-UMB)

GEO TECH DATA

(MUZAFFARNAGAR DETOUR)

PART. 3/3

EMPLOYER: DEDICATED FREIGHT CORRIDOR CORPORATION OF INDIA LTD
(A GOVERNMENT OF INDIA ENTERPRISE)
MINISTRY OF RAILWAYS

COUNTRY: **INDIA**

INDEX

List of Abbreviations

BH	Borehole
CBR	California Bearing Ratio
CD	Consolidated Drained
CH	Chainage
CR	Core Recovery
CRR	Cyclic Resistance Ratio
CSR	Cyclic Stress Ratio
CU	Consolidated Undrained
DBE	Design Basis Earthquake
DCPT	Dynamic Cone Penetration Test
E	Easting
EGL	Existing Ground Level
ERT	Electrical Resistivity Test
FS/ FOS	Factor of Safety
FSW	Free Swell Index
GL	Ground Level
GWT	Ground Water Table
HFL	High Flood Level
IRC	Indian Road Congress
IS	Indian Standard
LL	Liquid Limit
MJB	Major Bridge
MNB	Minor Bridge
MSF	Magnitude Scaling Factor
N	Northing
NABL	National Accreditation Board for Testing and Calibration Laboratories
NMC	Natural Moisture Content
OMC	Optimum Moisture Content
PI	Plasticity Index
PL	Plastic Limit
PLI	Point Load Index
PLT	Plate Load Test
RL	Reduce Level
RQD	Rock Quality Designation
SCPT	Static Cone Penetration Test
SPT	Standard Penetration Test
TP	Trial Pit
UC	Unconfined Compression

UCS	Unconfined Compressive Strength
UDS	Undisturbed Sample
UU	UnconsolidatedUndrained
VST	Vane Shear Test
VUP	Vehicular Under Pass

CHAPTER I
INDRODUCTION

1.1 General

M/s. Skylark Designer & Engineers Pvt. Ltd. has been entrusted with DPR preparation at Muzaffarnagar to Saharanpur Section of DFCC Meerut. On behalf of Skylark Designer & Engineers Pvt. Ltd, M/s. Xplorer Consultancy Services Pvt. Ltd. is authorized to carry out the Laboratory testing of Soil samples supplied by Skylark for Muzaffarnagar - Saharanpur Section from Ch. 1+790km to Ch.38+930km of DFCC Meerut.

Accordingly, as per the specifications provided by M/s. Skylark Designer & Engineers Pvt. Ltd, M/s Xplorer Consultancy Services Pvt. Ltd. carried Laboratory testing of soil samples, engineering analyses and recommending the type of foundations for the proposed structures LOA No. Skylark/GT/DFCCIL-Meerut/Khurja-Dadri Section/Xplorer/2015/01 dated 20.04.2015

1.2 Scope of Work

The scope of work broadly comprises of the followings:

- Carrying out various laboratory tests
  - Natural Moisture Content (NMC)
  - Sieve and Hydrometer Analysis
  - Atterberg Limits
  - Bulk and Dry Density
  - Unconsolidated Un-drained (UU) Triaxial Test / Unconfined Compression Test (UC)
  - Direct Shear Test
  - Chemical Analysis of Soil for pH, Sulphate and Chlorides.
- Analysis and recommending type of foundations

  The field investigation was carried out by M/s Skylark and the samples are supplied to our laboratory for carrying out required test on the selected samples. The details of laboratory test quantities are presented in Table 1.1

Table 1.1 Details of Laboratory Test Quantities

Chainage	Borehole	Boring in Soil	Grain Size Analysis	Atterberg	Specific Gravity	MC, Density	Direct Shear Test	UU/UC	Chemical Analysis of Soil
1+790	BH-1	30.0	4	2	1	4	2	1	1
	BH-2	30.0	4	3	1	2	2	0	0
1+980	BH-1	30.0	5	4	1	3	3	0	1
2+010	BH-1	30.0	5	4	1	3	2	2	1
2+286	BH-1	12.0	3	1	1	0	2	0	1
3+360	BH-1	12.0	3	2	1	1	2	0	1
5+322	BH-1	12.0	3	2	1	1	1	1	1
6+550	BH-1	30.0	4	3	1	1	3	0	1
	BH-2	30.0	4	3	1	1	0	1	0
8+440	BH-1	12.0	3	2	1	2	0	1	1
10+540	BH-1	30.0	3	1	1	0	2	0	1
11+753	BH-1	30.0	3	1	1	1	2	0	0
13+260	BH-1	30.0	3	1	1	1	1	1	1
14+150	BH-1	30.0	3	1	1	1	1	0	1
15+800	BH-1	30.0	3	1	1	1	2	0	1
17+790	BH-1	30.0	4	2	1	3	2	0	1
18+900	BH-1	12.0	3	2	1	2	0	1	1
19+680	BH-1	12.0	3	1	1	1	2	0	1
20+960	BH-1	12.0	2	1	1	1	2	0	1
22+700	BH-1	12.0	3	1	1	2	2	0	1
24+269	BH-1	30.0	3	1	1	2	2	0	1
25+880	BH-1	30.0	3	1	1	2	2	0	1
27+960	BH-1	30.0	4	2	1	2	2	0	1
28+840	BH-1	30.0	4	1	1	3	2	1	1
30+236	BH-1	30.0	4	1	1	2	3	0	1
31+820	BH-1	30.0	3	1	1	0	2	0	1
33+310	BH-1	12.0	2	1	1	1	2	1	1
34+920	BH-1	30.0	4	2	1	2	3	0	1
36+585	BH-1	30.0	4	1	1	1	2	0	1
	BH-2	30.0	4	2	1	1	2	0	1
38+930	BH-1	30.0	3	2	1	3	2	1	1

1.3 Scope of Report

This report covers the interpretation of field and laboratory test results and recommendations regarding foundation types along with recommended bearing capacities and pile capacities for the various bridges.

1.4 Organization of the Report

This report is presented in five (4) chapters as follows
Chapter I: Introduction
Chapter II: Laboratory Studies
Chapter III: General Site and Subsurface Condition
Chapter IV: Analysis and Recommendation

CHAPTER II

LABORATORY STUDIES

2.1 General

The laboratory tests were performed on undisturbed and selected SPT samples. The laboratory tests were performed in accordance with relevant IS codes. Lab test results are presented in Annexure C. General descriptions of laboratory testing are presented below:

2.2 Physical Properties

2.2.1 Natural Moisture Content

To measure natural moisture content, a specimen from an undisturbed sample is taken in a container and its weight recorded as total weight. The sample is then dried in an oven at 105-110° C for 18-24 hours. After drying, the dry weight is taken and weight of water is calculated simply by subtracting the dry weight from the total weight. The moisture content is then calculated as the percentage of the weight of water over weight of dry soil.

2.2.2 Grain Size and Hydrometer Analysis

The grain size analysis has been carried out utilizing both sieve and hydrometer analysis.

The sieve analysis was carried out by wet sieving method in which the material was first washed through a 4.75 mm test sieve nested in a 75 μm test sieve. The soils retained in the sieves were then dried in an oven. The dried soils were then sieved by dry sieving by passing the soils through a series of square mesh sieves, which become progressively finer down to 75 μm mesh. Each fraction thus collected was then weighed and the percentage retained on each sieve was calculated by dividing individual weights by the total sample weight.

The soils passing through 75 μm mesh was analyzed by sedimentation using hydrometer method. The hydrometer method involves measuring the rate of settlement of fine particles suspended in a solution. Utilizing the principle of Stokes' law, particle size can be directly related to its rate of settlement in a fluid such as water. From this process, the particle diameter and percentage finer is calculated.

2.2.3 Atterberg Limits

Liquid limit of a specimen is derived using the cone penetration method. Plastic limit is defined as the moisture content of a specimen at the point where it can be satisfactorily rolled into a 3mm diameter thread without cracking. Plasticity index is

then derived by subtracting the plastic limit from the liquid limit.

2.2.4 Specific Gravity

The sample is dried overnight in an oven at 110° C, cooled in desiccators, grind and sieved through 24mm/4.75mm IS Sieve for fine/coarse grained soils. About 10gm of sieved sample is taken in a specific gravity bottle and sufficient distilled water is added to just cover the soil and left it for soaking for 10-15 minutes after which it is shaken well and more distilled water added to fill the bottle about half. It is then placed in a sand bath to de-air. After air is totally removed, it is cooled and fills completely with water.

Various weights, e.g. , weight of empty bottle, weight of bottle filled with water, weight of bottle filled with water and sample, etc are taken from which specific gravity is calculated.

2.2.5 Bulk and Dry Density

The bulk density is the measured weight of a solid cylindrical soil specimen taken from an undisturbed sample divided by its volume. The dry density was calculated from bulk density and moisture content.

2.2.6 Unconsolidated Undrained (UU) Triaxial Test / Unconfined Compression Test (UC)

This test was performed as a set of three single stage tests. The general testing procedure is as explained below.

Three specimens were taken from a single undisturbed sample. The soil specimens were trimmed and cut until the length to diameter ratio is approximately two. The specimens were then weighed, measured and placed in a triaxial cell and were sheared under undrained conditions at a constant cell pressure and strain rate. Axial load and displacement were recorded at regular intervals until a maximum deviator stress, or 20% of strain, is reached. Cell pressures of 100, 200 and 300 kPa have been used for three specimens.

In case the sample was not adequate for three specimens, UC test was carried out on one specimen. This test is conducted without any confining pressure.

2.2.7 Direct Shear Test

Since the subsoil contains fair amount of sand, sampling for triaxial tests was not possible. Hence Direct Shear Tests were carried out. The tests were performed on remoulded samples under normal stresses of 50, 100 and 150 kPa. The samples were prepared at densities corresponding to SPT values.

2.2.8 Chemical Analysis

Chemical analysis was carried out to determine of pH, total SO_3, organic material and Chloride contents. The tests were carried out as per relevant IS code.

2.2.8.1 Measurement of pH

20gm of soil sample is mixed with 50ml of distilled water. The suspension is stirred for few seconds and is allowed to stand for 1 hour with occasional stirring. It is stirred again, immediately before testing.

The pH meter is calibrated with standard buffers and the pH of the soil suspension is measured.

2.2.8.2 Chloride

5 to 6 drops of potassium chromate indicator is added to 100 ml of filtered water sample to get yellow colour and then titrated against silver nitrate solution (0.028N)
End Point: Yellow to Brick Red Colour
Chloride (mg/l) = (V_2-V_1) x 35.46 x 1000 x N) / (ml of sample taken)
V_1 = Initial burette reading
V_2= Final burette reading
N = 0.028

2.2.8.3 Sulphate

100ml filtered Soil water extract is taken in a beaker. Then Barium Chloride Solution is added to the soil water extract and the mixture is allowed the ppt to settle and digest the ppt. at low temperature on a hot plate for 30 minutes. Filter the ppt. with Whatman No. 42 and wash with hot water till it is chloride free. Ignite the filter paper at 700°C in muffle furnace in weighed crucible (W1). Cool the crucible in desiccators and weigh (W2).

Sulphates (as SO_3), gm/l = (W2-W1) * 0.343*1000/100

CHAPTER-III

GENERAL SITE AND SUBSURFACE CONDITION

3.1 Site Geology

The site is underlain by the quaternary alluvium deposited by Ganga and Yamuna river system. Lithologically the alluvial sediment comprise of sand, silt, clay and *kankar* in varying proportions.

3.2 Subsoil Stratifications

Based on the findings of field and laboratory test results bore logs have been prepared incorporating all field and laboratory test results. A sub-soil profile for site showing the variations in subsoil stratification across the site, at borehole locations, are furnished in Annexure A.

As seen from the profiles, this site comprises of alluvial deposits consisting mainly of non- plastic Silty and Sandy soil with intermittent clayey silt layer. Top 5.0 m soils are generally in loose to medium dense state followed by medium to denser state.

3.2.1 Major Bridge at Ch. 1+790 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.1. Top 11.0m soil is medium dense Silty SAND with SPT varying from 12 to 20 followed by very stiff to hard silty CLAY with SPT varying from 27 to 33 underlain by sandy SILT/Silty SAND with SPT varying from 31 to 60 upto termination depth of 30.0m.

3.2.2 Major Bridge at Ch. 1+980 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.2. Top 8.0m soil is loose to medium dense silty SAND with SPT varying from 4 to 18 followed by medium dense sandy SILT with SPT varying from 20 to 25 underlain by medium dense to dense fine SAND/sandy SILT with SPT varying from 27 to 44 upto termination depth of 30.0m.

3.2.3 Ch. 2+010 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.3. Top 8.0m soil is loose to medium dense sandy SILT with SPT varying from 6 to 12 followed by very stiff silty CLAY with SPT varying from 15 to 28 upto depth 15.0m. Below this dense fine SAND encountered with SPT varying from 36

to 47 underlain by hard silty CLAY with SPT varying from 30 to 35 upto termination depth of 30.0m.

3.2.4 Minor Bridge at Ch. 2+286 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.4. Top 11.0m soil is loose to medium dense silty SAND with SPT varying from 6 to 25 followed by medium dense fine sand with SPT varying from 14 to 31 upto termination depth of 12.0m.

3.2.5 Ch. 3+360 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.5. Top 6.0m soil is loose sandy SILT with SPT varying from 5 to 8 followed by medium dense silty SAND with SPT varying from 14 to 26 upto termination depth of 12.0m.

3.2.6 Ch. 5+322 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.6. Top 6m soil is loose sandy SILT with SPT varying from 4 to 8 followed by very stiff silty CLAY with SPT varying from 16 to 22 upto termination depth of 12.0m.

3.2.7 Major Bridge at Ch. 6+550 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey, silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.7. Top 20.0m soil is medium dense to dense silty SAND with SPT varying from 11 to 38 followed by hard silty CLAY with SPT varying from 37 to 46 underlain by very dense sandy SILT with SPT varying from 52 to 60 upto termination depths of 30.0m.

3.2.8 Ch. 8+440km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and clayey soils. A graph showing variation in SPT with depth is presented in Fig. 3.8. Top 6m soil is firm to very stiff silty CLAY with SPT varying from 5 to 16 followed by medium dense sandy SILT with SPT varying from 18 to 28 upto termination depth of 12.0m.

3.2.9 Major Bridge at Ch. 10+540 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.9. Top 12.0m soil is loose to medium dense fine SAND with SPT varying from 5 to 26 followed dense sandy SILT with SPT varying from 30 to 38 underlain by dense silty SAND with SPT varying from 30 to 48 upto termination depth of 30.0m.

3.2.10 Major Bridge at Ch. 11+753 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.10. Top 12m soil is loose to medium dense sandy SILT with SPT varying from 5 to 24 followed by medium dense to very dense fine SAND with SPT varying from 25 to 73 upto termination depth of 30.0m.

3.2.11 Major Bridge at Ch. 13+260 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of sandy and clayey soils. A graph showing variation in SPT with depth is presented in Fig. 3.11. Top 12.0m soil is very stiff to hard silty CLAY with SPT varying from 17 to 32 followed by dense to very dense silty SAND with SPT varying from 29 to 58 upto termination depth of 30.0m.

3.2.12 Major Bridge at Ch. 14+150 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.12. Top 12.0m soil is loose to medium dense sandy SILT with SPT varying from 8 to 22 followed by medium dense to dense silty SAND with SPT varying from 25 to 32 underlain by dense to very dense fine SAND with SPT varying from 32 to 64 upto termination depth of 30.0m.

3.2.13 Major Bridge at Ch. 15+800 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.13. Top 12m soil is loose to medium dense sandy SILT with SPT varying from 6 to 21 followed by medium dense to very dense fine SAND with SPT varying from 23 to 65 upto termination depth of 30.0m.

3.2.14 Major Bridge at Ch. 17+790 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.14. Top 12m soil is loose to medium dense sandy SILT with SPT varying from 7 to 22 followed by medium dense silty SAND with SPT varying from 26 to 37 underlain by medium dense to dense fine SAND with SPT varying from 21 to 39 upto termination depth of 30.0m.

3.2.15 Minor Bridge at Ch. 18+900 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.15. Top 9.0m soil is stiff silty CLAY with SPT varying from 10 to 13 followed by medium dense to dense silty SAND with SPT varying from 21 to 35 upto termination depth of 12.0m.

3.2.16 Minor Bridge at Ch. 19+680 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.16. Top 9.0m soil is loose to medium dense sandy SILT with SPT varying from 7 to 18 followed by medium dense silty SAND with SPT varying from 21 to 26 upto termination depth of 12.0m.

3.2.17 Ch. 20+960 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.17. Top 9.0m soil is loose to medium dense sandy SILT with SPT varying from 5 to 21 followed by medium dense fine SAND with SPT varying from 21 to 23 upto termination depth of 12.0m.

3.2.18 Minor Bridge at Ch. 22+700 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty soils. A graph showing variation in SPT with depth is presented in Fig. 3.18 Top 4.5m soil is loose sandy SILT with SPT varying from 6 to 8 followed by medium dense sandy SILT with SPT varying from 12 to 23 upto termination depth of 12.0m.

3.2.19 Major Bridge at Ch. 24+269 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.19 Top 13.5m soil is loose to medium dense sandy SILT with SPT varying from 6 to 33 followed by dense to very dense sandy SILT with SPT varying from 39 to 52 underlain by dense o very dense fine SAND with SPT varying from 43 to 62 upto termination depth of 30.0m.

3.2.20 Major Bridge at Ch. 25+880 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of sandy and silty soils. A graph showing variation in SPT with depth is presented in Fig. 3.20 Top 12m soil is loose to medium dense sandy SILT with SPT varying from 6 to 18 followed by medium dense to very dense fine SAND with SPT varying from 17 to 74 upto termination depth of 30.0m.

3.2.21 Major Bridge at Ch. 27+960 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay, silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.21 Top 12.0m soil is loose to medium dense sandy SILT with SPT varying from 4 to 22 followed by medium dense to very dense fine SAND with SPT varying from 28 to 56 upto termination depth of 30.0m. There is clay layer sandwiched in between sandy soil from depth 17.0m to 20.0m with SPT varying from 42 to 48.

3.2.22 Major Bridge at Ch. 28+840 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clayey, silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.22 Top 5m soil is stiff silty CLAY with SPT varying from 9 to 12 followed by medium dense to dense sandy SILT with SPT varying from 15 to 45 underlain by very dense fine SAND with SPT varying from 55 to 65 upto termination depth of 30.0m.

3.2.23 Major Bridge at Ch. 30+236 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.23 Top 12m soil is sandy SILT with SPT varying from 7 to 21 followed by medium dense to dense sandy SILT with SPT varying from 26 to 42 underlain by dense to very dense fine SAND with SPT varying from 36 to 53 upto termination depth of 30.0m.

3.2.24 Major Bridge at Ch. 31+820 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.24 Top 12.0m soil is loose to medium dense silty SAND with SPT varying from 8 to 21 followed by medium dense to very dense fine SAND with SPT varying from 25 to 65 upto termination depth of 30.0m.

3.2.25 Minor Bridge at Ch. 33+310 km

As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.25 Top 9.0m soil is loose to medium dense sandy SILT with SPT varying from 7 to 17 followed by medium dense silty SAND with SPT varying from 18 to 29 upto termination depth of 12.0m.

3.2.26 Major Bridge at Ch. 34+920 km

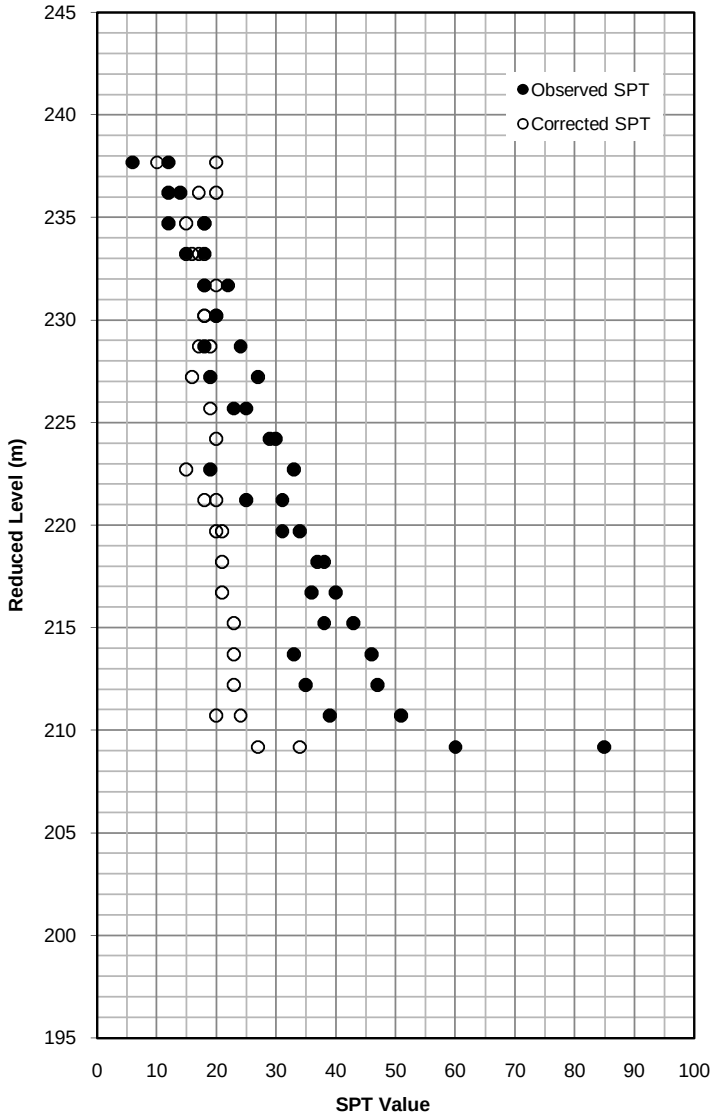
As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of silty and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.26 Top 12.0m soil is sandy SILT with SPT varying from 4 to 23 followed by medium dense to dense fine SAND with SPT varying from 25 to 31 underlain by dense to very dense sandy SILT/fine SAND with SPT varying from 30 to 46 upto termination depth of 30.0m.

3.2.27 Major Bridge at Ch. 36+585 km

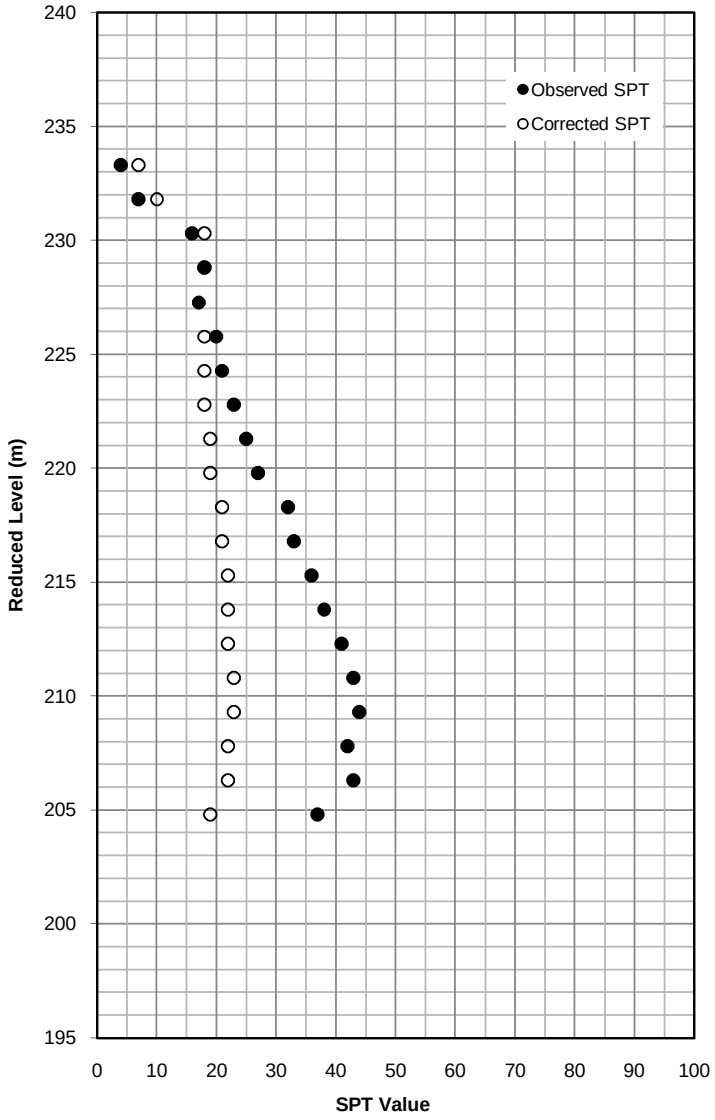
As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay, silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.27 Top 12m soil is loose to medium dense silty SAND with SPT varying from 9 to 23 followed by medium dense to dense fine sand with SPT varying from 27 to 45 underlain by sandy SILT/silty CLAY with SPT varying from 39 to 57 upto termination depth of 30.0m.

3.2.28 Major Bridge at Ch. 38+930 km

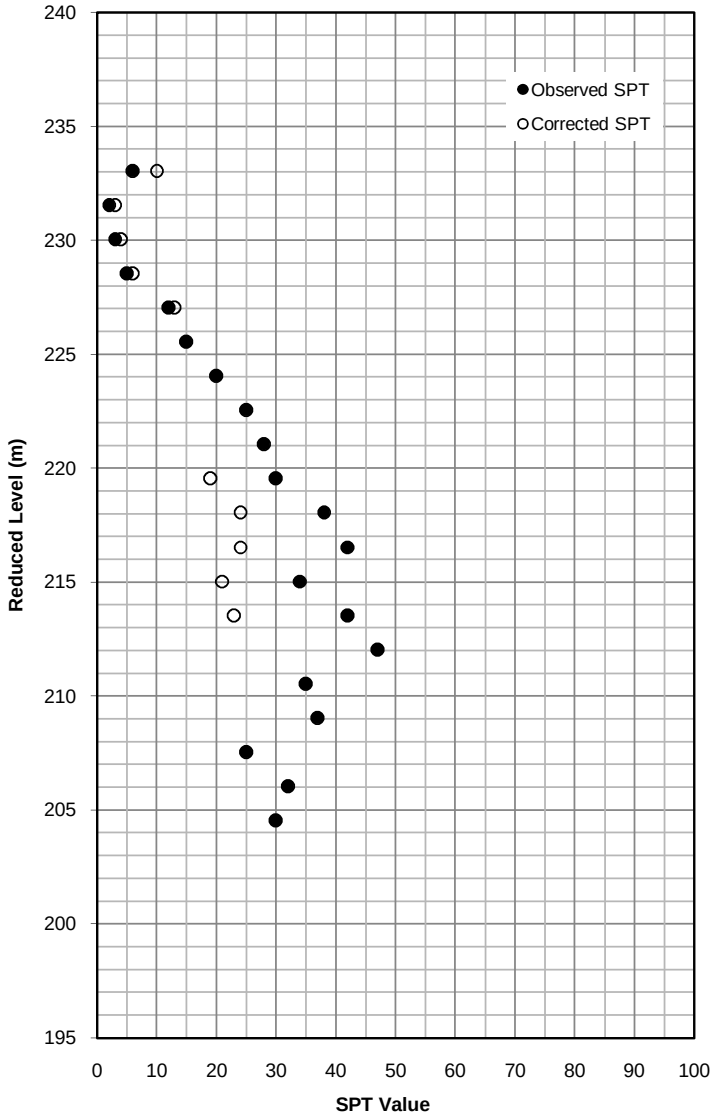
As seen from the profiles, the investigated site mainly comprises of alluvial deposits consisting of clay, silt and sandy soils. A graph showing variation in SPT with depth is presented in Fig. 3.28. Top 14m soil is loose to medium dense sandy SILT with SPT varying from 9 to 21 followed by very stiff to hard silty CLAY with SPT varying from 20 to 56underlain by very dense fine SAND with SPT varying from 54 to 69 upto termination depth of 30.0m.



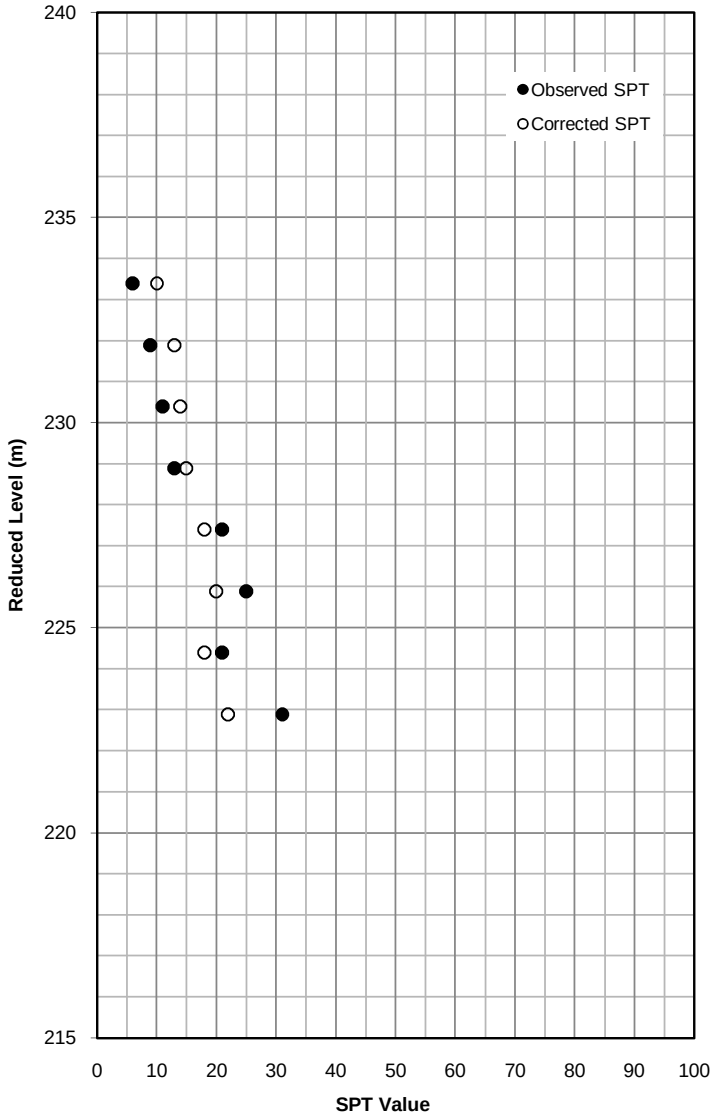
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1 & BH-2)** **Chainage : 1+790km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.1**	**SHEET No. 1 of 1**



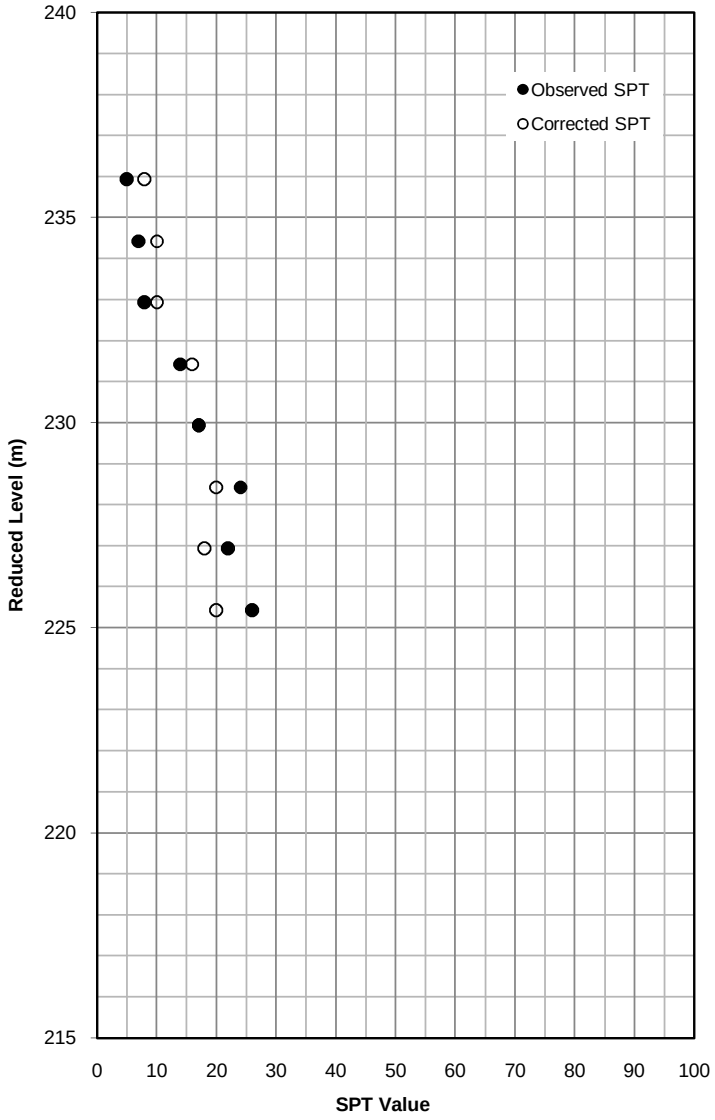
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 1+980km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.2**	**SHEET No. 1 of 1**



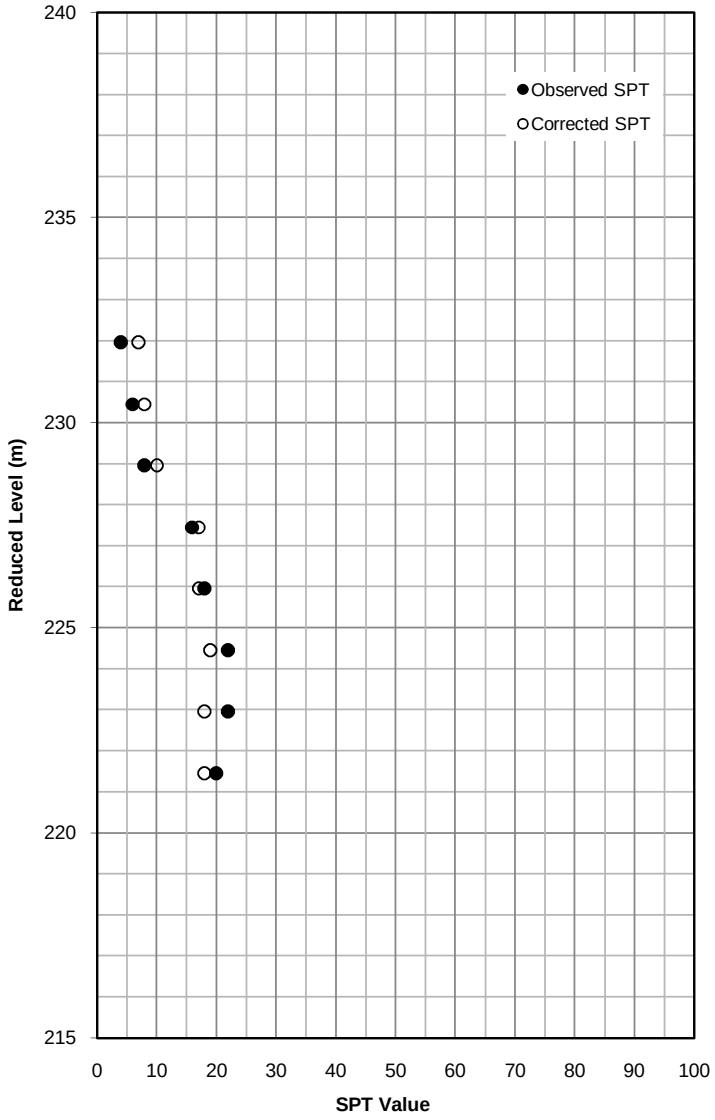
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 2+010km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.3**	**SHEET No. 1 of 1**



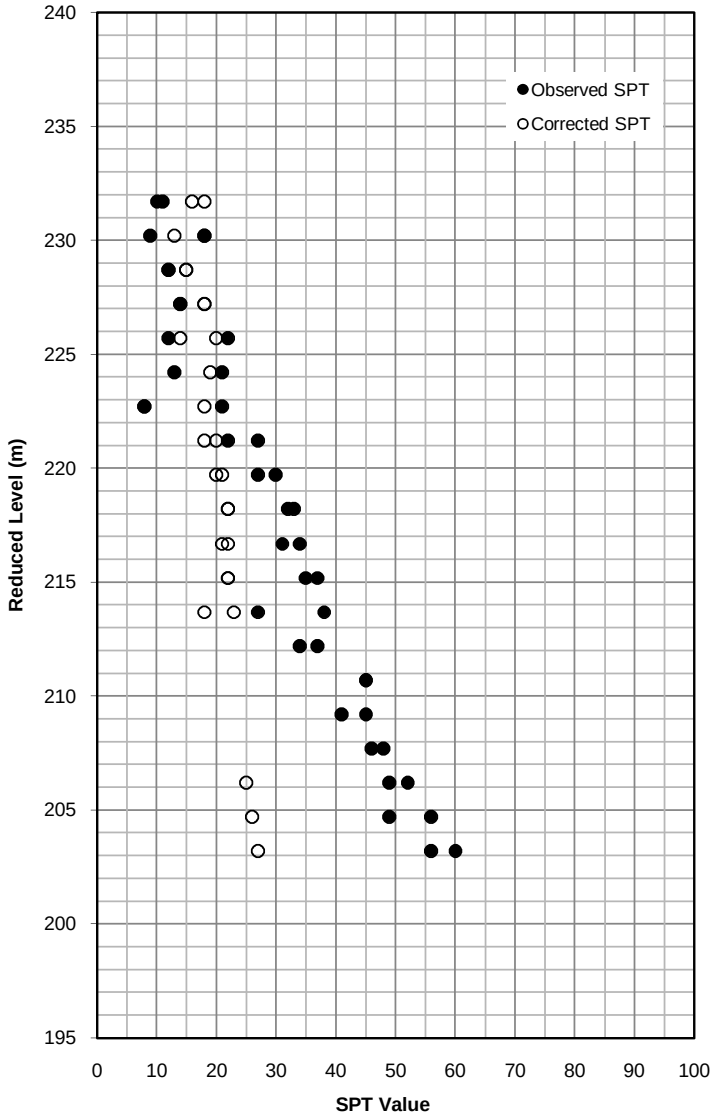
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut		
CLIENT: Skylark	Variation of SPT Value with Depth (BH-1) Chainage : 2+286km	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.4	SHEET No. 1 of 1



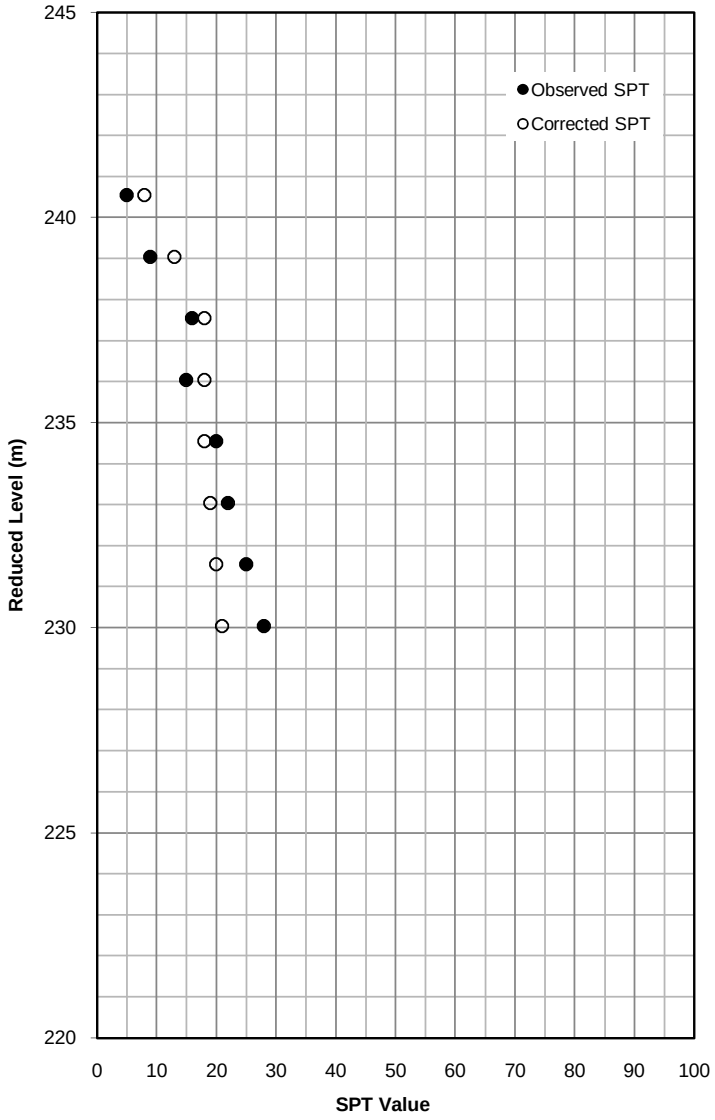
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 3+360km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.5**	**SHEET No. 1 of 1**



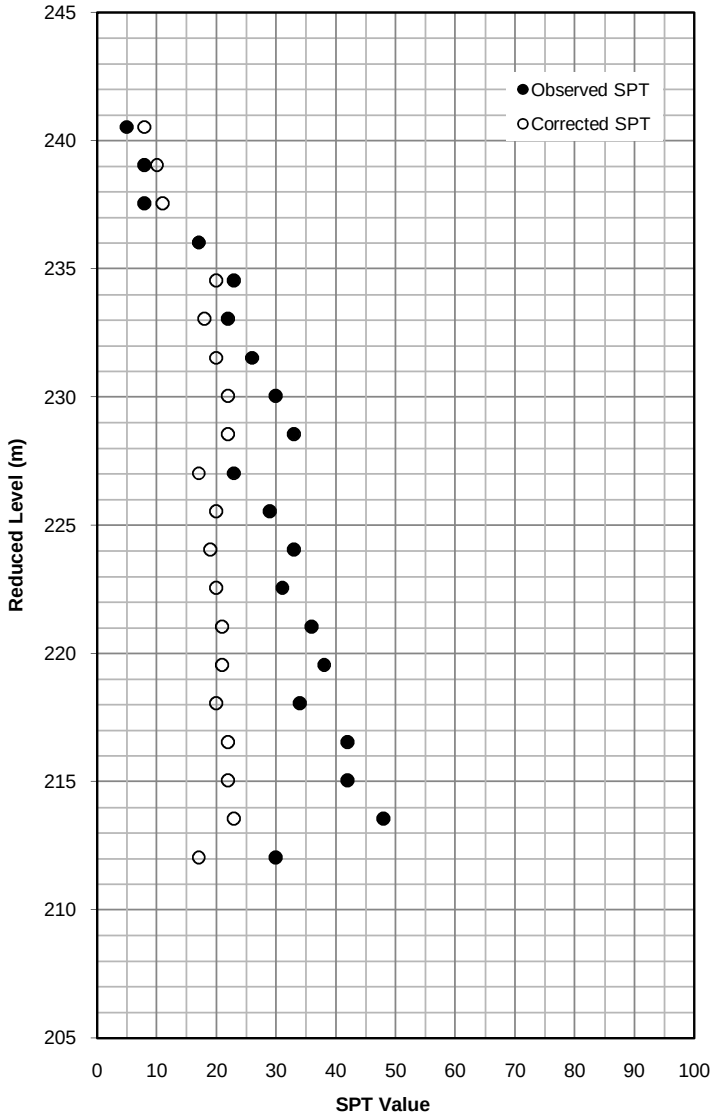
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut		
CLIENT: Skylark	Variation of SPT Value with Depth (BH-1) Chainage : 5+322km	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.6	SHEET No. 1 of 1



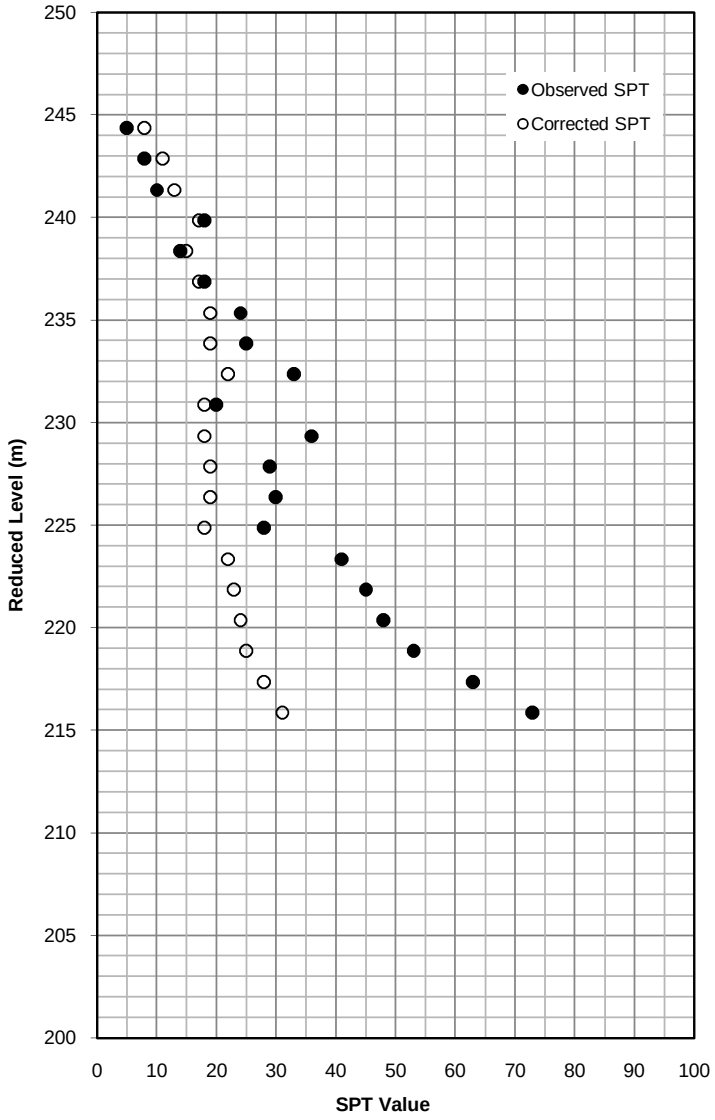
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1& BH-2)** **Chainage : 6+550km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.7**	**SHEET No. 1 of 1**



Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut		
CLIENT: Skylark	Variation of SPT Value with Depth (BH-1) Chainage : 8+440km	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.8	SHEET No. 1 of 1

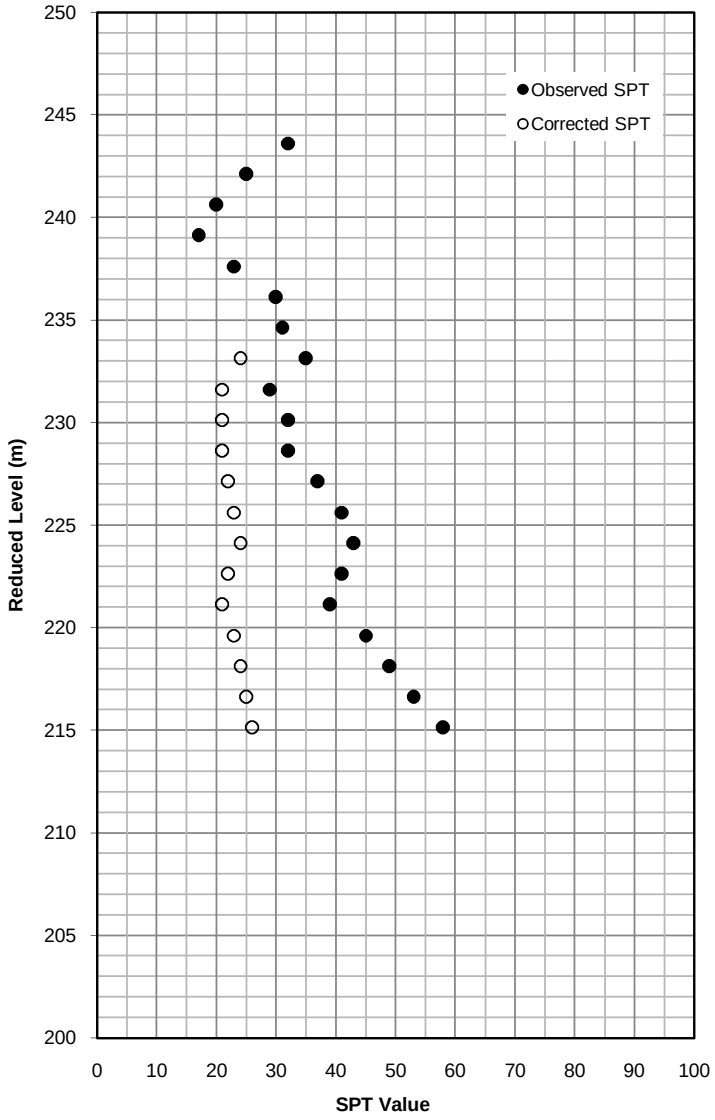


Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 10+540km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.9**	**SHEET No. 1 of 1**



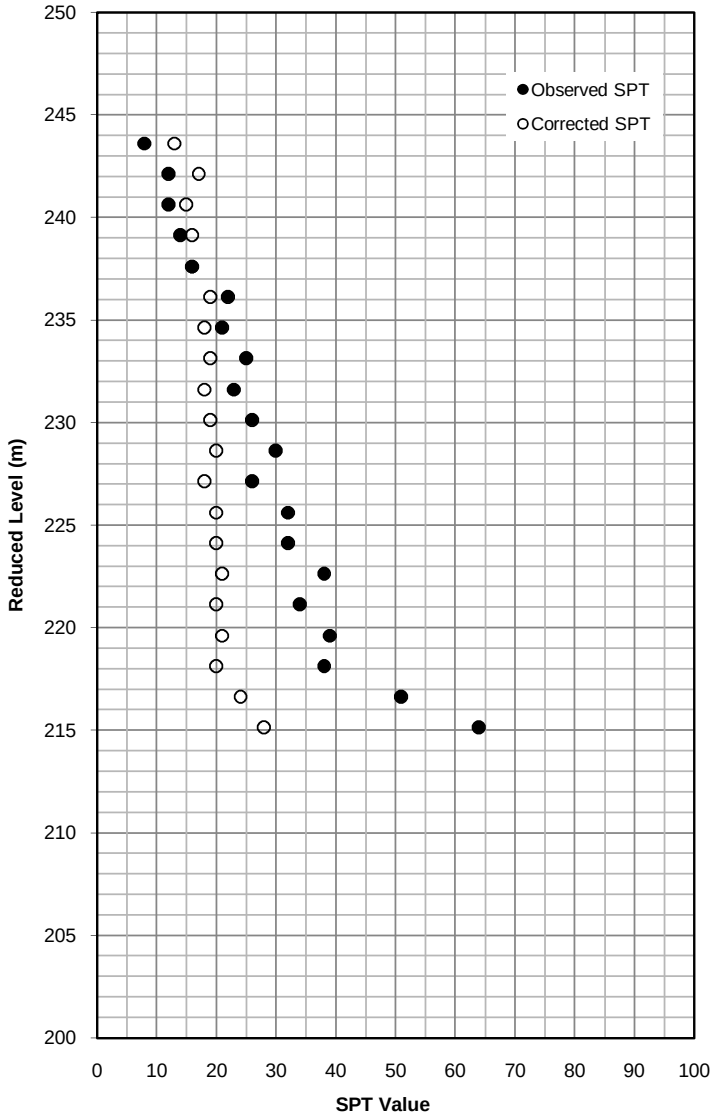
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

CLIENT: Skylark	**Variation of SPT Value with Depth (BH-1)** **Chainage : 11+753km**
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	**FIG. NO.** 3.10 / **SHEET No.** 1 of 1

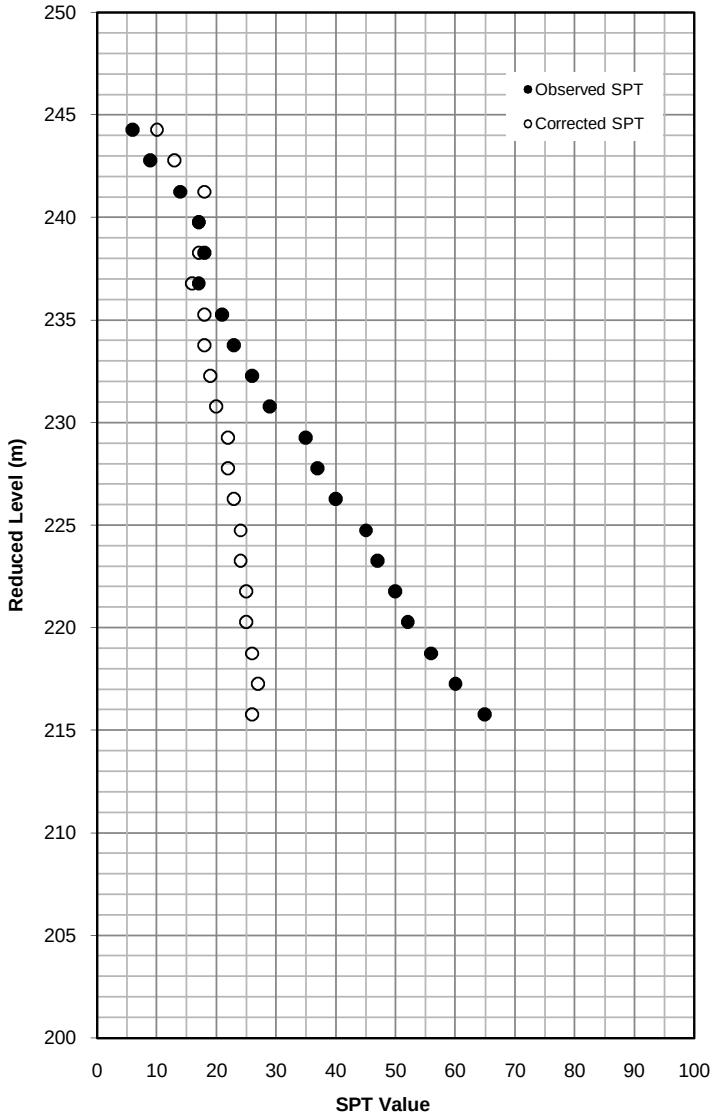


Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

CLIENT: Skylark	**Variation of SPT Value with Depth (BH-1)** **Chainage : 13+260km**
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	**FIG. NO.** 3.11 / **SHEET No.** 1 of 1

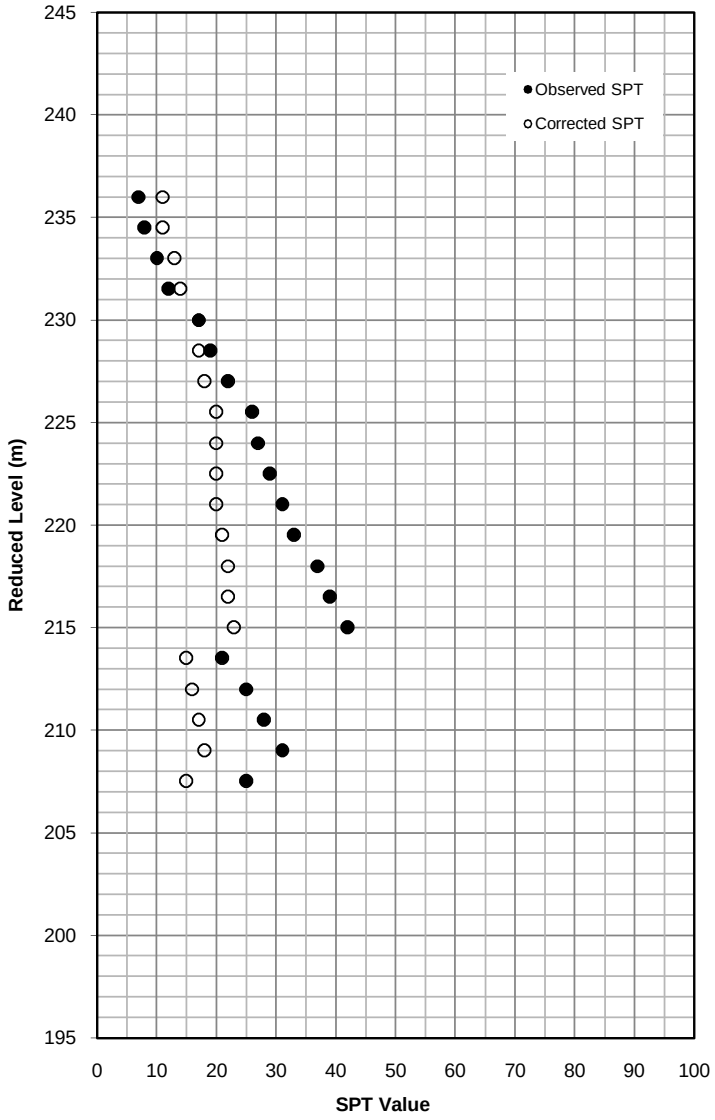


Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut		
CLIENT: Skylark	Variation of SPT Value with Depth (BH-1) Chainage : 14+150km	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.12	SHEET No. 1 of 1

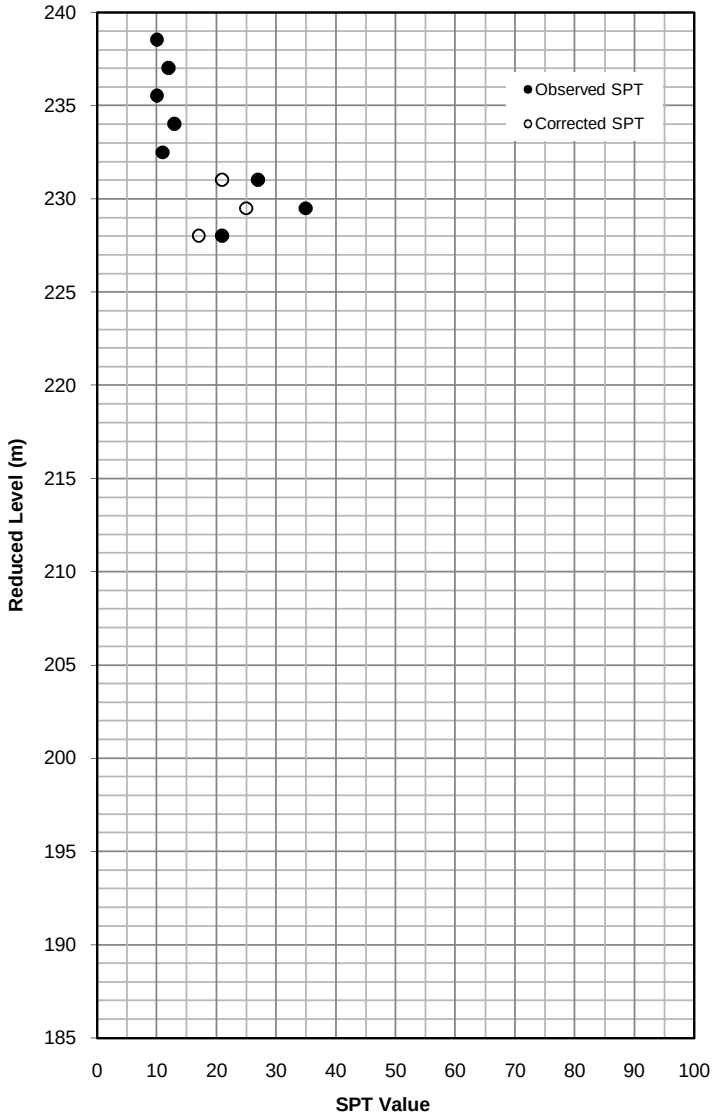


Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

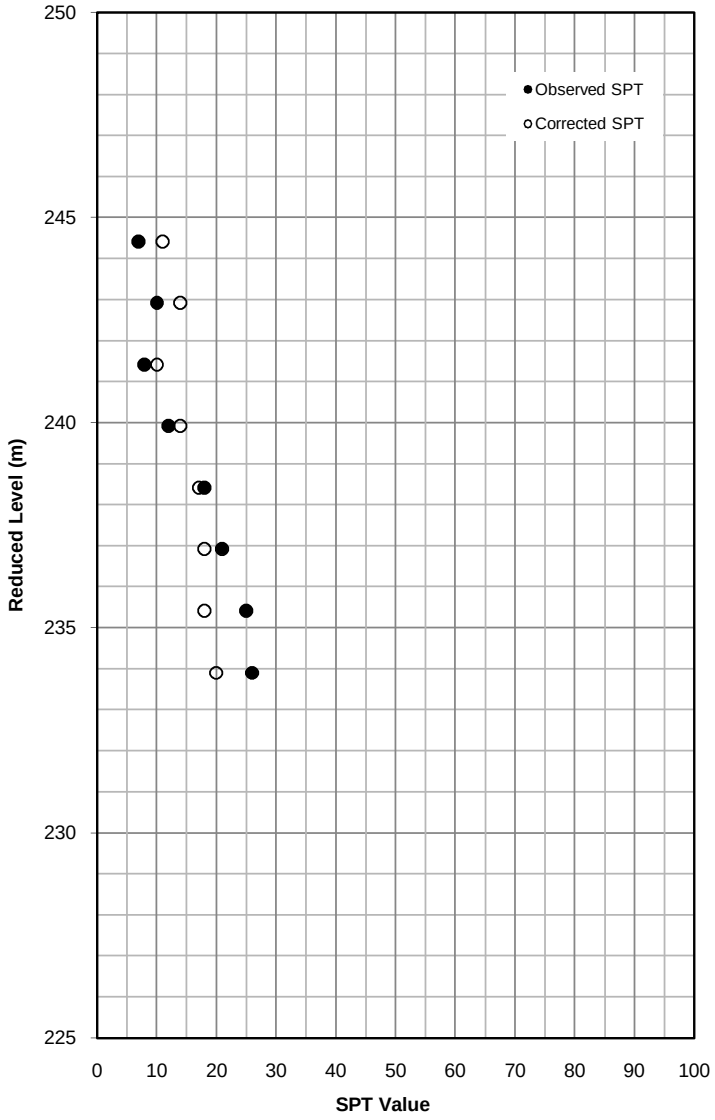
CLIENT: Skylark	**Variation of SPT Value with Depth (BH-1)** **Chainage : 15+800km**
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	**FIG. NO.** 3.13 / **SHEET No.** 1 of 1



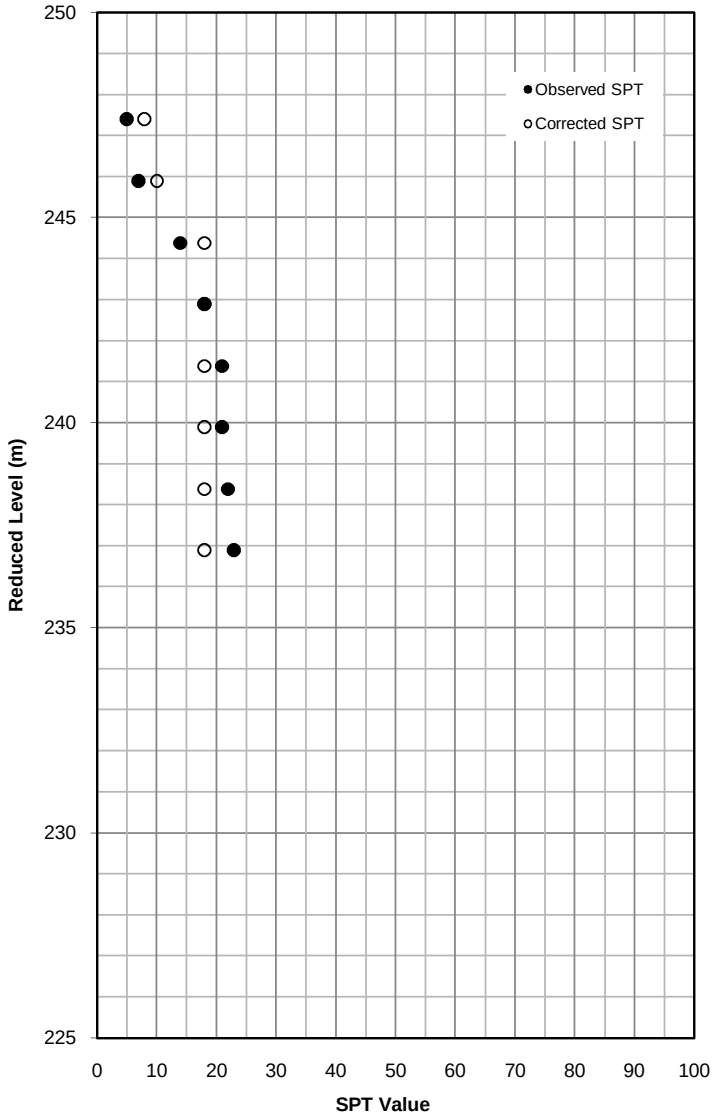
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 17+790km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.14**	**SHEET No. 1 of 1**



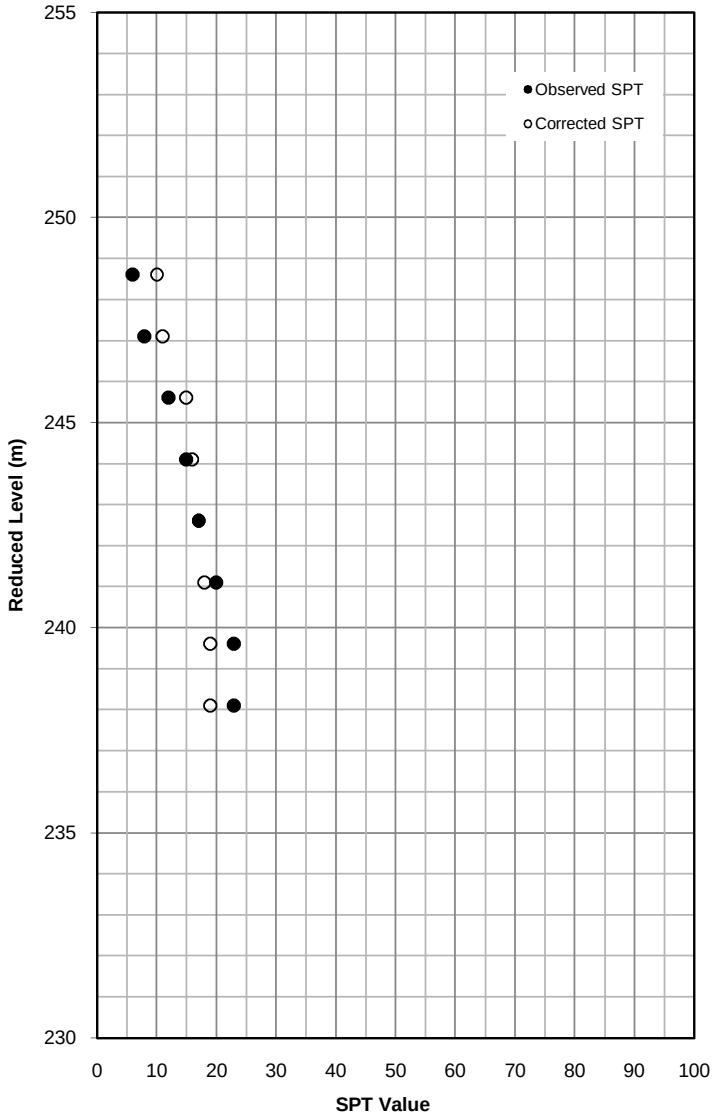
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 18+900km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.15**	**SHEET No. 1 of 1**



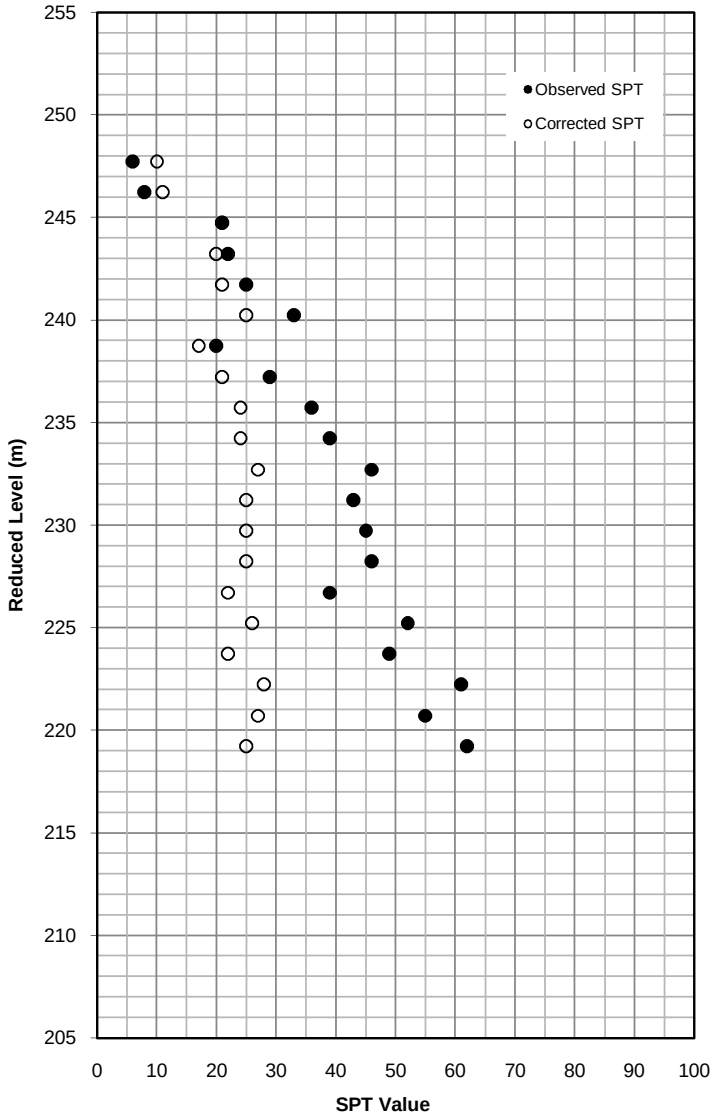
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut		
CLIENT: Skylark	Variation of SPT Value with Depth (BH-1) Chainage : 19+680km	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.16	SHEET No. 1 of 1



Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut		
CLIENT: Skylark	Variation of SPT Value with Depth (BH-1) Chainage : 20+960km	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.17	SHEET No. 1 of 1

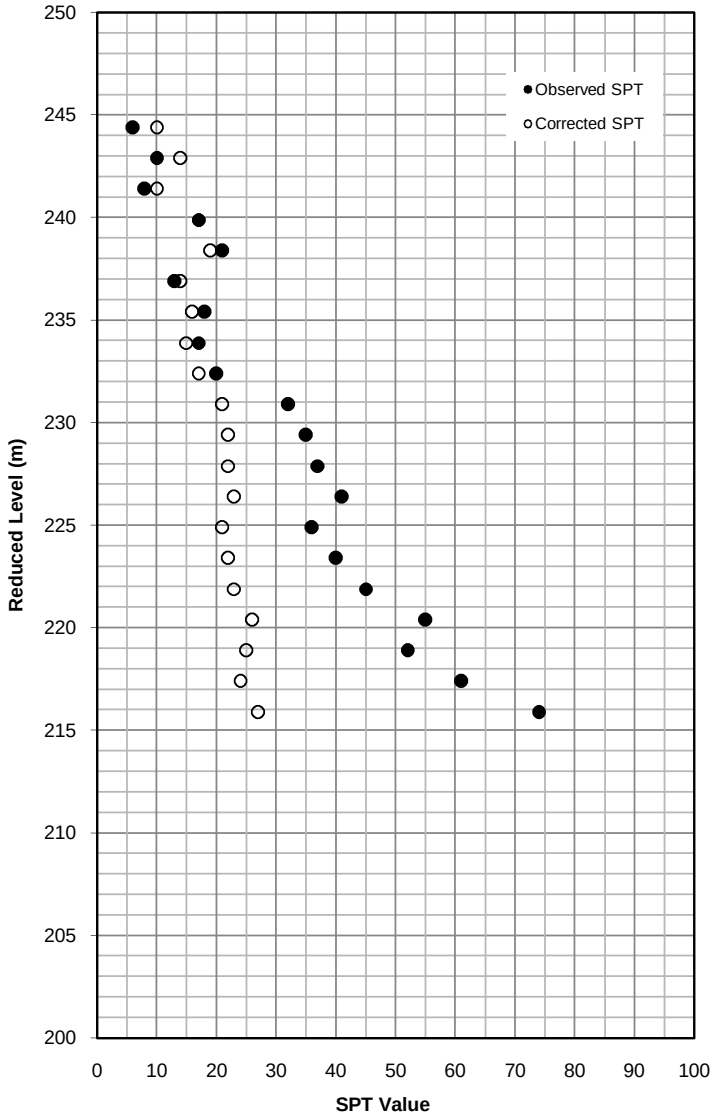


Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut		
CLIENT: Skylark	Variation of SPT Value with Depth (BH-1) Chainage : 22+700km	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.18	SHEET No. 1 of 1



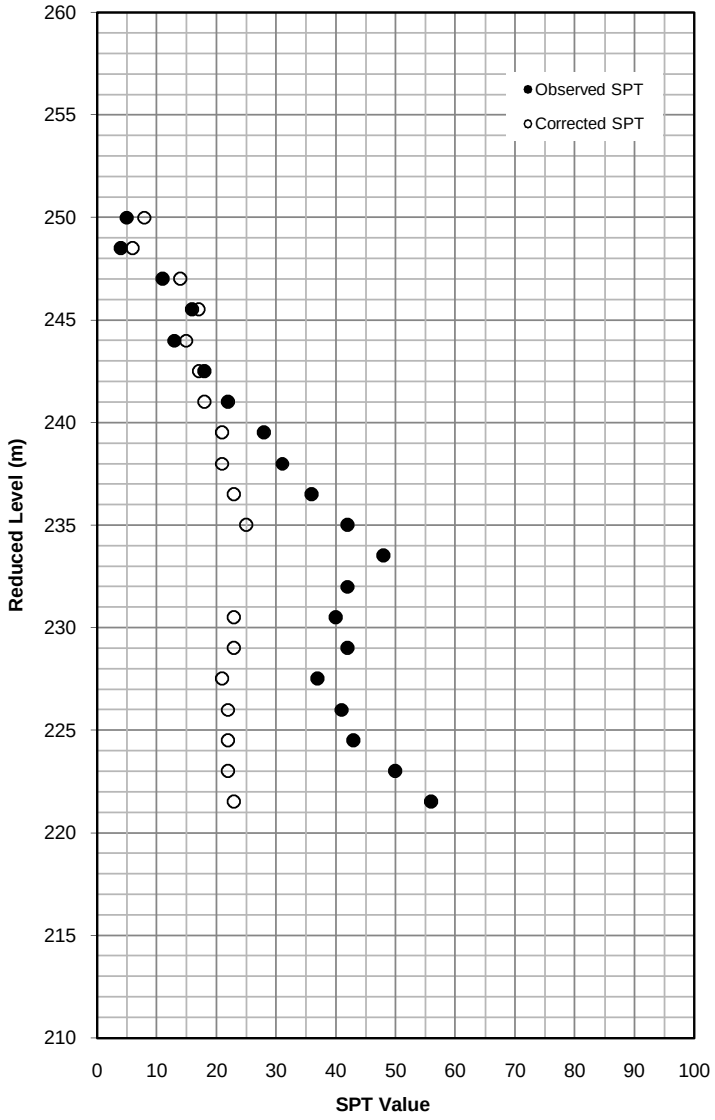
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 24+269km**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.19** / **SHEET No. 1 of 1**



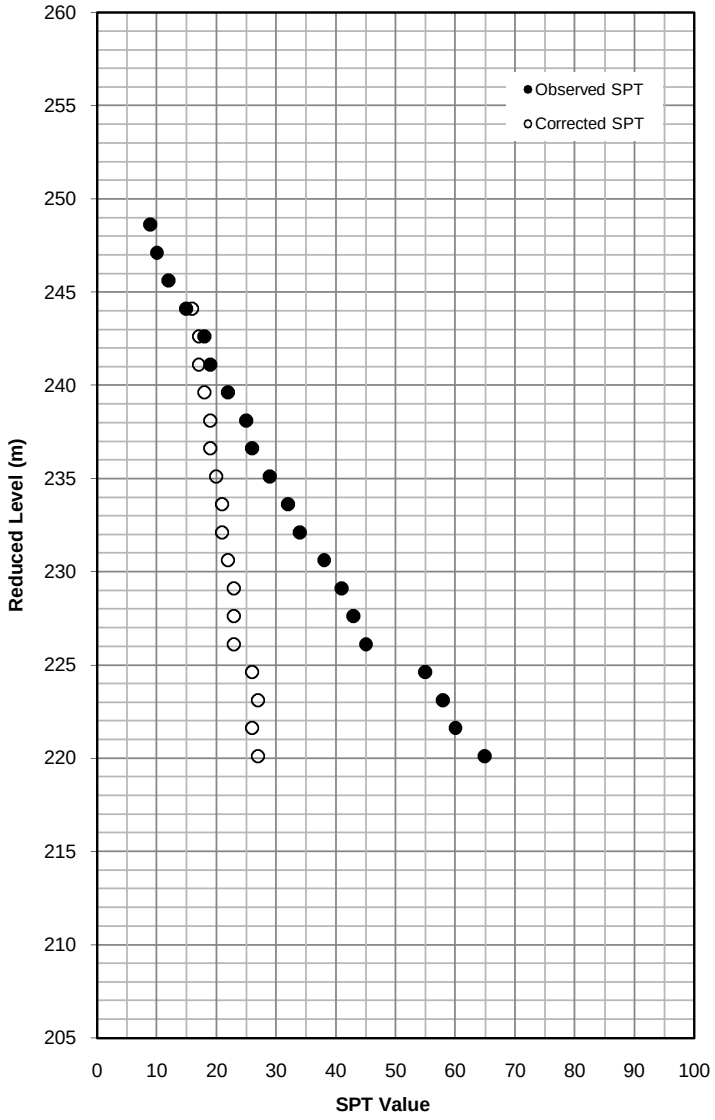
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 25+880km**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.20** / **SHEET No. 1 of 1**



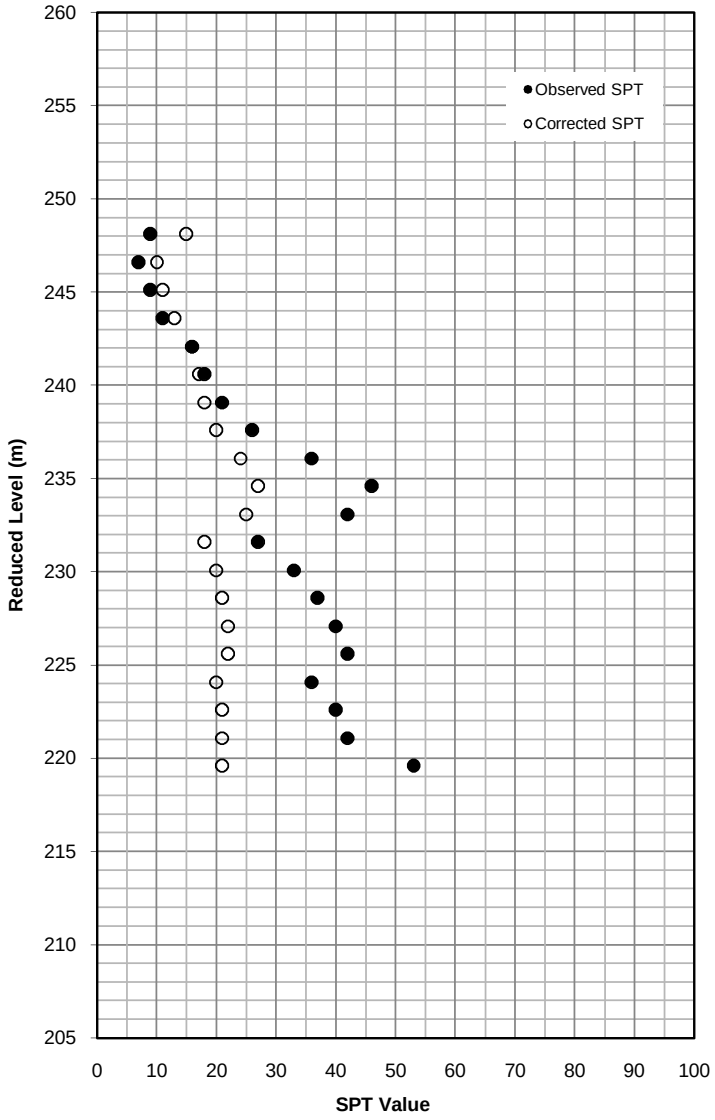
Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

CLIENT: Skylark	**Variation of SPT Value with Depth (BH-1)** **Chainage : 27+960km**
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	**FIG. NO.** 3.21 / **SHEET No.** 1 of 1

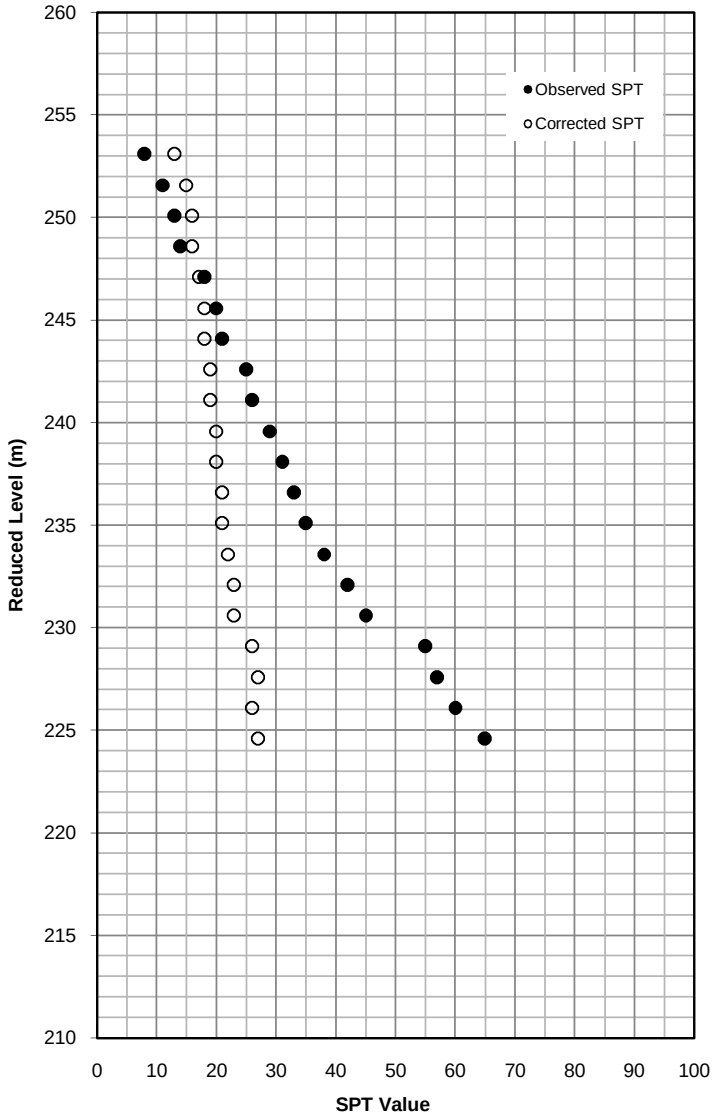


Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

CLIENT: **Skylark**	**Variation of SPT Value with Depth (BH-1)** **Chainage : 28+840km**
CONTRACTOR : **XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.22** / **SHEET No. 1 of 1**

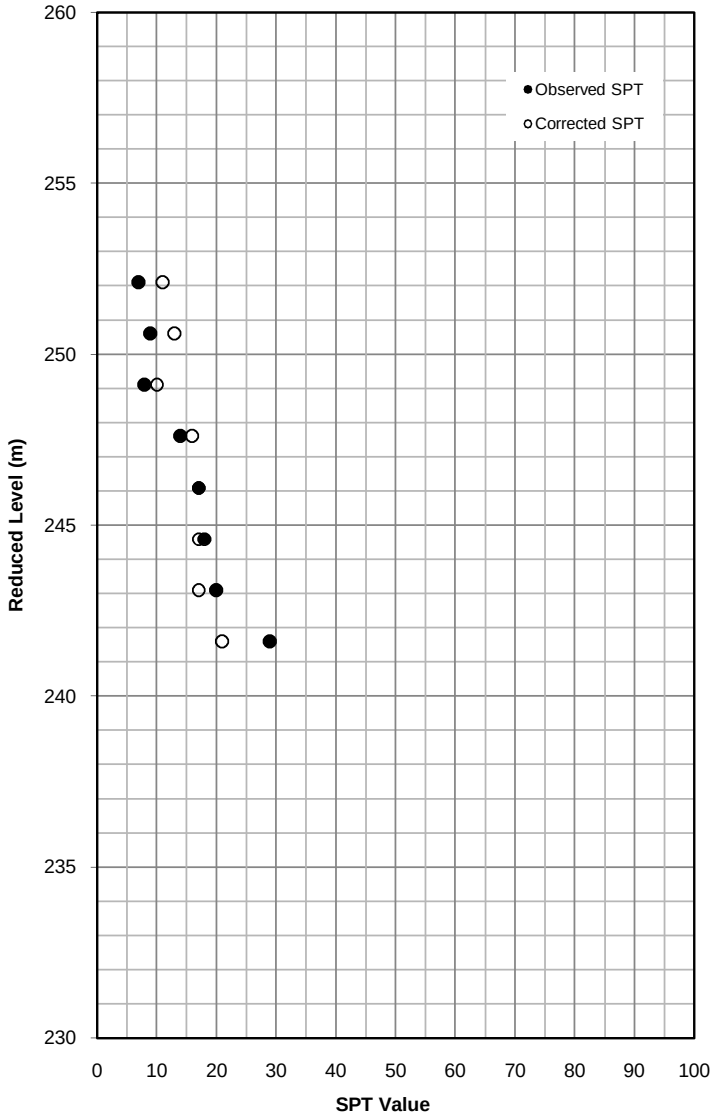


Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 30+236km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.23**	**SHEET No. 1 of 1**

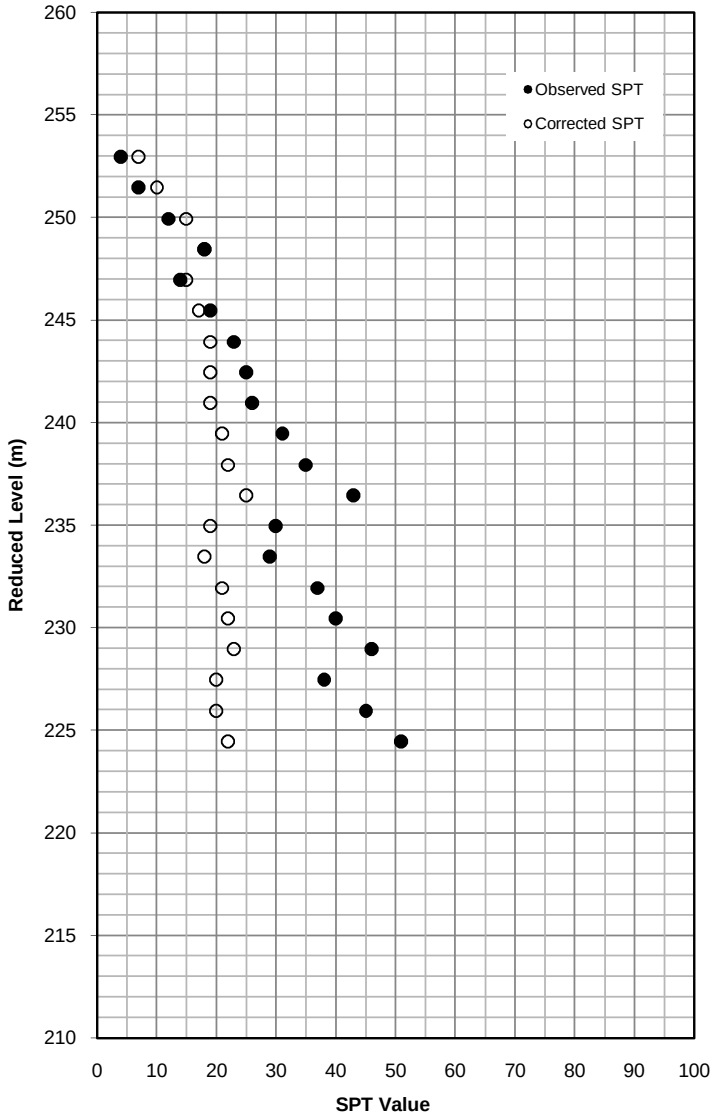


Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

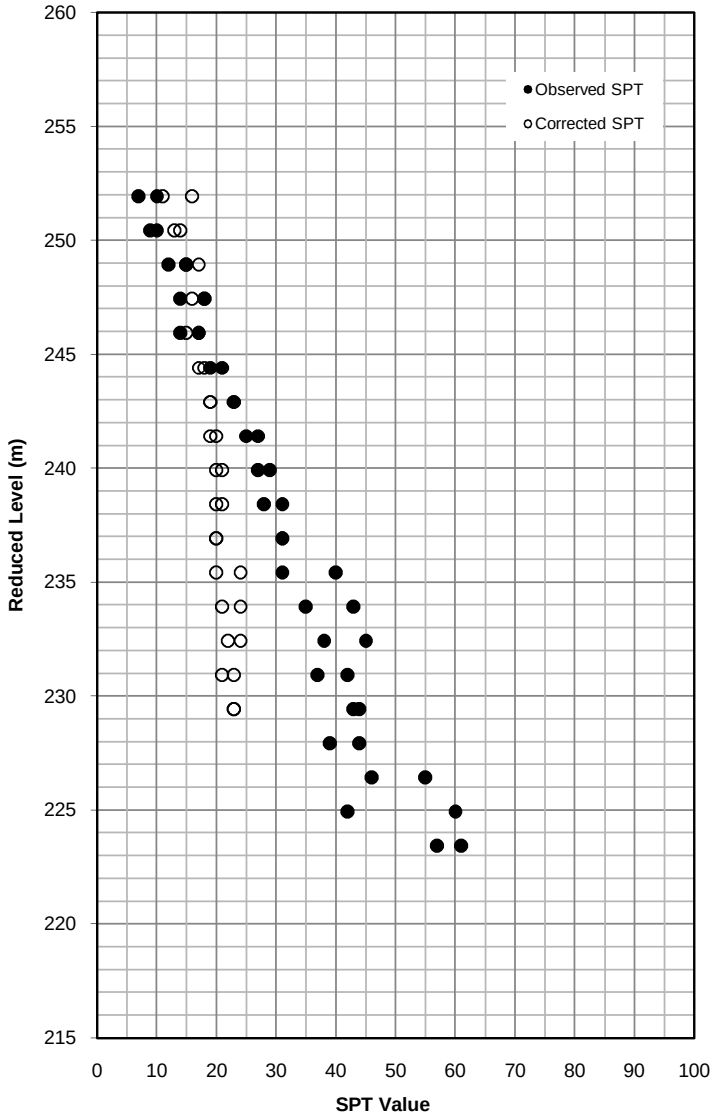
CLIENT: Skylark	**Variation of SPT Value with Depth (BH-1)** **Chainage : 31+820km**
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	**FIG. NO.** 3.24 / **SHEET No.** 1 of 1



Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: **Skylark**		**Variation of SPT Value with Depth (BH-1)** **Chainage : 33+310km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.25**	**SHEET No. 1 of 1**

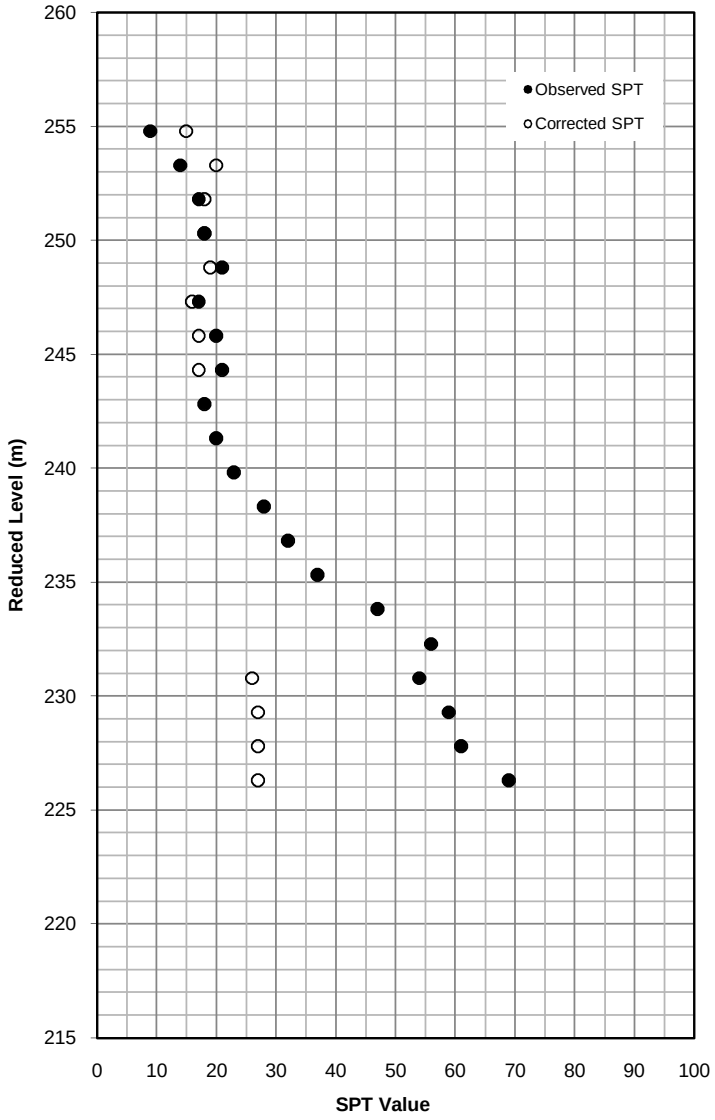


Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut		
CLIENT: Skylark	Variation of SPT Value with Depth (BH-1) Chainage : 34+920km	
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	FIG. NO. 3.26	SHEET No. 1 of 1



Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

CLIENT: Skylark	**Variation of SPT Value with Depth (BH-1& BH-2)** **Chainage : 36+585km**
CONTRACTOR : XPLORER CONSULTANCY SERVICES PVT. LTD.	**FIG. NO.** 3.27 / **SHEET No.** 1 of 1



Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut			
CLIENT: Skylark		**Variation of SPT Value with Depth (BH-1)** **Chainage : 38+930km**	
CONTRACTOR :	**XPLORER CONSULTANCY SERVICES PVT. LTD.**	**FIG. NO. 3.28**	**SHEET No. 1 of 1**

CHAPTER-IV

ANALYSIS AND RECOMMENDATION

4.1 Subsoil Profile

The subsoil stratification as revealed from the borelogs in annexure A indicates that soils mainly comprises of alluvial deposits consisting of clay and fine grained soils. Generally, soils at upper horizons are Sandy SILT (ML) and Silty CLAY (CL). Soils at upper horizon upto 5.0 m depths are found to be in loose to medium dense. The soils below this are generally competent, non-plastic, medium dense to dense Fine SAND. The design parameters have been selected duly considering all the field and laboratory test results and presented in Table 4.1

Table 4.1 Design Subsoil Profile

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	^{0}
1	1+790	I	0	11	11	Medium Dense Silty SAND	16	18	0	30
		II	11	20	9	Medium Dense Sandy SILT	24	19	0	31
		III	20	28	8	Hard Silty CLAY	36	19.5	165	0
		IV	28	30	2	Dense Fine SAND	55	20	0	34
2	1+980	I	0	8	8	Medium Dense Silty SAND	12	18	0	30
		II	8	15	7	Medium Dense Sandy SILT	22	19	0	31
		III	15	20	5	Dense Fine SAND	32	19.5	0	32
		IV	20	30	10	Dense Sandy SILT	41	20	0	32
3	2+010	I	0	8	8	Loose Sandy SILT	8	18	0	28
		II	8	15	7	Very Stiff Silty CLAY	22	19	80	0
		III	15	23	8	Dense Fine SAND	40	19.5	0	32
		IV	23	30	7	Hard Silty CLAY	32	20	185	0

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	^{0}
4	2+286	I	0	4.5	4.5	Loose Silty SAND	7	18	0	30
		II	4.5	12	7.5	Medium Dense Silty SAND	20	19	0	31
5	3+360	I	0	5	5	Loose Sandy SILT	6	18	0	28
		II	5	12	7	Medium Dense Silty SAND	20	19	0	31
6	5+322	I	0	6	6	Loose Silty SAND	6	18	0	29
		II	6	12	6	Very Stiff Silty CLAY	20	19	85	0
7	6+550	I	0	13	13	Medium Dense Silty SAND	16	18	0	30
		II	13	20	7	Dense Silty SAND	32	19	0	31
		III	20	30	10	Hard Silty CLAY	47	20	235	0
8	8+440	I	0	5	5	Stiff Silty CLAY	10	18	50	0
		II	5	12	7	Medium Dense Sandy SILT	22	19	0	31
9	10+540	I	0	6	6	Loose Fine SAND	7	18	0	30
		II	6	12	12	Medium Dense Fine SAND	22	19	0	31
		III	12	25	13	Dense Sandy SILT	32	19.5	0	31
		IV	25	30	5	Dense Silty SAND	40	20	0	33
10	11+753	I	0	6	6	Loose Sandy SILT	7	18	0	29
		II	6	12	6	Medium Sandy SILT	18	19	0	30
		III	12	20	8	Medium Fine SAND	27	19.5	0	31
		IV	20	30	10	Dense Fine SAND	50	20	0	33

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	^{0}
11	13+260	I	0	12	12	Very Stiff Silty CLAY	25	18	110	0
		II	12	20	8	Dense Silty SAND	34	19	0	32
		III	20	30	10	Dense Silty SAND	46	20	0	33
12	14+150	I	0	12	12	Medium Dense Sandy SILT	15	18	0	30
		II	12	20	8	Medium Dense Silty SAND	27	19	0	31
		III	20	30	10	Dense Fine SAND	42	20	0	32
13	15+800	I	0	12	12	Medium Dense Sandy SILT	14	18	0	29
		II	12	20	8	Dense Fine SAND	31	19	0	31
		III	20	30	10	Very Dense Fine SAND	53	20	0	33
14	17+790	I	0	12	12	Medium Dense Sandy SILT	13	18	0	29
		II	12	20	8	Dense Silty SAND	30	19	0	31
		III	20	30	10	Dense Sandy SILT	30	20	0	32
15	18+900	I	0	9	9	Stiff Silty CLAY	11	18	55	0
		II	9	12	11	Medium Dense Silty SAND	27	19	0	31
16	19+680	I	0	5	5	Medium Dense Sandy SILT	8	18	0	29
		II	5	12	7	Medium Dense Silty SAND	20	19	0	31
17	20+960	I	0	5	5	Medium Dense Sandy SILT	6	18	0	28
		II	5	12	7	Medium Dense Silty SAND	20	19	0	31
18	22+700	I	0	4.5	4.5	Loose Sandy SILT	7	18	0	29
		II	4.5	12	7.5	Medium Dense Sandy SILT	18	19	0	30

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	^{0}
19	24+269	I	0	4.5	4.5	Loose Sandy SILT	7	18	0	29
		II	4.5	13	8.5	Medium Dense Sandy SILT	25	19	0	30
		III	13	25	12	Dense Sandy SILT	43	19.5	0	32
		IV	25	30	5	Very Dense Fine SAND	55	20	0	34
20	25+880	I	0	12	12	Medium Dense Sandy SILT	13	18	0	29
		II	12	20	8	Medium Dense Fine SAND	30	19	0	31
		III	20	30	10	Very Dense Fine SAND	52	20	0	34
21	27+960	I	0	12	12	Medium Dense Sandy SILT	12	18	0	28
		II	12	17	5	Dense Fine SAND	31	19	0	31
		III	17	20	3	Hard Silty CLAY	45	19.5	225	0
		IV	20	30	10	Dense Fine SAND	44	20	0	33
22	28+840	I	0	5	5	Stiff Silty CLAY	10	18	48	0
		II	5	16	11	Medium Dense Sandy SILT	22	19	0	30
		III	16	25	9	Dense Sandy SILT	38	19.5	0	31
		IV	25	30	5	Very Dense Fine SAND	59	20	0	33
23	30+236	I	0	6	6	Loose Sandy SILT	8	18	0	29
		II	6	14	8	Medium Dense Sandy SILT	18	19	0	30
		III	14	25	11	Dense Sandy SILT	38	19.5	0	31
		IV	25	30	5	Dense Fine SAND	42	20	0	33
24	31+820	I	0	12	12	Medium Dense Silty SAND	15	18	0	30
		II	12	25	13	Medium Dense Fine SAND	33	19	0	31
		III	25	30	5	Very Dense Fine SAND	59	20	0	33

S.No	Chainage	Soil layer	Depth(m)		Thickness (m)	Soil Type	SPT Value Obs.	Bulk Density	c	φ
		Layer No.	From (m)	To (m)				KN/m^3	KPa	^{0}
25	33+310	I	0	5	9	Medium Dense Sandy SILT	8	18	0	29
		II	5	12	3	Medium Dense Silty SAND	20	19	0	31
26	34+920	I	0	4.5	4.5	Loose Sandy SILT	5	18	0	28
		II	4.5	12	7.5	Medium Dense Sandy SILT	17	19	0	30
		III	12	17	5	Medium Dense Fine SAND	27	19.5	0	31
		IV	17	25	8	Dense Sandy SILT	35	20	0	31
		V	25	30	5	Dense Fine SAND	45	20	0	33
27	36+585	I	0	12	12	Medium Dense Sandy SILT	15	18	0	29
		II	12	20	8	Medium Dense Silty SAND	30	19	0	31
		III	20	25	5	Dense Sandy SILT	41	19.5	0	31
		IV	25	30	5	Hard Silty CLAY	50	20	250	0
28	38+930	I	0	14	14	Medium Dense Sandy SILT	17	18	0	30
		II	14	20	6	Very Stiff Silty CLAY	25	19	100	0
		III	20	25	5	Hard Silty CLAY	46	19.5	230	0
		IV	25	30	5	Very Dense Fine SAND	60	20	0	33

4.2 Ground Water Table

The ground water table as encountered during the site investigation works is presented in Table 4.2.

Table 4.2: Observed Ground Water Table

Chainage (km)	BH No.	Observed Ground Water Table(m)

1+790	BH-1	7.0
	BH-2	6.5
1+980	BH-1	4.0
2+010	BH-1	3.5
2+286	BH-1	10.0
3+360	BH-1	10.5
5+322	BH-1	4.5
6+550	BH-1	3.5
	BH-2	3.7
8+440	BH-1	Not met
10+540	BH-1	13.0
11+753	BH-1	10.0
13+260	BH-1	10.0
14+150	BH-1	7.0
15+800	BH-1	11.0
17+790	BH-1	7.0
18+900	BH-1	7.0
19+680	BH-1	9.0
20+960	BH-1	10.0
22+700	BH-1	10.0
24+269	BH-1	8.0
25+880	BH-1	3.5
27+960	BH-1	6.0
28+840	BH-1	4.5
30+236	BH-1	6.0
31+820	BH-1	7.5
33+310	BH-1	4.5
34+920	BH-1	6.0
36+585	BH-1	4.5
	BH-2	4.0
38+930	BH-1	7.0

It may be noted that the ground water found at shallower depth in most of the borehole and hence it is likely that the GWT will rise during monsoon. Accordingly, the design ground water table (GWT) has been considered at the existing ground surface.

4.3 Liquefaction

As per IS 1893:2002, the site falls under earthquake zone-IV. The top soil upto around 5.0 are loose non plastic silt and sandy soils at various locations and are likely to liquefy during earthquake. The soils below 5.0 m are mainly medium dense to

dense and are not liquefiable. For minor bridges the depth of liquefiable soil layer below founding level is 3.0m; hence for safe design of the structure proper treatment of this 3.0m thick liquefiable layer is required. Hence it is recommended to replace 3.0m natural soil below the founding level by structurally compacted sandy soil compacted to 85% of relative density. With this treatment, the recommended bearing capacities are presented in table 4.3. As major bridges are on pile foundations; the effect of top 5.0m overburden soils on pile capacities has been neglected.

4.4 Recommendations Regarding Type of Foundation

Based on the loading condition, open foundation for minor bridges and pile foundation for major bridges are considered suitable as per the subsoil conditions.

4.4.1 Shallow / Open Foundation

A properly designed foundation has to satisfy two limit states. They are limit state of shear strength and limit state of settlement.
Based on shear strength properties, the net Safe Bearing Capacities are calculated using Hansen's General Bearing Capacity Equation as recommended by Indian Standards with a Factor of Safety equal to 2.5 which takes care of L/B ratio, depth of foundation etc. along with other parameters. The calculations have been performed as per IS: 6403 using following equation:

$$Q\ (Safe, Net) = \frac{\left((C.N_c.S_c.d_c.i_c)+\left((y*D).(N_q-1).S_q.d_q.i_q\right)+\left(0.5.B.\gamma.N_\gamma.S_\gamma.d_\gamma.i_\gamma.W\right)\right)}{FS}$$

Where, C = Cohesion in kPa

N_c, N_q&N_γ = Bearing Capacity Factors taken from IS: 6403

S_c, S_q&S_γ = Shape Factors taken from IS: 6403

d_c, d_q&d_γ = Depth Factors taken from IS: 6403

i_c, i_q&i_γ = Inclination Factors taken from IS: 6403

γ = Unit Weight in kN/m^3

D = Depth of foundation in m

B = Width of foundation in m

W = Correction factor for water table (Taken as 0.5)

FS = Factor of Safety (2.5)

Detailed calculations are presented in Annexure – B

The foundation settlements are estimated using compressibility characteristics of the sub-soils. Computations are performed using isotropic stress distribution. The settlement for each layer is obtained and total settlement is arrived by adding

components of each layer. This is corrected for depth factor as recommended by Fox and rigidity factor. Settlement analyses have been performed as per IS: 8009 – Part I using following equations:

For Clayey (Plastic) Soils

Settlement (Δ in mm) = m_v*H*ΔP*μ_g*d_f*Rigidity Factor

Where, m_v = Coefficient of volume compressibility

H = Thickness of layer in m

ΔP = Pressure Increment = P*I

P = Design Bearing Capacity in kPa

I = Influence Factor for Immediate Settlement taken from Fig.18 of IS: 8009 (Part-I)

μ_g = A Factor Related to Pore Pressure Parameter A and the Dimensions of Loaded Area (From Table 1 of IS: 8009 (Part-1))

d_f = Depth Factor taken from Fig.12 of IS:8009 (Part-I)

Rigidity Factor = 0.8 taken from IS: 8009 (Part-I)

For Non-Plastic Soils (Sand/Silt)

Settlement (Δ in mm) = $2.303*\frac{H}{C}*\text{Log}_{10}((Po+\Delta P)/Po)*d_f*$Rigidity Factor

Where, H = Thickness of layer in m

ΔP = Pressure Increment = P*I

P = Design Bearing Capacity in kPa

I = Influence Factor for Immediate Settlement taken from Fig.18 of

IS: 8009 (Part-I)

d_f = Depth Factor taken from Fig.12 of IS: 8009 (Part-I)

Rigidity Factor = 0.8 taken from IS: 8009 (Part-I)

P_o = Overburden Pressure in kN/m^2

C = 1.5 x (C_{kd}/ P_o)

C_{kd}/N – Taken from available correlations as per IS 2911 (Part1, Sec-2).

Detailed calculations are presented in Annexure – B

Allowable Bearing Capacities have been estimated for an allowable settlement of 25mm. The estimated safe and allowable bearing capacities are presented in Table 4.3

Table 4.3: Estimated Safe and Allowable Bearing Capacities

Location	Depth of Foundation(m)	Size of Foundation(m)	Shape	Safe Bearing capacity from Shear (KPa)	Allowable Bearing Capacity (KPa)
					25mm
2+286	2.0	5.5X4.5	Rectangular	135	90
18+900	2.0	5.5X4.5	Rectangular	140	90
19+680	2.0	5.5X4.5	Rectangular	135	100
22+700	2.0	5.5X4.5	Rectangular	135	85
33+310	2.0	5.5X4.5	Rectangular	135	100

4.4.2 Pile Foundations

The computation of pile capacities has been carried out as per IS: 2911 (Part I/ Sec 2) – 2010 using following equation:

Ultimate Pile Capacity = Sum of skin friction for various layers + end bearing

$$= \Sigma f_u A_s + q_u A_p$$

For Non-Plastic (SAND/SILT) Soils,

Skin Friction, f_u (in kN) = $K*P_o*\tan\delta$

Where,

K = Coefficient of Earth Pressure (Taken as 1 from IS 2911 (Part1, Sec1))

P_o = Overburden Pressure in kN/m^2 at the centre of the layer (Limited to 15 times pile diameter)

$\delta = \varphi$

End Bearing, q_u (in kN) = $P_o * N_q$

Where,

P_o = Overburden Pressure in kN/m^2 at the pile tip (Limited to 15 times pile diameter)

Nq = Taken From Fig.1 of Amendment No.1 of IS: 2911 (Part1, Sec-2)-2010

For Plastic (CLAY) Soils,

Skin Friction, f_u (in kN) = α*C

Where, C = Cohesion in kPa (taken from laboratory test results / available correlations with SPT.)

α = Reduction Factor Taken From IS:2911 (Part-1, Sec-2)-2010

End Bearing, q_u (in kN) = 9*C

A factor of safety of 2.5 has been adopted for both skin friction and end bearing to arrive at allowable pile capacity. For estimating uplift capacity a FOS of 3 has been applied on the skin friction component.
Calculations are presented in Annexure-B

Pile head deflection has been estimated for both fixed and free head conditions as per Annexure-D (Addendum No.3) of IS 2911 Part1 Sec2. Lateral capacity has been estimated corresponding to a deflection of 1% of diameter (i.e., 10mm 12 mm for 1200mm dia. piles) at pile head or at bottom of liquefiable layer. For working piles, as the rotation at the pile head is restrained, capacity corresponding to fixed head has to be considered. Grade of concrete considered is M30. The Pile Capacities are presented in Table 4.4 below

Table 4.4 Recommended Pile Capacities

Chainage (km)	Structures	Pile Dia (m)	Pile Length below COL (m)	Comp. (T)	Pull out (T)	Lateral Capacity(T)	
						Fixed Head	Free Head
1+790	Major Bridge	1.0	28.0	300	160	32	12
		1.2	28.0	400	200	50	20
1+980	Major Bridge	1.0	23.0	300	150	25	10
		1.2	20.0	400	160	42	16
6+550	Major Bridge	1.0	28.0	280	170	32	12
		1.2	28.0	350	200	50	20
10+540	Major	1.0	26.0	320	130	17	5

	Bridge	1.2	22.0	320	110	29	9
11+753	Major Bridge	1.0	25.0	300	120	15	5
		1.2	18.0	450	130	27	9
13+260	Major Bridge	1.0	21.0	320	140	18	7
		1.2	17.0	350	130	25	10
14+150	Major Bridge	1.0	24.0	300	150	30	11
		1.2	21.0	400	160	48	19
15+800	Major Bridge	1.0	24.0	300	110	16	6
		1.2	21.0	400	110	28	9
17+790	Major Bridge	1.0	28.0	300	150	16	6
		1.2	21.0	300	100	28	9
24+269	Major Bridge	1.0	26.0	350	140	21	7
		1.2	21.0	350	110	37	13
25+880	Major Bridge	1.0	22.0	300	100	18	6
		1.2	22.0	470	120	30	10
27+960	Major Bridge	1.0	24.0	300	110	17	6
		1.2	21.0	400	100	28	10
28+840	Major Bridge	1.0	26.0	380	180	11	4
		1.2	22.0	400	180	16	6
30+236	Major Bridge	1.0	26.0	300	120	15	5
		1.2	21.0	300	100	27	9
31+820	Major Bridge	1.0	26.0	360	170	30	11

		1.2	23.0	400	180	48	19
34+920	Major Bridge	1.0	26.0	330	140	18	6
		1.2	23.0	350	140	30	10
36+585	Major Bridge	1.0	20.0	240	110	30	11
		1.2	20.0	350	150	48	19
38+930	Major Bridge	1.0	26.0	320	140	34	13
		1.2	26.0	480	180	54	21

4.5 Chemical Properties of Water

A summary of chemical properties results of water is presented in Table 4.5.

Table 4.5 Chemical Properties Test Results

Chainage	BH. No.	Soil-Water Extract		
		SO_3(mg/l)	Cl(mg/l)	pH value
1+790	BH-1	Nil	99.29	7.72
1+980	BH-1	Nil	119.15	7.52
2+010	BH-1	Nil	109.22	7.81
2+286	BH-1	Nil	109.22	7.54
3+360	BH-1	Nil	119.15	7.55
5+322	BH-1	Nil	79.43	7.66
6+550	BH-1	Nil	89.36	7.45
8+440	BH-1	Nil	109.22	7.81
10+540	BH-1	Nil	89.36	7.45
13+260	BH-1	Nil	99.29	7.65
14+150	BH-1	Nil	79.43	7.25
15+800	BH-1	Nil	109.22	7.50
17+790	BH-1	Nil	119.15	7.21
18+900	BH-1	Nil	109.22	7.39
19+680	BH-1	Nil	129.07	7.10
20+960	BH-1	Nil	148.93	6.99
22+700	BH-1	Nil	139.00	7.01
24+269	BH-1	Nil	109.22	7.15
25+880	BH-1	Nil	129.07	7.11
27+960	BH-1	Nil	119.15	7.05

28+840	BH-1	Nil	109.22	7.30
30+236	BH-1	Nil	129.07	7.12
31+820	BH-1	Nil	109.22	7.02
33+310	BH-1	Nil	119.15	7.14
34+920	BH-1	Nil	158.86	7.26
36+585	BH-1	Nil	148.93	7.19
	BH-2	Nil	119.15	7.20
38+930	BH-1	Nil	109.22	7.22

As per Table 3, IS: 456-2000, the exposure conditions for foundation works is low. As seen from the chemical analysis of subsoil and ground water the pH value is in near neutral condition (between 6 to 8). The SO_3 content of ground water falls in Class 1 (Table 4, IS: 456-2000).

The chloride contents in ground water are generally low. There is no specific recommendation in IS: 456 as regard to allowable limits of chloride in ground water. Warnings on chlorides in concrete are given in terms of chlorides coming from mix constituents like use of chloride based admixtures or contaminated aggregates rather than penetration of chlorides into concrete from environment.

4.6 Conclusions

- The findings presented in this report are based the subsoil conditions as found at the borehole locations. In case of any variation in subsoil conditions at the actual foundation location the matter shall be referred to the designer.
- In general the soils encountered at the investigated sites mainly comprises of non-plastic alluvial deposits of sandy silt and medium to dense fine sand with intermittent clayey soil.
- For the proposed Minor & Major Bridges, open and pile foundation are investigated respectively. The recommendation bearing and pile capacities are presented in Table 4.3 and Table 4.4
- After excavation, the founding strata shall be thoroughly checked and if any variation is found between the strata encountered and that reported in this report the matter shall be referred to the designer.
- The bearing and pile capacities can be increased under wind/seismic loading conditions as per provisions in relevant IS and/or IRC codes. The pile capacities need to be ascertained at site by conducting initial load tests.

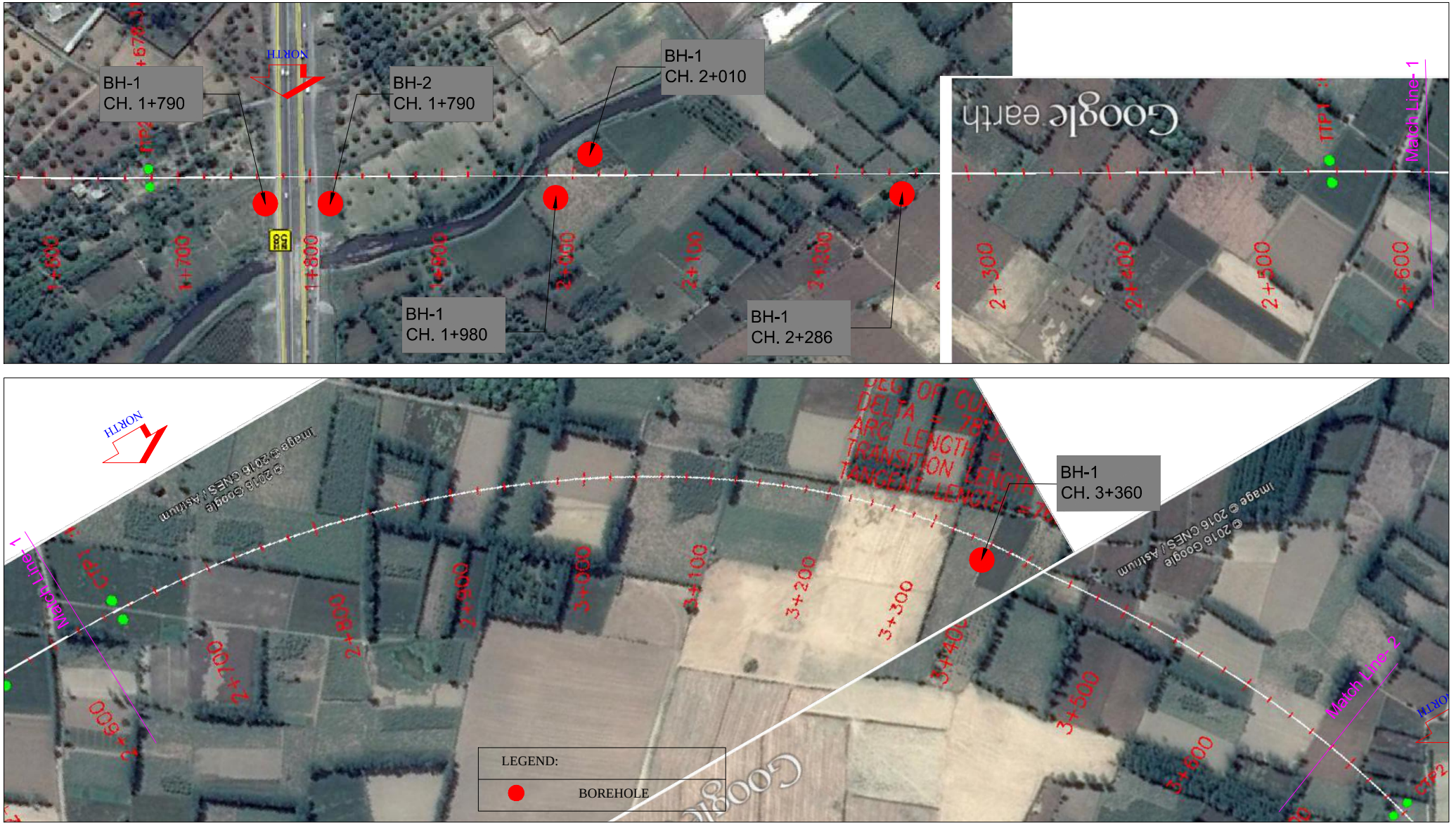
(P.K. KUNDU)

List of References

S. No.	References
1	IS: 2131-1981:- Method For Standard Penetration Test For Soils.
2	IS: 1498-1970:- Classification and Identification of Soils For General Engineering Purposes.
3	IRC: 5 -1998:- Standard Specifications and Code of Practice For Road Bridges (Section-I – General Features of Design)
4	IRC: 78 -2014:- Standard Specifications and Code of Practice For Road Bridges (Section-VII – Foundations and Substructure)
5	IS: 1904-1986:- Code of Practice for Design and Construction of Foundations in Soils.
6	IS:2911 Part1,Sec-2-2010:- Design and Construction of Pile Foundations Bored Cast in-Situ Concrete piles
7	Foundation Analysis and Design by J.E. Bowles, McGraw-Hill, 1997
8	Settlement of Structures on Clay Soils by C.J.Padfield, M.J.Sharrock, Construction Industry Research and Information Association, 1983
9	Foundation Design and Construction by M. J. Tomlinson, Prentice Hall, 2001
10	Soil Mechanics in Engineering by Karl Terzaghi, Read Books, 2010
11	Foundation Design Manual by N.V. Nayak, Dhanpat Rai Publications, New Delhi, 1996
12	Geotechnical Engineering Hand Book by M. Carter, Pentech Press, 1983
13	Correlations of Soil Properties by Michael Carter and Stephen P Bentley, Pentech, 1991

ANNEXURE A

- LOCATION PLAN
- BORELOGS
- SOIL PROFILE



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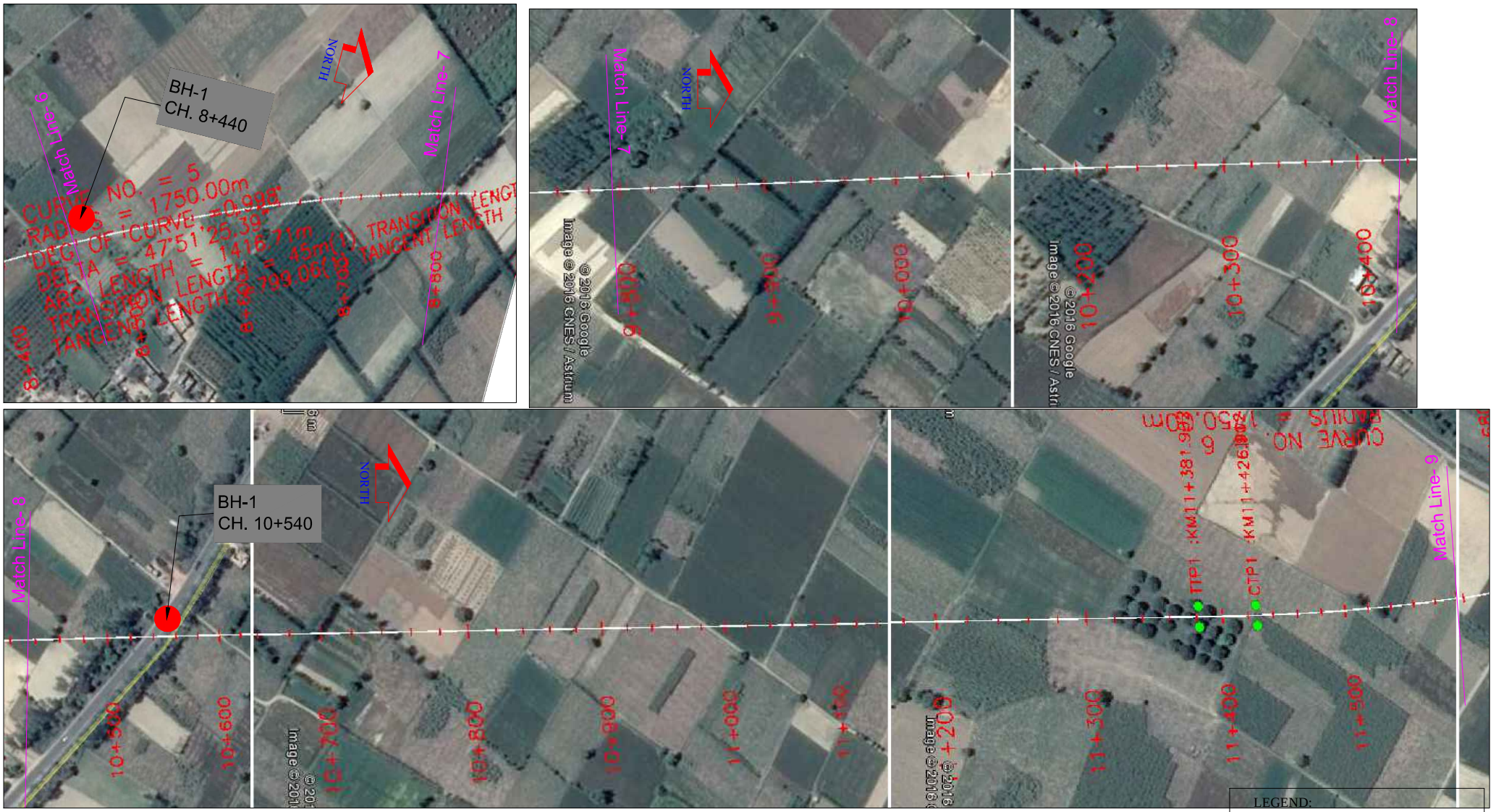

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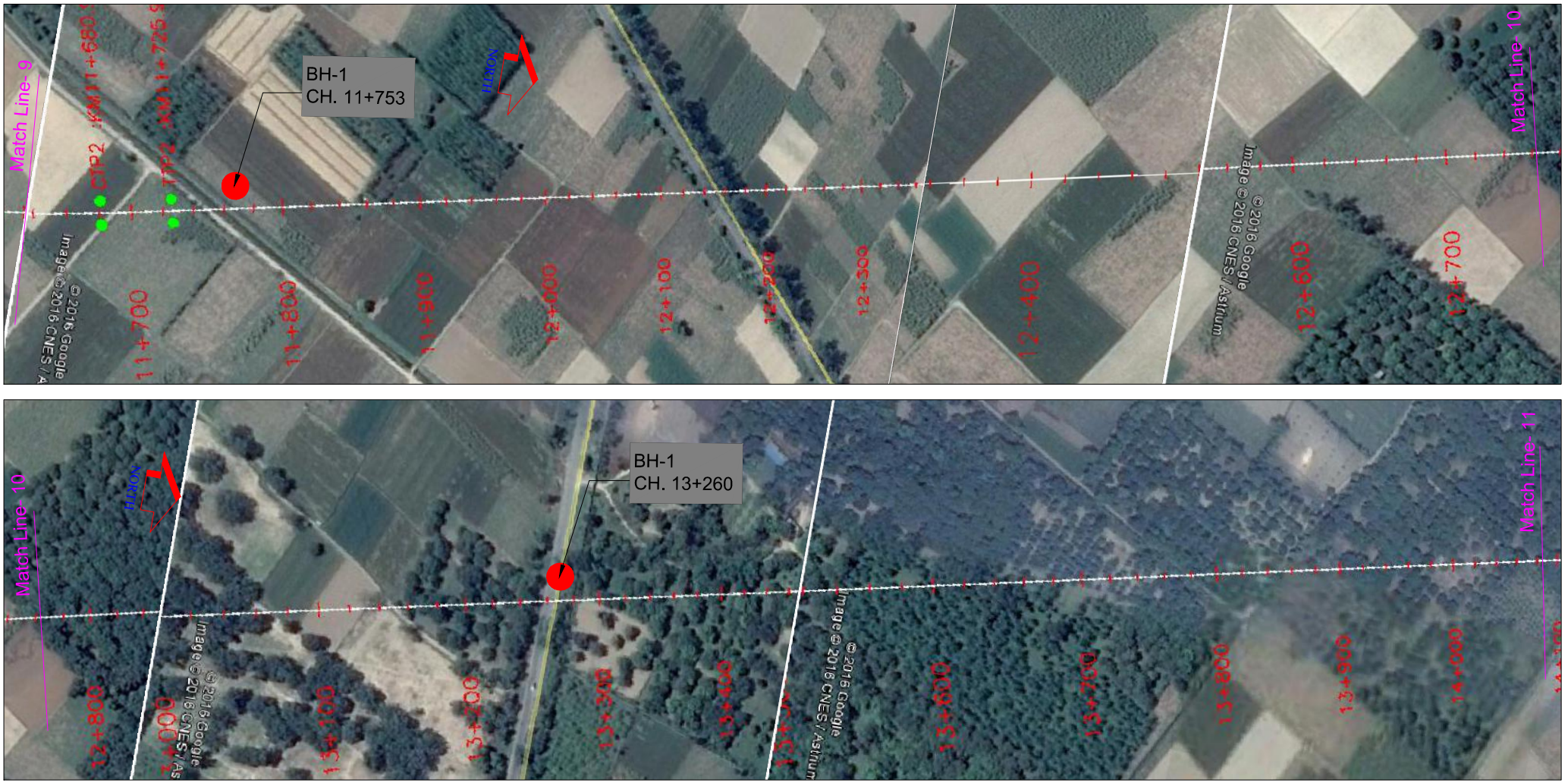

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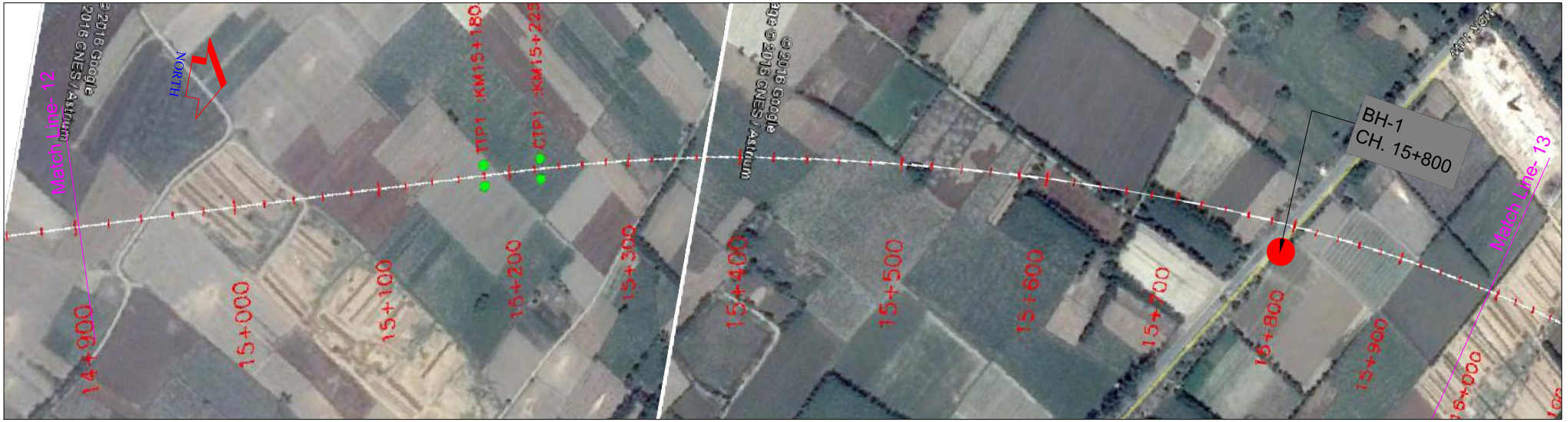

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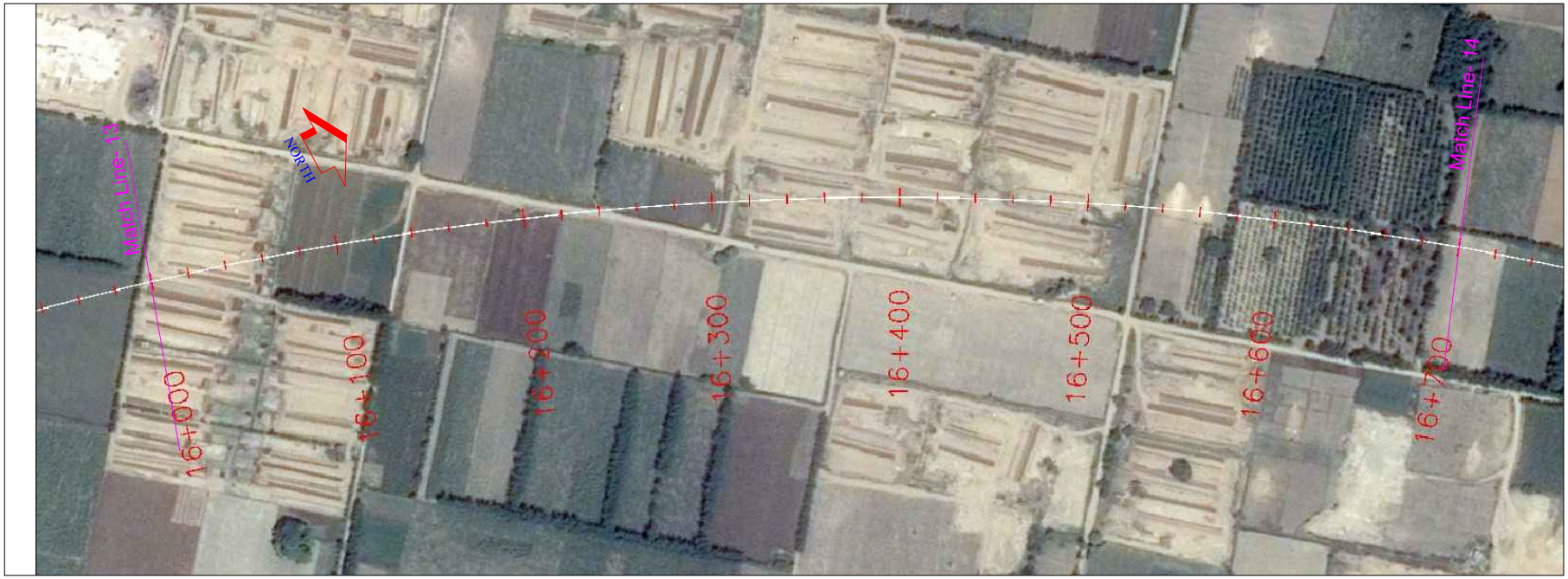

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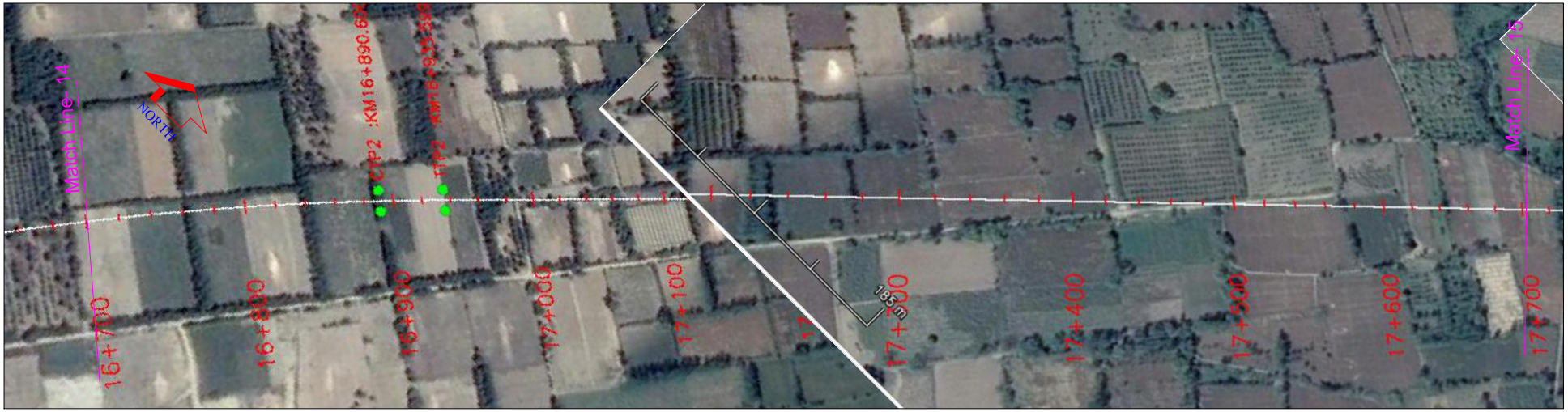

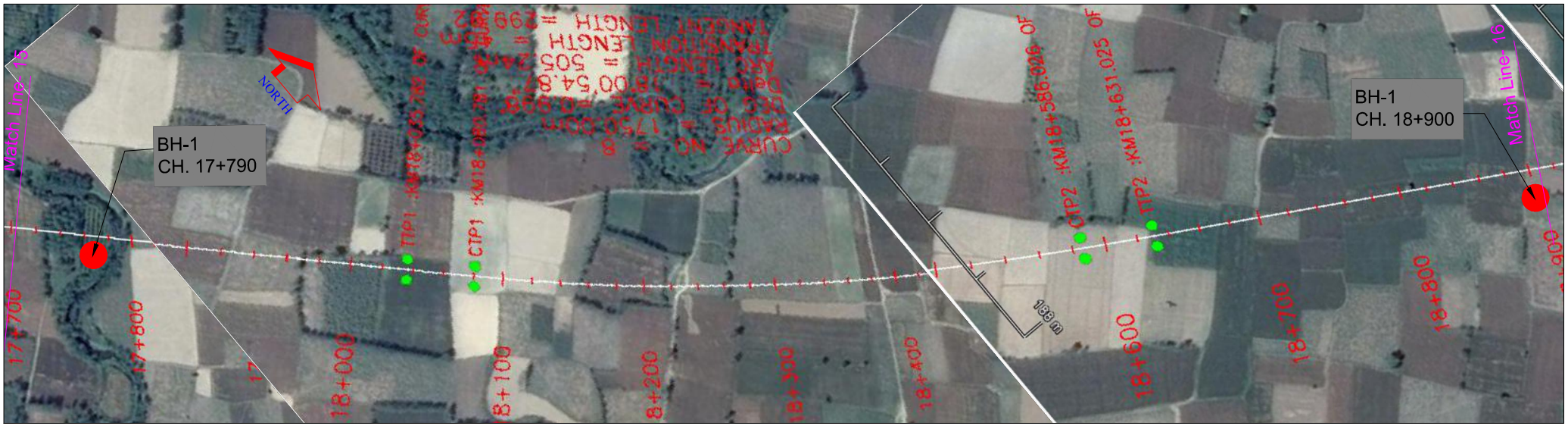

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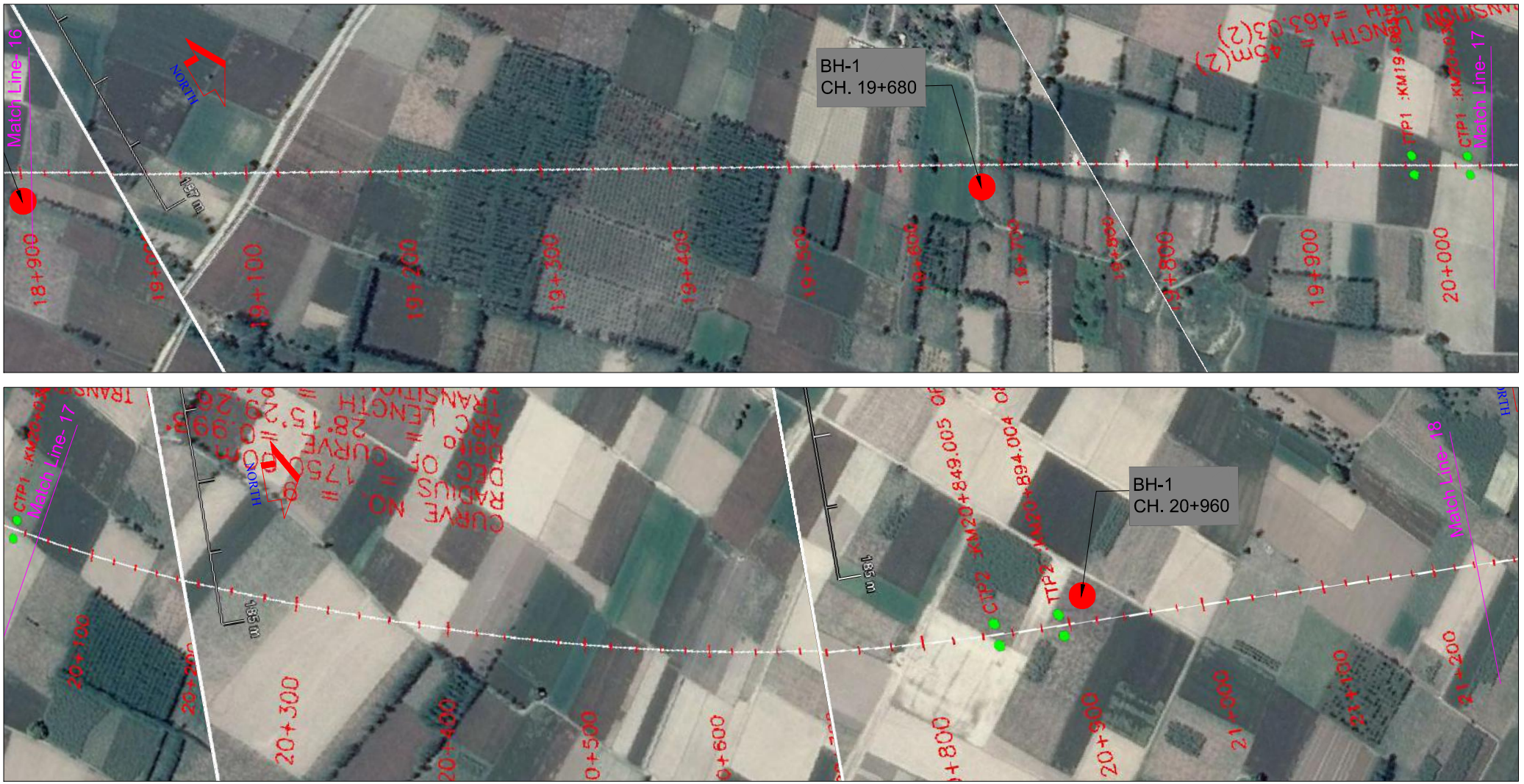

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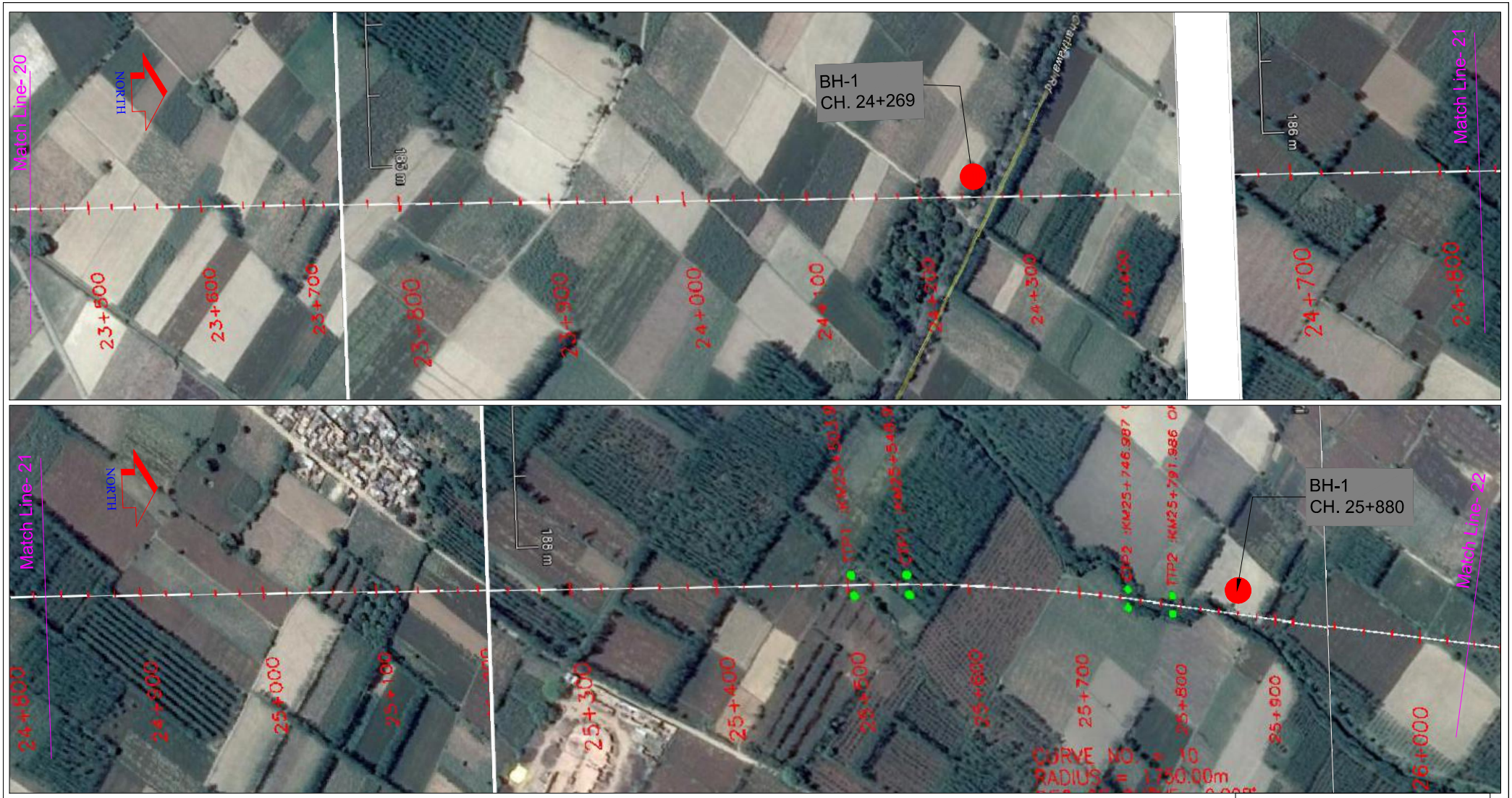

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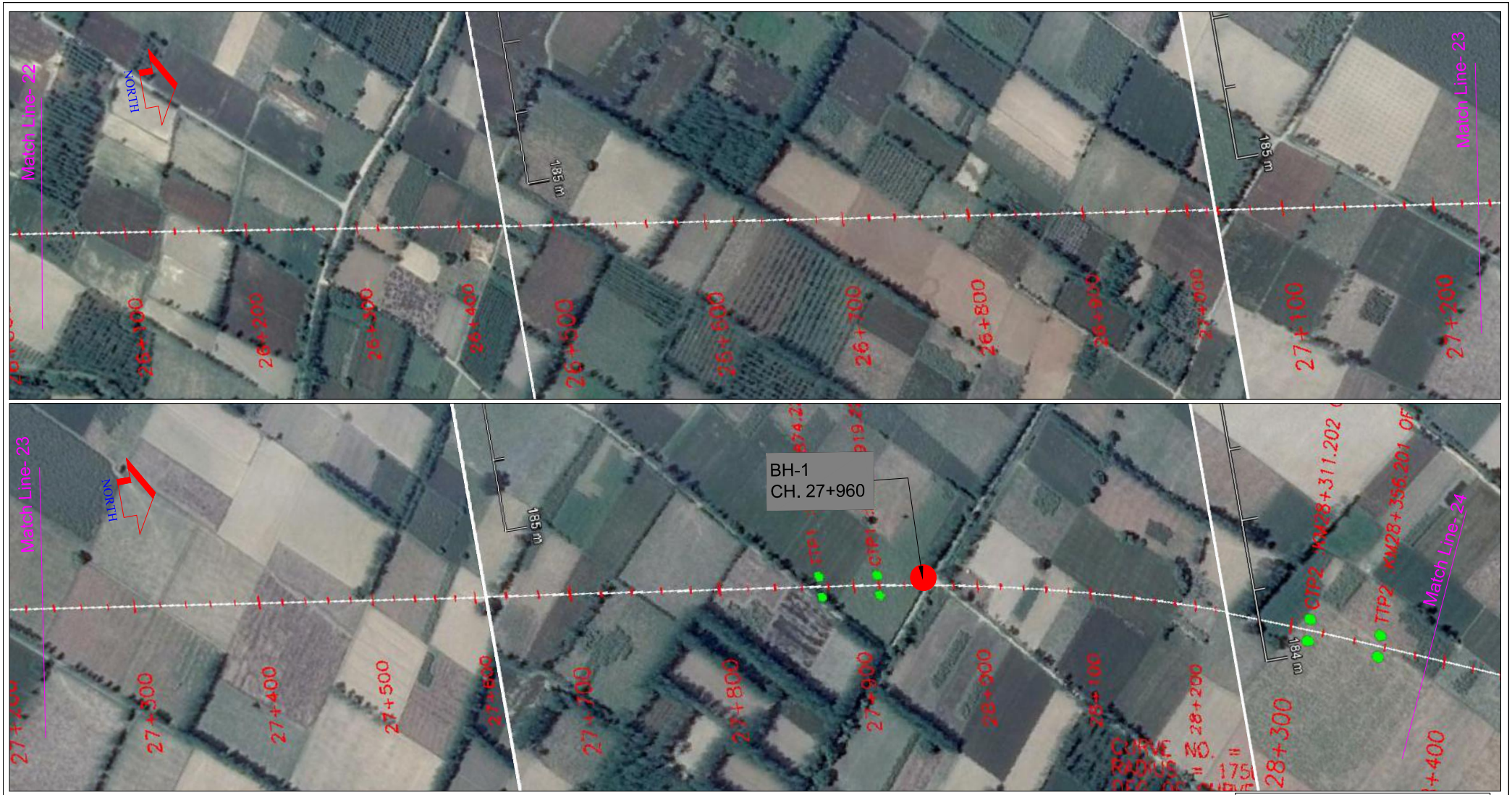


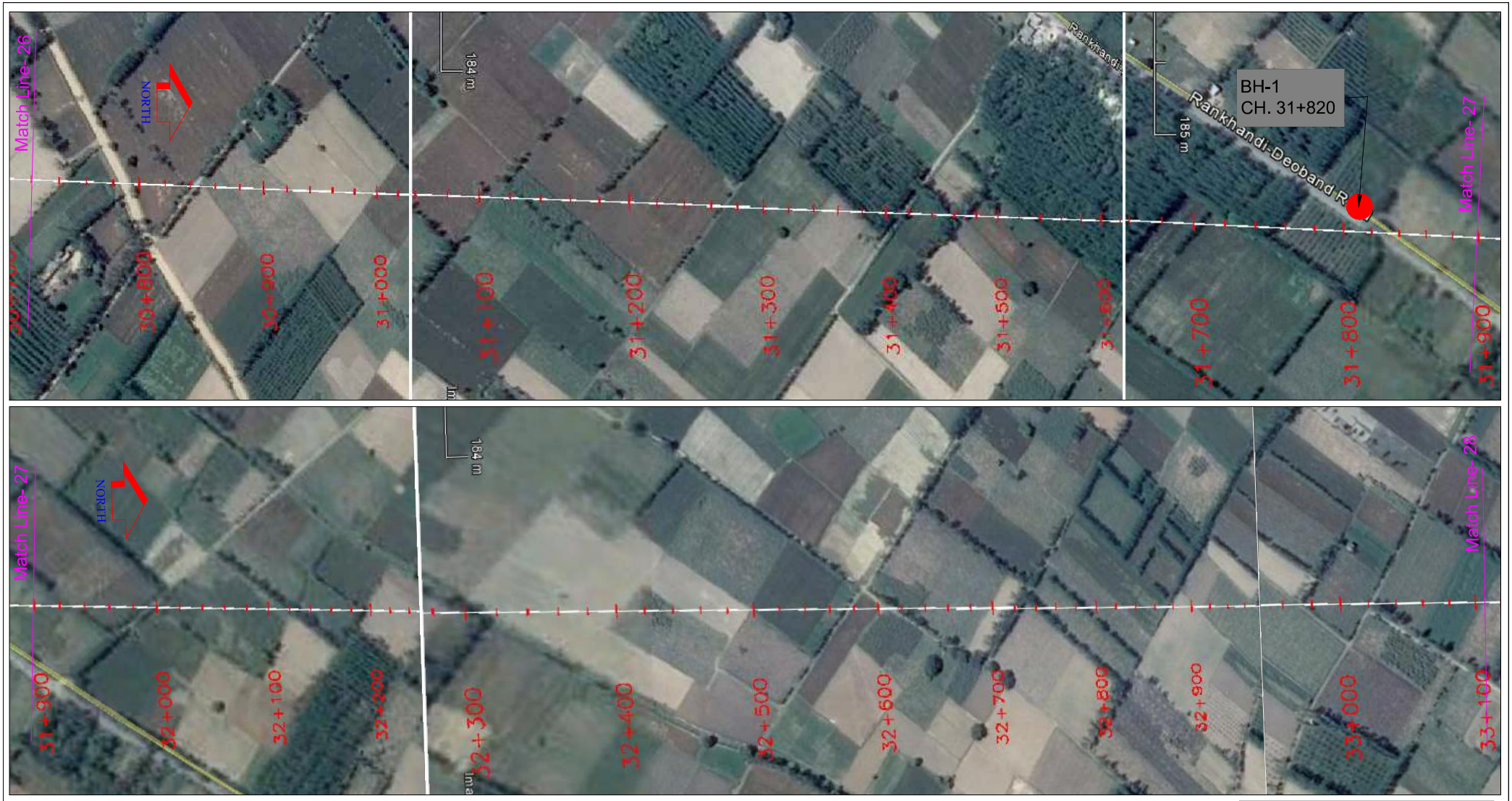
LEGEND:

BOREHOLE

CLIENT: skylark Designer and Engineers (P) Limited	PROJECT: Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut	DRAWING TITLE: Borehole Location Plan	AGENCY: XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/12 March, 2016

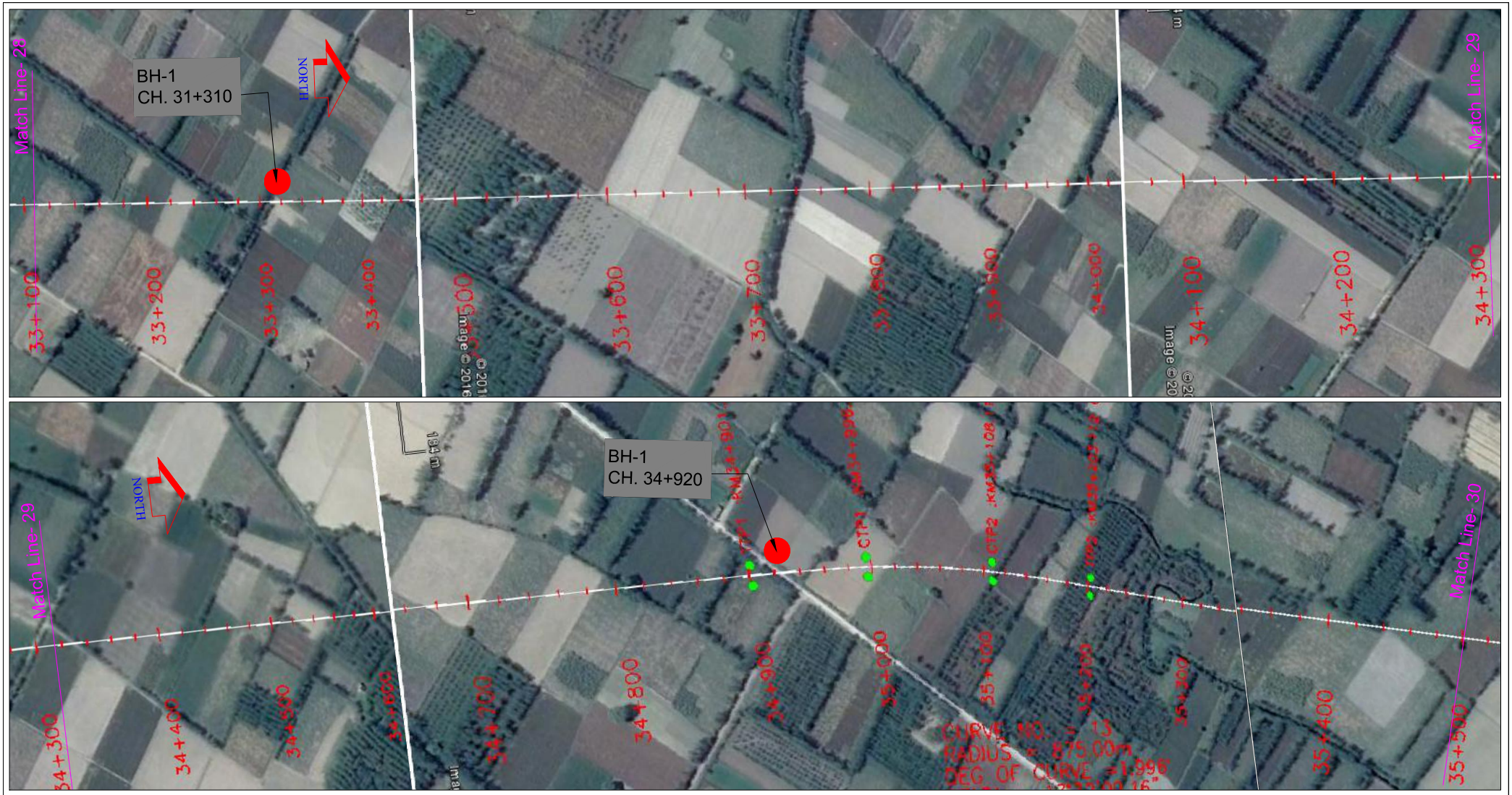
LEGEND:
BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/13 March, 2016



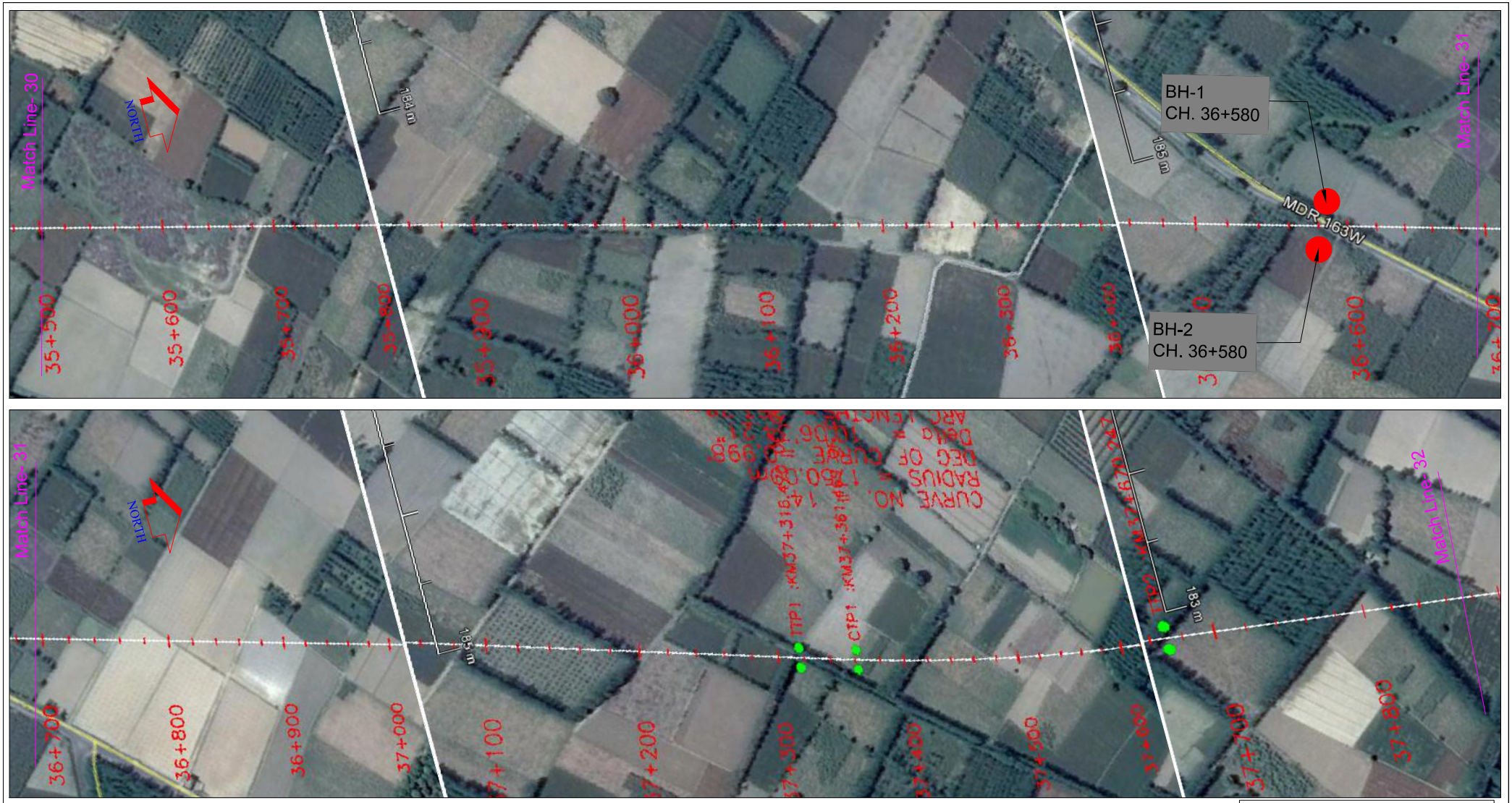
LEGEND:
BOREHOLE

CLIENT: skylark Designer and Engineers (P) Limited	PROJECT: Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut	DRAWING TITLE: Borehole Location Plan	AGENCY: XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/14 March, 2016



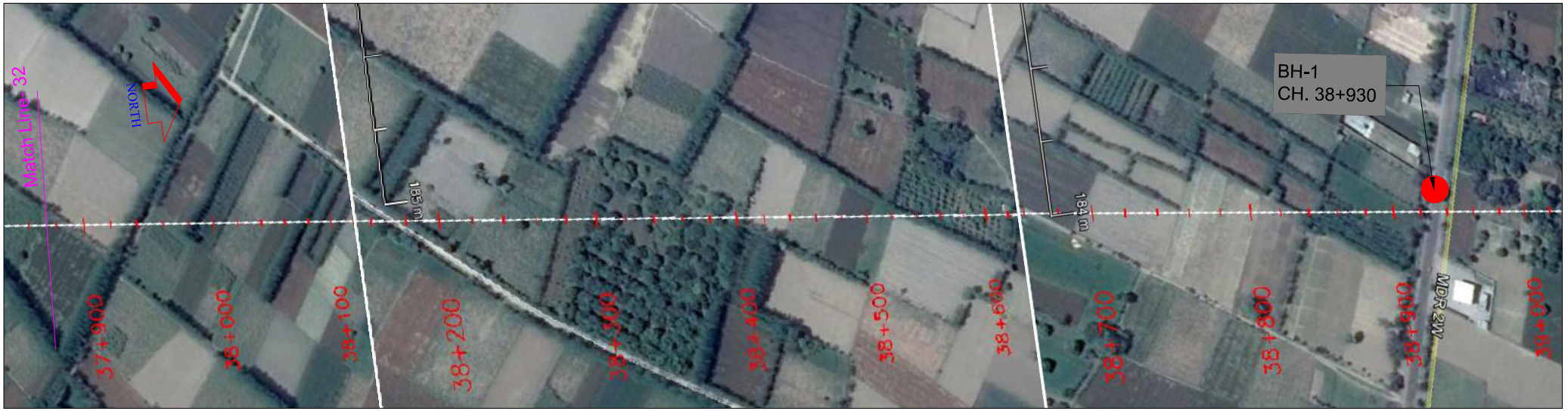
LEGEND:
BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	DRG. NO. PWD/LOCATION/15
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	March, 2016



LEGEND:
BOREHOLE

CLIENT: skylark Designer and Engineers (P) Limited	PROJECT: Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut	DRAWING TITLE: Borehole Location Plan	AGENCY: XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/16 March, 2016



LEGEND:
BOREHOLE

CLIENT:	PROJECT:	DRAWING TITLE:	AGENCY:	
skylark Designer and Engineers (P) Limited	Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut	Borehole Location Plan	XPLORER Xplorer Consultancy Services Pvt. Ltd. Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul, Gurgaon-122001, Haryana, India Tel: +91-124-4388659, Fax: +91-124-4241962 Email: xplorer@xplorer.in, Website: www.xplorer.in	DRG. NO. PWD/LOCATION/17 March, 2016

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 1+790

Co-ordinate: E: 762244.22 N: 323673.00

Reduce Level: 239.196

Borehole dia : 150 mm

Ground Water Table : 3.50 m

Termination Depth : 30.45 m

Date : 02-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Medium Dense Silty SAND			0.50-1.00	DS-1																									
2				SW-SM	1.50-1.95	SPT-1	12	20				0	92	8												0	30.8				
3					3.00-3.45	SPT-2	14	20																							
4																															
5					4.50-4.95	SPT-3	18	19																							
6																															
7					6.00-6.45	SPT-4	16	17																							
8					7.50-7.95	SPT-5	19	18																							
9																															
10					9.00-9.45	SPT-6	20	18																							
11					10.50-10.95	SPT-7	24	19																							
		Very Stiff to Hard Silty CLAY		CI	11.00-11.50	UDS-4			37	22	15	1	4	80	15	28.2	2.02	1.57	2.66					166				Nil	99.29	7.72	
12					12.00-12.45	SPT-8	27																								
13																															
14					13.50-13.95	SPT-9	23																								
15																															
16					15.00-15.45	SPT-10	29																								
17					16.50-16.95	SPT-11	33																								
		Dense Sandy SILT		ML	17.00 -17.50	UDS-6			33	NP		0	16	76	8	22	1.94	1.59													
18					18.00-18.45	SPT-12	31	20																							
19																															
20					19.50-19.95	SPT-13	34	21																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 1+790

Co-ordinate: E: 762244.22 N: 323673.00

Reduce Level: 239.196

Borehole dia : 150 mm

Ground Water Table : 3.50 m

Termination Depth : 30.45 m

Date : 02-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense Sandy SILT			21.00-21.45	SPT-14	37	21																							
22																															
23					22.50-22.95	SPT-15	36	21																							
					23.00-23.50	UDS-8										22.2	2.03	1.66													
24																															
					24.00-24.45	SPT-16	43	23																							
25																															
26					25.50-25.95	SPT-17	46	23																							
					26.00-26.50	UDS-9										19.2	2.09	1.75													
27																															
				SM	27.00-27.45	SPT-18	47	23				0	79	21												0	34.4				
28																															
		Dense to Very Dense Silty SAND																													
29					28.50-28.95	SPT-19	51	24																							
30					30.00-30.45	SPT-20	60	27																							
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 2

Page 1 of 2

Location : CH 1+790

Co-ordinate: E: 762217.53 N: 3253674.95

Reduce Level: 239.196 m

Borehole dia : 150 mm

Ground Water Table : 6.50 m

Termination Depth : 30.45 m

Date : 03-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil: Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Silty SAND		SM	0.50-1.00	DS-1																								
2					1.50-1.95	SPT-1	6	10				0	83	17												0	29.8				
					2.00-2.50	UDS-1																									
3																														
4		Medium Dense Silty SAND			3.00-3.45	SPT-2	12	17																						
5					4.50-4.95	SPT-3	12	15																						
6					6.00-6.45	SPT-4	15	16																						
7																														
8					7.50-7.95	SPT-5	22	20																						
9																														
10					9.00-9.45	SPT-6	20	18																						
11					10.50-10.95	SPT-7	18	17																						
				ML	11.00-11.50	UDS-4			29	NP		0	12	84	4	25.6	2.17	1.73													
12					12.00-12.45	SPT-8	19	16																						
13																														
14					13.50-13.95	SPT-9	25	19																						
15																														
					15.00-15.45	SPT-10	30	20																						
16		Medium Dense Sandy SILT																												
17					16.50-16.95	SPT-11	19	15																						
				ML	17.00 -17.50	UDS-6			25	NP		0	44	56	0	20.1	2.02	1.68	2.69							0	30.9				
18					18.00-18.45	SPT-12	25	18																						
19																														
20					19.50-19.95	SPT-13	31	20																						

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of BoringShell & Auger

Borehole No. 2

Page 2 of 2

Location : CH 1+790

Co-ordinate: E: 762217.53 N: 3253674.95

Reduce Level: 239.196 m

Borehole dia : 150 mm

Ground Water Table : 6.50 m

Termination Depth : 30.45 m

Date : 03-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense Sandy SILT			21.00-21.45	SPT-14	38																								
22																															
23					22.50-22.95	SPT-15	40																								
24																															
25					24.00-24.45	SPT-16	38																								
26																															
27					25.50-25.95	SPT-17	33																								
28		Hard Silty CLAY		CL	27.00-27.45	SPT-18	35		34	23	11	6	10	70	14																
29		Dense to Very Dense Fine SAND			28.50-28.95	SPT-19	39	20																							
30					30.00-30.45	SPT-20	85	34																							
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring : Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 1+980

Co-ordinate: E: 762039.06 N: 3253653.76

Reduce Level: 234.738 m

Borehole dia : 150 mm

Ground Water Table : 4.00 m

Termination Depth : 30.45 m

Date : 01-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil: Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Silty SAND		SM	0.50-1.00	DS-1																								
2					1.50-1.95	SPT-1	4	7	25	NP		0	65	35												0	31				
3					3.00-3.45	SPT-2	7	10																								
4																														
5		Medium Dense Silty SAND			4.50-4.95	SPT-3	16	18																								
6																														
7					6.00-6.45	SPT-4	18	18																								
8					7.50-7.95	SPT-5	17	17																								
				ML	8.00-8.50	UDS-3			32	NP		0	2	89	9	25	1.84	1.47	2.64									Nil	119.2	7.52	
9																														
					9.00-9.45	SPT-6	20	18																								
10																														
11		Medium Dense Sandy SILT			10.50-10.95	SPT-7	21	18																								
12					12.00-12.45	SPT-8	23	18																								
13																														
14					13.50-13.95	SPT-9	25	19																								
15																														
				SP	15.00-15.45	SPT-10	27	19				4	94	2												0	33				
16																														
17					16.50-16.95	SPT-11	32	21																								
18		Medium Dense to Dense Fine SAND																												
					18.00-18.45	SPT-12	33	21																								
19																														
20					19.50-19.95	SPT-13	36	22																								

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring : Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 1+980

Co-ordinate: E: 762039.06 N: 3253653.76

Reduce Level: 234.738 m

Borehole dia : 150 mm

Ground Water Table : 4.00 m

Termination Depth : 30.45 m

Date : 01-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21					21.00-21.45	SPT-14	38	22																							
22																														
23					22.50-22.95	SPT-15	41	22																							
				ML	23.00-23.50	UDS-8			30	NP		3	5	84	8	21.8	1.8	1.48													
24					24.00-24.45	SPT-16	43	23																							
25		Dense Sandy SILT																												
26					25.50-25.95	SPT-17	44	23																							
				ML	26.00-26.50	UDS-9			29	NP		0	3	89	8	27.8	1.85	1.45								0	31.9				
27					27.00-27.45	SPT-18	42	22																							
28																														
29					28.50-28.95	SPT-19	43	22																							
30					30.00-30.45	SPT-20	37	19																							
		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of BoringShell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 2+010

Co-ordinate: E: 762005.75 N: 3253651.39

Reduce Level: 234.533 m

Borehole dia : 150 mm

Ground Water Table : 3.50 m

Termination Depth : 30.45 m

Date : 01-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose to Medium Dense Sandy SILT		ML	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	6	10	29	NP		0	31	66	3											0	28.0				
3																															
					3.00-3.45	SPT-2	2	3																							
4																															
5					4.50-4.95	SPT-3	3	4																							
6																															
					6.00-6.45	SPT-4	5	6																							
7																															
8					7.50-7.95	SPT-5	12	13																							
				CL	8.00-8.50	UDS-3			34	22	12	7	7	75	11	24.6	1.94	1.58	2.67					62				Nil	109.2	7.81	
9																															
					9.00-9.45	SPT-6	15																								
10																															
11		Very Stiff Silty CLAY			10.50-10.95	SPT-7	20																								
12																															
					12.00-12.45	SPT-8	25																								
13																															
14					13.50-13.95	SPT-9	28																								
15																															
		Dense Fine SAND		SP	15.00-15.45	SPT-10	36	23				0	96	4								0	32.1							
16																															
					16.50-16.95	SPT-11	39	24																							
17																															
18					18.00-18.45	SPT-12	42	24																							
19																															
20					19.50-19.95	SPT-13	34	21																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 2+010

Co-ordinate: E: 762005.75 N: 3253651.39

Reduce Level: 234.533 m

Borehole dia : 150 mm

Ground Water Table : 3.50 m

Termination Depth : 30.45 m

Date : 01-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense Fine SAND			21.00-21.45	SPT-14	42	23																							
22																															
23					22.50-22.95	SPT-15	47	25																							
				CI	23.00-23.50	UDS-8			36	23	13	1	2	82	15	26	1.82	1.45													
24					24.00-24.45	SPT-16	35																								
25																															
26					25.50-25.95	SPT-17	37																								
		Hard Silty CLAY		CI	25.00-25.50	UDS-9			45	23	22	0	2	76	22	30.1	2.07	1.59						215							
27					27.00-27.45	SPT-18	25																								
28																															
29					28.50-28.95	SPT-19	32																								
30					30.00-30.45	SPT-20	30																								
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 2+286

Co-ordinate: E: 761728.55 N: 3253627.58

Reduce Level: 234.882 m

Borehole dia : 150 mm

Ground Water Table : 10.00 m

Termination Depth : 12.45 m

Date : 03-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Silty SAND		SM	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	6	10	23	NP		0	55	45	0											0	29.9				
3					3.00-3.45	SPT-2	9	13																							
4																															
5		Medium Dense Silty SAND			4.50-4.95	SPT-3	11	14																							
6																															
7				SM	6.00-6.45	SPT-4	13	15				0	81	19					2.65												
8					7.50-7.95	SPT-5	21	19																							
9																															
10					9.00-9.45	SPT-6	25	20																							
11		Medium Dense to Dense Fine SAND		SP	10.50-10.95	SPT-7	21	18				0	96	4											0	32.5				
12					12.00-12.45	SPT-8	31	22																							
		Borehole terminated at 12.45m depth																													
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 1

Location : CH 3+360

Co-ordinate: E: 760728.50 N: 3253854.68

Reduce Level: 237.425 m

Borehole dia : 150 mm

Ground Water Table : 10.50 m

Termination Depth : 12.45 m

Date : 03-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT		ML	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	5	8	24	NP		0	35	65	0				2.67							0	28.9				
3																															
					3.00-3.45	SPT-2	7	10																							
4																															
5					4.50-4.95	SPT-3	8	10																							
6																															
		Medium Dense Silty SAND		SM	6.00-6.45	SPT-4	14	16				0	67	33																	
7																															
8					7.50-7.95	SPT-5	17	17																							
9																															
					9.00-9.45	SPT-6	24	20																							
10																															
11					10.50-10.95	SPT-7	22	18																							
		Medium Dense Sandy SILT		ML	11.00-11.50	UDS-4			28	NP		1	19	80	0	20.8	1.97	1.63								0	31	Nil	119.2	7.55	
12					12.00-12.45	SPT-8	26	20																							
		Borehole terminated at 12.45m depth																													
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar - Saharanpur Section of DFCC Meerut

Method of Boring : Rotary

Borehole No. 1

Page 1 of 1

Location : CH 5+322

Co-ordinate: E: 760082.12 N: 3255691.48

Reduce Level: 233.449 m

Borehole dia : 150 mm

Ground Water Table : 7.00 m

Termination Depth : 12.45 m

Date : 02-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Silty SAND		SM	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	4	7				0	57	43												0	29.7				
3																															
4					3.00-3.45	SPT-2	6	8																							
5					4.50-4.95	SPT-3	8	10																							
6																															
7		Very Stiff Silty CLAY		CI	6.00-6.45	SPT-4	16		41	18	23	2	4	77	17				2.65												
8					7.50-7.95	SPT-5	18																								
9																															
10					9.00-9.45	SPT-6	22																								
11					10.50-10.95	SPT-7	22																								
		Very Stiff Silty CLAY		CL	11.00-11.50	UDS-4			30	20	10	0	6	82	12	22.1	1.89	1.55							87			Nil	79.43	7.66	
12					12.00-12.45	SPT-8	20																								
		Borehole terminated at 12.45m depth																													
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of BoringShell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 6+550

Co-ordinate: E: 759746.95 N: 3256863.89

Reduce Level: 233.189 m

Borehole dia : 150 mm

Ground Water Table : 3.50 m

Termination Depth : 30.45 m

Date : 01-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Medium Dense Silty SAND			0.50-1.00	DS-1																									
2				SM	1.50-1.95	SPT-1	11	18	23	NP		0	76	24												0	30.1				
3					3.00-3.45	SPT-2	12	17																							
4																															
5					4.50-4.95	SPT-3	14	18																							
6																															
7					6.00-6.45	SPT-4	12	14																							
8					7.50-7.95	SPT-5	21	19																							
9																															
10				SM	9.00-9.45	SPT-6	6	6				0	82	18					2.66							0	32.2	Nil	89.36	7.45	
11					10.50-10.95	SPT-7	22	18																							
12																															
13					12.00-12.45	SPT-8	27	20																							
14		Dense Silty SAND			13.50-13.95	SPT-9	32	22																							
15																															
16					15.00-15.45	SPT-10	31	21																							
17					16.50-16.95	SPT-11	35	22																							
18																															
19					18.00-18.45	SPT-12	38	23																							
20					19.50-19.95	SPT-13	31	20																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 6+550

Co-ordinate: E: 759746.95 N: 3256863.89

Reduce Level: 233.189 m

Borehole dia : 150 mm

Ground Water Table : 3.50 m

Termination Depth : 30.45 m

Date : 01-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
				CI	20.00-20.50	UDS-7			37	23	14	1	3	79	17	29.6	2.05	1.58														
21					21.00-21.45	SPT-14	37																									
22																															
23					22.50-22.95	SPT-15	45																									
24		Hard Silty CLAY																													
25					24.00-24.45	SPT-16	41																									
26					25.50-25.95	SPT-17	46																									
27																															
					27.00-27.45	SPT-18	52	25																								
28																															
		Very Dense Sandy SILT																													
29				ML	28.50-28.95	SPT-19	56	26	31	NP		0	14	78	8											0	32				
					30.00-30.45	SPT-20	60	27																								
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 2

Page 1 of 2

Location : CH 6+550

Co-ordinate: E: 759735.46 N: 3256879.48

Reduce Level: 233.190 m

Borehole dia : 150 mm

Ground Water Table : 3.70 m

Termination Depth : 30.45 m

Date : 02-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Medium Dense Silty SAND			0.50-1.00	DS-1																								
2				SW-SM	1.50-1.95	SPT-1	10	16				0	89	11																
3					3.00-3.45	SPT-2	13	18																						
4																														
5					4.50-4.95	SPT-3	12	15																						
6					6.00-6.45	SPT-4	14	16																						
7																														
8					7.50-7.95	SPT-5	22	20																						
9																														
10		Very Stiff to Hard Silty CLAY		CL	9.00-9.45	SPT-6	13		34	22	12	2	6	80	12															
11		Medium to Dense Silty SAND			10.50-10.95	SPT-7	21	18																						
12																														
13					12.00-12.45	SPT-8	27	20																						
14					13.50-13.95	SPT-9	30	21																						
15																														
16					15.00-15.45	SPT-10	33	22																						
17					16.50-16.95	SPT-11	34	22																						
18																														
19					18.00-18.45	SPT-12	37	22																						
20					19.50-19.95	SPT-13	27	18																						

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of BoringShell & Auger

Borehole No. 2

Page 2 of 2

Location : CH 6+550

Co-ordinate: E: 759735.46 N: 3256879.48

Reduce Level: 233.190 m

Borehole dia : 150 mm

Ground Water Table : 3.70 m

Termination Depth : 30.45 m

Date : 02-02-2016

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
				CL	20.00-20.50	UDS-7			32	21	11	0	2	84	14	26.8	2.01	1.59							78						
21					21.00-21.45	SPT-14	34																								
22																														
23					22.50-22.95	SPT-15	45																								
24																														
25		Hard Silty CLAY			24.00-24.45	SPT-16	45																								
26					25.50-25.95	SPT-17	49																								
27																														
28					27.00-27.45	SPT-18	49																								
29				CI	28.50-28.95	SPT-19	49		38	21	17	0	5	79	16																
30					30.00-30.45	SPT-20	56																								
		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring: Shell & Auger

Borehole No. 1

Page 1 of 1

Location : CH 8+440

Co-ordinate: E: 758500.16 N: 3258232.93

Reduce Level: 242.033

Borehole dia : 150 mm

Ground Water Table : NIL m

Termination Depth : 12.45 m

Date : 06-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil: Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Firm to Very Stiff Silty CLAY			0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	5																									
				CL	2.00-2.50	UDS-1			33	20	13	0	4	85	11	24	2	1.61	2.64					50				Nil	109.2	7.81	
3																															
					3.00-3.45	SPT-2	9																									
4																															
					4.50-4.95	SPT-3	16																									
5																															
6																															
		Medium Dense Sandy SILT		ML	6.00-6.45	SPT-4	18	18				1	11	83	6																
7																															
					7.50-7.95	SPT-5	20	18																								
8																															
					9.00-9.45	SPT-6	22	19																								
9																															
					10.50-10.95	SPT-7	25	20																								
10																															
				ML	11.00-11.50	UDS-4			27	NP		0	15	77	8																
11																															
					12.00-12.45	SPT-8	28	21																								
12		Borelog terminated at 12.45m depth																													
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 10+540

Co-ordinate: E: 758022.66 N: 3260278.96

Reduce Level: 242.030 m

Borehole dia : 150 mm

Ground Water Table : 13.00 m

Termination Depth : 30.45 m

Date : 06-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil: Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Fine SAND		SW-SM	0.50-1.00	DS-1																								
2					1.50-1.95	SPT-1	5	8				0	89	11												0	30.1	Nil	89.36	7.45	
3					3.00-3.45	SPT-2	8	10																						
4																														
5					4.50-4.95	SPT-3	8	11																						
6																														
7		Medium Dense Fine SAND			6.00-6.45	SPT-4	17	17																						
8					7.50-7.95	SPT-5	23	20																						
9					9.00-9.45	SPT-6	22	19																						
10																														
11					10.50-10.95	SPT-7	26	20																						
12				ML	12.00-12.45	SPT-8	30	22	32	NP		1	6	85	8				2.68											
13		Dense Sandy SILT																												
14					13.50-13.95	SPT-9	33	22																						
15																														
16					15.00-15.45	SPT-10	23	17																						
17					16.50-16.95	SPT-11	29	20																						
18																														
19					18.00-18.45	SPT-12	33	21																						
20					19.50-19.95	SPT-13	31	20																						

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 10+540

Co-ordinate: E: 758022.66 N: 3260278.96

Reduce Level: 242.030 m

Borehole dia : 150 mm

Ground Water Table : 13.00 m

Termination Depth : 30.45 m

Date : 06-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (°)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense Sandy SILT		SM	21.00-21.45	SPT-14	36	21																							
22																															
23					22.50-22.95	SPT-15	38	21																							
24																															
25					24.00-24.45	SPT-16	34	20																							
26					25.50-25.95	SPT-17	42	22				2	73	25												0	31.3				
27																															
28		Dense Silty SAND			27.00-27.45	SPT-18	42	22																							
29					28.50-28.95	SPT-19	48	23																							
30					30.00-30.45	SPT-20	30	17																							
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring : Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 11+753

Co-ordinate: E: 757799.66 N: 3261446.70

Reduce Level: 245.850

Borehole dia : 150 mm

Ground Water Table : 10.00 m

Termination Depth : 30.45 m

Date : 06-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT			0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	5	8																							
				ML	2.00-2.50	UDS-1			34	61	5	0	34	61	5	14.5	1.86	1.63	2.66							0	29				
3																															
					3.00-3.45	SPT-2	8	11																							
4																															
5					4.50-4.95	SPT-3	10	13																							
6																															
					6.00-6.45	SPT-4	16	17																							
7		Medium Dense Sandy SILT																													
8					7.50-7.95	SPT-5	14	15																							
9																															
					9.00-9.45	SPT-6	18	17																							
10																															
11					10.50-10.95	SPT-7	24	19																							
12																															
				SP	12.00-12.45	SPT-8	25	19				1	97	2																	
13																															
					13.50-13.95	SPT-9	33	22																							
14																															
15					15.00-15.45	SPT-10	20	16																							
16		Medium Dense Fine SAND																													
17					16.50-16.95	SPT-11	26	18																							
18																															
					18.00-18.45	SPT-12	29	19																							
19																															
20					19.50-19.95	SPT-13	30	19																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring : Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 11+753

Co-ordinate: E: 757799.66 N: 3261446.70

Reduce Level: 245.850

Borehole dia : 150 mm

Ground Water Table : 10.00 m

Termination Depth : 30.45 m

Date : 06-02-2016

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Medium Dense to Very Dense Fine SAND		SP	21.00-21.45	SPT-14	28	18																						
22																														
23					22.50-22.95	SPT-15	41	22																						
24																														
25					24.00-24.45	SPT-16	45	23																						
26					25.50-25.95	SPT-17	48	24				1	95	4																
27																														
28					27.00-27.45	SPT-18	53	25																						
29					28.50-28.95	SPT-19	63	28																						
30					30.00-30.45	SPT-20	73	31																						
		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 13+260

Co-ordinate: E: 757799.66 N: 3261446.70

Reduce Level: 245.850 m

Borehole dia : 150 mm

Ground Water Table : 10.00 m

Termination Depth : 30.45 m

Date : 07-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Very Stiff to Hard Silty CLAY		CL	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	32																								
					2.00-2.50	UDS-1			32	22	10	0	2	87	11	21.1	1.92	1.58	2.67					104				Nil	99.29	7.65	
3					3.00-3.45	SPT-2	25																								
4																															
5					4.50-4.95	SPT-3	20																								
6					6.00-6.45	SPT-4	17																								
7																															
8					7.50-7.95	SPT-5	23																								
9					9.00-9.45	SPT-6	30																								
10																															
11					10.50-10.95	SPT-7	31																								
12																															
		Dense Silty SAND		SM	12.00-12.45	SPT-8	35	24				1	85	14												0	32.0				
13																															
14					13.50-13.95	SPT-9	29	21																							
15																															
16					15.00-15.45	SPT-10	32	21																							
17					16.50-16.95	SPT-11	32	21																							
18																															
19					18.00-18.45	SPT-12	37	22																							
20					19.50-19.95	SPT-13	41	23																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Location : CH 13+260

Co-ordinate: E: 757799.66 N: 3261446.70

Reduce Level: 245.850 m

Borehole dia : 150 mm

Ground Water Table : 10.00 m

Termination Depth : 30.45 m

Date : 07-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense to Very Dense Silty SAND		SM	21.00-21.45	SPT-14	43	24				6	74	20																	
22																															
23					22.50-22.95	SPT-15	41	22																							
24																															
25					24.00-24.45	SPT-16	39	21																							
26					25.50-25.95	SPT-17	45	23																							
27																															
28					27.00-27.45	SPT-18	49	24																							
29					28.50-28.95	SPT-19	53	25																							
30					30.00-30.45	SPT-20	58	26																							
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 14+150

Co-ordinate: E: 757018.16 N: 3263718.59

Reduce Level: 245.430 m

Borehole dia : 150 mm

Ground Water Table : 7.00 m

Termination Depth : 30.45 m

Date : 07-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose to Medium Dense Sandy SILT			0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	8	13																								
				ML	2.00-2.50	UDS-1			31	NP		0	33	61	6	16.4	1.91	1.64	2.63							0	30	Nil	79.43	7.25	
3					3.00-3.45	SPT-2	12	17																							
4																														
5					4.50-4.95	SPT-3	12	15																							
6																														
7					6.00-6.45	SPT-4	14	16																							
8					7.50-7.95	SPT-5	16	16																							
9																														
10					9.00-9.45	SPT-6	22	19																							
11					10.50-10.95	SPT-7	21	18																							
12																														
				SM	12.00-12.45	SPT-8	25	19				1	80	19																	
13		Medium Dense to Dense Silty SAND																												
14					13.50-13.95	SPT-9	23	18																							
15																														
16					15.00-15.45	SPT-10	26	19																							
17					16.50-16.95	SPT-11	30	20																							
18																														
19					18.00-18.45	SPT-12	26	18																							
20					19.50-19.95	SPT-13	32	20																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 14+150

Co-ordinate: E: 757018.16 N: 3263718.59

Reduce Level: 245.430 m

Borehole dia : 150 mm

Ground Water Table : 7.00 m

Termination Depth : 30.45 m

Date : 07-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21																														
					21.00-21.45	SPT-14	32	20																						
22																														
23					22.50-22.95	SPT-15	36	21																						
24																														
					24.00-24.45	SPT-16	34	20																						
25		Dense to Very Dense Fine SAND																												
26				SP	25.50-25.95	SPT-17	39	21				0	96	4																
27																														
					27.00-27.45	SPT-18	38	20																						
28																														
29					28.50-28.95	SPT-19	51	24																						
30					30.00-30.45	SPT-20	64	28																						
		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 15+800

Co-ordinate: E: 756579.79 N: 3265300.51

Reduce Level: 245.760 m

Borehole dia : 150 mm

Ground Water Table : 11.00 m

Termination Depth : 30.45 m

Date : 07-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1					0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	6	10																							
		Loose Sandy SILT		ML	2.00-2.50	UDS-1			27	NP		0	27	73	0	23.4	1.83	1.48	2.62							0	29.1	Nil	109.2	7.50	
3					3.00-3.45	SPT-2	9	13																							
4																															
5					4.50-4.95	SPT-3	14	18																							
6																															
7					6.00-6.45	SPT-4	17	17																							
8		Medium Dense Sandy SILT			7.50-7.95	SPT-5	18	17																							
9																															
10					9.00-9.45	SPT-6	17	16																							
11					10.50-10.95	SPT-7	21	18																							
12																															
				SW-SM	12.00-12.45	SPT-8	23	18				1	89	10																	
13																															
14					13.50-13.95	SPT-9	26	19																							
15																															
16					15.00-15.45	SPT-10	29	20																							
		Medium Dense to Dense Fine SAND																													
17					16.50-16.95	SPT-11	35	22																							
18																															
19					18.00-18.45	SPT-12	37	22																							
20					19.50-19.95	SPT-13	40	23																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 15+800

Co-ordinate: E: 756579.79 N: 3265300.51

Reduce Level: 245.760 m

Borehole dia : 150 mm

Ground Water Table : 13.00 m

Termination Depth : 30.45 m

Date : 07-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil: Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense to Very Dense Fine SAND		SW-SM	21.00-21.45	SPT-14	45	24																						
22																														
23					22.50-22.95	SPT-15	47	24																						
24																														
25					24.00-24.45	SPT-16	50	25																						
26					25.50-25.95	SPT-17	52	25				0	93	7												0	32.6				
27																														
28					27.00-27.45	SPT-18	56	26																						
29					28.50-28.95	SPT-19	60	27																						
30					30.00-30.45	SPT-20	65	28																						
		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Location : CH 17+790

Co-ordinate: E: 757458.52 N: 3267033.27

Reduce Level: 237.510 m

Borehole dia : 150 mm

Ground Water Table : 7.00 m

Termination Depth : 30.45 m

Date : 08-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT		ML	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	7	11																							
					2.00-2.50	UDS-1			28	NP		0	18	77	5	9.6	1.98	1.81	2.69							0	29	Nil	119.2	7.65	
3																															
					3.00-3.45	SPT-2	8	11																							
4																															
5					4.50-4.95	SPT-3	10	13																							
6																															
					6.00-6.45	SPT-4	12	14																							
7																															
8					7.50-7.95	SPT-5	17	17																							
9		Medium Dense Silty SAND																													
					9.00-9.45	SPT-6	19	17																							
10																															
11					10.50-10.95	SPT-7	22	18																							
12																															
				SM	12.00-12.45	SPT-8	26	20				1	86	13																	
13																															
					13.50-13.95	SPT-9	27	20																							
14																															
15					15.00-15.45	SPT-10	29	20																							
16		Medium Dense Silty SAND																													
17					16.50-16.95	SPT-11	31	20																							
18																															
					18.00-18.45	SPT-12	33	21																							
19																															
20					19.50-19.95	SPT-13	37	22																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Location : CH 17+790

Co-ordinate: E: 757458.52 N: 3267033.27

Reduce Level: 237.510 m

Borehole dia : 150 mm

Ground Water Table : 7.00 m

Termination Depth : 30.45 m

Date : 08-02-2016

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Medium Dense to Dense Fine SAND			21.00-21.45	SPT-14	39	22																						
22																														
23					22.50-22.95	SPT-15	42	23																						
				ML	23.00-23.50	UDS-8						0	12	88	0	22	2.03	1.66								0	32				
24																														
					24.00-24.45	SPT-16	21	15																						
25																														
					25.50-25.95	SPT-17	25	16																						
26				ML	25.00-25.50	UDS-9			31	NP		1	8	85	6	18.2	2.09	1.76													
27																														
					27.00-27.45	SPT-18	28	17																						
28																														
					28.50-28.95	SPT-19	31	18																						
29																														
					30.00-30.45	SPT-20	25	15																						
30		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 1

Location : CH 18+900

Co-ordinate: E: 757973.35 N: 3268010.08

Reduce Level: 240.010 m

Borehole dia : 150 mm

Ground Water Table : NIL m

Termination Depth : 12.45 m

Date : 09-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Stiff Silty CLAY			0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	10																								
				CL	2.00-2.50	UDS-1			33	20	13	0	2	87	11	18.7	1.93	1.63						55			Nil	109.2	7.39	
3					3.00-3.45	SPT-2	12																								
4					4.50-4.95	SPT-3	10																								
5				CL	5.00-5.50	UDS-2			34	21	13	1	14	73	12	29.1	2.08	1.61	2.67												
6					6.00-6.45	SPT-4	13																								
7					7.50-7.95	SPT-5	11																								
8				SM	9.00-9.45	SPT-6	27	21				0	76	24																	
9		Medium Dense to Dense Silty SAND			10.50-10.95	SPT-7	35	25																							
10					12.00-12.45	SPT-8	21	17																							
11		Borehole terminated at 12.45m depth																													
12																															
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 1

Location : CH 19+680

Co-ordinate: E: 758226.84 N: 3268747.08

Reduce Level: 245.906 m

Borehole dia : 150 mm

Ground Water Table : 0.00 m

Termination Depth : 12.45 m

Date : 09-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT		ML	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	7	11				0	46	54	0											0	29				
3																															
					3.00-3.45	SPT-2	10	14																							
4																															
5					4.50-4.95	SPT-3	8	10																							
		Medium Dense Sandy SILT		ML	5.00-5.50	UDS-2			29	NP		1	10	86	3	19.7	1.91	1.6	2.64									Nil	129.1	7.1	
6																															
					6.00-6.45	SPT-4	12	14																							
7																															
					7.50-7.95	SPT-5	18	17																							
8																															
9																															
		Medium Dense Silty SAND		SM	9.00-9.45	SPT-6	21	18				0	84	16																	
10																															
					10.50-10.95	SPT-7	25	18																							
11																															
12					12.00-12.45	SPT-8	26	20																							
		Borehole terminated at 12.45m depth																													
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 1

Location : CH 20+960

Co-ordinate: E: 758391.93 N: 3269996.63

Reduce Level: 248.883 m

Borehole dia : 150 mm

Ground Water Table : 10.00 m

Termination Depth : 12.45 m

Date : 10-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1					0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	5	8																							
		Loose Sandy SILT		ML	2.00-2.50	UDS-1			27	NP		0	8	90	2	22.6	2.03	1.65	2.66							0	28.1	Nil	148.9	6.99	
3					3.00-3.45	SPT-2	7	10																							
4																															
5					4.50-4.95	SPT-3	14	18																							
6																															
7		Medium Dense Sandy SILT			6.00-6.45	SPT-4	18	18																							
8					7.50-7.95	SPT-5	21	19																							
9																															
				SW-SM	9.00-9.45	SPT-6	21	18				1	94	5												0	31				
10																															
		Medium Dense Fine SAND																													
11					10.50-10.95	SPT-7	22	18																							
12					12.00-12.45	SPT-8	23	18																							
		Borehole terminated at 12.45m depth																													
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 1

Location : CH 22+700

Co-ordinate: E: 758112.96 N: 3271714.44

Reduce Level: 250.658 m

Borehole dia : 150 mm

Ground Water Table : 10.00 m

Termination Depth : 12.45 m

Date : 10-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1					0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	6	10																							
		Loose Sandy SILT		ML	2.00-2.50	UDS-1						0	11	89	0	8.4	1.85	1.71	2.62							0	29.3	Nil	139	7.01	
3					3.00-3.45	SPT-2	8	11																							
4																															
5					4.50-4.95	SPT-3	12	15																							
				ML	5.00-5.50	UDS-2			30	NP		1	7	87	5	10.1	1.75	1.59													
6																															
					6.00-6.45	SPT-4	15	16																							
7																															
8					7.50-7.95	SPT-5	17	17																							
		Medium Dense Sandy SILT																													
9																															
					9.00-9.45	SPT-6	20	18																							
10																															
11					10.50-10.95	SPT-7	23	19																							
12				SM	12.00-12.45	SPT-8	23	18				0	96	4																	
		Borehole terminated at 12.45m depth																													
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															

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BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 24+269

Co-ordinate: E: 757859.80 N: 3273262.93

Reduce Level: 249.215 m

Borehole dia : 150 mm

Ground Water Table : 8.00 m

Termination Depth : 30.45 m

Date : 10-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1					0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	6	10																							
		Loose Sandy SILT		ML	2.00-2.50	UDS-1						0	23	74	3	10.2	1.81	1.64	2.64							0	29.2	Nil	109.2	7.15	
3					3.00-3.45	SPT-2	8	11																							
4																															
5					4.50-4.95	SPT-3	21	21																							
6																															
7					6.00-6.45	SPT-4	22	20																							
8					7.50-7.95	SPT-5	25	21																							
9		Medium Dense Sandy SILT																													
10					9.00-9.45	SPT-6	33	25																							
11					10.50-10.95	SPT-7	20	17																							
12																															
13					12.00-12.45	SPT-8	29	21																							
14					13.50-13.95	SPT-9	36	24																							
				ML	14.00 -14.50	UDS-5			32	NP		1	2	89	8	10.8	1.85	1.67													
15					15.00-15.45	SPT-10	39	24																							
16																															
17		Dense Sandy SILT			16.50-16.95	SPT-11	46	27																							
18					18.00-18.45	SPT-12	43	25																							
19																															
20					19.50-19.95	SPT-13	45	25																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 24+269

Co-ordinate: E: 757859.80 N: 3273262.93

Reduce Level: 249.215 m

Borehole dia : 150 mm

Ground Water Table : 8.00 m

Termination Depth : 30.45 m

Date : 10-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense to Very Dense Sandy SILT			21.00-21.45	SPT-14	46	25																						
22																														
23					22.50-22.95	SPT-15	39	22																						
24																														
25					24.00-24.45	SPT-16	52	26																						
26		Dense to Very Dense Fine SAND		SW-SM	25.50-25.95	SPT-17	43	22				0	93	7												0	34.3				
27																														
28					27.00-27.45	SPT-18	61	28																						
29					28.50-28.95	SPT-19	55	27																						
30					30.00-30.45	SPT-20	62	25																						
		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 25+880

Co-ordinate: E: 757632.44 N: 3274855.65

Reduce Level: 245.884 m

Borehole dia : 150 mm

Ground Water Table : 3.50 m

Termination Depth : 30.45 m

Date : 10-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil: Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT			0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	6	10																							
				ML	2.00-2.50	UDS-1			26	NP		0	47	47	6	16.1	2	1.72	2.65							0	29.4	Nil	129.1	7.11	
3																															
					3.00-3.45	SPT-2	10	14																							
4																															
5					4.50-4.95	SPT-3	8	10																							
6																															
		Medium Dense Sandy SILT			6.00-6.45	SPT-4	17	17																							
7																															
8					7.50-7.95	SPT-5	21	19																							
9																															
					9.00-9.45	SPT-6	13	14																							
10																															
11					10.50-10.95	SPT-7	18	16																							
					11.00-11.50	UDS-4										20	2	1.7													
12																															
		Medium Dense to Dense Fine SAND		SP	12.00-12.45	SPT-8	17	15				1	96	3												0	30.4				
13																															
14					13.50-13.95	SPT-9	20	17																							
15																															
					15.00-15.45	SPT-10	32	21																							
16																															
17					16.50-16.95	SPT-11	35	22																							
18																															
					18.00-18.45	SPT-12	37	22																							
19																															
20					19.50-19.95	SPT-13	41	23																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Location : CH 25+880

Co-ordinate: E: 757632.44 N: 3274855.65

Reduce Level: 245.884 m

Borehole dia : 150 mm

Ground Water Table : 3.50 m

Termination Depth : 30.45 m

Date : 10-02-2016

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense to Very Dense Fine SAND		SP	21.00-21.45	SPT-14	36	21																						
22																														
23					22.50-22.95	SPT-15	40	22																						
24																														
25					24.00-24.45	SPT-16	45	23																						
26					25.50-25.95	SPT-17	55	26				0	98	2																
27																														
28					27.00-27.45	SPT-18	52	25																						
29					28.50-28.95	SPT-19	61	24																						
30					30.00-30.45	SPT-20	74	27																						
		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 27+960

Co-ordinate: E: 757586.00 N: 3276936.64

Reduce Level: 251.500 m

Borehole dia : 150 mm

Ground Water Table : 6.00 m

Termination Depth : 30.45 m

Date : 12-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1					0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	5	8																							
		Loose Sandy SILT		ML	2.00-2.50	UDS-1			30	NP		0	12	80	8	9.4	1.9	1.73	2.61							0	28	Nil	119.2	7.05	
3					3.00-3.45	SPT-2	4	6																							
4																															
5					4.50-4.95	SPT-3	11	14																							
6																															
					6.00-6.45	SPT-4	16	17																							
7																															
8					7.50-7.95	SPT-5	13	15																							
		Medium Dense Sandy SILT																													
9																															
					9.00-9.45	SPT-6	18	17																							
10																															
11					10.50-10.95	SPT-7	22	18																							
12																															
				SW-SM	12.00-12.45	SPT-8	28	21				1	91	8																	
13																															
					13.50-13.95	SPT-9	31	21																							
14																															
		Medium Dense to Dense Fine SAND																													
15					15.00-15.45	SPT-10	36	23																							
16																															
17					16.50-16.95	SPT-11	42	25																							
				CL	17.00 -17.50	UDS-6			32	22	10	5	4	79	12	11.2	1.87	1.69													
18																															
					18.00-18.45	SPT-12	48																								
19		Hard Silty CLAY																													
20					19.50-19.95	SPT-13	42																								

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Location : CH 27+960

Co-ordinate: E: 757586.00 N: 3276936.64

Reduce Level: 251.500 m

Borehole dia : 150 mm

Ground Water Table : 6.00 m

Termination Depth : 30.45 m

Date : 12-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil: Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense to Very Dense Fine SAND		SP	21.00-21.45	SPT-14	40	23																						
22																														
23					22.50-22.95	SPT-15	42	23																						
24																														
25					24.00-24.45	SPT-16	37	21																						
26					25.50-25.95	SPT-17	41	22				0	96	4												0	33.2				
27																														
28					27.00-27.45	SPT-18	43	22																						
29					28.50-28.95	SPT-19	50	22																						
30					30.00-30.45	SPT-20	56	23																						
		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 28+840

Co-ordinate: E: 757735.82 N: 3277802.42

Reduce Level: 250.096 m

Borehole dia : 150 mm

Ground Water Table : 4.50 m

Termination Depth : 30.45 m

Date : 12-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Stiff Silty CLAY		CL	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	9																								
				CL	2.00-2.50	UDS-1			34	22	12	0	4	82	14	9.7	1.87	1.71	2.66						48			Nil	109.2	7.3	
3					3.00-3.45	SPT-2	10																								
4																															
5					4.50-4.95	SPT-3	12																								
		Medium Dense Sandy SILT		ML	5.00-5.50	UDS-2			29	NP		1	10	84	5	10.1	1.88	1.71													
6					6.00-6.45	SPT-4	15	16																							
7																															
8					7.50-7.95	SPT-5	18	17																							
9																															
10					9.00-9.45	SPT-6	19	17																							
11					10.50-10.95	SPT-7	22	18																							
12					12.00-12.45	SPT-8	25	19																							
13																															
14					13.50-13.95	SPT-9	26	19																							
				ML	14.00 -14.50	UDS-5						2	26	72	0	11	1.87	1.69								0	31.5				
15					15.00-15.45	SPT-10	29	20																							
16																															
17		Dense Sandy SILT			16.50-16.95	SPT-11	32	21																							
18																															
19					18.00-18.45	SPT-12	34	21																							
20					19.50-19.95	SPT-13	38	22																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 28+840

Co-ordinate: E: 757735.82 N: 3277802.42

Reduce Level: 250.096 m

Borehole dia : 150 mm

Ground Water Table : 4.50 m

Termination Depth : 30.45 m

Date : 12-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N-value (Obs.)	SPT N-value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil: Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense Sandy SILT			21.00-21.45	SPT-14	41	23																							
22																															
23					22.50-22.95	SPT-15	43	23																							
24																															
25					24.00-24.45	SPT-16	45	23																							
26				SP	25.50-25.95	SPT-17	55	26				0	97	3												0	33.3				
27																															
28		Very Dense Fine SAND			27.00-27.45	SPT-18	58	27																							
29					28.50-28.95	SPT-19	60	26																							
30					30.00-30.45	SPT-20	65	27																							
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 30+236

Co-ordinate: E: 757625.83 N: 3279184.67

Reduce Level: 249.590 m

Borehole dia : 150 mm

Ground Water Table : 6.00 m

Termination Depth : 30.45 m

Date : 13-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT		ML	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	9	15																							
3					2.00-2.50	UDS-1						0	40	60	0	9.3	1.87	1.71	2.66							0	29.7	Nil	129.1	7.12	
4					3.00-3.45	SPT-2	7	10																							
5					4.50-4.95	SPT-3	9	11																							
6																															
7		Medium Dense Sandy SILT			6.00-6.45	SPT-4	11	13																							
8					7.50-7.95	SPT-5	16	16																							
9					9.00-9.45	SPT-6	18	17																							
10																															
11					10.50-10.95	SPT-7	21	18																							
12																															
13		Medium Dense Fine SAND		SP	12.00-12.45	SPT-8	26	20				1	96	3																	
14					13.50-13.95	SPT-9	36	24																							
15		Dense Sandy SILT		ML	14.00 -14.50	UDS-5			29	NP		0	6	89	5	21.5	1.86	1.53								0	30.9				
16					15.00-15.45	SPT-10	46	27																							
17					16.50-16.95	SPT-11	42	25																							
18																															
19					18.00-18.45	SPT-12	27	18																							
20					19.50-19.95	SPT-13	33	20																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 30+236

Co-ordinate: E: 757625.83 N: 3279184.67

Reduce Level: 249.590 m

Borehole dia : 150 mm

Ground Water Table : 6.00 m

Termination Depth : 30.45 m

Date : 13-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense Sandy SILT			21.00-21.45	SPT-14	37	21																							
22																															
23					22.50-22.95	SPT-15	40	22																							
24																															
25					24.00-24.45	SPT-16	42	22																							
26				SW-SM	25.50-25.95	SPT-17	36	20				1	91	8												0	33.7				
27																															
28		Dense to Very Dense Fine SAND			27.00-27.45	SPT-18	40	21																							
29					28.50-28.95	SPT-19	42	21																							
30					30.00-30.45	SPT-20	53	21																							
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 31+820

Co-ordinate: E: 757441.69 N: 3280761.97

Reduce Level: 254.578 m

Borehole dia : 150 mm

Ground Water Table : 7.50 m

Termination Depth : 30.45 m

Date : 13-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC Φ (o)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Silty SAND		SM	0.50-1.00	DS-1																								
2					1.50-1.95	SPT-1	8	13	25	NP		0	53	47	0				2.67							0	30.1	Nil	109.2	7.02	
3																														
4		Medium Dense Silty SAND			3.00-3.45	SPT-2	11	15																						
5					4.50-4.95	SPT-3	13	16																						
6					6.00-6.45	SPT-4	14	16																						
7																														
8					7.50-7.95	SPT-5	18	17																						
9																														
10					9.00-9.45	SPT-6	20	18																						
11					10.50-10.95	SPT-7	21	18																						
12				SW-SM	12.00-12.45	SPT-8	25	19				1	90	9																
13		Medium Dense to Dense Fine SAND																												
14					13.50-13.95	SPT-9	26	19																						
15																														
16					15.00-15.45	SPT-10	29	20																						
17					16.50-16.95	SPT-11	31	20																						
18																														
19					18.00-18.45	SPT-12	33	21																						
20					19.50-19.95	SPT-13	35	21																						

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 31+820

Co-ordinate: E: 757441.69 N: 3280761.97

Reduce Level: 254.578 m

Borehole dia : 150 mm

Ground Water Table : 7.50 m

Termination Depth : 30.45 m

Date : 13-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC Φ (o)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense to Very Dense Fine SAND		SW-SM	21.00-21.45	SPT-14	38	22				0	88	12												0	32.8				
22																															
23					22.50-22.95	SPT-15	42	23																							
24																															
25					24.00-24.45	SPT-16	45	23																							
26					25.50-25.95	SPT-17	55	26																							
27																															
28					27.00-27.45	SPT-18	57	27																							
29																															
30					28.50-28.95	SPT-19	60	26																							
		Borehole terminated at depth of 30.45m			30.00-30.45	SPT-20	65	27																							
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 1

Location : CH 33+310

Co-ordinate: E: 757269.23 N: 3282241.22

Reduce Level: 253.595 m

Borehole dia : 150 mm

Ground Water Table : 4.50 m

Termination Depth : 12.45 m

Date : 14-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT		ML	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	7	11																							
					2.00-2.50	UDS-1			25	NP		0	9	91	0	20.7	1.78	1.47	2.64							0	28.7	Nil	119.2	7.14	
3																															
					3.00-3.45	SPT-2	9	13																							
4																															
5					4.50-4.95	SPT-3	8	10																							
6																															
		Medium Dense Sandy SILT			6.00-6.45	SPT-4	14	16																							
7																															
8					7.50-7.95	SPT-5	17	17																							
9																															
				SM	9.00-9.45	SPT-6	18	17				1	86	13												0	31				
10																															
		Medium Dense Silty SAND																													
11					10.50-10.95	SPT-7	20	17																							
12					12.00-12.45	SPT-8	29	21																							
		Borehole terminated at 12.45m depth																													
13																															
14																															
15																															
16																															
17																															
18																															
19																															
20																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 34+920

Co-ordinate: E: 757082.08 N: 3283841.49

Reduce Level: 254.442 m

Borehole dia : 150 mm

Ground Water Table : 6.00 m

Termination Depth : 30.45 m

Date : 14-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT		ML	0.50-1.00	DS-1																								
2					1.50-1.95	SPT-1	4	7																						
3					2.00-2.50	UDS-1			29	NP		0	4	91	5	7.8	1.86	1.73	2.67							0	27.3	Nil	158.9	7.26	
4					3.00-3.45	SPT-2	7	10																						
5		Medium Dense Sandy SILT			4.50-4.95	SPT-3	12	15																						
6					6.00-6.45	SPT-4	18	18																						
7																														
8					7.50-7.95	SPT-5	14	15																						
9																														
10					9.00-9.45	SPT-6	19	17																						
11					10.50-10.95	SPT-7	23	19																						
12																														
13		Medium Dense to Dense Fine SAND		SW-SM	12.00-12.45	SPT-8	25	19				1	93	6												0	32.5				
14					13.50-13.95	SPT-9	26	19																						
15																														
16					15.00-15.45	SPT-10	31	21																						
17					16.50-16.95	SPT-11	35	22																						
18		Dense Sandy SILT		ML	17.00 -17.50	UDS-6			28	NP		6	4	86	4	7.4	1.88	1.75													
19					18.00-18.45	SPT-12	43	25																						
20					19.50-19.95	SPT-13	30	19																						

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Location : CH 34+920

Co-ordinate: E: 757082.08 N: 3283841.49

Reduce Level: 254.442 m

Borehole dia : 150 mm

Ground Water Table : 6.00 m

Termination Depth : 30.45 m

Date : 14-02-2016

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21					21.00-21.45	SPT-14	29	18																							
22																														
23		Dense Sandy SILT			22.50-22.95	SPT-15	37	21																							
24					24.00-24.45	SPT-16	40	22																							
25																														
26				SW-SM	25.50-25.95	SPT-17	46	23				1	91	8												0	33.1				
27																														
28		Dense to Very Dense Fine SAND			27.00-27.45	SPT-18	38	20																							
29					28.50-28.95	SPT-19	45	20																							
30					30.00-30.45	SPT-20	51	22																							
		Borehole terminated at depth of 30.45m																												
31																														
32																														
33																														
34																														
35																														
36																														
37																														
38																														
39																														
40																														

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 36+585

Co-ordinate: E: 757251.76 N: 3285496.05

Reduce Level: 253.413 m

Borehole dia : 150 mm

Ground Water Table : 4.50 m

Termination Depth : 30.45 m

Date : 15-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1					0.50-1.00	DS-1																									
2		Loose Silty SAND		SM	1.50-1.95	SPT-1	10	16				0	61	39					2.62							0	31	Nil	148.9	7.19	
3					3.00-3.45	SPT-2	9	13																							
4																															
5		Medium Dense Silty SAND			4.50-4.95	SPT-3	12	15																							
6					6.00-6.45	SPT-4	18	18																							
7																															
8					7.50-7.95	SPT-5	14	15																							
9																															
10					9.00-9.45	SPT-6	19	17																							
11					10.50-10.95	SPT-7	23	19																							
12				SW-SM	12.00-12.45	SPT-8	27	20				1	91	8													0	31.7				
13																															
14					13.50-13.95	SPT-9	29	21																							
15																															
16		Medium Dense to Dense Fine SAND			15.00-15.45	SPT-10	28	20																							
17					16.50-16.95	SPT-11	31	20																							
18																															
19					18.00-18.45	SPT-12	40	24																							
20					19.50-19.95	SPT-13	43	24																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 36+585

Co-ordinate: E: 757251.76 N: 3285496.05

Reduce Level: 253.413 m

Borehole dia : 150 mm

Ground Water Table : 4.50 m

Termination Depth : 30.45 m

Date : 15-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Dense Fine SAAND			21.00-21.45	SPT-14	45	24																							
22																															
23					22.50-22.95	SPT-15	37	21																							
		Dense Sandy SILT		ML	23.00-23.50	UDS-8			32	NP		1	31	62	6	11.7	1.83	1.64													
24																															
					24.00-24.45	SPT-16	44	23																							
25																															
26				CL	25.50-25.95	SPT-17	39					0	11	77	12																
					25.00-25.50	UDS-9																									
27																															
					27.00-27.45	SPT-18	46																								
28		Hard Silty CLAY																													
29					28.50-28.95	SPT-19	42																								
30					30.00-30.45	SPT-20	57																								
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 2

Page 1 of 2

Location : CH 36+585

Co-ordinate: E: 757248.05 N: 3285499.81

Reduce Level: 253.413 m

Borehole dia : 150 mm

Ground Water Table : 4.00 m

Termination Depth : 30.45 m

Date : 15-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT		ML	0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	7	11	28	NP		0	32	61	7											0	28.1	Nil	119.2	7.2	
3					3.00-3.45	SPT-2	10	14																							
4																															
5		Medium Dense Sandy SILT			4.50-4.95	SPT-3	15	17																							
6					6.00-6.45	SPT-4	14	16																							
7																															
8					7.50-7.95	SPT-5	17	17																							
9																															
10					9.00-9.45	SPT-6	21	18																							
11					10.50-10.95	SPT-7	23	19																							
12																															
		Medium Dense to Dense Silty SAND		SM	12.00-12.45	SPT-8	25	19				1	85	14					2.61												
13																															
14					13.50-13.95	SPT-9	27	20																							
15																															
16					15.00-15.45	SPT-10	31	21																							
17					16.50-16.95	SPT-11	31	20																							
18																															
19					18.00-18.45	SPT-12	31	20																							
20					19.50-19.95	SPT-13	35	21																							

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 2

Page 2 of 2

Location : CH 36+585

Co-ordinate: E: 757248.05 N: 3285499.81

Reduce Level: 253.413 m

Borehole dia : 150 mm

Ground Water Table : 4.00 m

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XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (°)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
		Dense Sandy SILT		ML	20.00-20.50	UDS-7			29	NP		0	14	81	5	17.4	1.89	1.61								0	30.5				
21					21.00-21.45	SPT-14	38	22																								
22																															
23					22.50-22.95	SPT-15	42	23																								
24																															
25					24.00-24.45	SPT-16	43	23																								
26		Hard Silty CLAY		CL	25.50-25.95	SPT-17	44				2	9	77	12																	
27																															
28					27.00-27.45	SPT-18	55																									
29					28.50-28.95	SPT-19	60																									
30					30.00-30.45	SPT-20	61																									
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 1 of 2

Location : CH 38+930

Co-ordinate: E: 757277.50 N: 3287830.82

Reduce Level: 256.300 m

Borehole dia : 150 mm

Ground Water Table : 7.00 m

Termination Depth : 30.45 m

Date : 17-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	PL	PI	Grain size Analysis (%) Gravel	Sand	Silt	Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Cc	Pc	Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (o)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
1		Loose Sandy SILT			0.50-1.00	DS-1																									
2					1.50-1.95	SPT-1	9	15																							
				ML	2.00-2.50	UDS-1			29	NP		1	5	91	3	11.7	1.76	1.58	2.62							0	29.9	Nil	188.7	7.33	
3					3.00-3.45	SPT-2	14	20																							
4		Medium Dense Sandy SILT																													
5					4.50-4.95	SPT-3	17	18																							
6					6.00-6.45	SPT-4	18	18																							
7					7.50-7.95	SPT-5	21	19																							
8					9.00-9.45	SPT-6	17	16																							
9					10.50-10.95	SPT-7	20	17								26.3	1.84	1.45													
10					12.00-12.45	SPT-8	21	17																							
11					13.50-13.95	SPT-9	18	15																							
12				CL	14.00 -14.50	UDS-5			33	21	12	1	3	84	12	28	1.82	1.42						104							
13					15.00-15.45	SPT-10	20																								
14					16.50-16.95	SPT-11	23																								
15		Very Stiff to Hard Silty CLAY			18.00-18.45	SPT-12	28																								
16					19.50-19.95	SPT-13	32																								
17																															
18																															
19																															
20																															

Prepared By: Checked By:

BORE LOG

Project : Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

Method of Boring Shell & Auger

Borehole No. 1

Page 2 of 2

Location : CH 38+930

Co-ordinate: E: 757277.50 N: 3287830.82

Reduce Level: 256.300 m

Borehole dia : 150 mm

Ground Water Table : 7.00 m

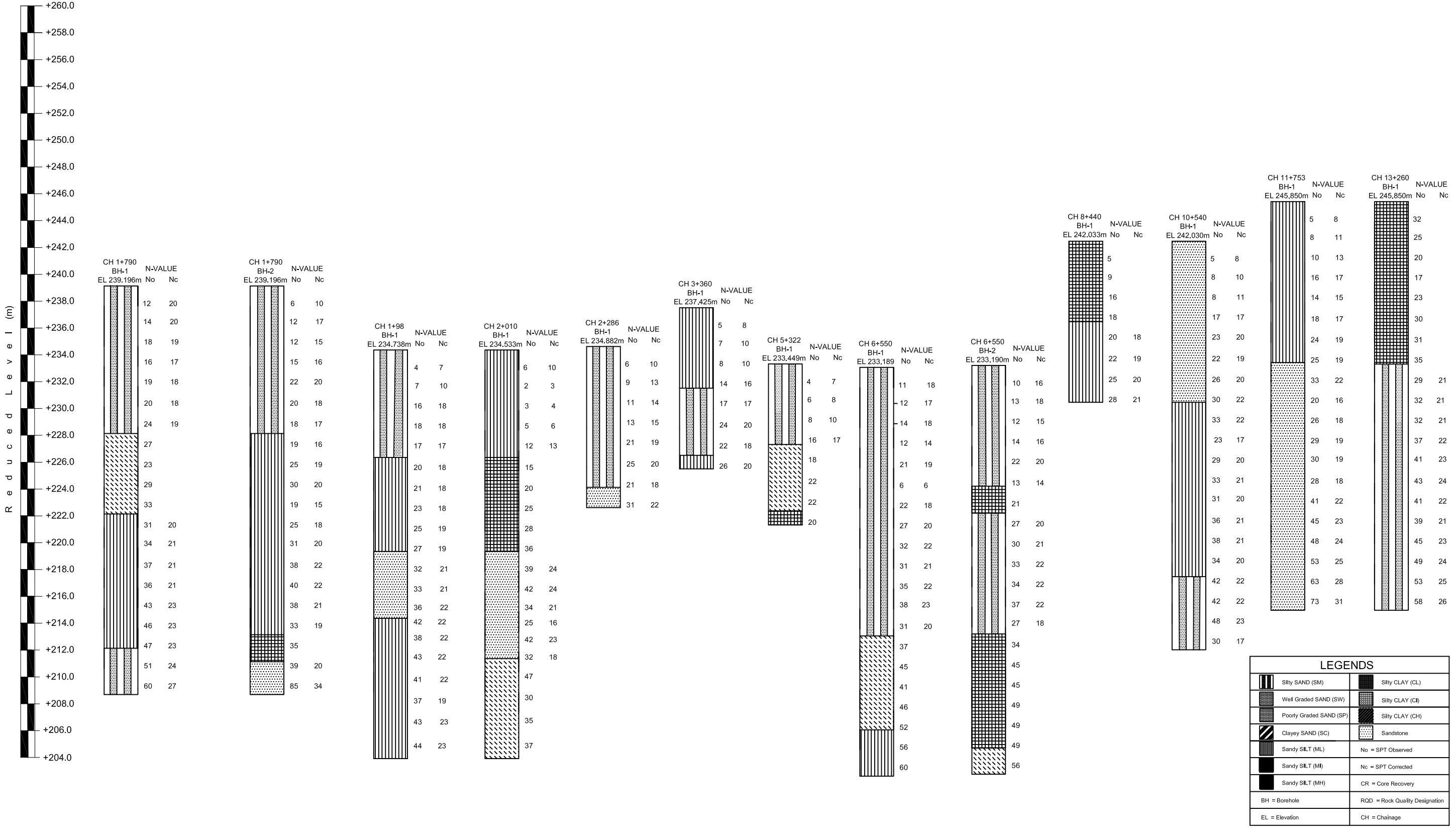
Termination Depth : 30.45 m

Date : 17-02-2016

XPLORER CONSULTANCY SERVICES (P) LTD.

Depth (m)	R.L. (m)	Strata Description	Legend	IS Classification	Sample Depth (m)	Sample Type	SPT N - value (Obs.)	SPT N - value (Corr.)	Atterberg Limit (%) LL	Atterberg Limit (%) PL	Atterberg Limit (%) PI	Grain size Analysis (%) Gravel	Grain size Analysis (%) Sand	Grain size Analysis (%) Silt	Grain size Analysis (%) Clay	Water Content (%)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Specific Gravity	Consolidation Test e_0	Consolidation Test Cc	Consolidation Test Pc	Consolidation Test Cr	UU c (kPa)	UC c (kPa)	Direct Shear c (kPa)	Direct Shear Φ (°)	Chemical Analysis of soil Sulphates mg/l	Chlorides mg/l	pH Value	Organic (%)
21		Hard Silty CLAY			21.00-21.45	SPT-14	37																								
22																															
23					22.50-22.95	SPT-15	47																								
24																															
25					24.00-24.45	SPT-16	56																								
26		Very Dense Fine SAND		SW-SM	25.50-25.95	SPT-17	54	26				0	91	9												0	32.1				
27																															
28					27.00-27.45	SPT-18	59	27																							
29					28.50-28.95	SPT-19	61	27																							
30					30.00-30.45	SPT-20	69	27																							
		Borehole terminated at depth of 30.45m																													
31																															
32																															
33																															
34																															
35																															
36																															
37																															
38																															
39																															
40																															

Prepared By: Checked By:



CLIENT:

skylark
Designer and Engineers (P) Limited

PROJECT:

Geotechnical Investigation Works at
Muzaffarnagar-Saharanpur Section of DFCC Meerut

DRAWING TITLE:

Soil Profile

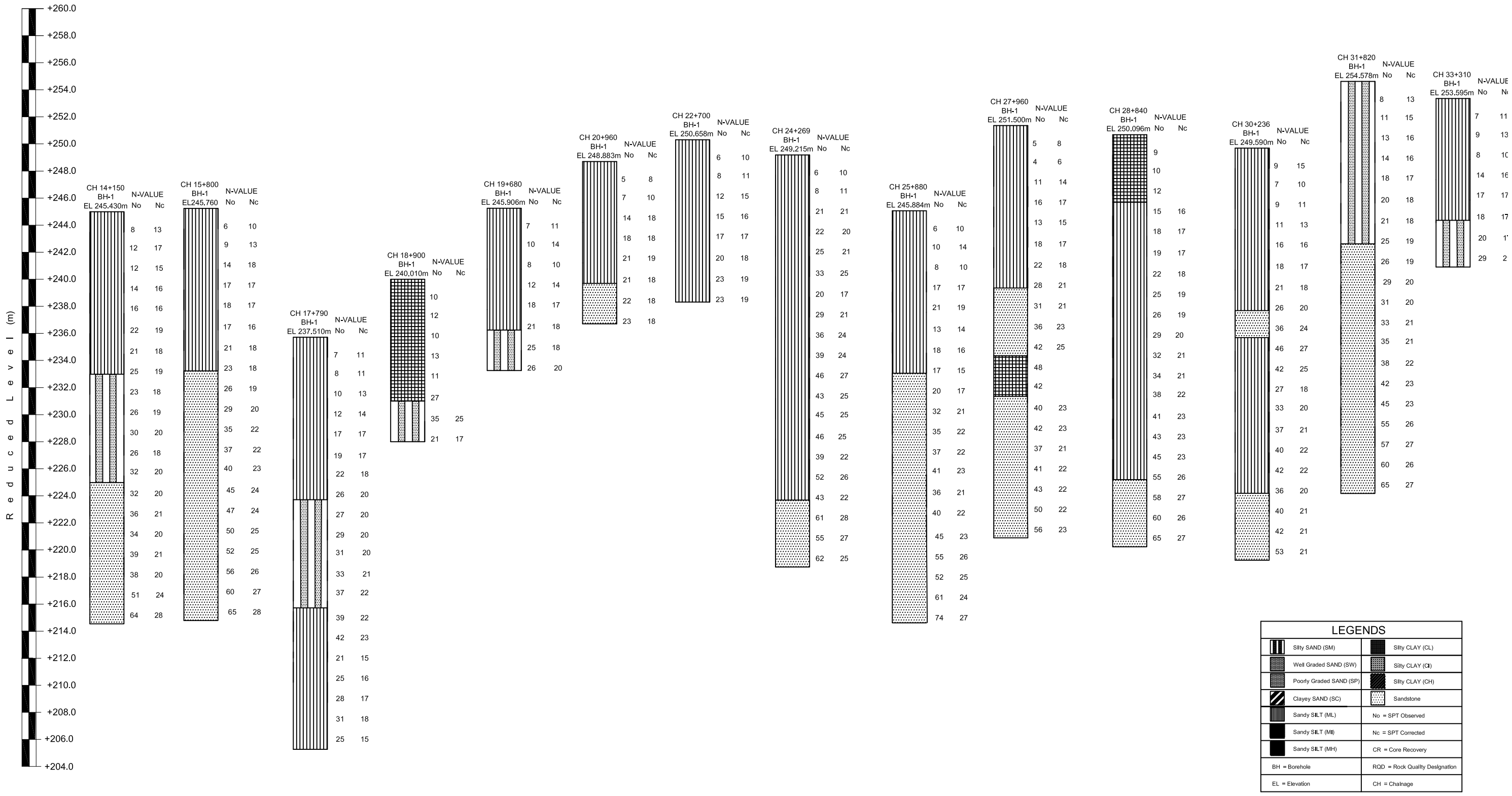
AGENCY:

XPLORER
CONSULTANCY SERVICES (P) LTD.
explore. engineer. deliver

Xplorer Consultancy Services Pvt. Ltd.
Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul,
Gurgaon-122001, Haryana, India
Tel: +91-124-4388659, Fax: +91-124-4241962
Email: xplorer@xplorer.in, Website: www.xplorer.in

DRG. NO. SKYLARK/PROFILE/01

March, 2016



CLIENT:

skylark
Designer and Engineers (P) Limited

PROJECT:

Geotechnical Investigation Works at Muzaffarnagar-Saharanpur Section of DFCC Meerut

DRAWING TITLE:

Soil Profile

AGENCY:

XPLORER
CONSULTANCY SERVICES (P) LTD.
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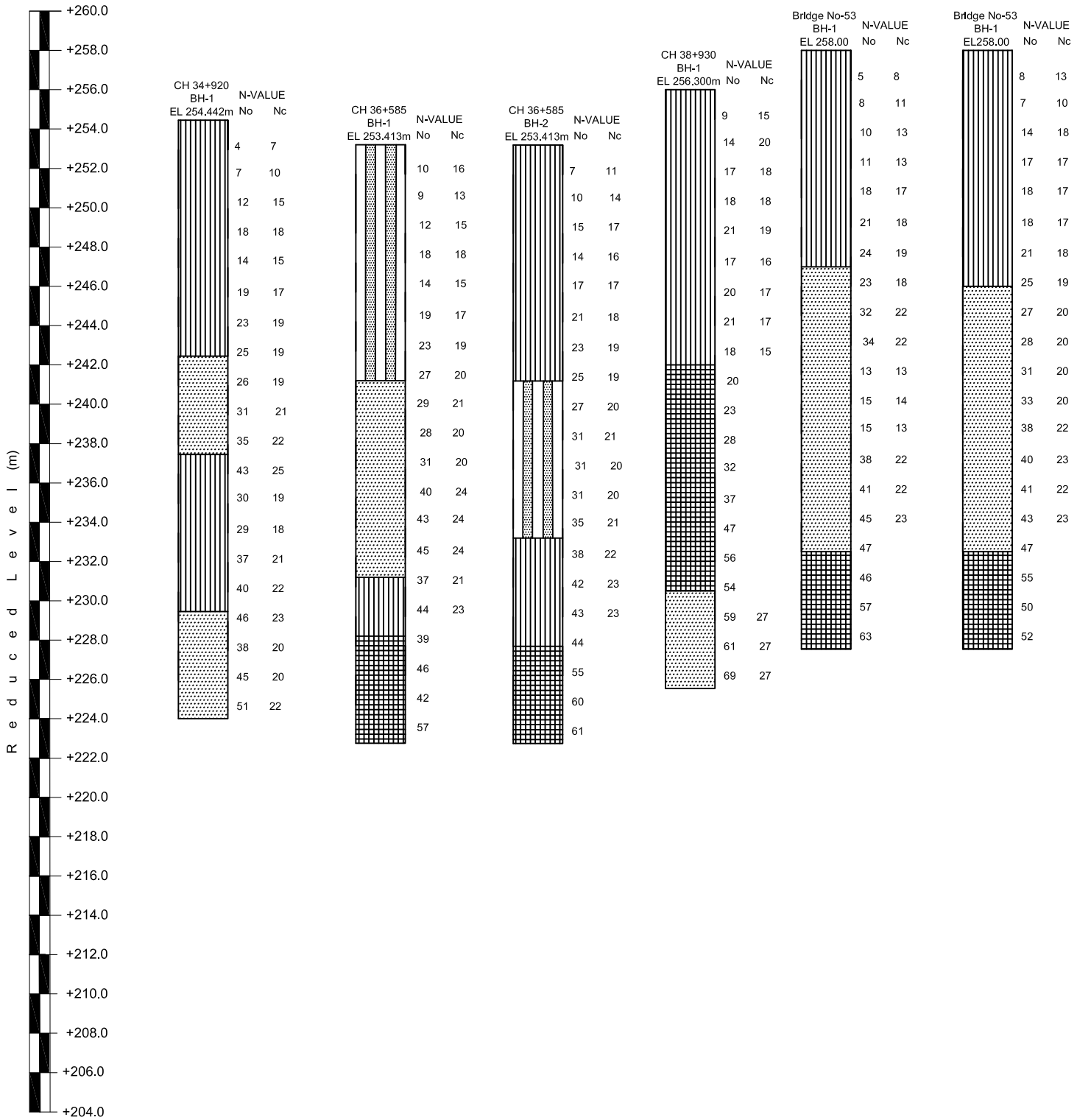
Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul,
Gurgaon-122001, Haryana, India
Tel: +91-124-4388659, Fax: +91-124-4241962
Email: xplorer@xplorer.in, Website: www.xplorer.in

DRG. NO. SKYLARK/PROFILE/02

March, 2016



LEGENDS

Silty SAND (SM)	Silty CLAY (CL)
Well Graded SAND (SW)	Silty CLAY (CI)
Poorly Graded SAND (SP)	Silty CLAY (CH)
Clayey SAND (SC)	Sandstone
Sandy SILT (ML)	No = SPT Observed
Sandy SILT (MI)	Nc = SPT Corrected
Sandy SILT (MH)	CR = Core Recovery
BH = Borehole	RQD = Rock Quality Designation
EL = Elevation	CH = Chainage

CLIENT:

skylark
Designer and Engineers (P) Limited

PROJECT:

Geotechnical Investigation Works at
Muzaffarnagar-Saharanpur Section of DFCC Meerut

DRAWING TITLE:

Soil Profile

AGENCY:

XPLORER
CONSULTANCY SERVICES (P) LTD.
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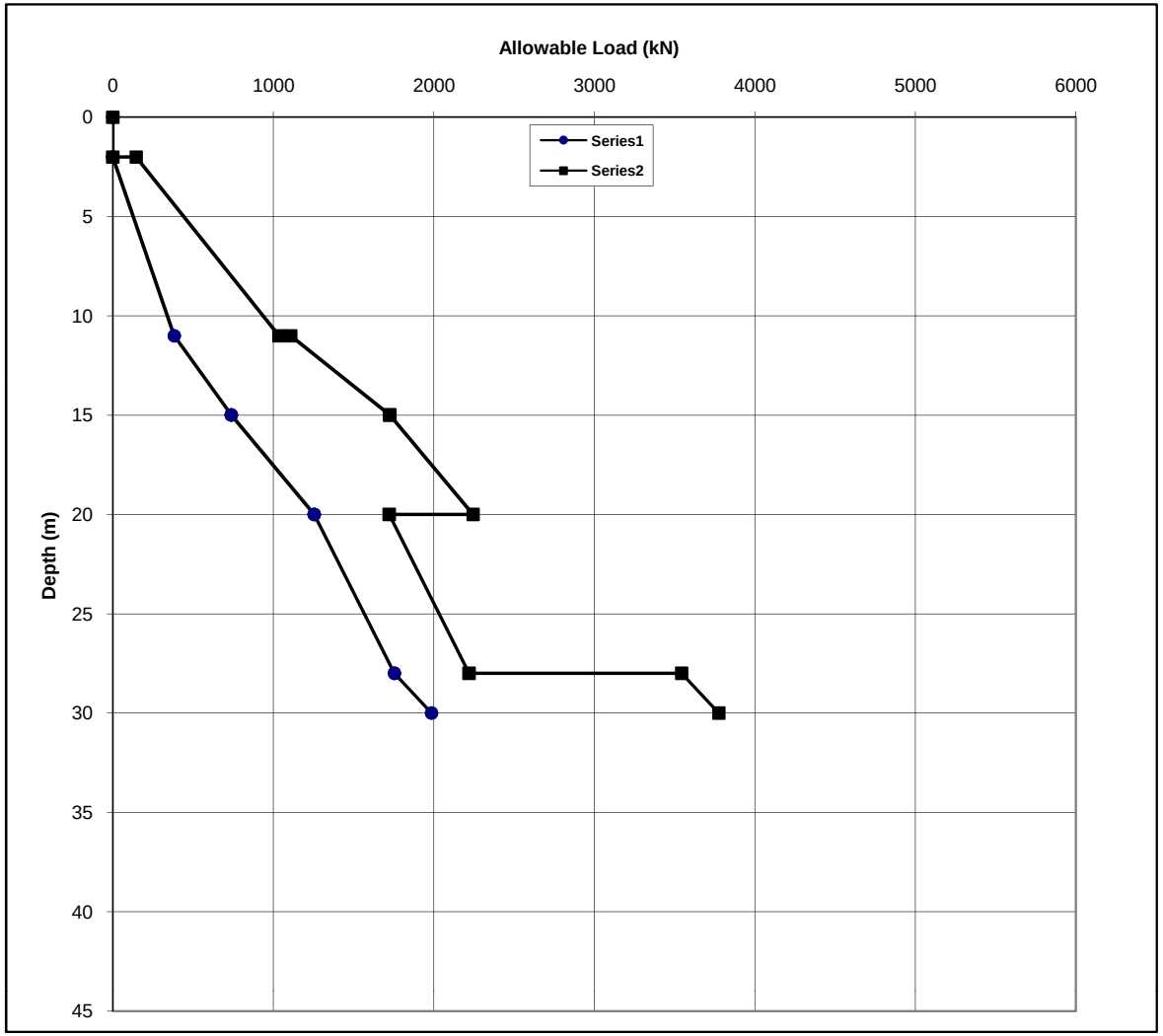
Plot No. 3, First Floor, Sector- 18, Opp. HIPA, Sarhaul,
Gurgaon-122001, Haryana, India
Tel: +91-124-4388659, Fax: +91-124-4241962
Email: xplorer@xplorer.in, Website: www.xplorer.in

DRG. NO. SKYLARK/PROFILE/03

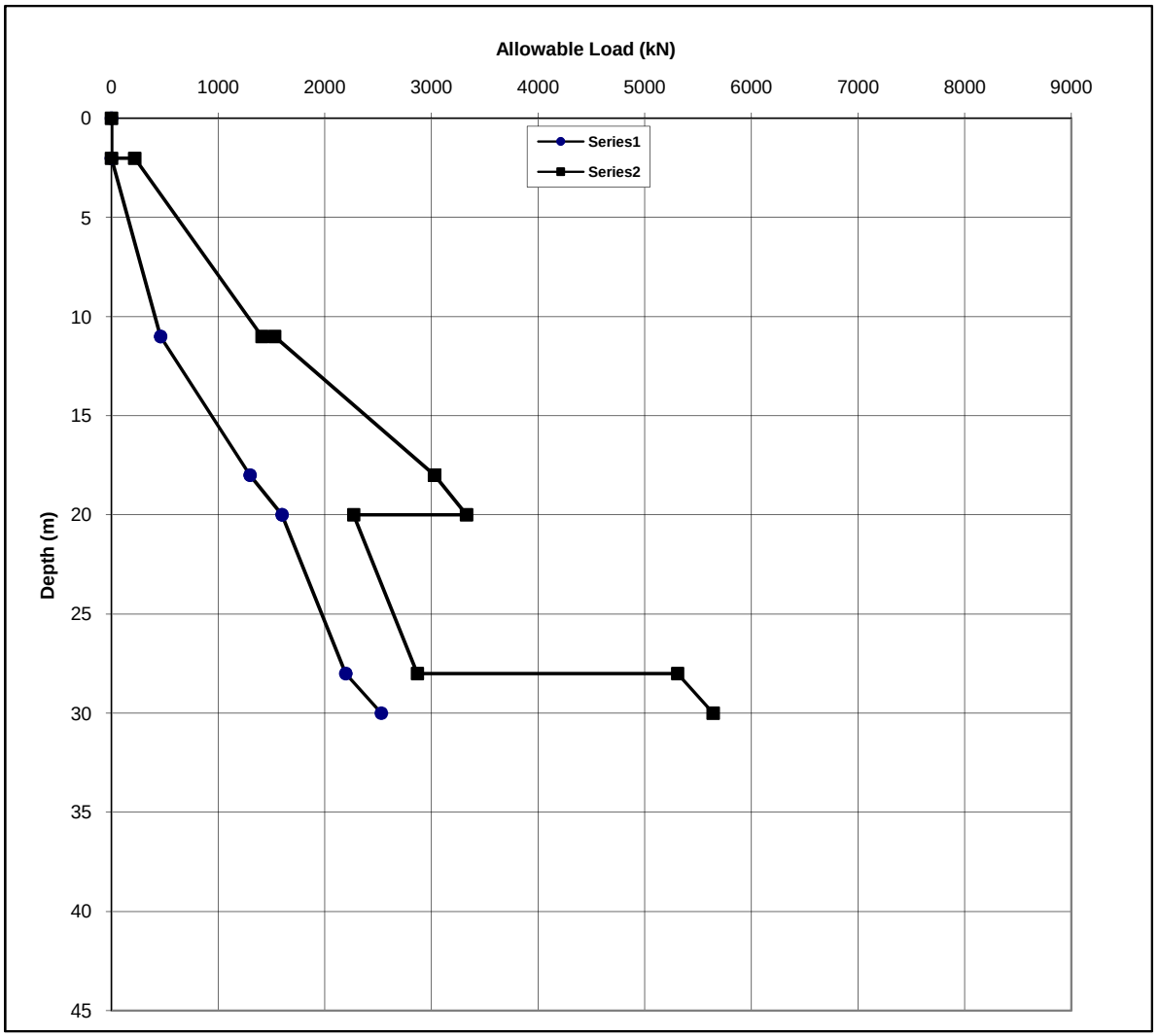
March, 2016

ANNEXURE B- BEARING CAPACITY AND PILE CAPACITY CALCULATIONS



Allowable Pile Capacity at Major Bridge Ch. 1+790

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 1+790

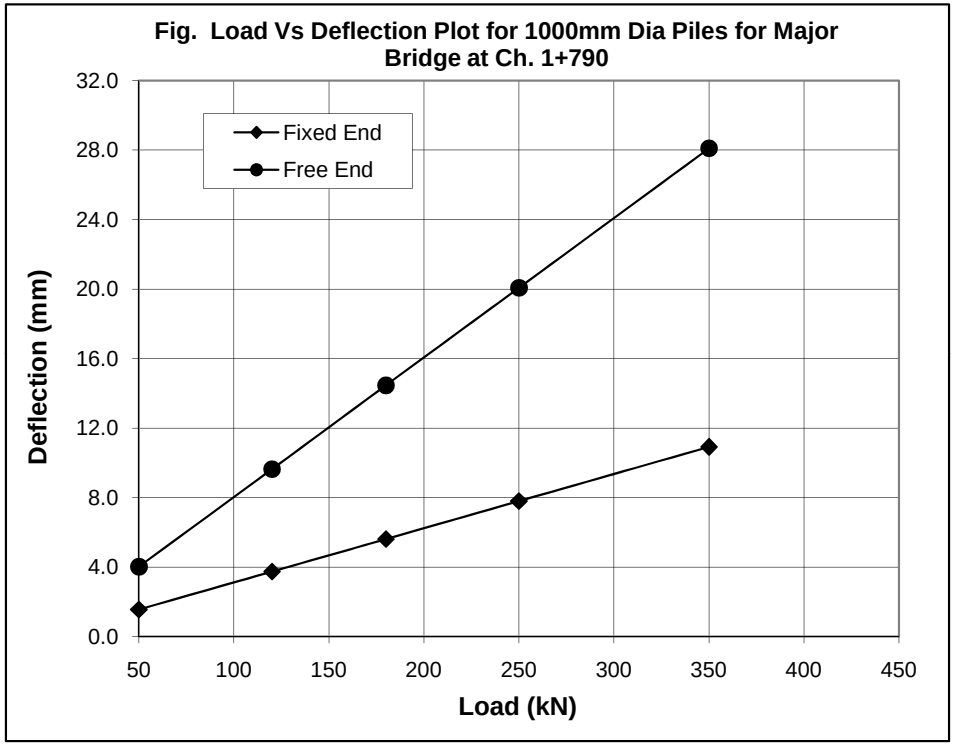
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 1+790 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.220	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	359.73	
L_f/T=	2.2	Fixed
L_f (Fixed)=	791.42	cm
L_f/T=	1.9	Free
L_f (Free)=	683.50	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.56	4.02
120	3.74	9.64
180	5.61	14.46
250	7.79	20.08
350	10.91	28.11



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 320kN (for fixed head condition)

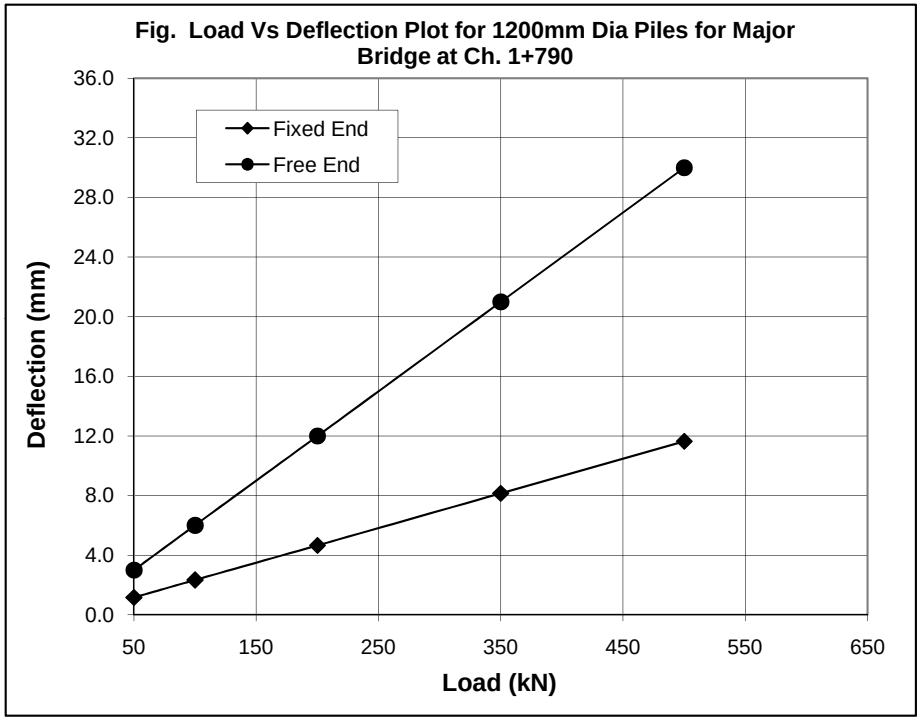
= 120 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 1+790 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.220	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	416.22	
L_f/T=	2.2	Fixed
L_f (Fixed)=	915.69	cm
L_f/T=	1.9	Free
L_f (Free)=	790.83	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

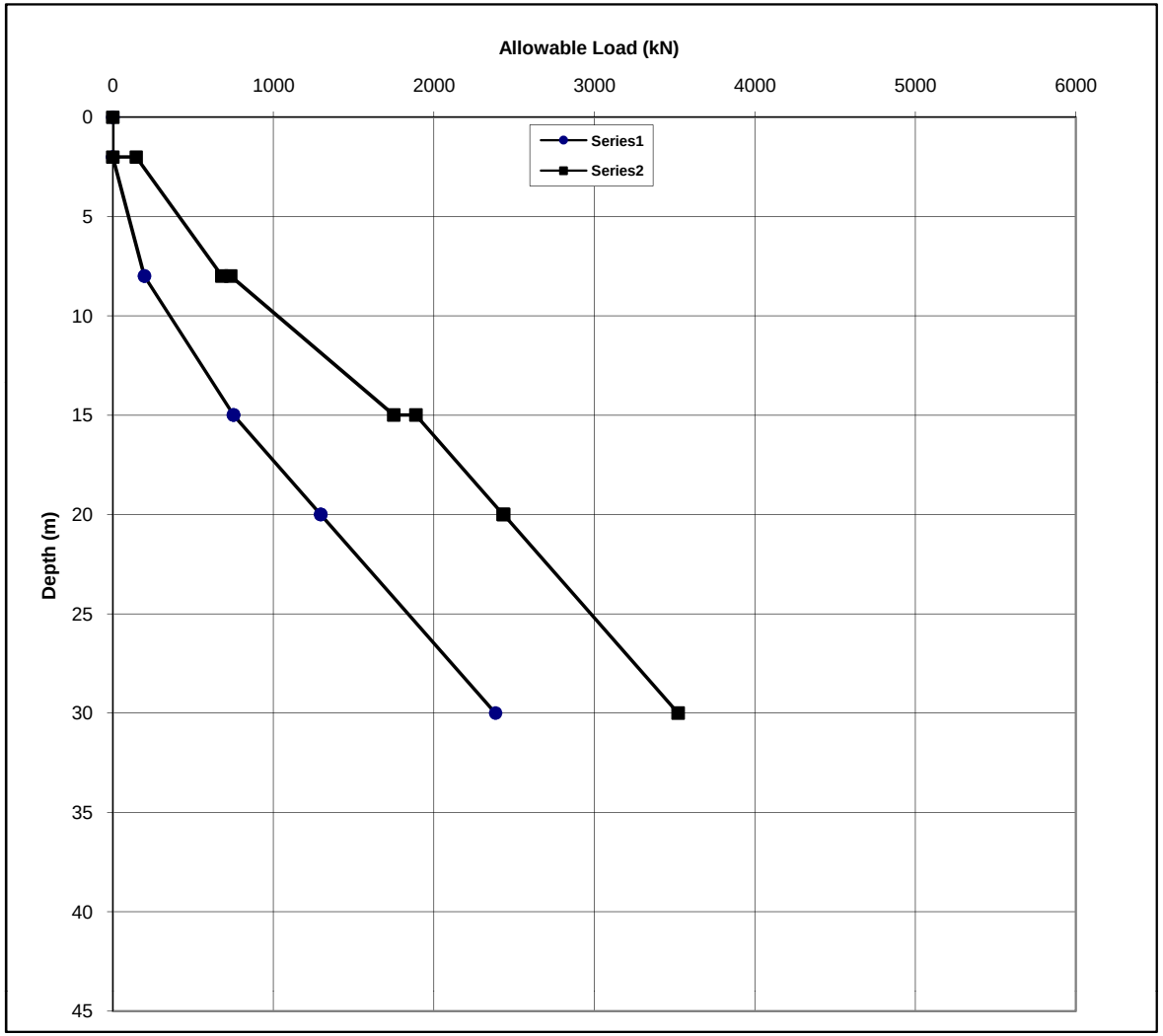
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.16	3.00
100	2.33	6.00
200	4.66	12.00
350	8.15	21.00
500	11.64	29.99



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

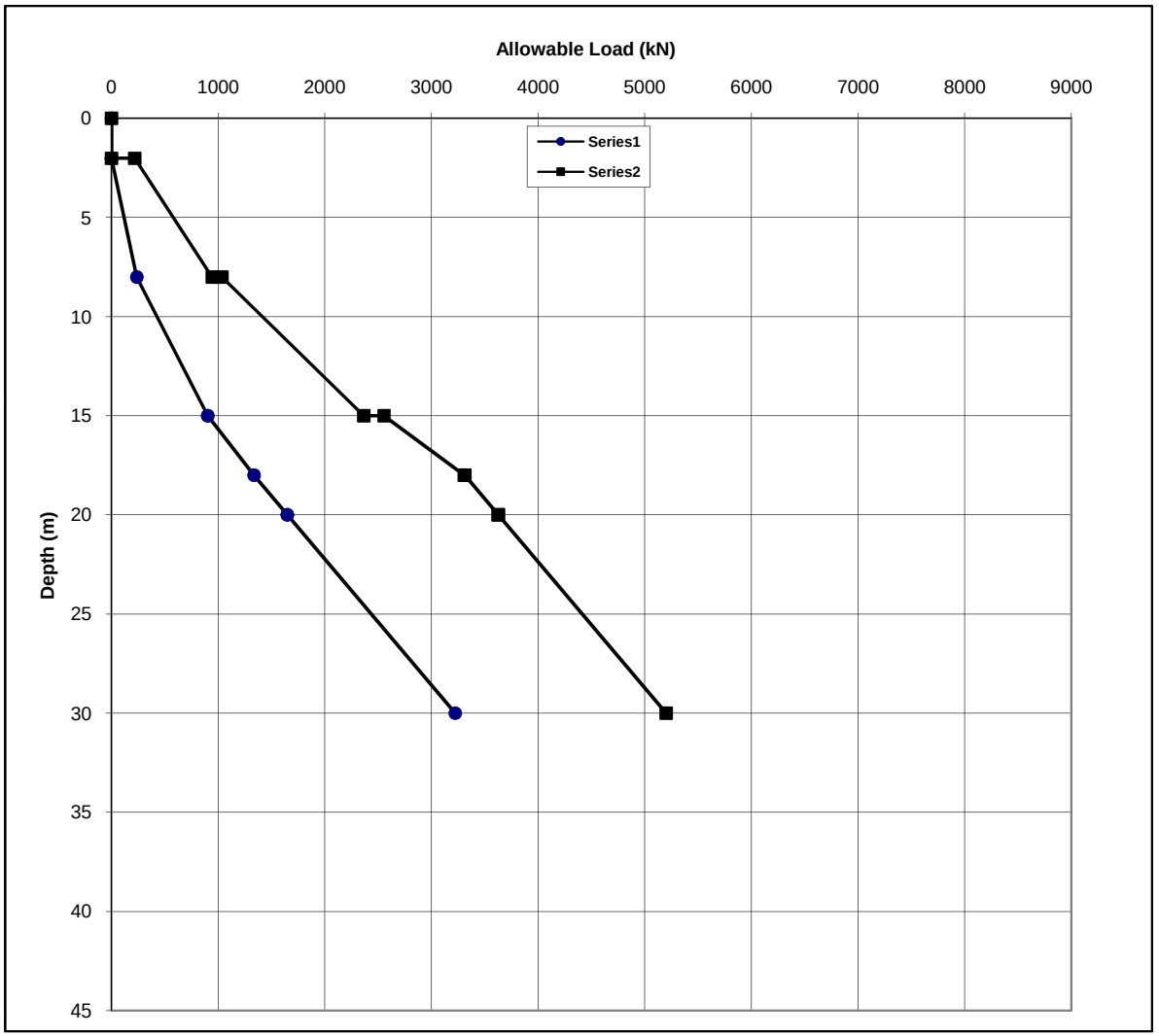
= 500kN (for fixed head condition)

= 200kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 1+980

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 1+980

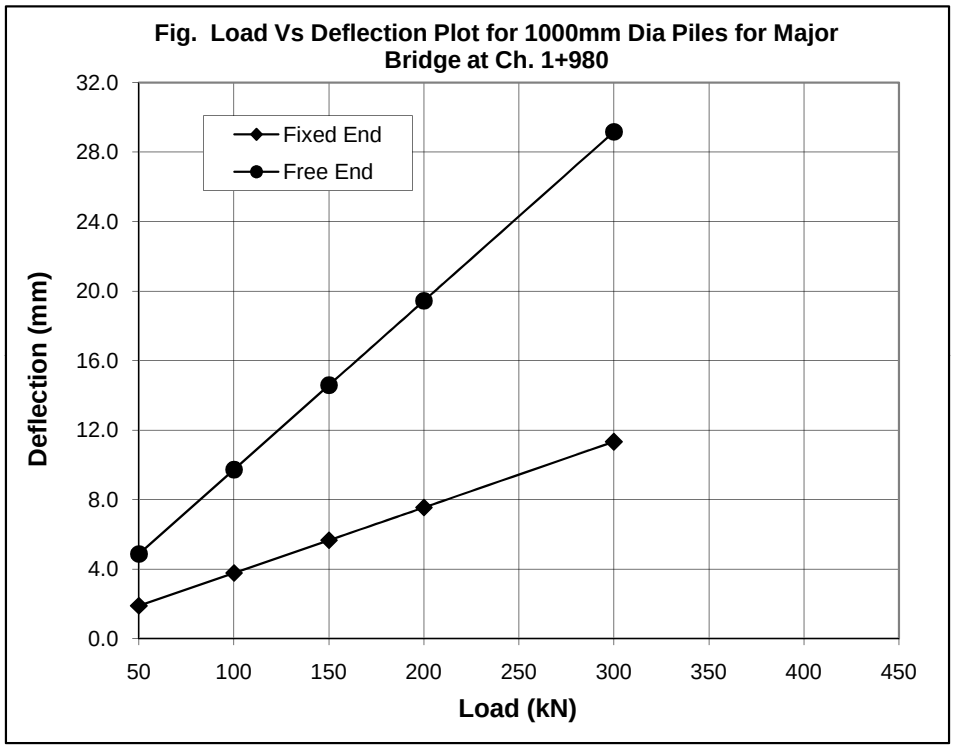
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 1+980 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.160	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	383.39	
L_f/T=	2.2	Fixed
L_f (Fixed)=	843.46	cm
L_f/T=	1.9	Free
L_f (Free)=	728.44	cm
L_1=	0	cm
d=	Q(L_1+L_f)^3/12EI	Fixed
	Q(L_1+L_f)^3/3EI	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.89	4.86
100	3.77	9.72
150	5.66	14.58
200	7.55	19.44
300	11.32	29.16



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 250kN (for fixed head condition)

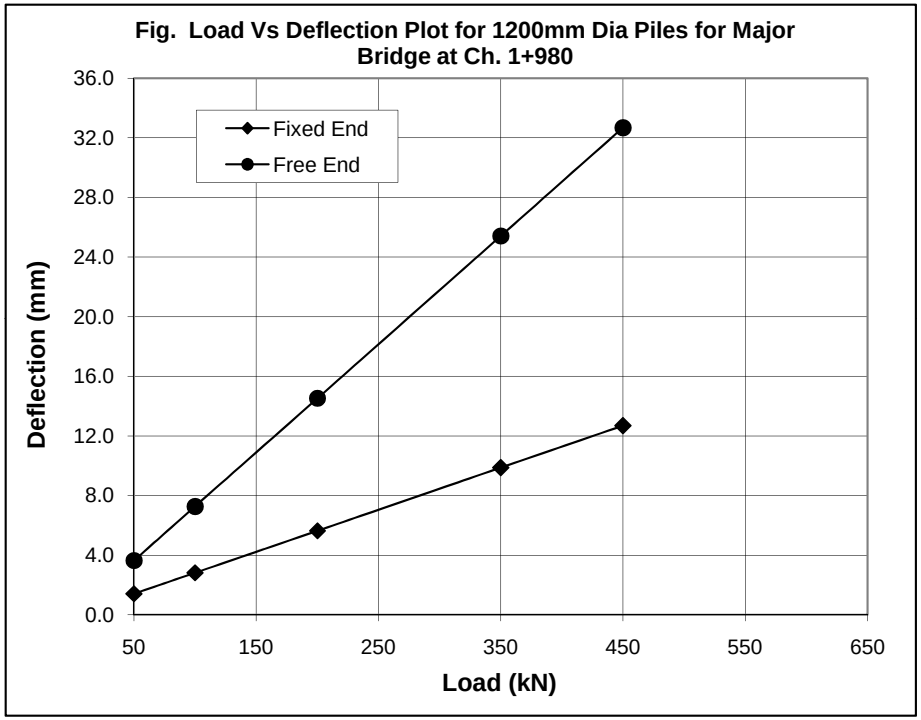
= 100 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 1+980 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.160	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	443.60	
L_f/T=	2.2	Fixed
L_f (Fixed)=	975.91	cm
L_f/T=	1.9	Free
L_f (Free)=	842.83	cm
L_1=	0	cm
d=	Q(L_1+L_f)^3/12EI	Fixed
	Q(L_1+L_f)^3/3EI	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.41	3.63
100	2.82	7.26
200	5.64	14.52
350	9.86	25.42
450	12.68	32.68



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

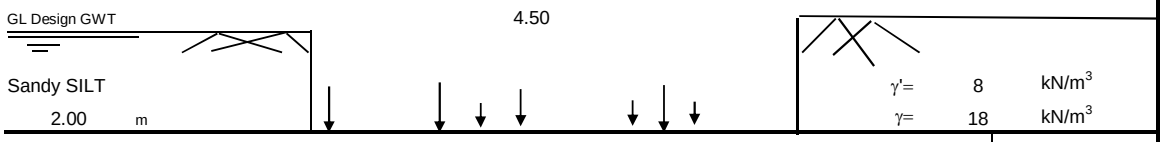
= 420kN (for fixed head condition)

= 160kN (for free head condition)

Calculation for Bearing Capacity at Minor Bridge CH 2+286 km

Footing Size: 5.5x4.5 m

Depth : 2.00 m



Layer - I — Silty SAND — Z_1

Compacted Sand (85% Relative Density)

N_{av}=	7	
ϕ_{av}=	31	degree
c_{av}=	0	kPa
γ_{av}=	8	kN/m^3

4.50 m

Layer - II — Silty SAND — ……Z_2

N_{av}=	20	
ϕ_{av}=	31	degree
c_{av}=	0	kPa
γ_{av}=	9	kN/m^3

12.00 m

Safe Bearing Capacity from Shear Failure

Design ϕ= 31 degree

For Layer - I

As ϕ is 31° Intermediate Shear failure is considered

Q(safe)= $(cN_cs_cd_ci_c+(\gamma*D)(N_q-1)s_qd_qi_q+0.5B\gamma N_\gamma s_\gamma d_\gamma i_{\gamma W}/FS$

FS= 2.5 w= 0.5

N_c=	33.34	N_q=	21.38	N_γ=	27.54	General shear failure
N_c=	17.19	N_q=	8.1	N_γ=	7.59	Local shear failure
N_c=	19.88	N_q=	10.31	N_γ=	10.92	Intermediate condition
S_c=	1.164	S_q=	1.164	S_γ=	0.67	
dc=	1+0.2*(D/B)*tan(45+φ/2)=		1.16			
dq=dγ=	1+0.1*(D/B)*tan(45+φ/2)		1.08			
ic=iq=	(1-α/90)^2=	1.00	ig=	(1-α/φ)^2=	1.00	α=0

Q_{safe-I}= 139.0 kPa

Design Bearing Capacity= **135 kPa**

Settlement for Layer - I

δ (mm) = $m_v*H*\Delta p*\mu_g*d_f$*Rigidity Factor (0.8) — for clay

m_v= m2/kN μ_g=

δ (mm)= $[2.303*(H/C)*\log_{10}\{(p_o+\Delta p)/p_o\}]*d_f$*Rigidity Factor (0.8) — for sand

C=1.5*(C_{kd}/p_o)= 218.8 C_{kd}/N= 250 KN/m^2 1st layer I = 0.92

p_o= 12 p= 135.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_1 (mm)= 19.54

Settlement for Layer-II

δ (mm) = $m_v * H * \Delta p * \mu_g * d_f$ * Rigidity Factor (0.8) for clay

m_v= m2/kN μ_g=

δ (mm)= $[2.303 * (H/C) * \log_{10}\{(p_o + \Delta p)/p_o\}] * d_f$ * Rigidity Factor (0.8) for sand IS:8009 (Part I)

$C = 1.5 * (C_{kd}/p_o)$= 129.0 C_{kd}/N= 300 KN/m^2 2nd layer I = 0.28

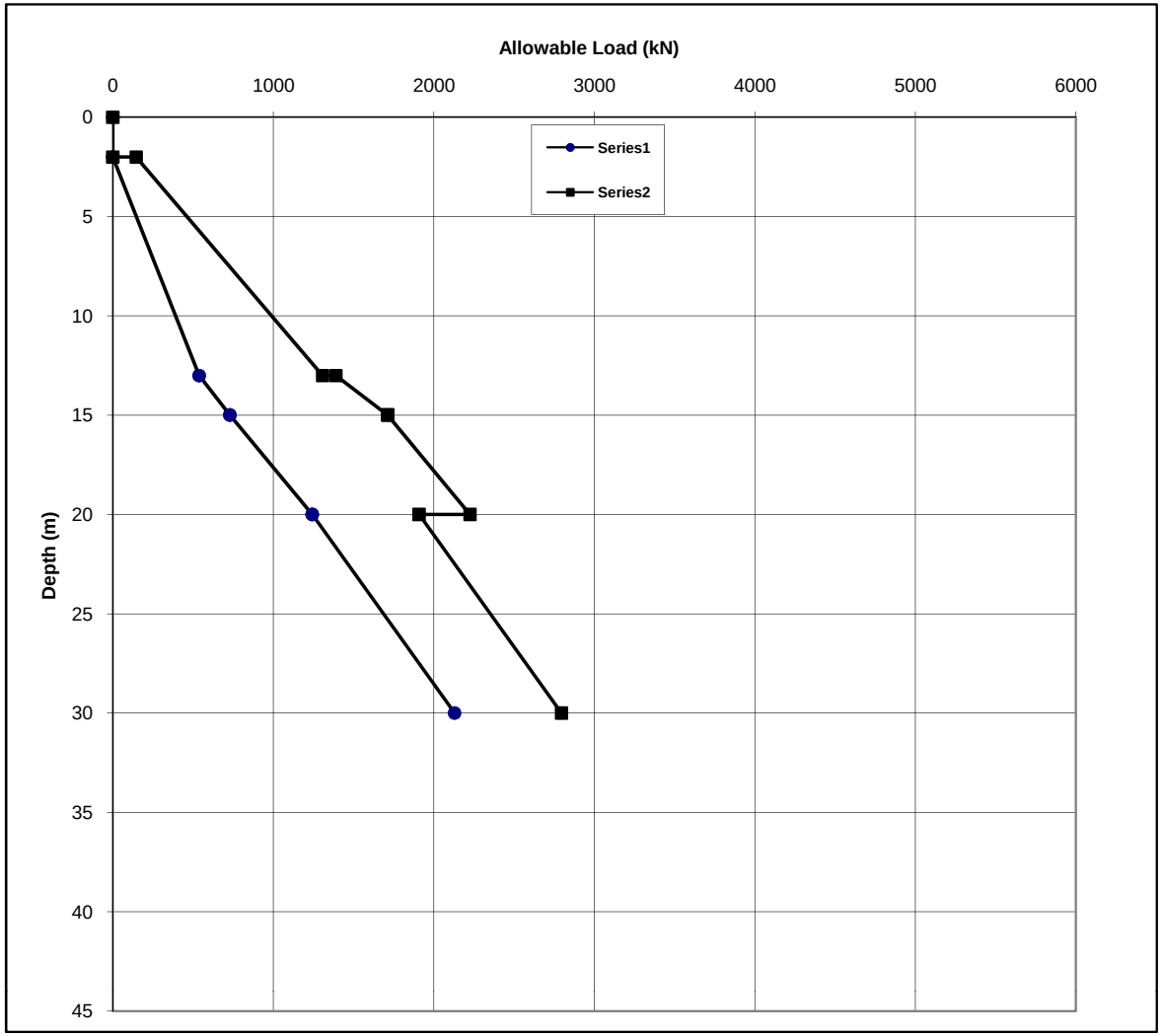
p_o= 69.75 p= 135.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_2 (mm)= 17.72

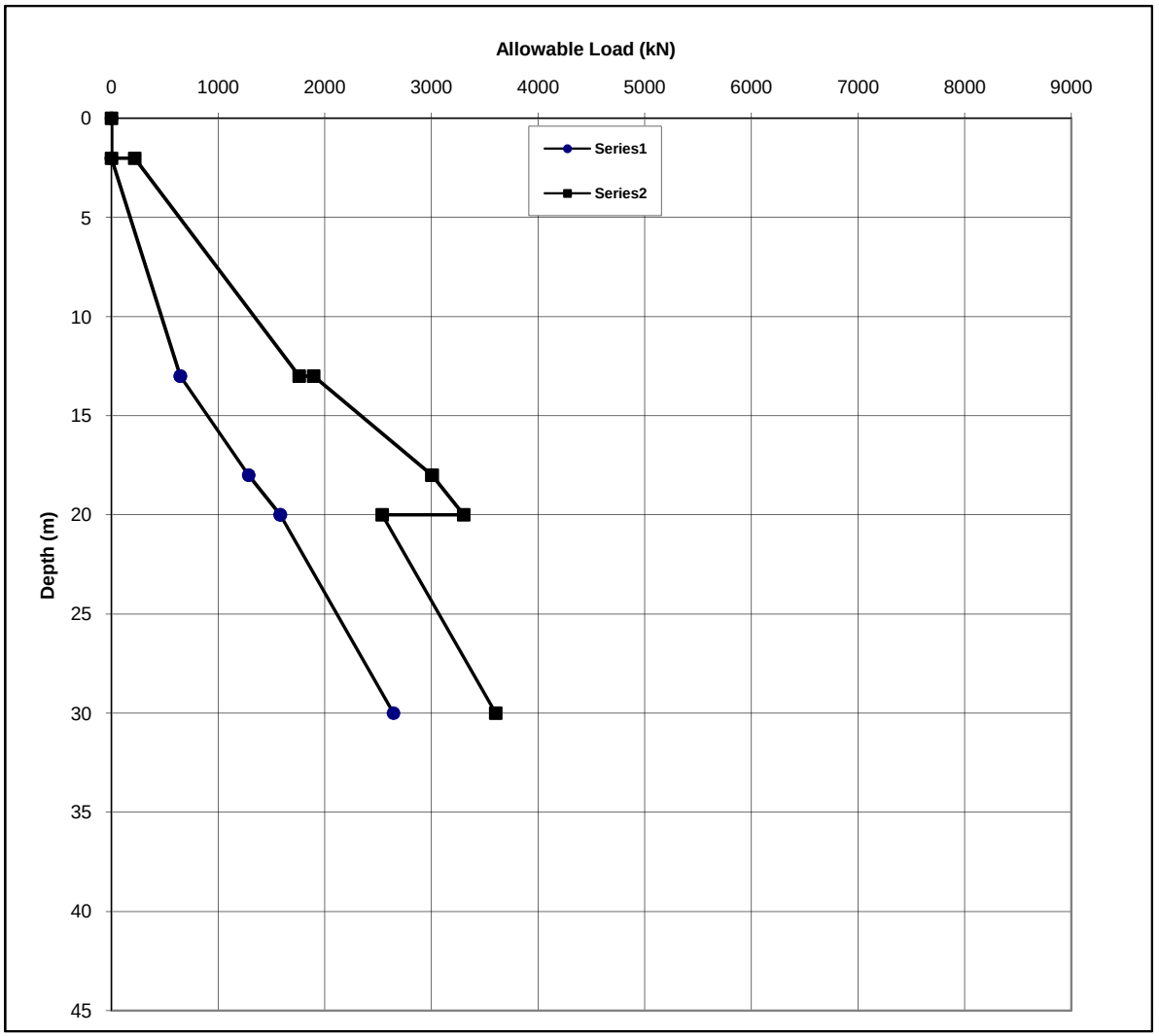
Total settlement = 37.26 mm

Allowable Bearing capacity for 25mm settlement= 93.3 KPa



Allowable Pile Capacity at Major Bridge Ch. 6+550

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 6+550

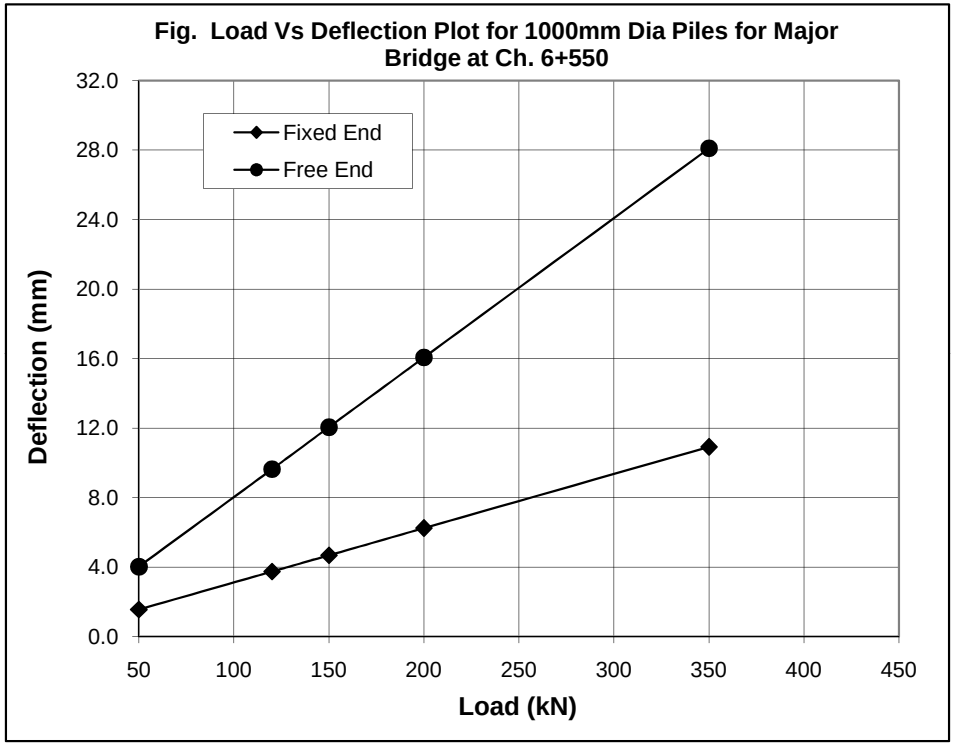
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 6+550 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.220	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	359.73	
L_f/T=	2.2	Fixed
L_f (Fixed)=	791.42	cm
L_f/T=	1.9	Free
L_f (Free)=	683.50	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.56	4.02
120	3.74	9.64
150	4.68	12.05
200	6.23	16.06
350	10.91	28.11



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 320kN (for fixed head condition)

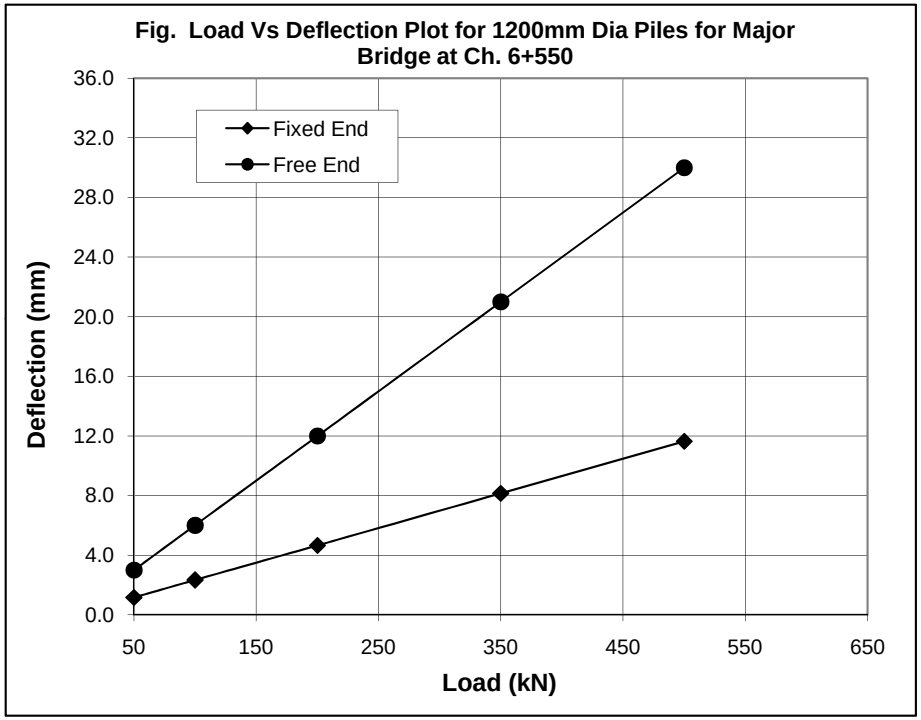
= 120 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 6+550 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.220	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	416.22	
L_f/T=	2.2	Fixed
L_f (Fixed)=	915.69	cm
L_f/T=	1.9	Free
L_f (Free)=	790.83	cm
L_1=	0	cm
d=	Q(L_1+L_f)^3/12EI	Fixed
	Q(L_1+L_f)^3/3EI	Free

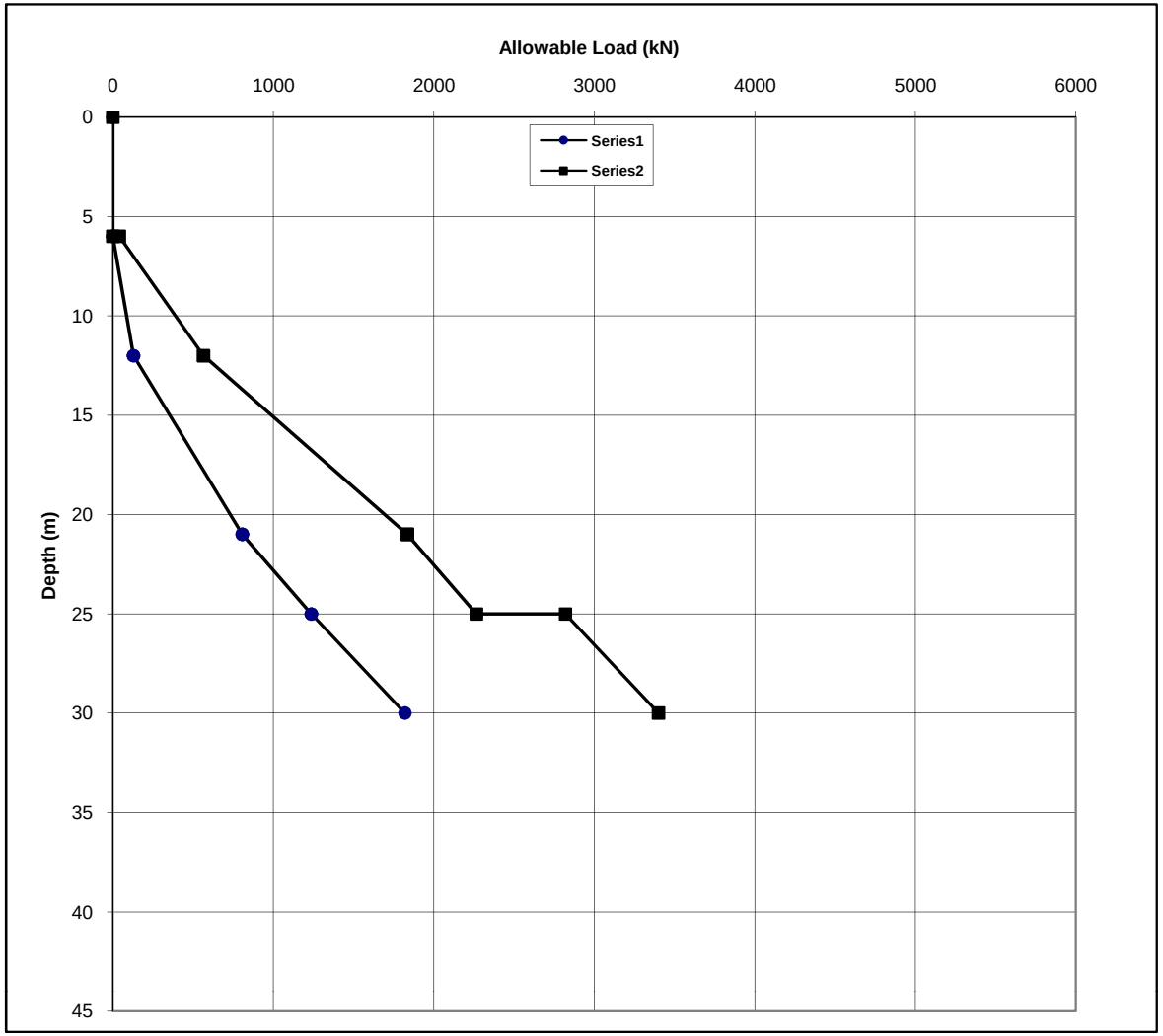
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.16	3.00
100	2.33	6.00
200	4.66	12.00
350	8.15	21.00
500	11.64	29.99



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

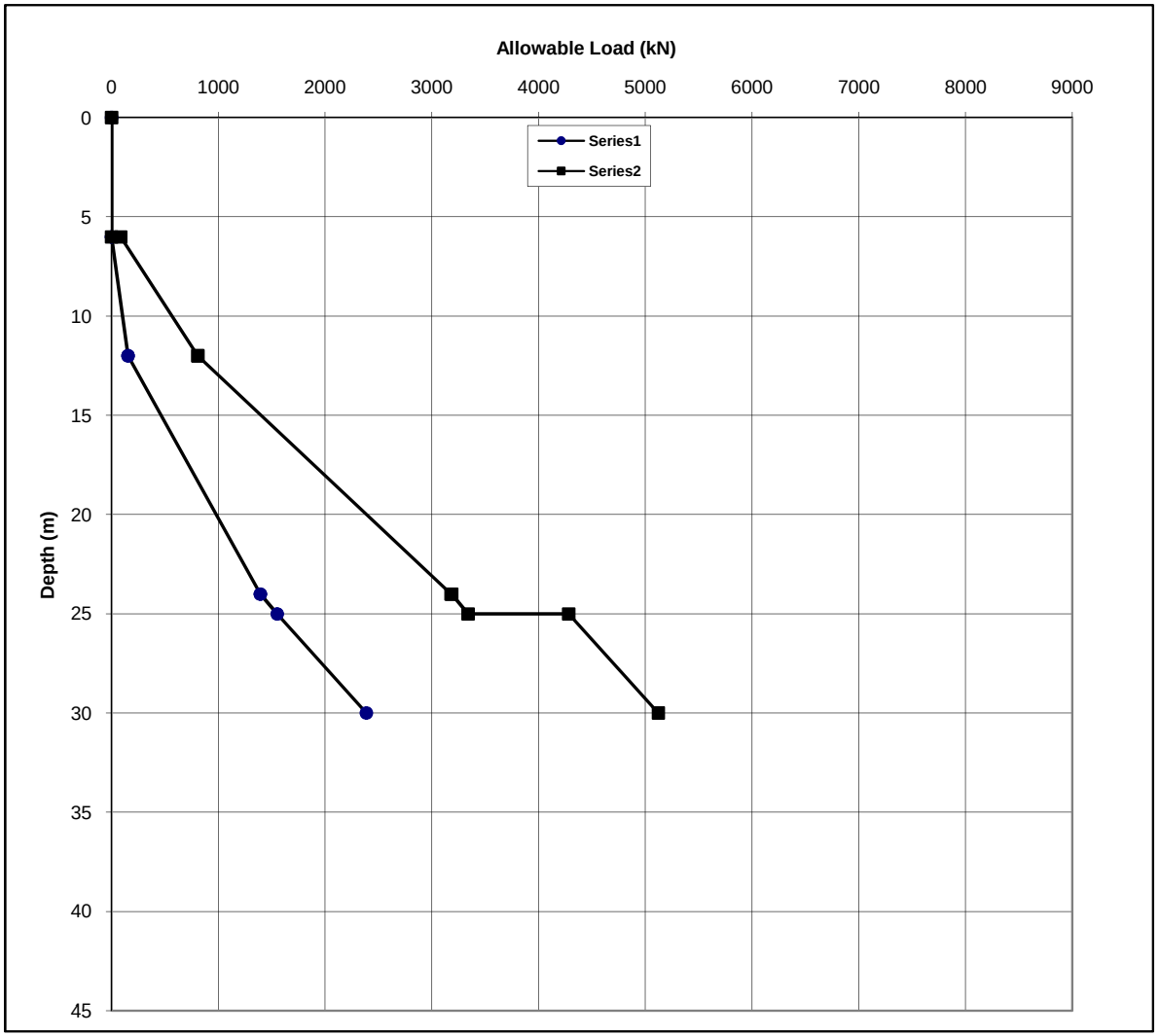
= 500kN (for fixed head condition)

= 200kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 10+540

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 10+540

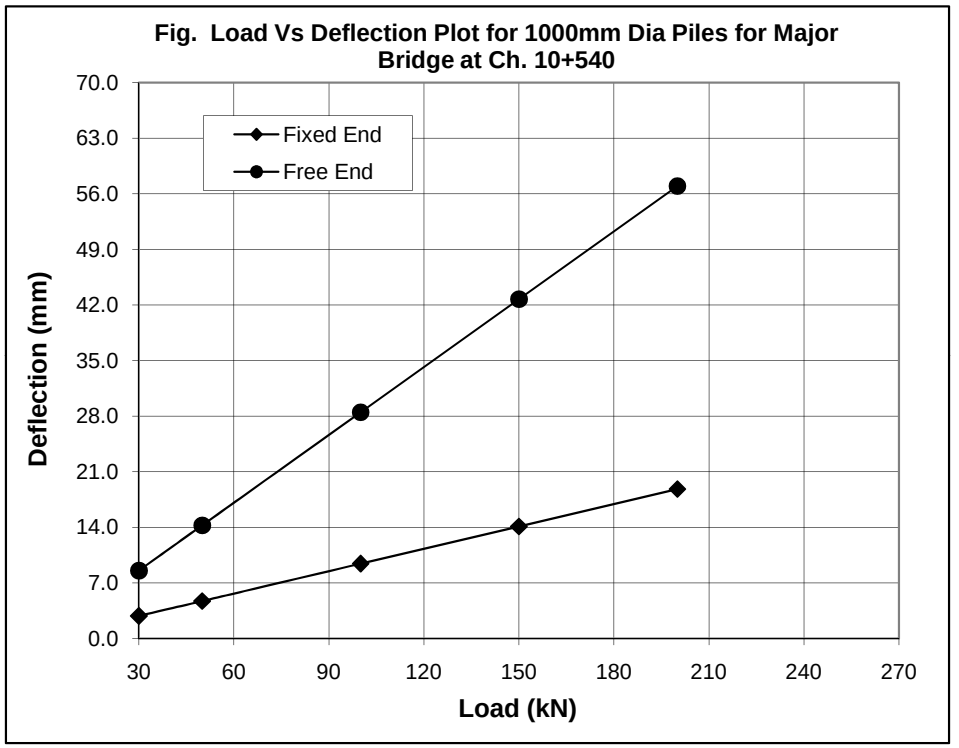
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 10+540 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.300	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	338.10	
L_f/T=	2.2	Fixed
L_f (Fixed)=	743.82	cm
L_f/T=	1.9	Free
L_f (Free)=	642.39	cm
L_1=	400	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
30	2.82	8.55
50	4.70	14.24
100	9.41	28.49
150	14.11	42.73
200	18.82	56.97



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 170kN (for fixed head condition)

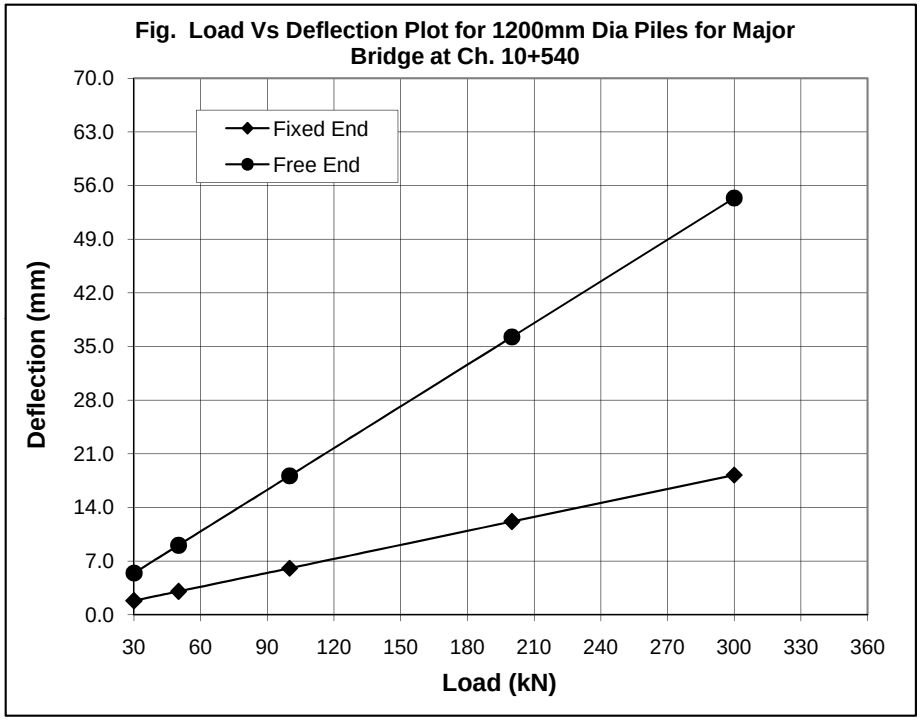
= 50 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 10+540 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.300	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	391.19	
L_f/T=	2.2	Fixed
L_f (Fixed)=	860.62	cm
L_f/T=	1.9	Free
L_f (Free)=	743.26	cm
L_1=	400	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

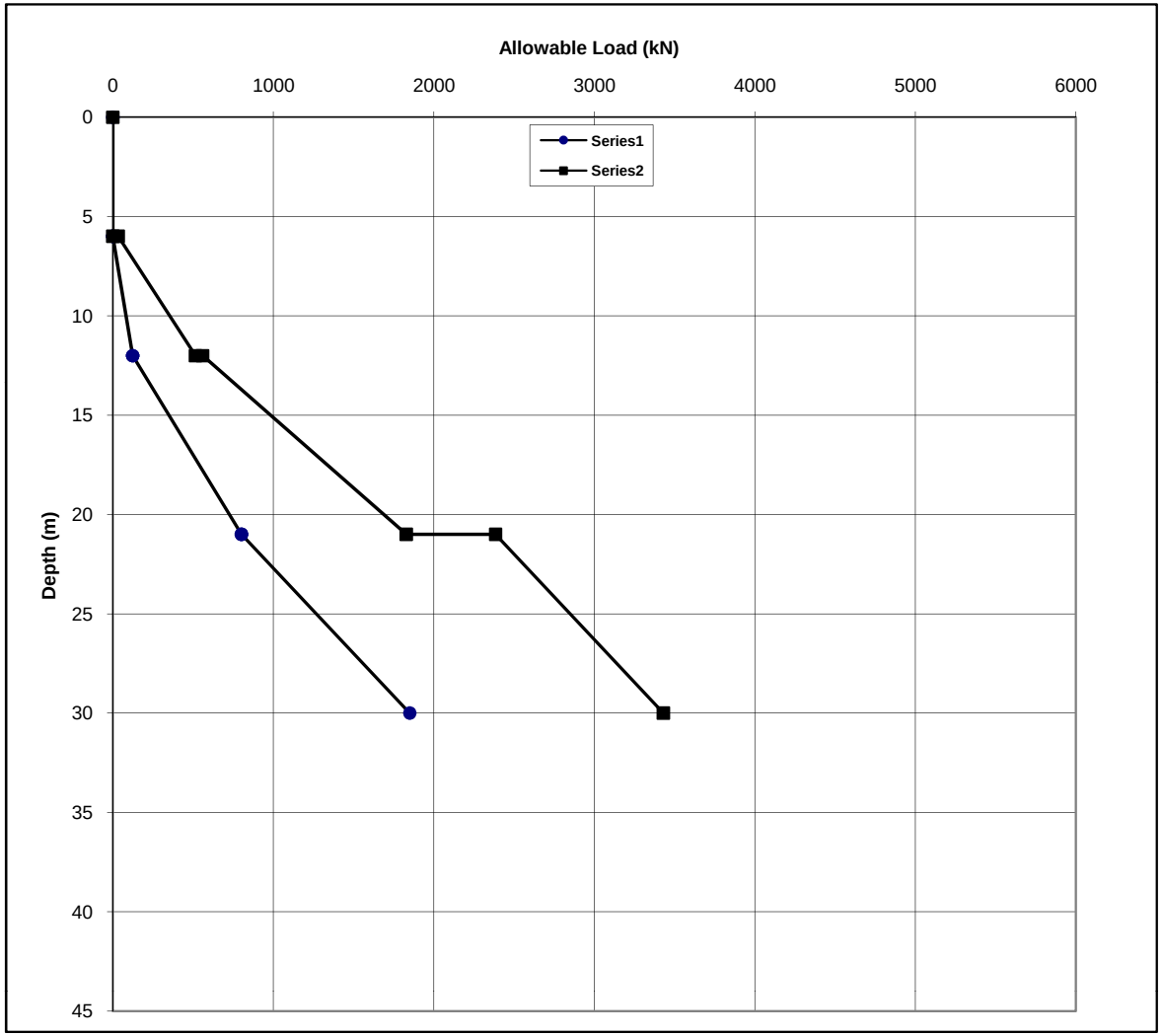
Q (kN)	d (mm) - Fixed	d (mm) - Free
30	1.82	5.44
50	3.04	9.06
100	6.07	18.12
200	12.15	36.25
300	18.22	54.37



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

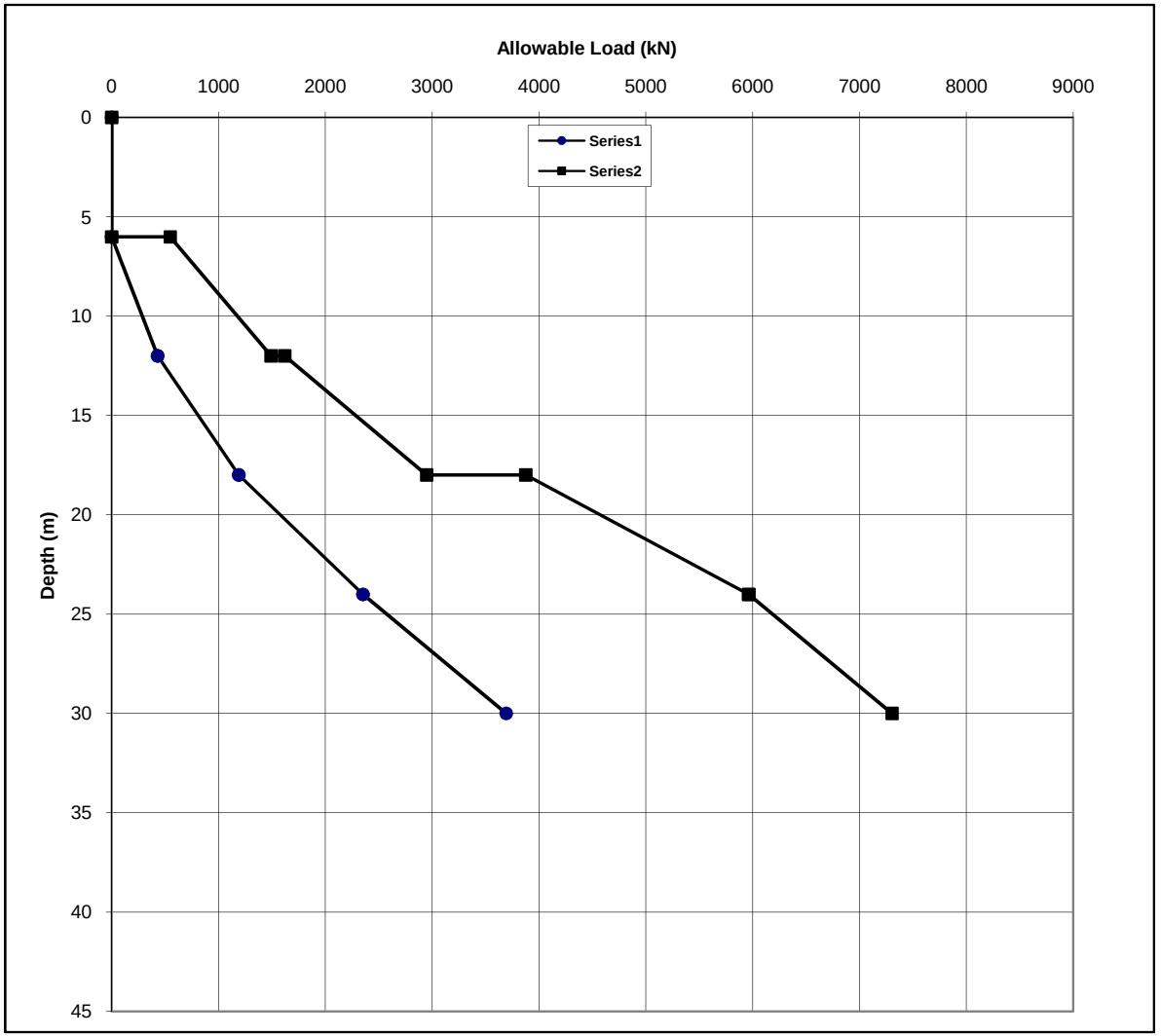
= 290kN (for fixed head condition)

= 90kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 11+735

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 11+735

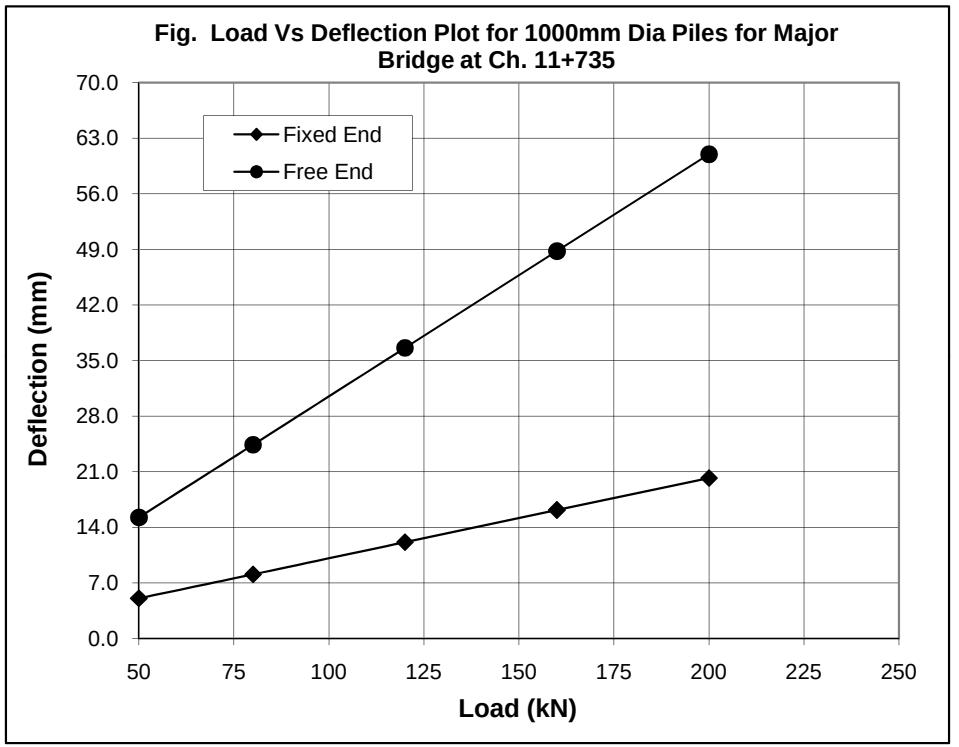
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 11+735 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.250	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	350.65	
L_f/T=	2.2	Fixed
L_f (Fixed)=	771.44	cm
L_f/T=	1.9	Free
L_f (Free)=	666.24	cm
L_1=	400	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	5.05	15.24
80	8.09	24.39
120	12.13	36.58
160	16.17	48.78
200	20.22	60.97



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 150kN (for fixed head condition)

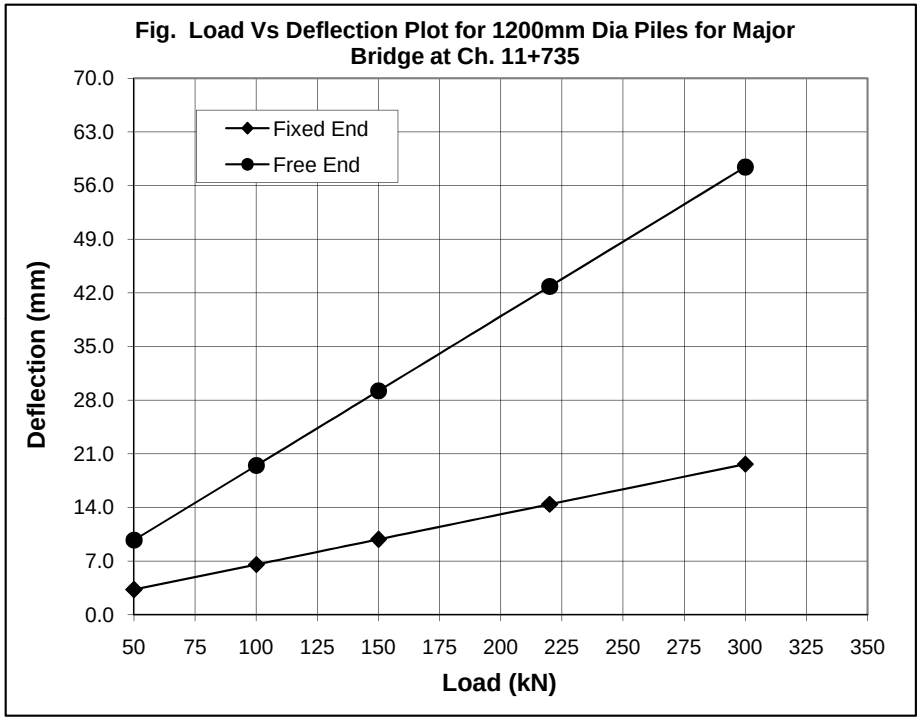
= 50 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 11+735 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.250	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	405.72	
L_f/T=	2.2	Fixed
L_f (Fixed)=	892.58	cm
L_f/T=	1.9	Free
L_f (Free)=	770.86	cm
L_1=	400	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

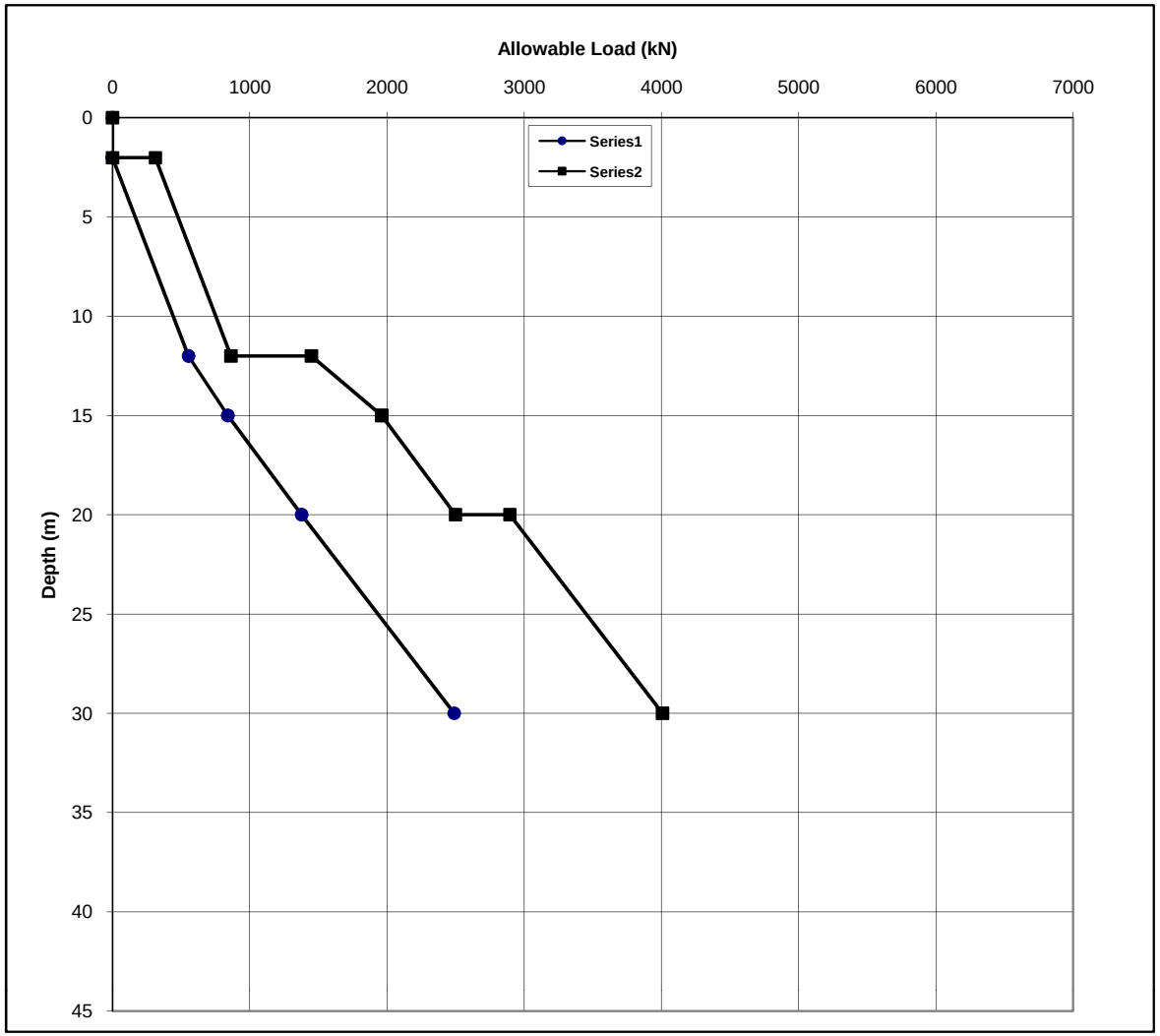
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	3.27	9.73
100	6.55	19.47
150	9.82	29.20
220	14.41	42.83
300	19.65	58.41



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

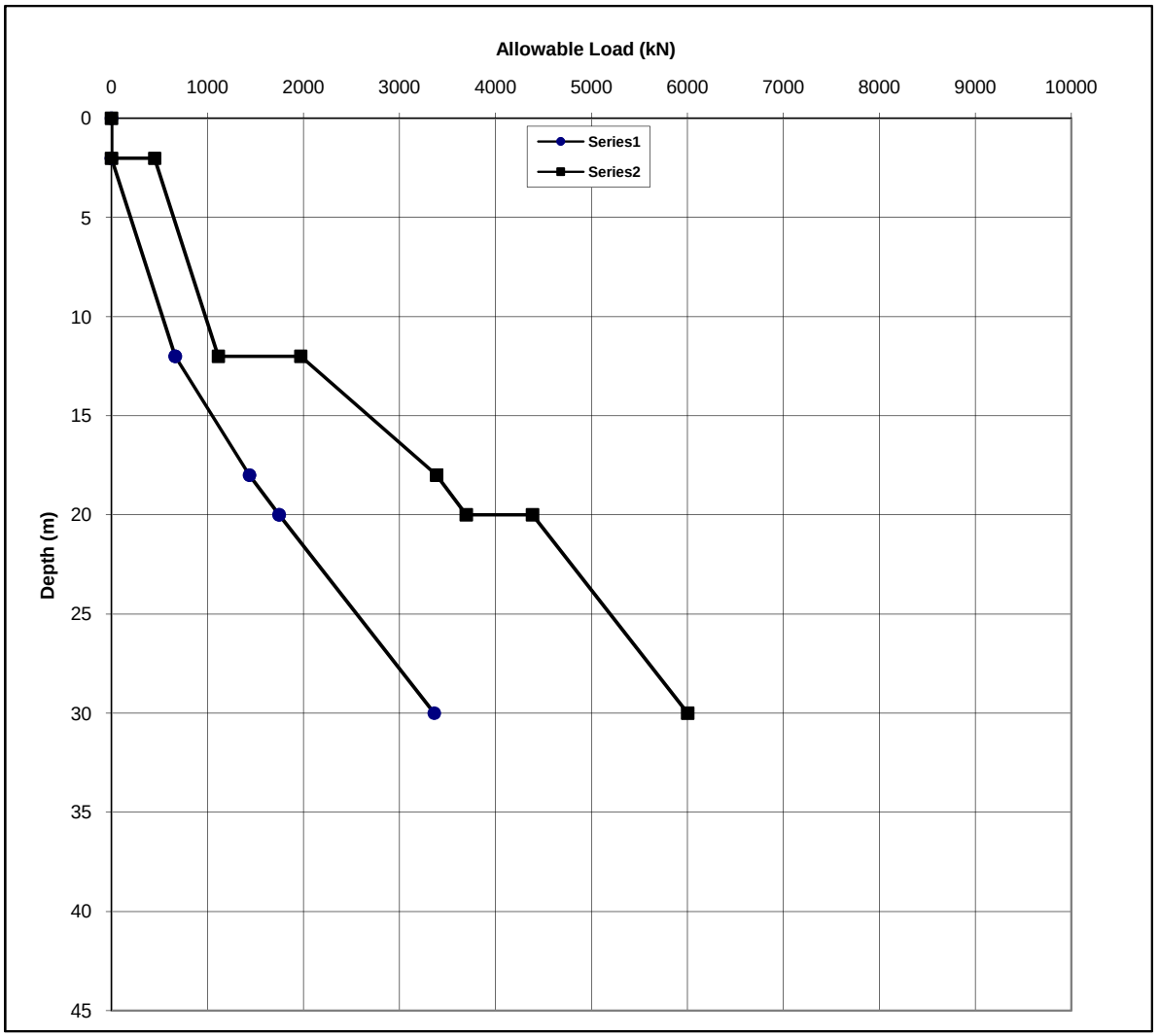
= 270kN (for fixed head condition)

= 90kN (for free head condition)



Allowable Pile Capacity Major Bridge at Chainage 13+260

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



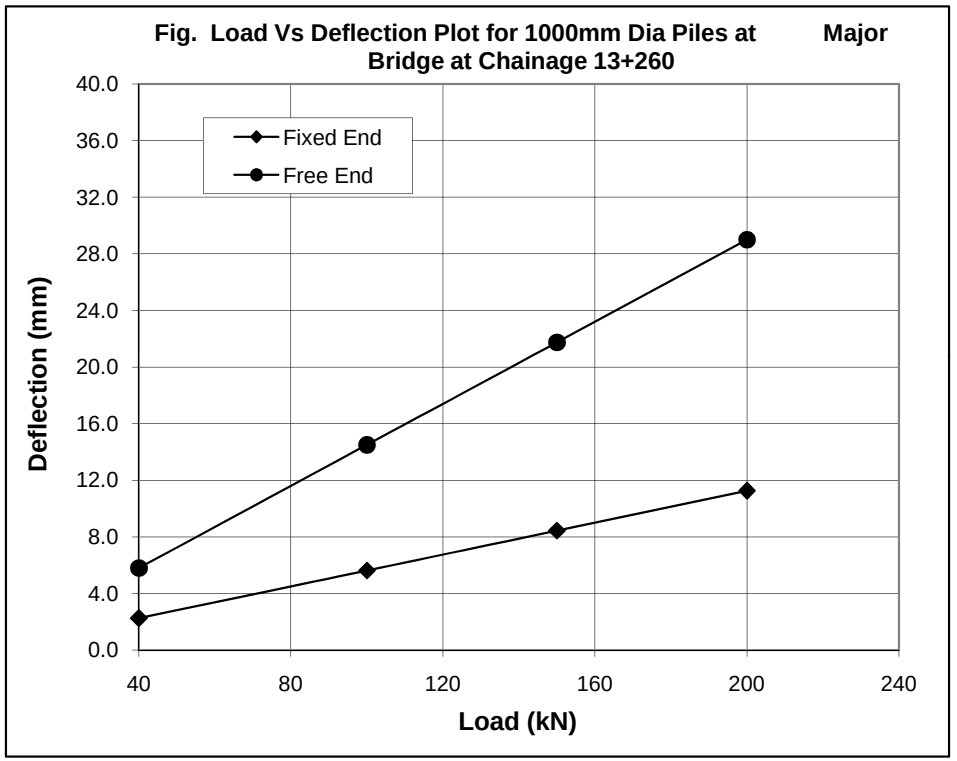
Allowable Pile Capacity Major Bridge at Chainage 13+260

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE AT MAJOR BRIDGE CHAINAGE 13+260 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
K_1	1.800	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	$kg\text{-}cm^2$
K=(K1*0.3)/(1.5B)	0.36	kg/cm^3

T=	(EI/KB)^0.25	
	438.03	
L_f/T=	2.2	Fixed
L_f (Fixed)=	963.67	cm
L_f/T=	1.9	Free
L_f (Free)=	832.26	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free



Q (kN)	d (mm) - Fixed	d (mm) - Free
40	2.25	5.80
100	5.63	14.50
150	8.44	21.75
200	11.25	29.00

Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 180kN (for fixed head condition)

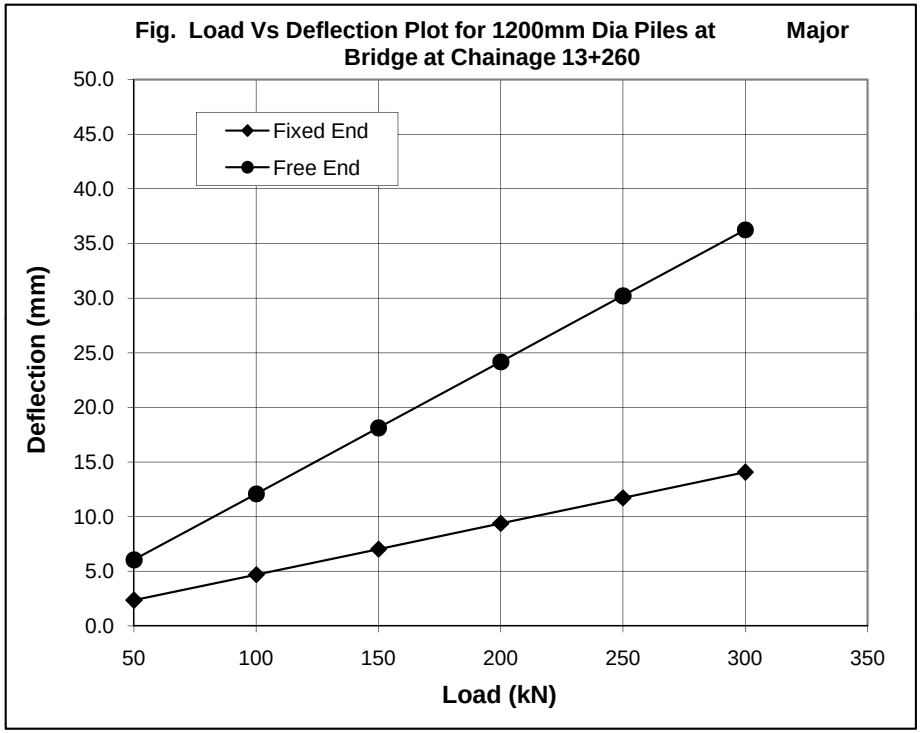
= 70 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE AT MAJOR BRIDGE CHAINAGE 13+260 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
K_1	1.800	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	$kg\text{-}cm^2$
K=(K1*0.3)/(1.5B)	0.3	kg/cm^3

T=	(EI/KB)^0.25	
	525.64	
L_f/T=	2.2	Fixed
L_f (Fixed)=	1156.41	cm
L_f/T=	1.9	Free
L_f (Free)=	998.72	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

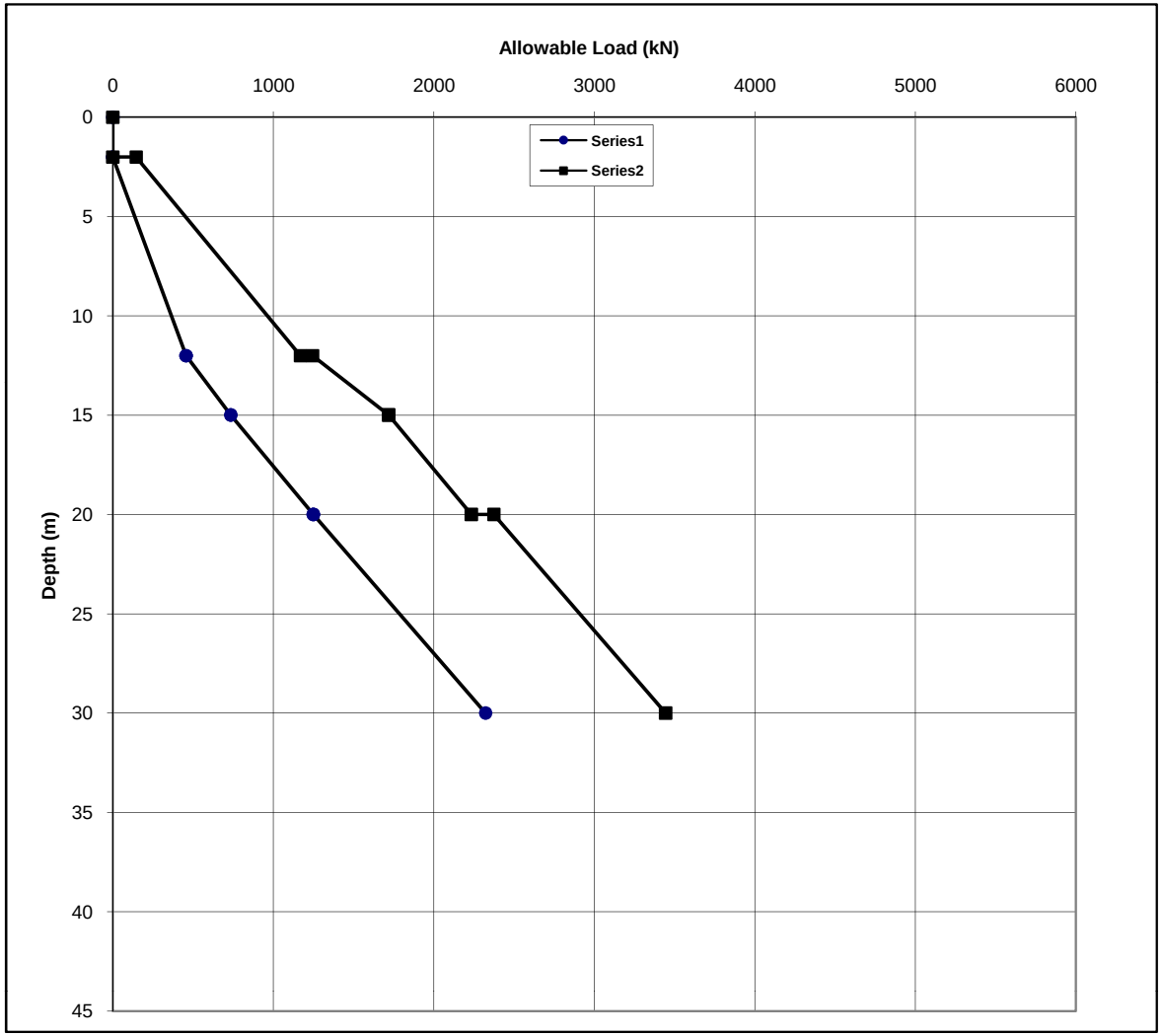
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	2.34	6.04
100	4.69	12.08
150	7.03	18.12
200	9.38	24.16
250	11.72	30.21
300	14.07	36.25



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

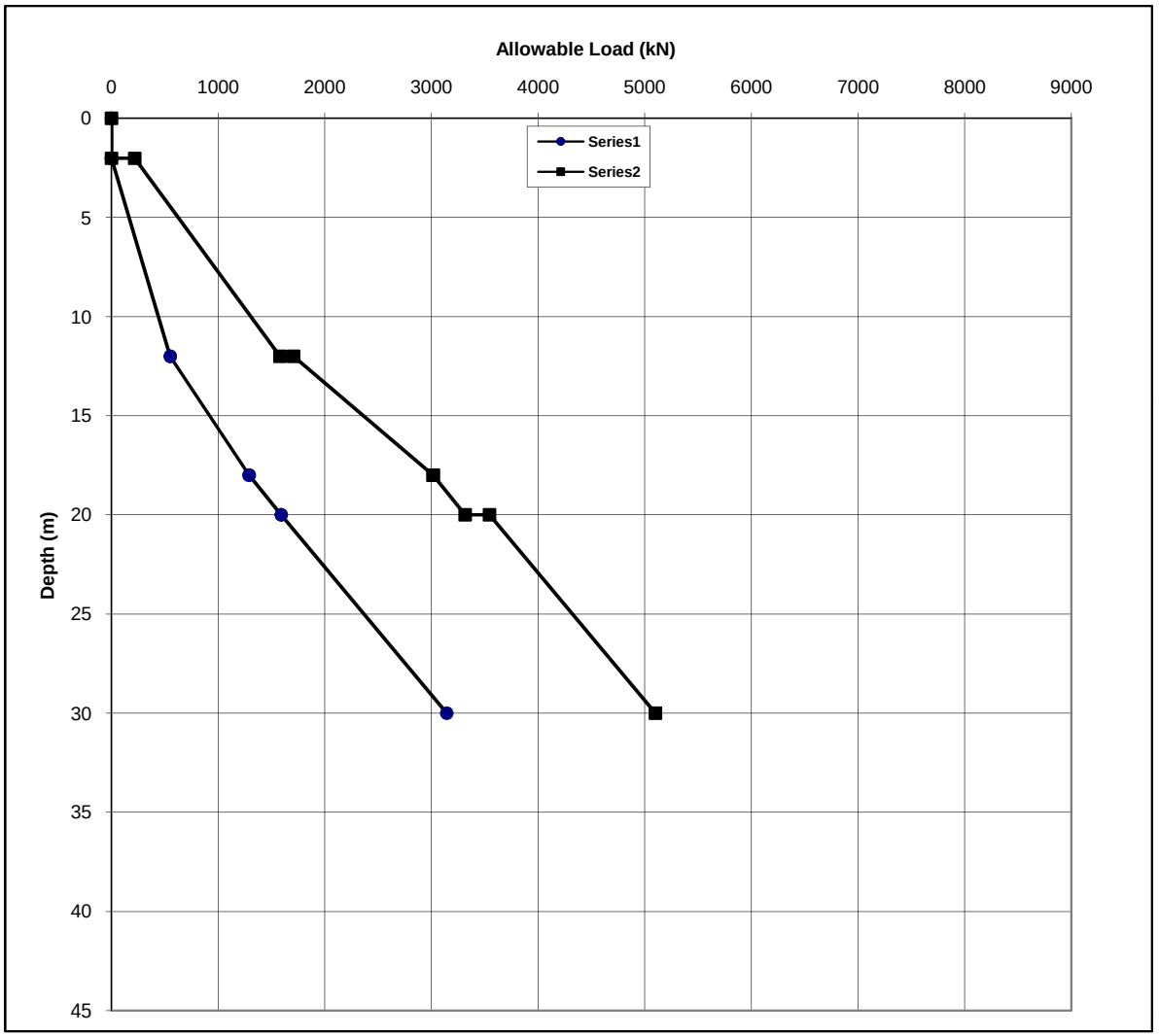
= 250kN (for fixed head condition)

= 100kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 14+150

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 14+150

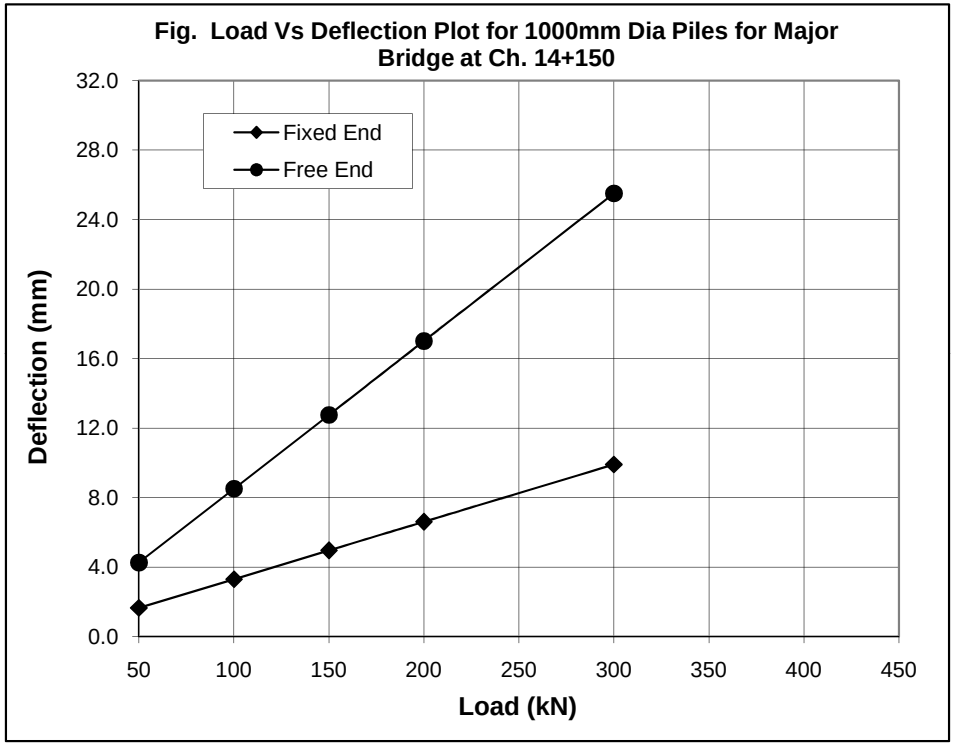
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 14+150 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	366.66	
L_f/T=	2.2	Fixed
L_f (Fixed)=	806.65	cm
L_f/T=	1.9	Free
L_f (Free)=	696.65	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.65	4.25
100	3.30	8.50
150	4.95	12.75
200	6.60	17.01
300	9.90	25.51



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 300kN (for fixed head condition)

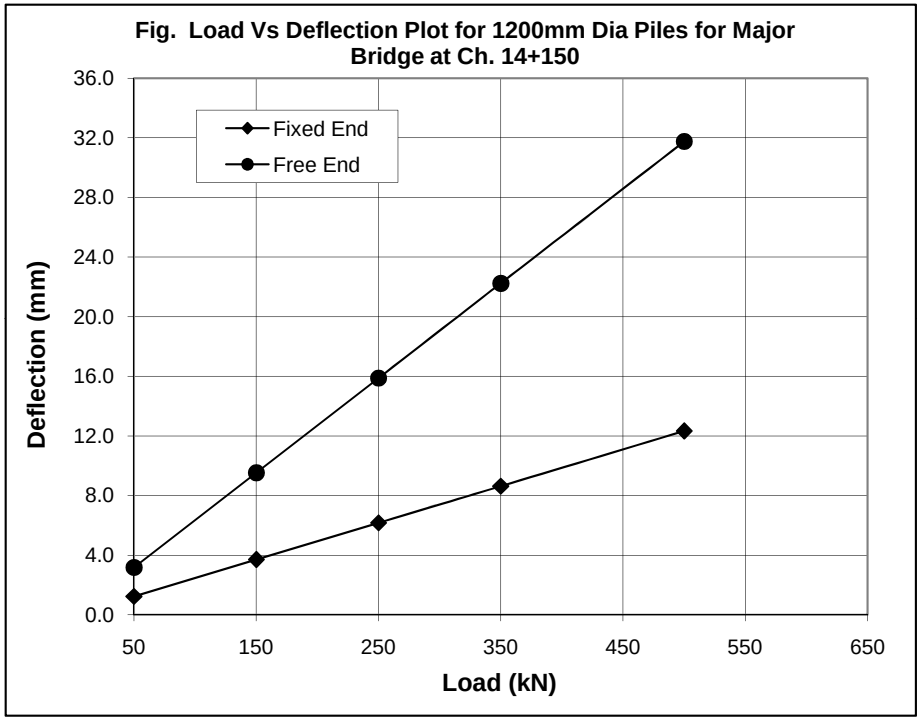
= 110 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 14+150 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	424.23	
L_f/T=	2.2	Fixed
L_f (Fixed)=	933.32	cm
L_f/T=	1.9	Free
L_f (Free)=	806.05	cm
L_1=	0	cm
d=	Q(L_1+L_f)^3/12EI	Fixed
	Q(L_1+L_f)^3/3EI	Free

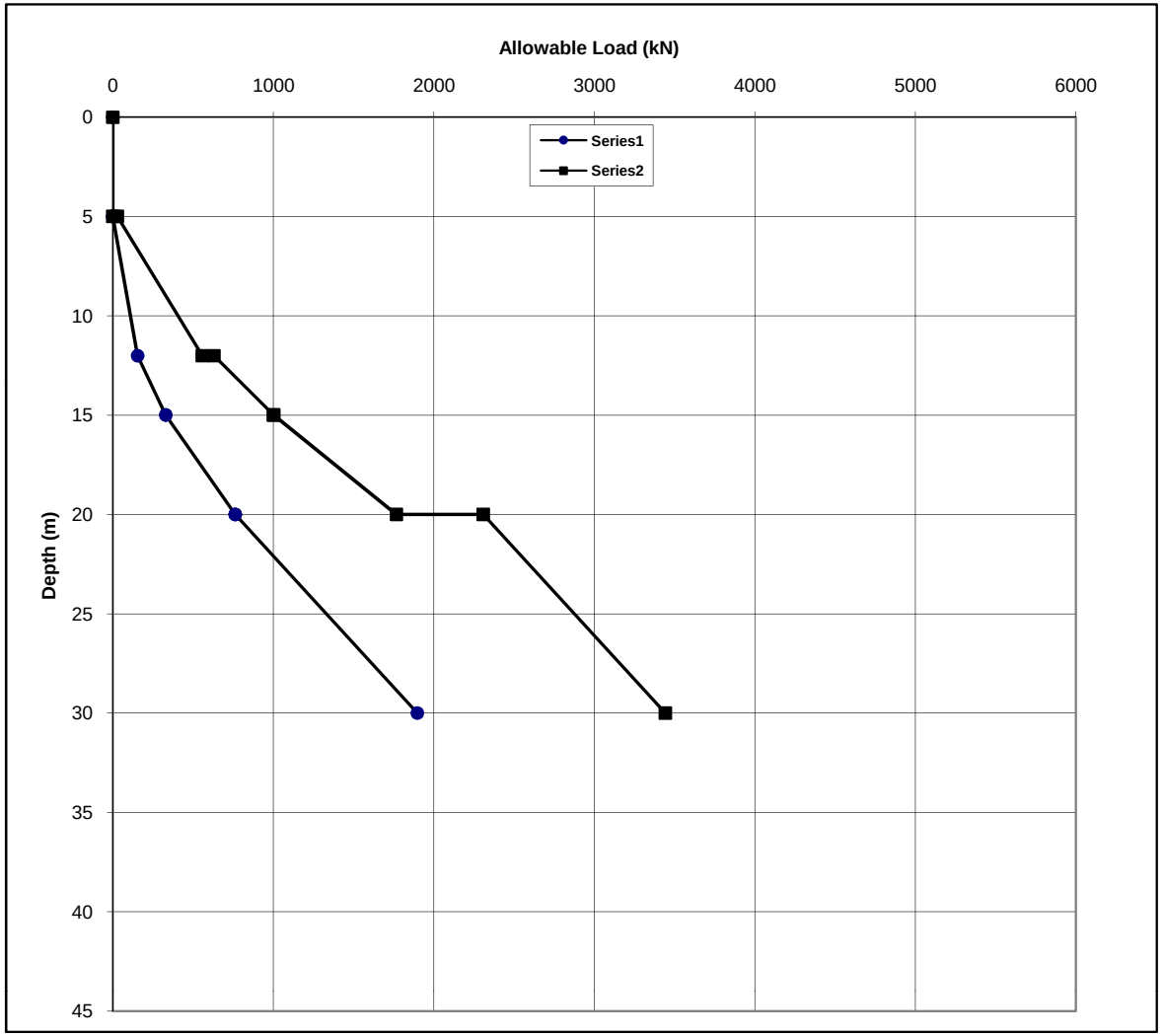
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.23	3.18
150	3.70	9.53
250	6.16	15.88
350	8.63	22.23
500	12.33	31.76



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

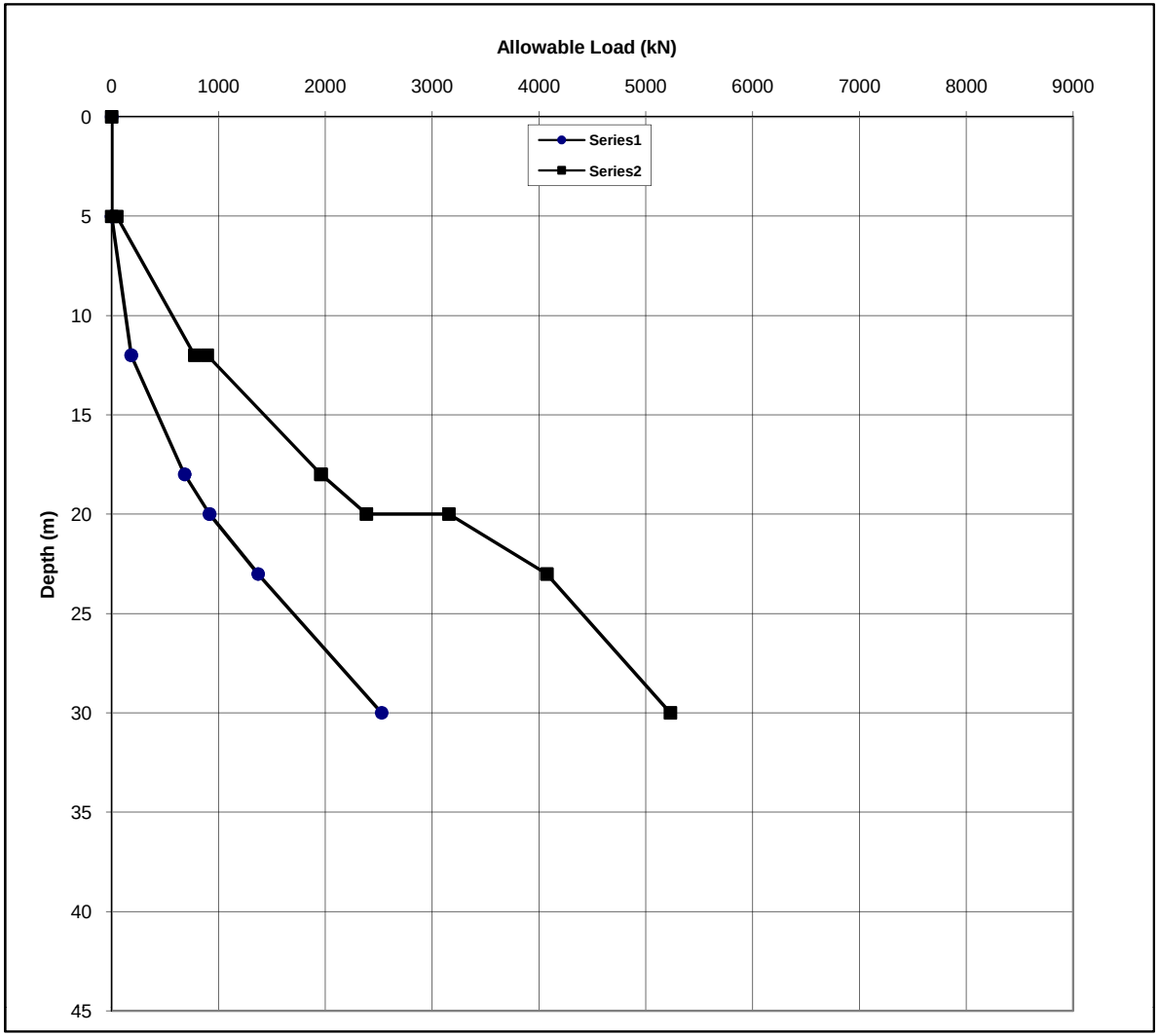
= 480kN (for fixed head condition)

= 190kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 15+800

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 15+800

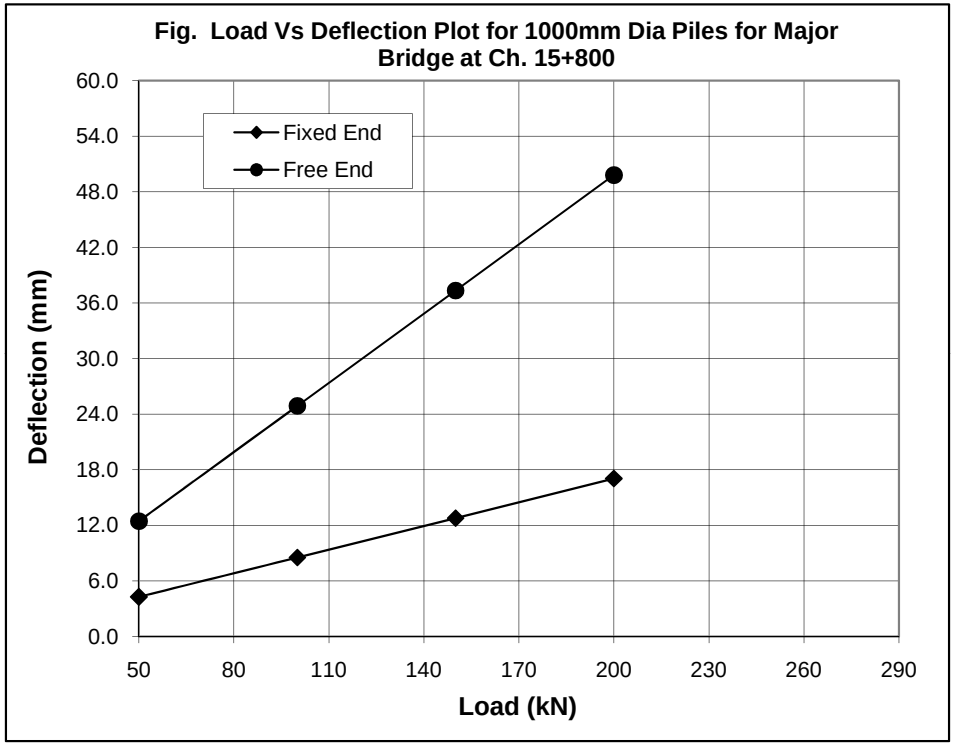
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 15+800 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	366.66	
L_f/T=	2.2	Fixed
L_f (Fixed)=	806.65	cm
L_f/T=	1.9	Free
L_f (Free)=	696.65	cm
L_1=	300	cm
d=	Q(L_1+L_f)^3/12EI	Fixed
	Q(L_1+L_f)^3/3EI	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
20	1.70	4.98
50	4.26	12.45
100	8.52	24.90
150	12.78	37.35
200	17.04	49.80



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 160kN (for fixed head condition)

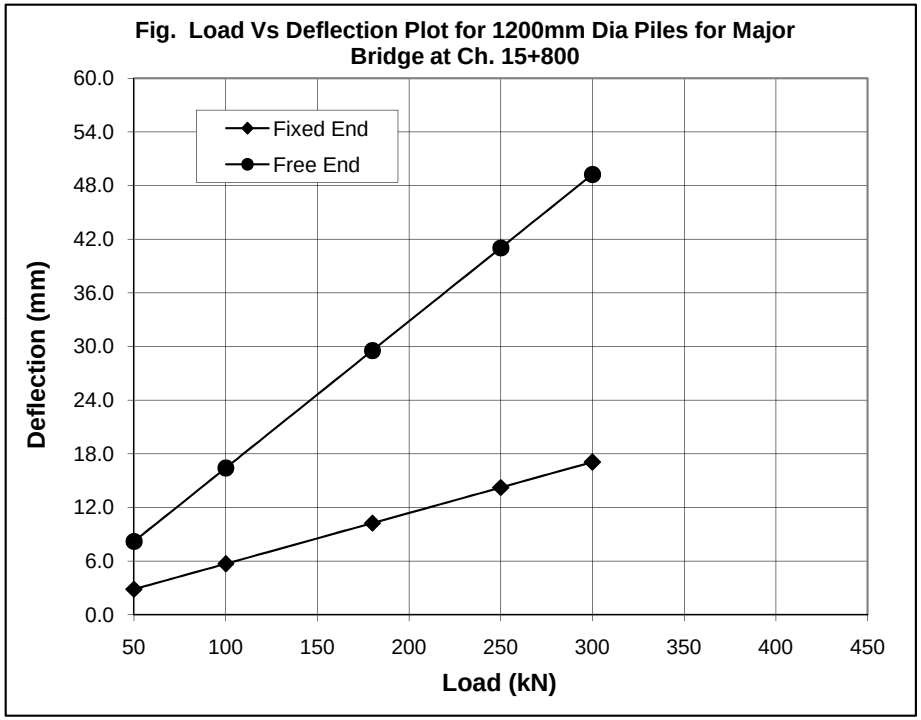
= 60 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 15+800 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	424.23	
L_f/T=	2.2	Fixed
L_f (Fixed)=	933.32	cm
L_f/T=	1.9	Free
L_f (Free)=	806.05	cm
L_1=	300	cm
d=	Q(L_1+L_f)^3/12EI	Fixed
	Q(L_1+L_f)^3/3EI	Free

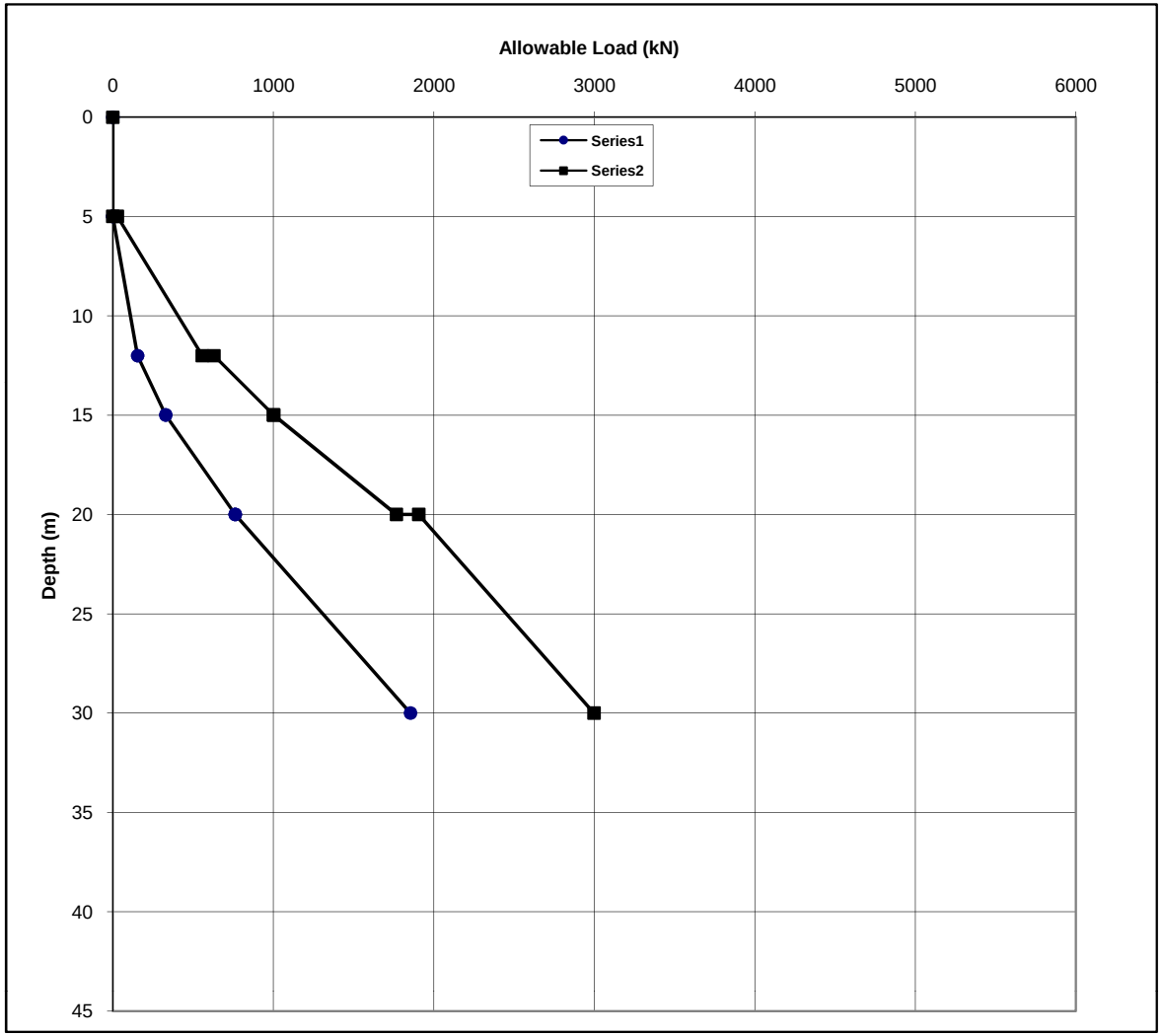
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	2.84	8.21
100	5.69	16.41
180	10.24	29.54
250	14.22	41.03
300	17.06	49.23



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

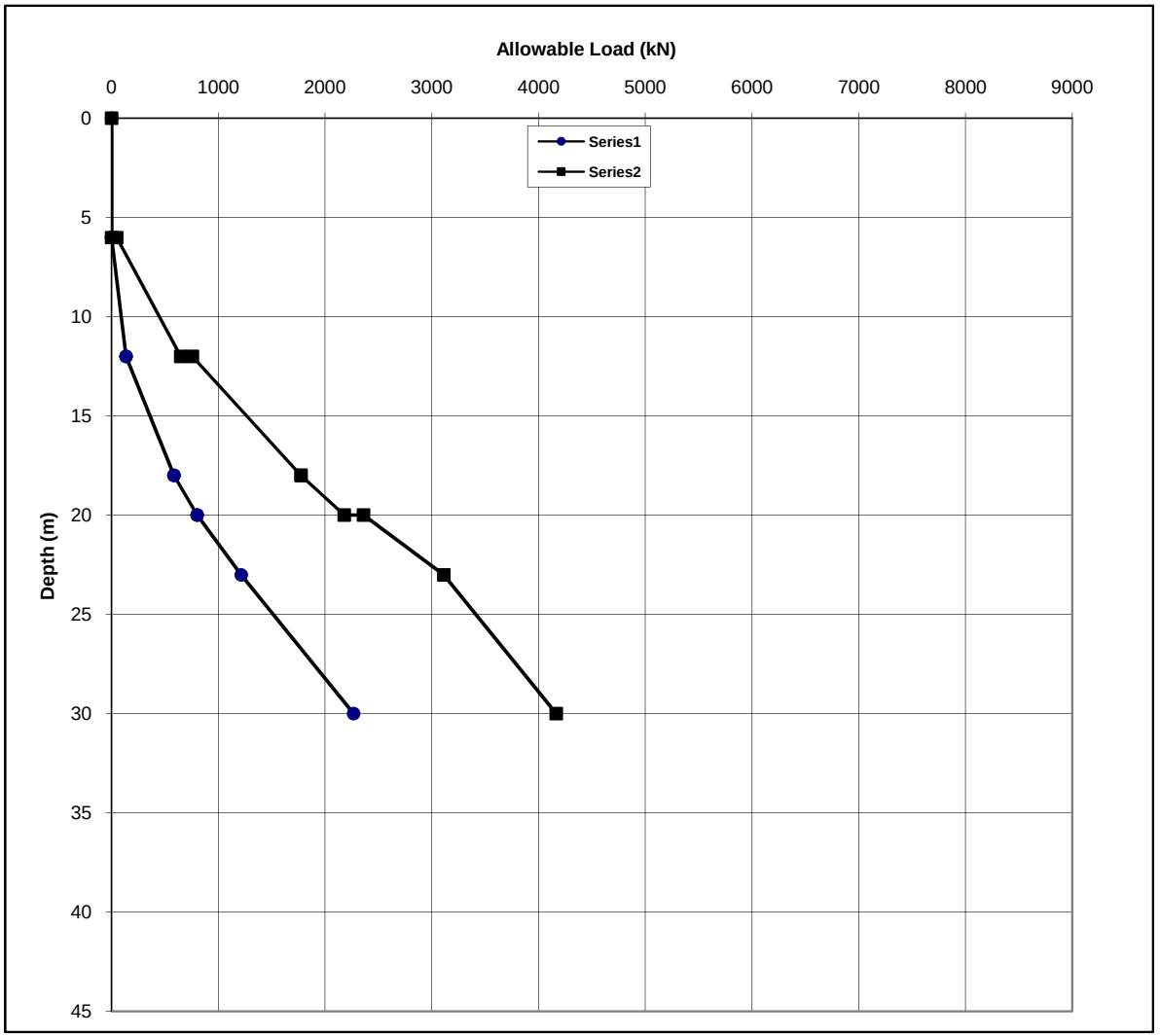
= 280kN (for fixed head condition)

= 90kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 17+790

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 17+790

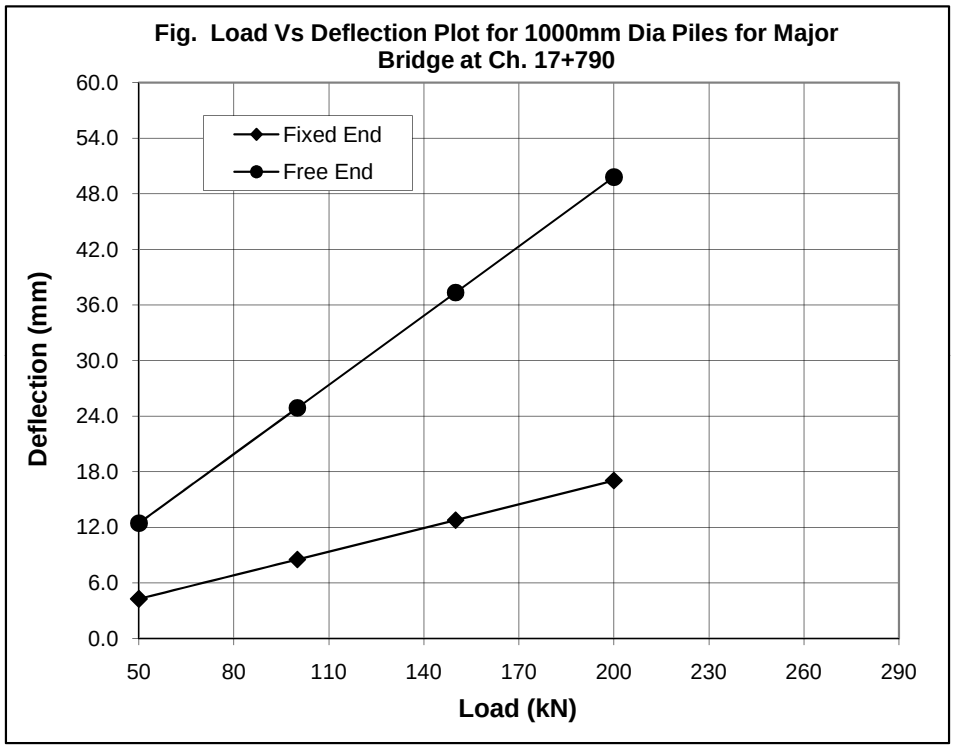
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 17+790 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	366.66	
L_f/T=	2.2	Fixed
L_f (Fixed)=	806.65	cm
L_f/T=	1.9	Free
L_f (Free)=	696.65	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
20	1.70	4.98
50	4.26	12.45
100	8.52	24.90
150	12.78	37.35
200	17.04	49.80



Hence lateral capacity (load corresponding to 14mm deflection)

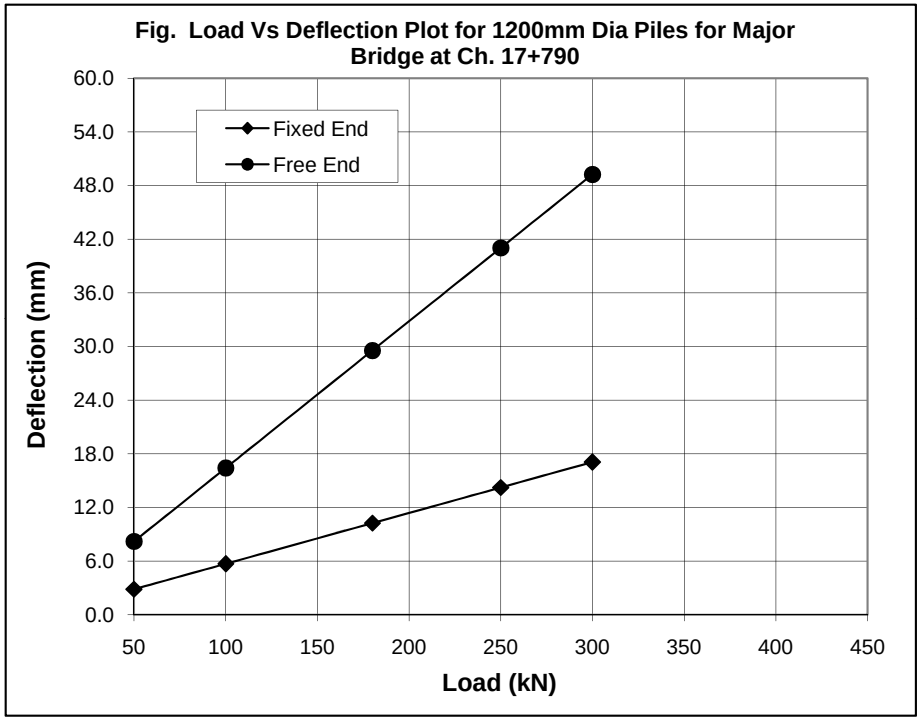
= 160kN (for fixed head condition)
= 60 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 17+790 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	424.23	
L_f/T=	2.2	Fixed
L_f (Fixed)=	933.32	cm
L_f/T=	1.9	Free
L_f (Free)=	806.05	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	2.84	8.21
100	5.69	16.41
180	10.24	29.54
250	14.22	41.03
300	17.06	49.23



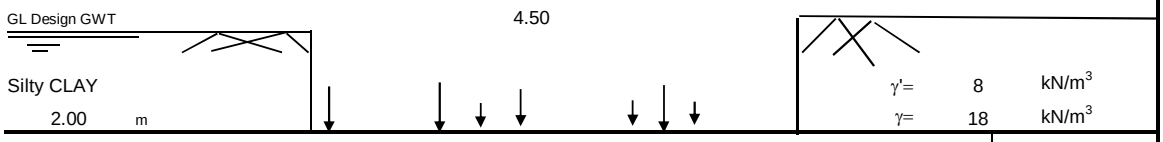
Hence lateral capacity (load corresponding to 16mm deflection)

= 280kN (for fixed head condition)
= 90kN (for free head condition)

Calculation for Bearing Capacity at Minor Bridge CH 18+900 km

Footing Size: 5.5x4.5 m

Depth : 2.00 m



Layer - I

	Silty	CLAY	
N_{av}=	11		
ϕ_{av}=	0	degree	
c_{av}=	55	kPa	
γ_{av}=	8	kN/m^3	

Z_1

9.00 m

Layer - II

	Silty	SAND	
N_{av}=	27		
ϕ_{av}=	31	degree	
c_{av}=	0	kPa	
γ_{av}=	9	kN/m^3	

.....Z_2

12.00 m

Safe Bearing Capacity from Shear Failure

Design ϕ= 0 degree

For Layer - I

Q(safe)= $(cN_cs_cd_ci_c+(\gamma*D)(N_q-1)s_qd_qi_q+0.5B\gamma N_\gamma s_\gamma d_\gamma i_{\gamma W}/FS$

FS=	2.5			w=	0.5		
N_c=	5.14	N_q=	1		N_γ=	0.00	Local shear failure
S_c=	1.164	S_q=	1.164		S_γ=	0.67	
dc=	1+0.2*(D/B)*tan(45+φ/2)=				1.09		
dq=dγ=	1+0.1*(D/B)*tan(45+φ/2)				1.04		
ic=iq=	(1-α/90)^2=	1.00		ig=	(1-α/φ)^2=	1.00	α=0

Q_{safe-I}= 143.3 kPa

Design Bearing Capacity= **140 kPa**

Settlement for Layer - I

δ (mm) = $m_v*H*\Delta p*\mu_g*d_f$*Rigidity Factor (0.8) — for clay

m_v= 0.00015 m2/kN μ_g= 0.7

δ (mm)= $[2.303*(H/C)*\log_{10}\{(p_o+\Delta p)/p_o\}]*d_f$*Rigidity Factor (0.8) — for sand

C=1.5*(C_{kd}/p_o)= 0.0 C_{kd}/N= KN/m^2 — 1st layer I = 0.48

p_o= 30 p= 140.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_1 (mm)= 34.77

Settlement for Layer-II

δ (mm) = m_v*H*Δp*μ_g*d_f*Rigidity Factor (0.8) for clay

m_v= m2/kN μ_g=

δ (mm)= [2.303*(H/C)*$\log_{10}$(p_o+Δp)/p_o)]*d_f*Rigidity Factor (0.8) for sand IS:8009 (Part I)

C=1.5*(C_{kd}/p_o)= 118.4 C_{kd}/N= 250 KN/m^2 2nd layer I = 0.152

p_o= 85.5 p= 140.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_2 (mm)= 3.96

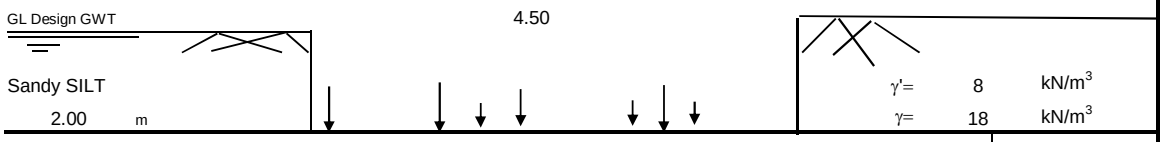
Total settlement = 38.74 mm

Allowable Bearing capacity for 25mm settlement= 92.5 KPa

Calculation for Bearing Capacity at Minor Bridge CH 19+680 km

Footing Size: 5.5x4.5 m

Depth : 2.00 m



Layer - I

Compacted Sand
(85% Relative Density)

	Sandy SILT	
N_{av}=	8	
ϕ_{av}=	31	degree
c_{av}=	0	kPa
γ_{av}=	8	kN/m^3

5.00 m

Layer - II

	Silty SAND	
N_{av}=	20	
ϕ_{av}=	31	degree
c_{av}=	0	kPa
γ_{av}=	9	kN/m^3

12.00 m

Safe Bearing Capacity from Shear Failure

Design ϕ= 31 degree

For Layer - I

As ϕ is 31° Intermediate Shear failure is considered

Q(safe)= $(cN_cs_cd_ci_c+(\gamma*D)(N_q-1)s_qd_qi_q+0.5B\gamma N_\gamma s_\gamma d_\gamma i_{\gamma W}/FS$

FS= 2.5 w= 0.5

N_c=	33.34	N_q=	21.38	N_γ=	27.54	General shear failure
N_c=	17.19	N_q=	8.1	N_γ=	7.59	Local shear failure
N_c=	19.88	N_q=	10.31	N_γ=	10.92	Intermediate condition
S_c=	1.164	S_q=	1.164	S_γ=	0.67	

dc= 1+0.2*(D/B)*tan(45+φ/2)= 1.16

dq=dγ= 1+0.1*(D/B)*tan(45+φ/2) 1.08

ic=iq= (1-α/90)^2= 1.00 ig= (1-α/φ)^2= 1.00 α=0

Q_{safe-I}= 139.0 kPa

Design Bearing Capacity= **135 kPa**

Settlement for Layer - I

δ (mm) = $m_v*H*\Delta p*\mu_g*d_f$*Rigidity Factor (0.8) for clay

m_v= m2/kN μ_g=

δ (mm)= $[2.303*(H/C)*\log_{10}\{(p_o+\Delta p)/p_o\}]*d_f$*Rigidity Factor (0.8) for sand

C=1.5*(C_{kd}/p_o)= 214.3 C_{kd}/N= 250 KN/m^2 1st layer I = 0.88

p_o= 14 p= 135.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_1 (mm)= 22.17

Settlement for Layer-II

δ (mm) = m_v*H*Δp*μ_g*d_f*Rigidity Factor (0.8) for clay

m_v= m2/kN μ_g=

δ (mm)= [2.303*(H/C)*$\log_{10}$(p_o+Δp)/p_o)]*d_f*Rigidity Factor (0.8) for sand IS:8009 (Part I)

C=1.5*(C_{kd}/p_o)= 125.9 C_{kd}/N= 300 KN/m^2 2nd layer I = 0.2

p_o= 71.5 p= 135.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_2 (mm)= 12.54

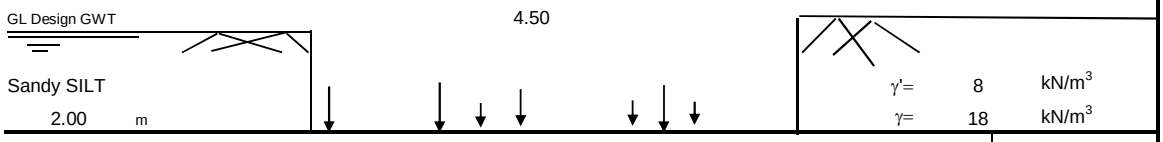
Total settlement = 34.72 mm

Allowable Bearing capacity for 25mm settlement= 100.1 KPa

Calculation for Bearing Capacity at Minor Bridge CH 22+700 km

Footing Size: 5.5x4.5 m

Depth : 2.00 m



Layer - I

Compacted Sand
(85% Relative Density)

	Sandy SILT		
N_{av}=	7		
ϕ_{av}=	31	degree	
c_{av}=	0	kPa	
γ_{av}=	8	kN/m^3	

Z_1

4.50 m

Layer - II

	Silty SAND		
N_{av}=	18		
ϕ_{av}=	30	degree	
c_{av}=	0	kPa	
γ_{av}=	9	kN/m^3	

Z_2

12.00 m

Safe Bearing Capacity from Shear Failure

Design ϕ= 31 degree

For Layer - I

As ϕ is 31° Intermediate Shear failure is considered

Q(safe)= $(cN_cs_cd_ci_c+(\gamma*D)(N_q-1)s_qd_qi_q+0.5B\gamma N_\gamma s_\gamma d_\gamma i_{\gamma W}/FS$

FS= 2.5 w= 0.5

N_c=	33.34	N_q=	21.38	N_γ=	27.54	General shear failure
N_c=	17.19	N_q=	8.1	N_γ=	7.59	Local shear failure
N_c=	19.88	N_q=	10.31	N_γ=	10.92	Intermediate condition
S_c=	1.164	S_q=	1.164	S_γ=	0.67	
dc=	1+0.2*(D/B)*tan(45+φ/2)=		1.16			
dq=dγ=	1+0.1*(D/B)*tan(45+φ/2)		1.08			
ic=iq=	(1-α/90)^2= 1.00		ig=	(1-α/φ)^2=	1.00	α=0

Q_{safe-I}= 139.0 kPa

Design Bearing Capacity= **135 kPa**

Settlement for Layer - I

δ (mm) = $m_v*H*\Delta p*\mu_g*d_f$*Rigidity Factor (0.8) for clay

m_v= m2/kN μ_g=

δ (mm)= $[2.303*(H/C)*\log_{10}\{(p_o+\Delta p)/p_o\}]*d_f$*Rigidity Factor (0.8) for sand

C=1.5*(C_{kd}/p_o)= 218.8 C_{kd}/N= 250 KN/m^2 1st layer I = 0.92

p_o= 12 p= 135.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_1 (mm)= 19.54

Settlement for Layer-II

δ (mm) = $m_v * H * \Delta p * \mu_g * d_f$ * Rigidity Factor (0.8) for clay

m_v= m2/kN μ_g=

δ (mm)= $[2.303 * (H/C) * \log_{10}\{(p_o + \Delta p)/p_o\}] * d_f$ * Rigidity Factor (0.8) for sand IS:8009 (Part I)

$C = 1.5 * (C_{kd}/p_o)$= 116.1 C_{kd}/N= 300 KN/m^2 2nd layer I = 0.28

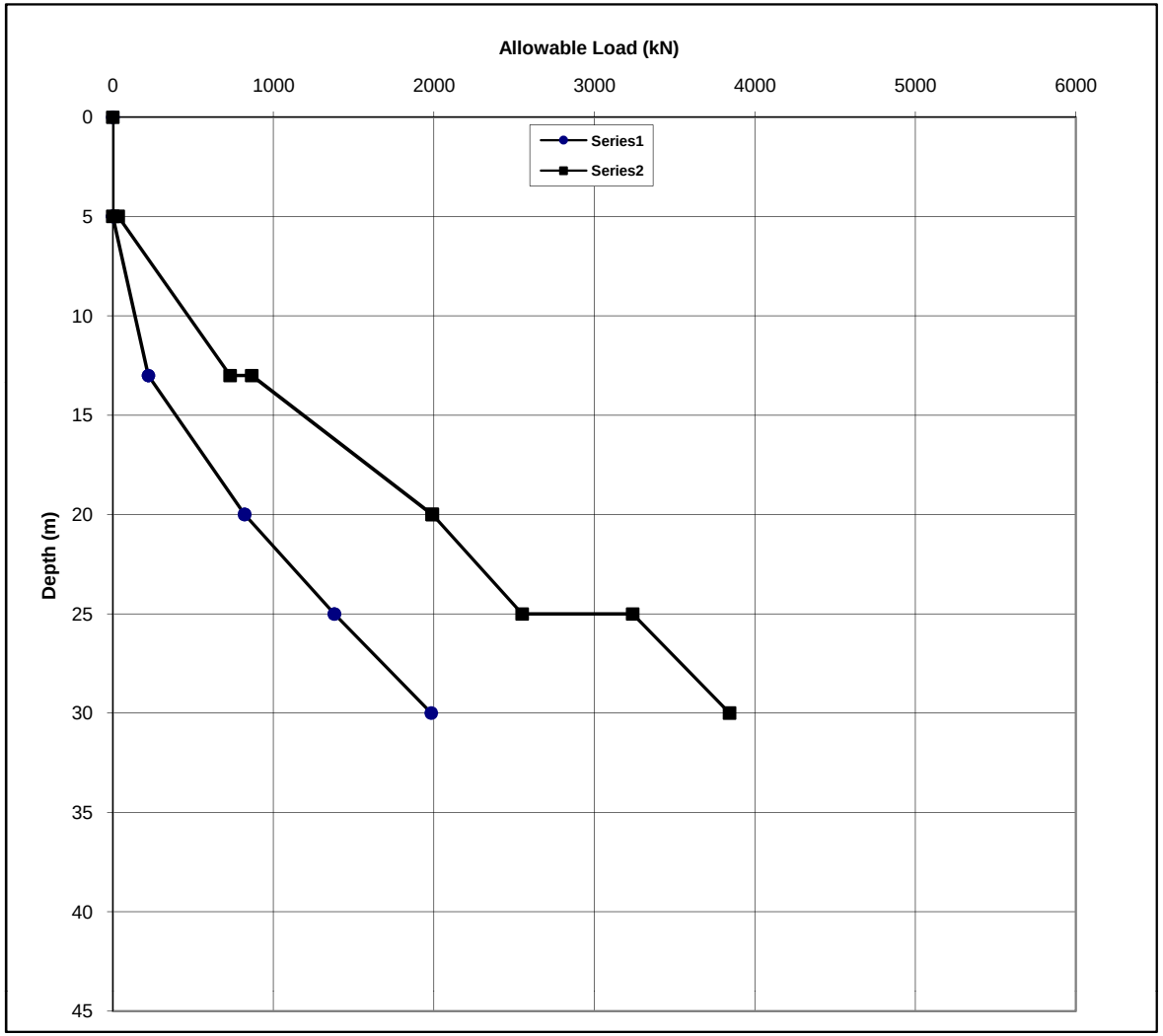
p_o= 69.75 p= 135.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_2 (mm)= 19.69

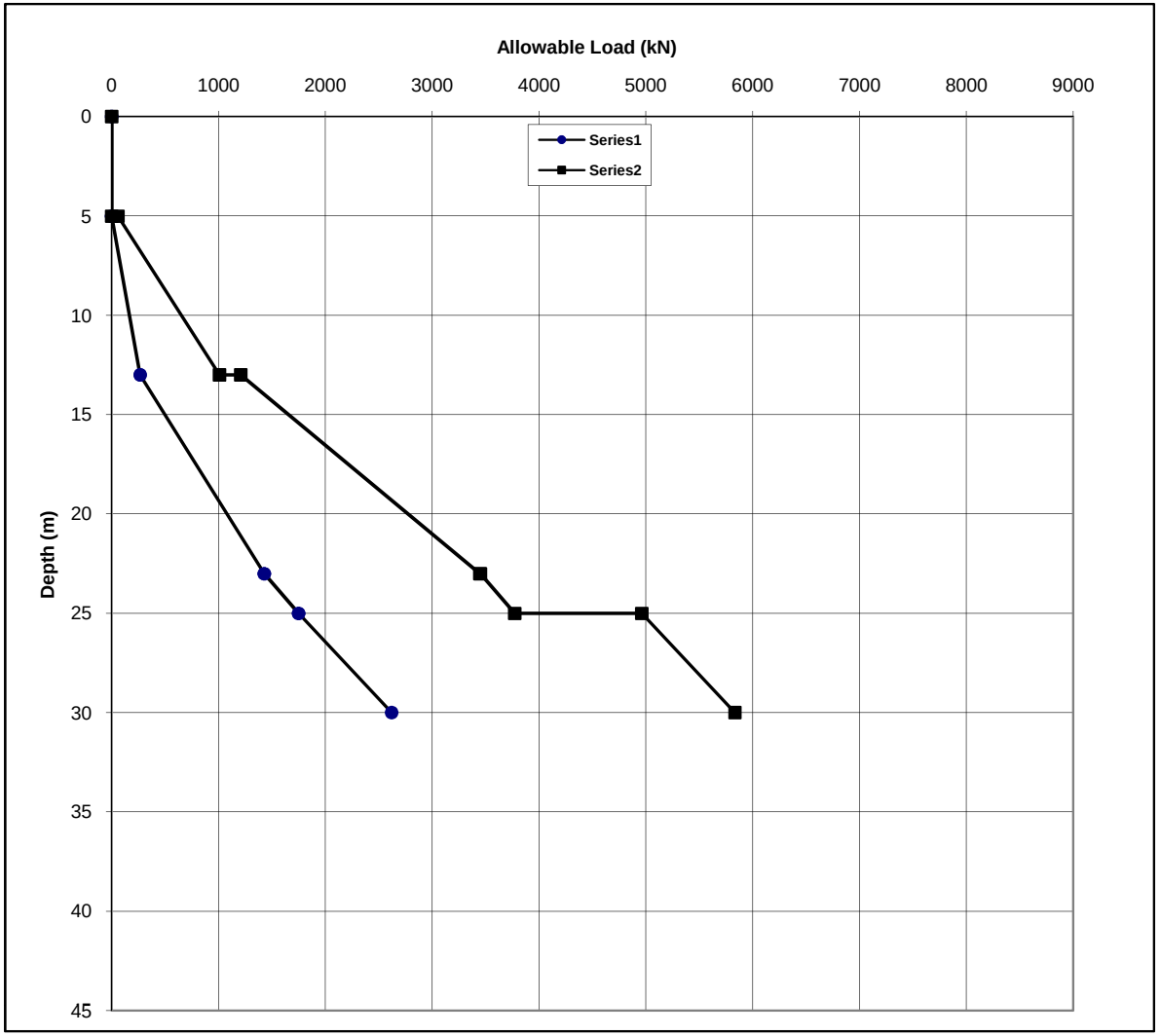
Total settlement = 39.23 mm

Allowable Bearing capacity for 25mm settlement= 88.6 KPa



Allowable Pile Capacity at Major Bridge Ch. 24+269

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 24+269

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

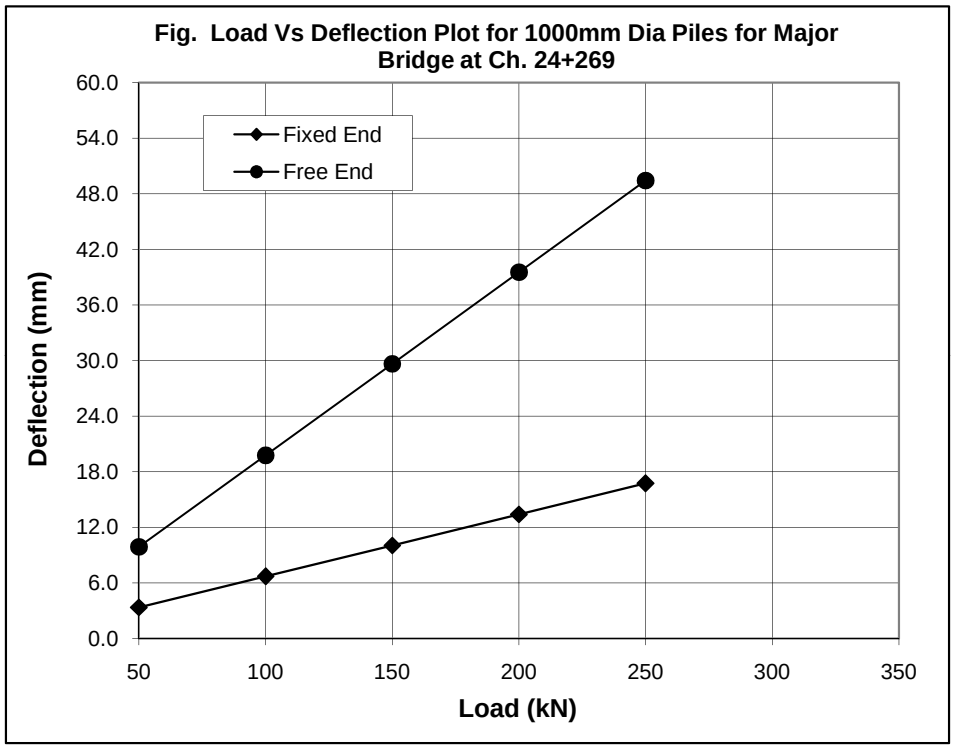
LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 24+269 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.350	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	327.83	
L_f/T=	2.2	Fixed
L_f (Fixed)=	721.23	cm
L_f/T=	1.9	Free
L_f (Free)=	622.88	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	3.35	9.88
100	6.70	19.77
150	10.05	29.65
200	13.39	39.54
250	16.74	49.42

Hence lateral capacity (load corresponding to 15mm deflection)



= 210kN (for fixed head condition)
= 70 kN (for free head condition)

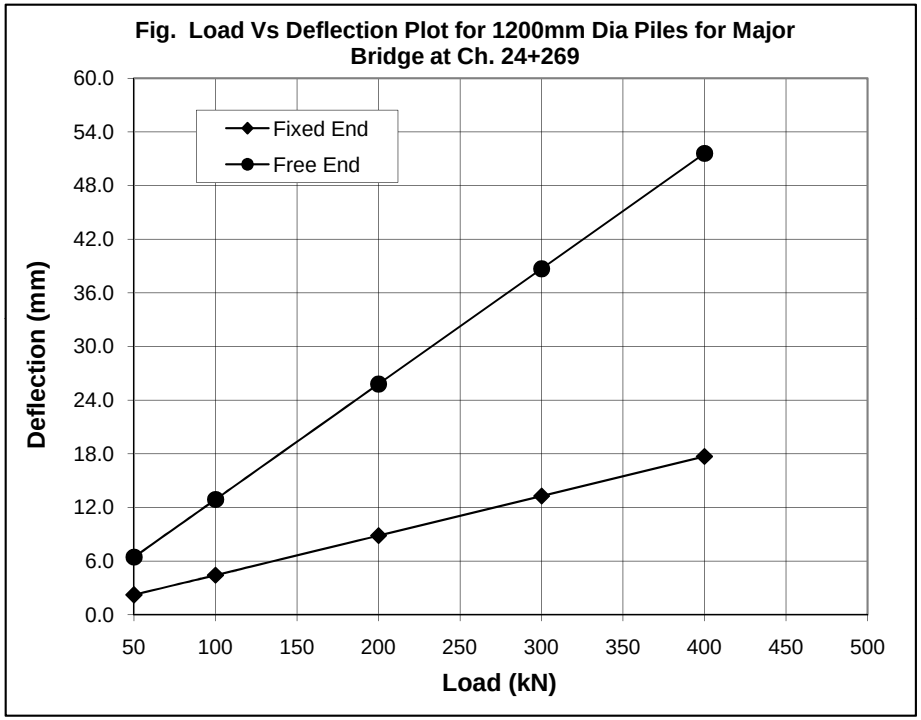
LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 24+269 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.350	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

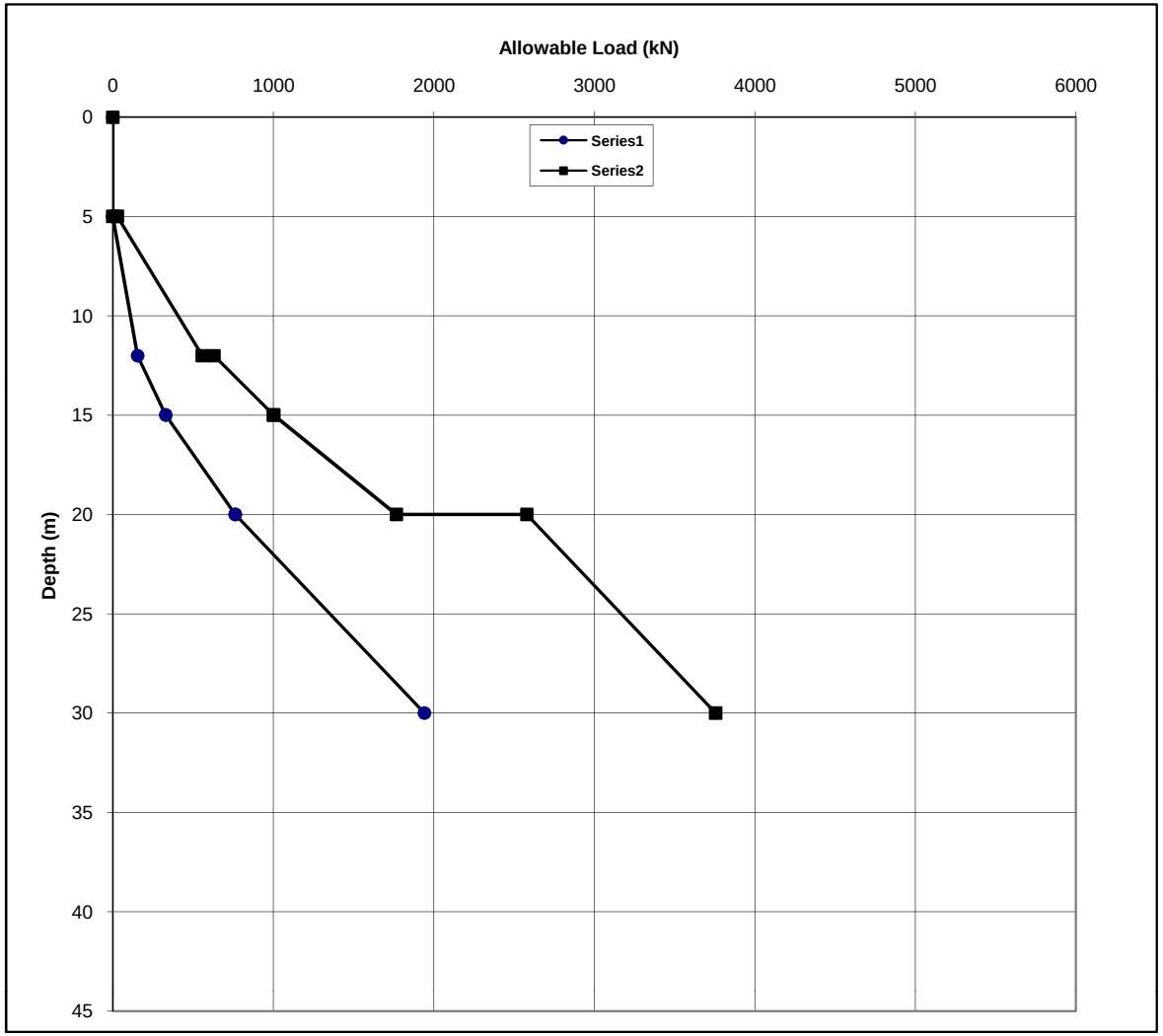
T=	(EI/ηh)^0.2	
	379.31	
L_f/T=	2.2	Fixed
L_f (Fixed)=	834.49	cm
L_f/T=	1.9	Free
L_f (Free)=	720.70	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	2.21	6.45
100	4.43	12.90
200	8.86	25.80
300	13.28	38.69
400	17.71	51.59

Hence lateral capacity (load corresponding to 17mm deflection)

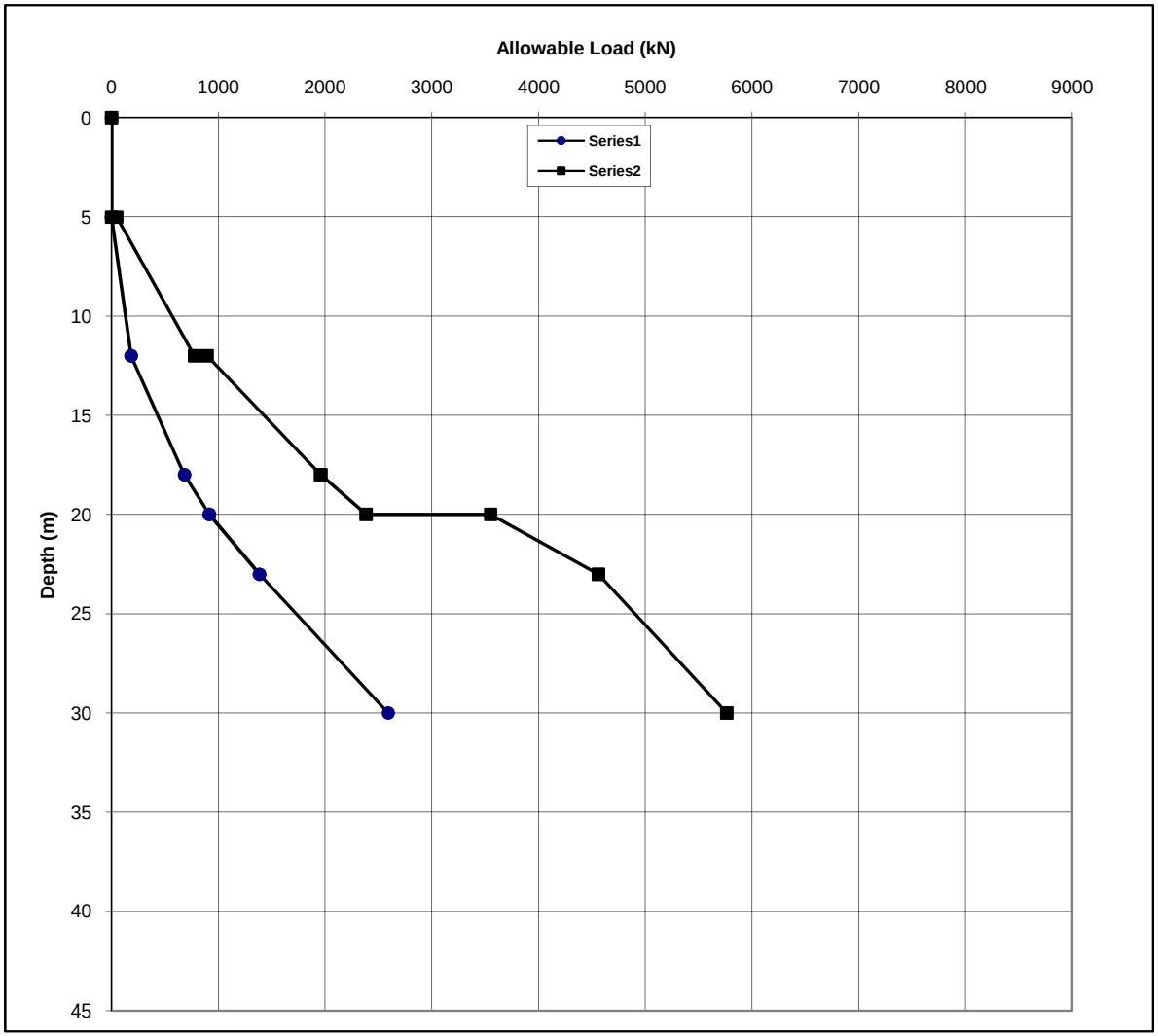


= 370kN (for fixed head condition)
= 130kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 25+880

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 25+880

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

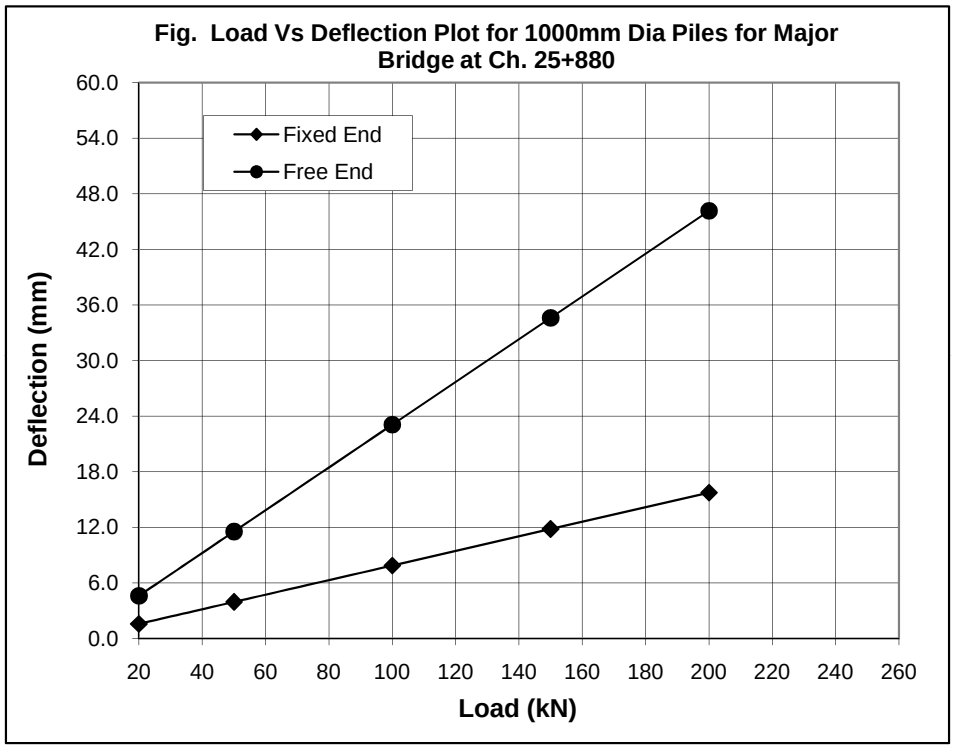
LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 25+880 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.240	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	353.53	
L_f/T=	2.2	Fixed
L_f (Fixed)=	777.76	cm
L_f/T=	1.9	Free
L_f (Free)=	671.70	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
20	1.57	4.62
50	3.94	11.54
100	7.87	23.08
150	11.81	34.61
200	15.74	46.15

Hence lateral capacity (load corresponding to 14mm deflection)



= 180kN (for fixed head condition)
= 60 kN (for free head condition)

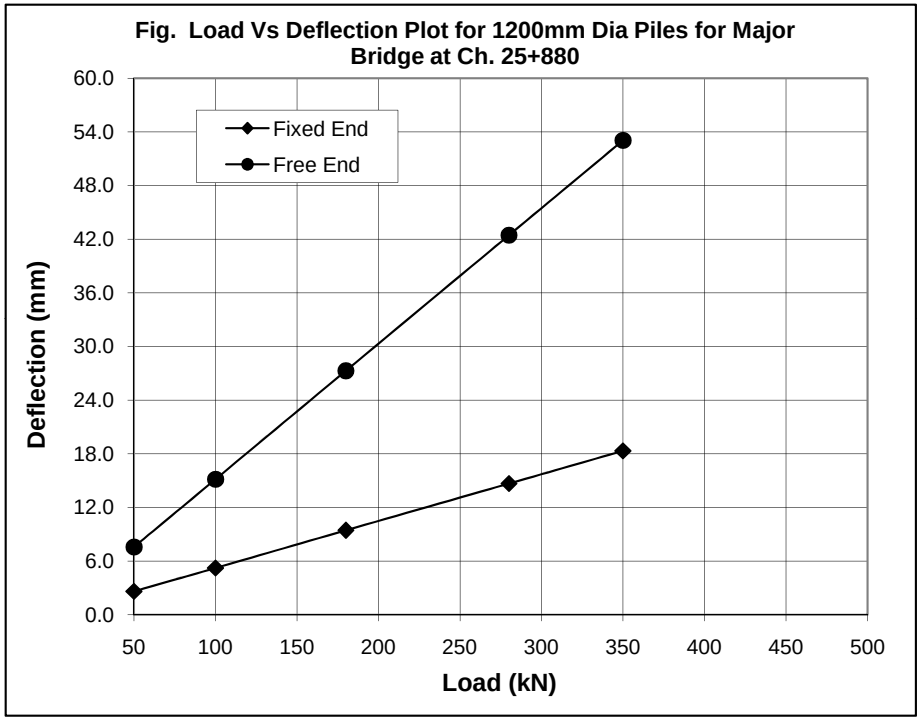
LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 25+880 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.240	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

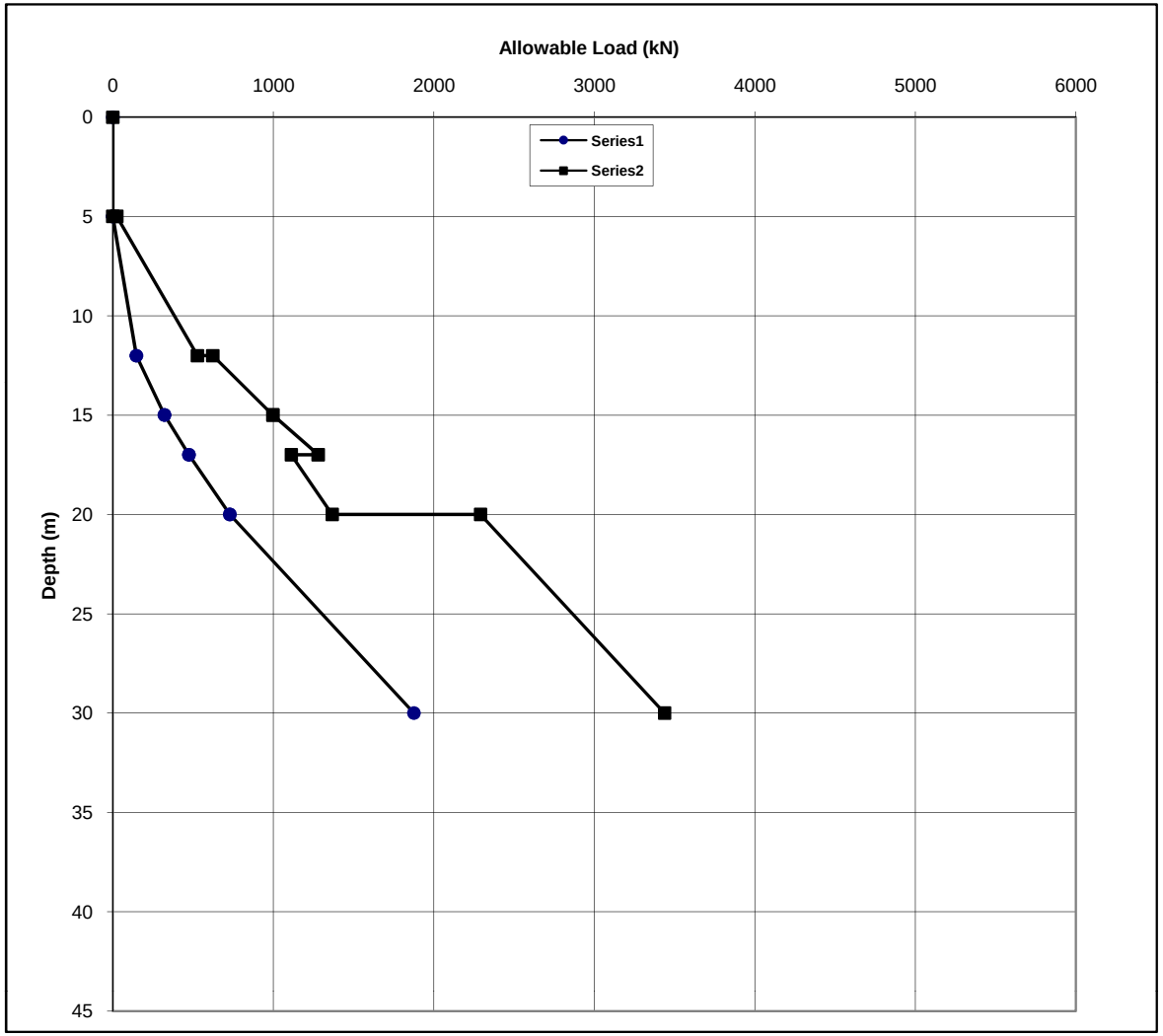
T=	(EI/ηh)^0.2	
	409.04	
L_f/T=	2.2	Fixed
L_f (Fixed)=	899.90	cm
L_f/T=	1.9	Free
L_f (Free)=	777.18	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	2.62	7.58
100	5.24	15.16
180	9.43	27.29
280	14.67	42.45
350	18.33	53.06

Hence lateral capacity (load corresponding to 16mm deflection)

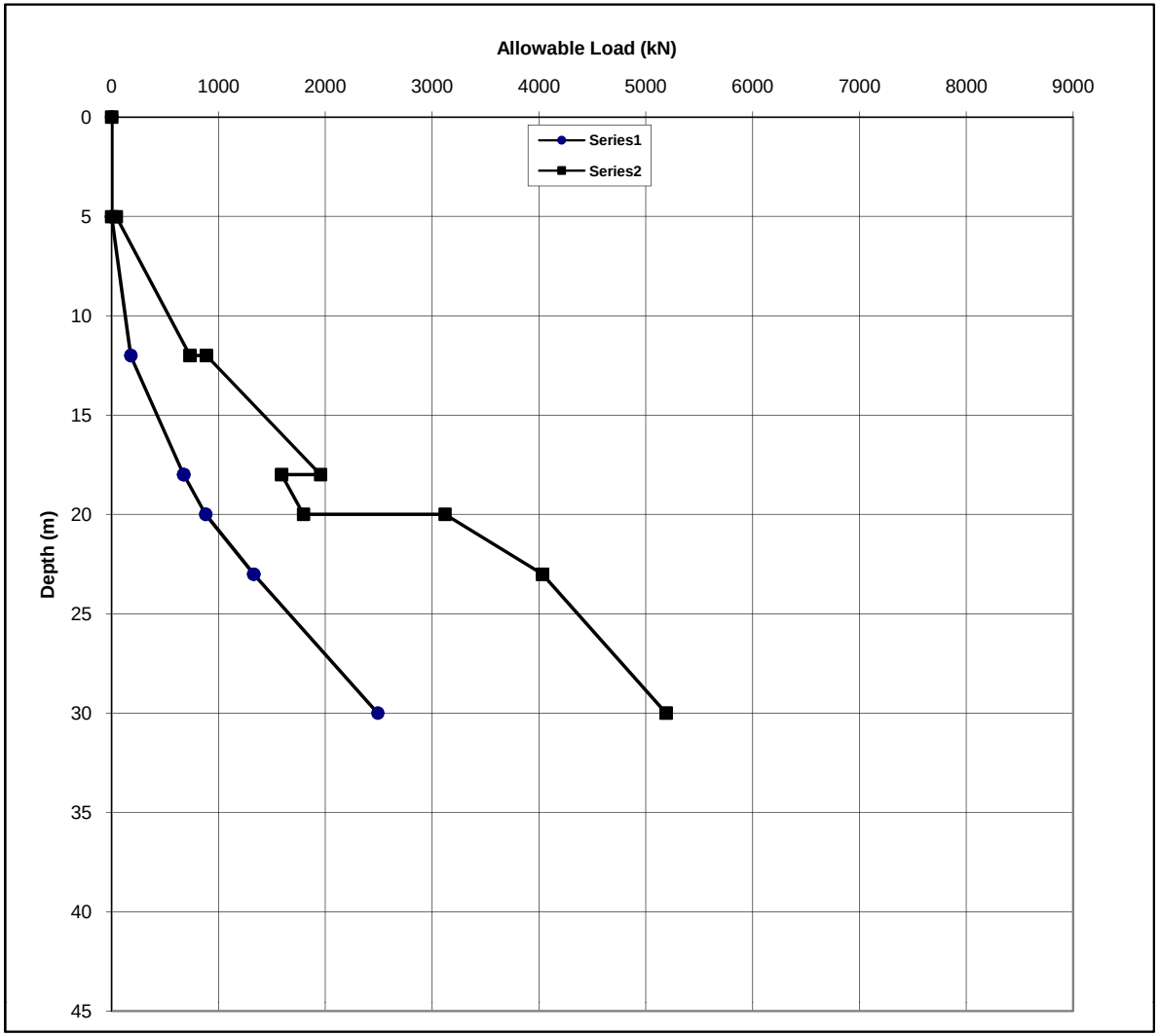


= 300kN (for fixed head condition)
= 100kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 27+960

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 27+960

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

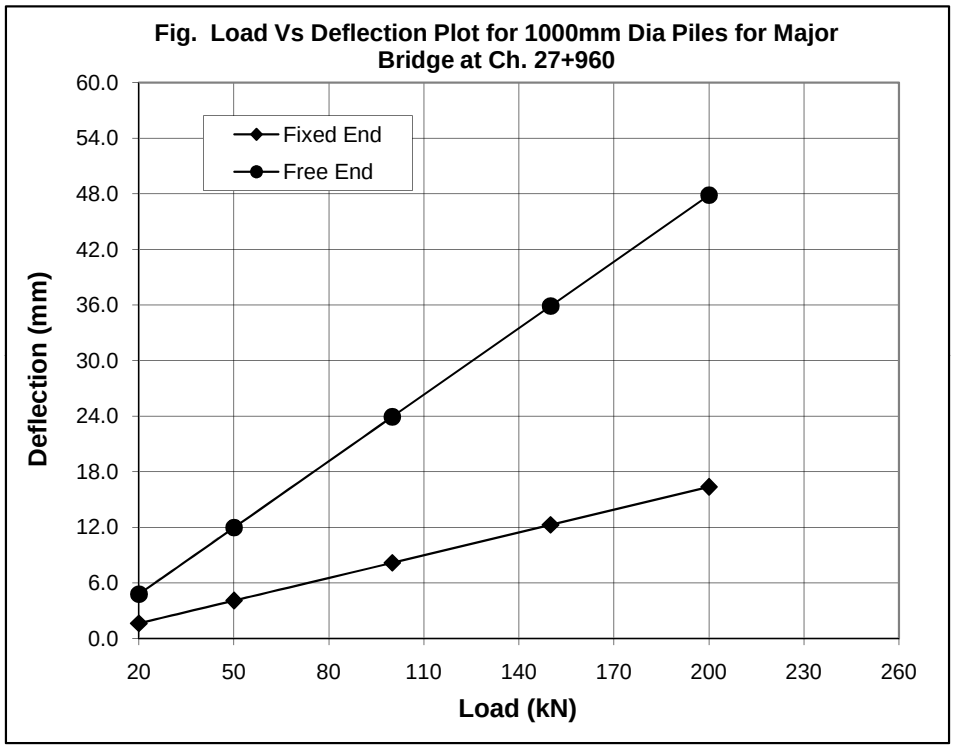
LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 27+960 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.220	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	359.73	
L_f/T=	2.2	Fixed
L_f (Fixed)=	791.42	cm
L_f/T=	1.9	Free
L_f (Free)=	683.50	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
20	1.63	4.79
50	4.09	11.96
100	8.17	23.93
150	12.26	35.89
200	16.35	47.85

Hence lateral capacity (load corresponding to 14mm deflection)



= 170kN (for fixed head condition)
= 60 kN (for free head condition)

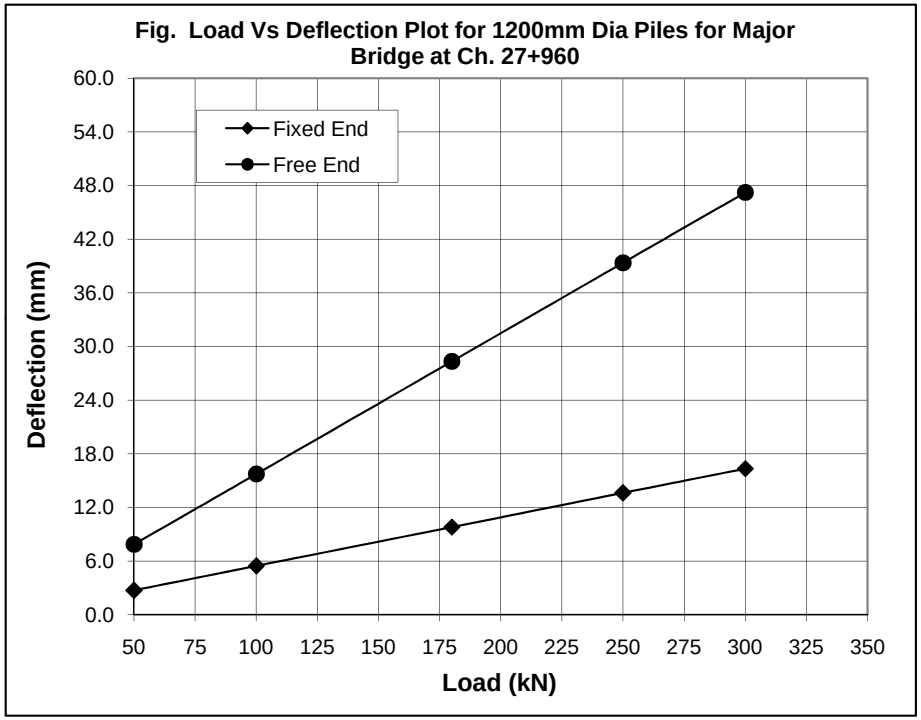
LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 27+960 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.220	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

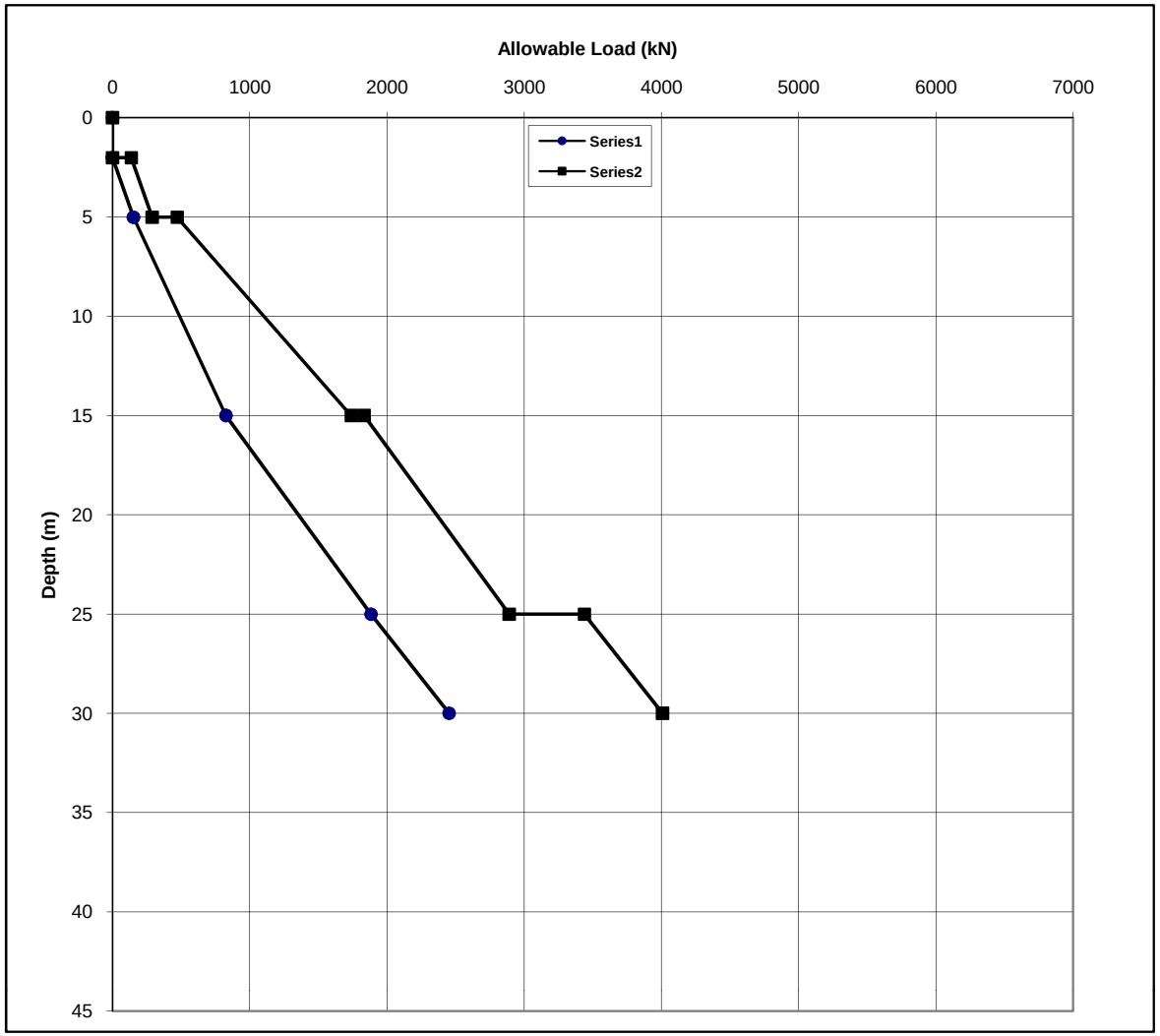
T=	(EI/ηh)^0.2	
	416.22	
L_f/T=	2.2	Fixed
L_f (Fixed)=	915.69	cm
L_f/T=	1.9	Free
L_f (Free)=	790.83	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	2.72	7.87
100	5.45	15.74
180	9.81	28.34
250	13.62	39.36
300	16.34	47.23

Hence lateral capacity (load corresponding to 16mm deflection)

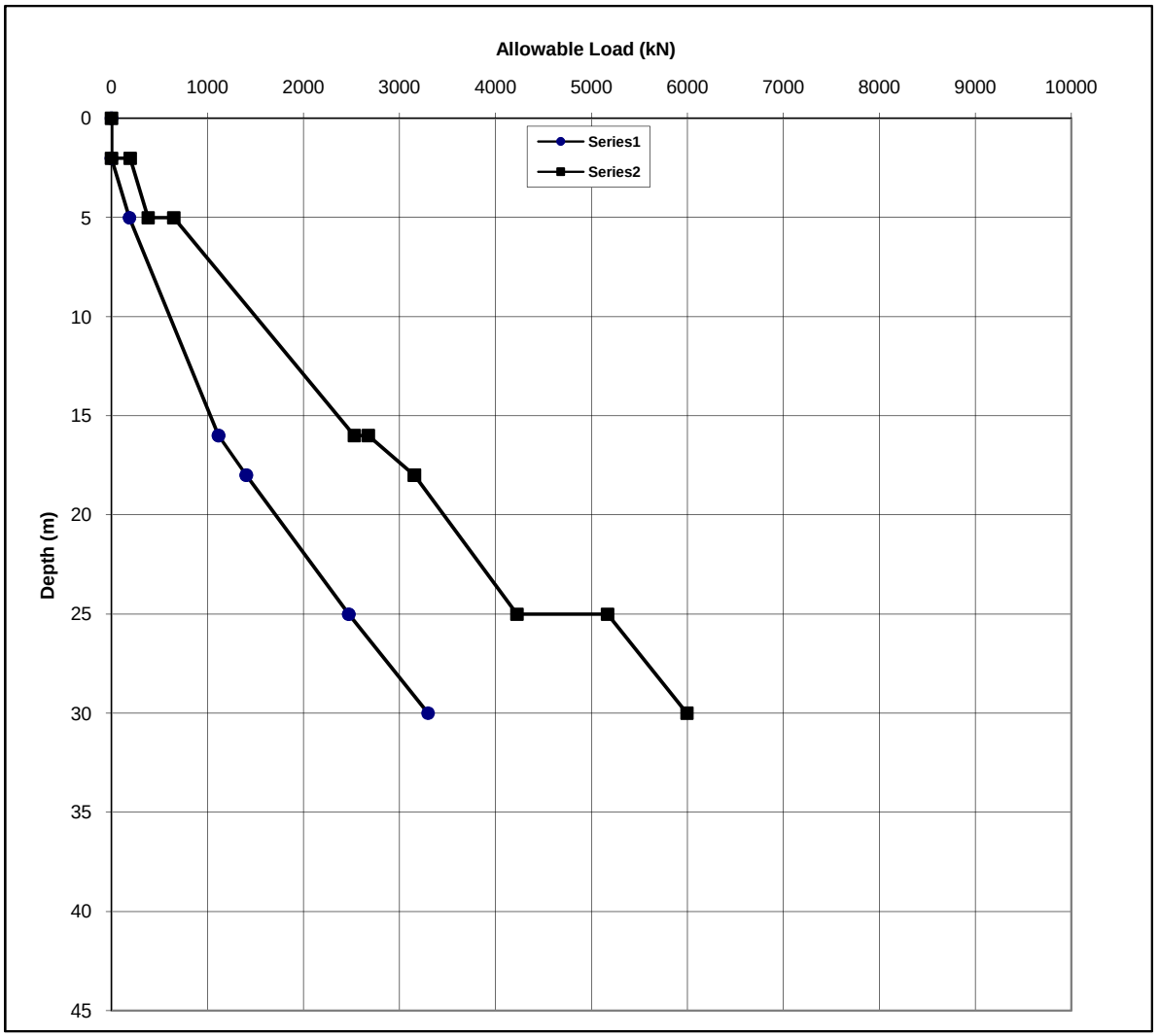


= 280kN (for fixed head condition)
= 100kN (for free head condition)



Allowable Pile Capacity Major Bridge at Chainage 28+840

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity Major Bridge at Chainage 28+840

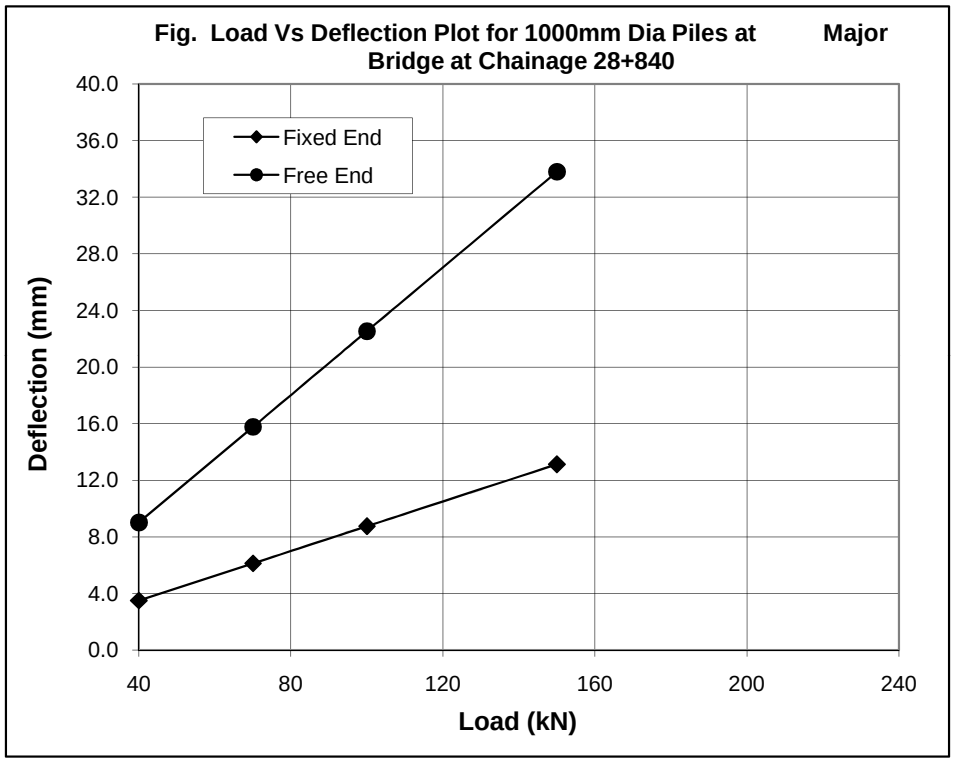
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE AT MAJOR BRIDGE CHAINAGE 28+840 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
K_1	1.000	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	$kg\text{-}cm^2$
K=(K1*0.3)/(1.5B)	0.2	kg/cm^3

T=	(EI/KB)^0.25	
	507.37	
L_f/T=	2.2	Fixed
L_f (Fixed)=	1116.22	cm
L_f/T=	1.9	Free
L_f (Free)=	964.01	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
40	3.50	9.01
70	6.12	15.77
100	8.74	22.53
150	13.12	33.80



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 110kN (for fixed head condition)

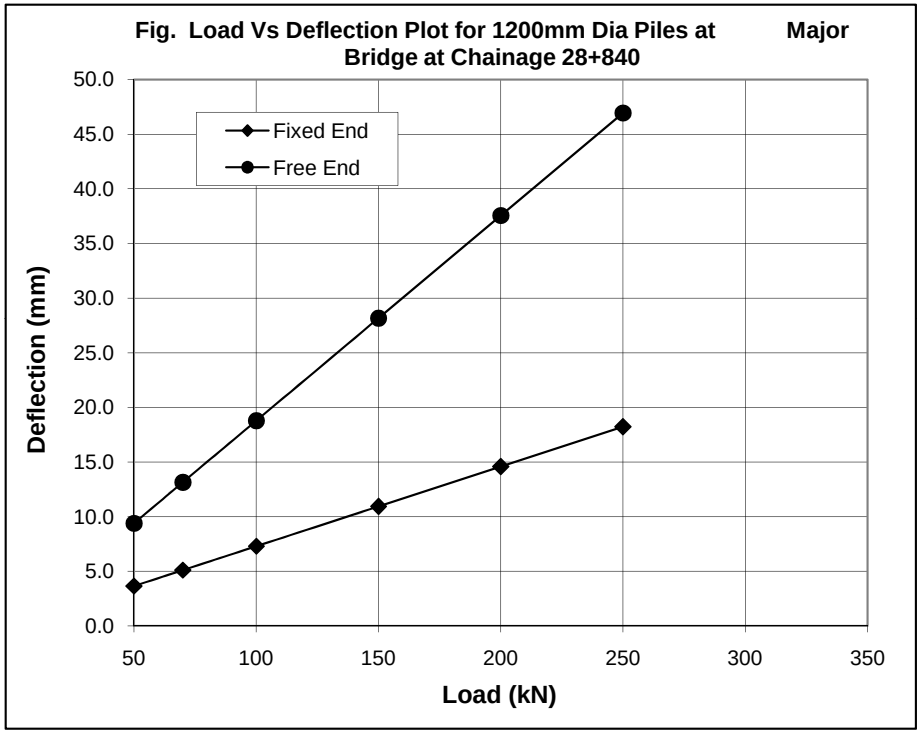
= 40 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE AT MAJOR BRIDGE CHAINAGE 28+840 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
K_1	1.000	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	$kg\text{-}cm^2$
K=(K1*0.3)/(1.5B)	0.166666667	kg/cm^3

T=	(EI/KB)^0.25	
	608.85	
L_f/T=	2.2	Fixed
L_f (Fixed)=	1339.46	cm
L_f/T=	1.9	Free
L_f (Free)=	1156.81	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

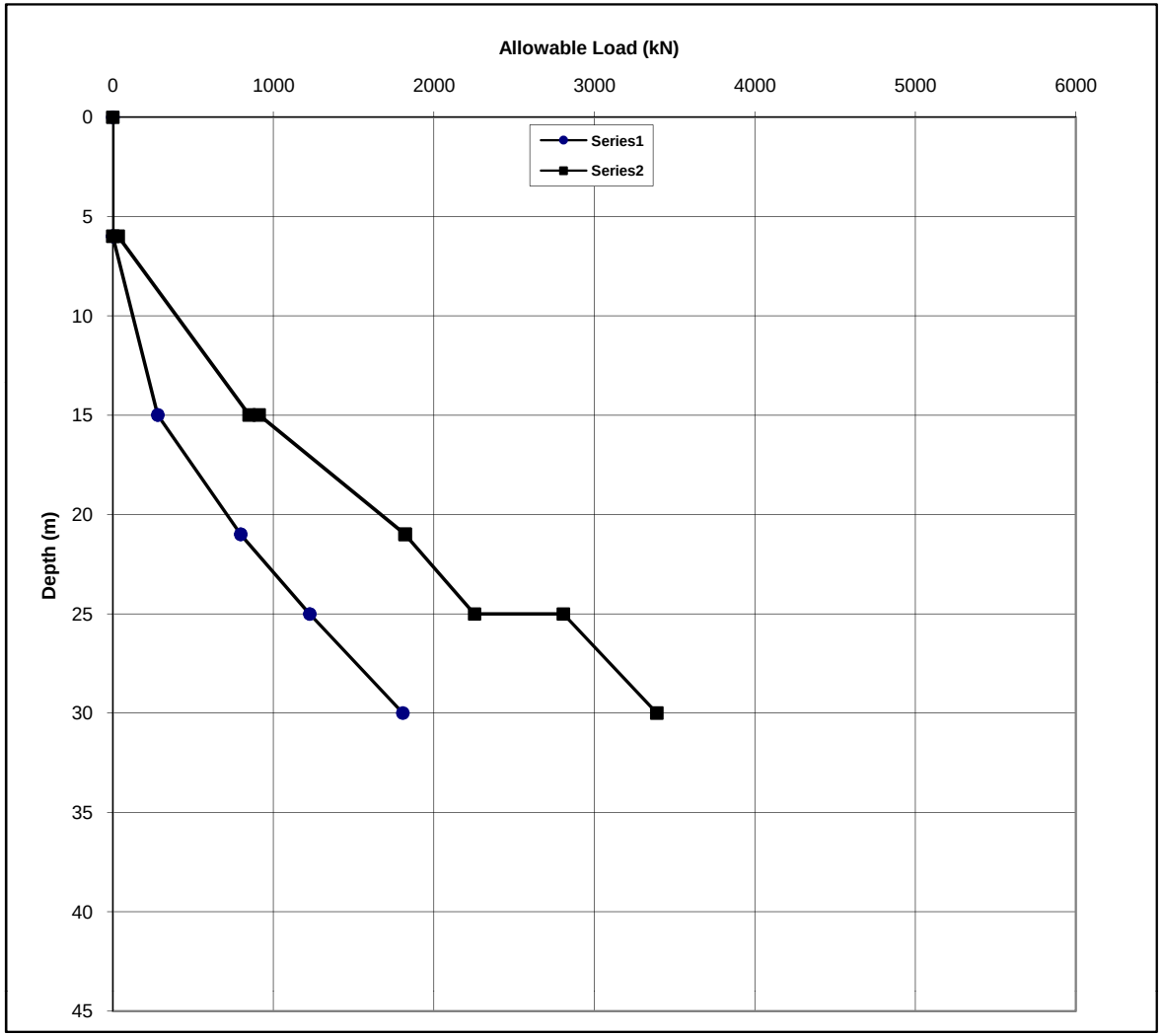
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	3.64	9.39
70	5.10	13.14
100	7.29	18.78
150	10.93	28.16
200	14.57	37.55
250	18.22	46.94



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

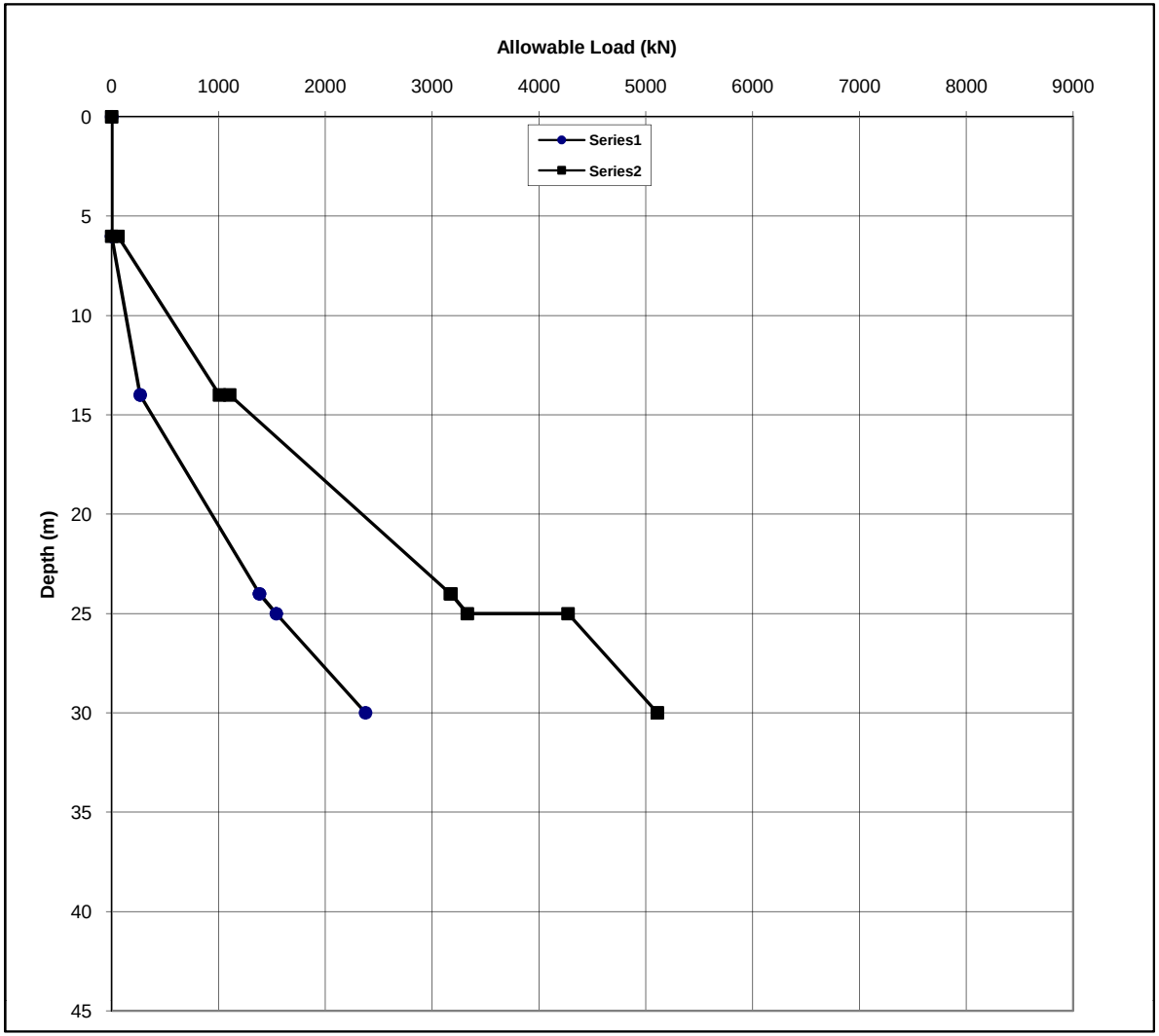
= 160kN (for fixed head condition)

= 60kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 30+236

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 30+236

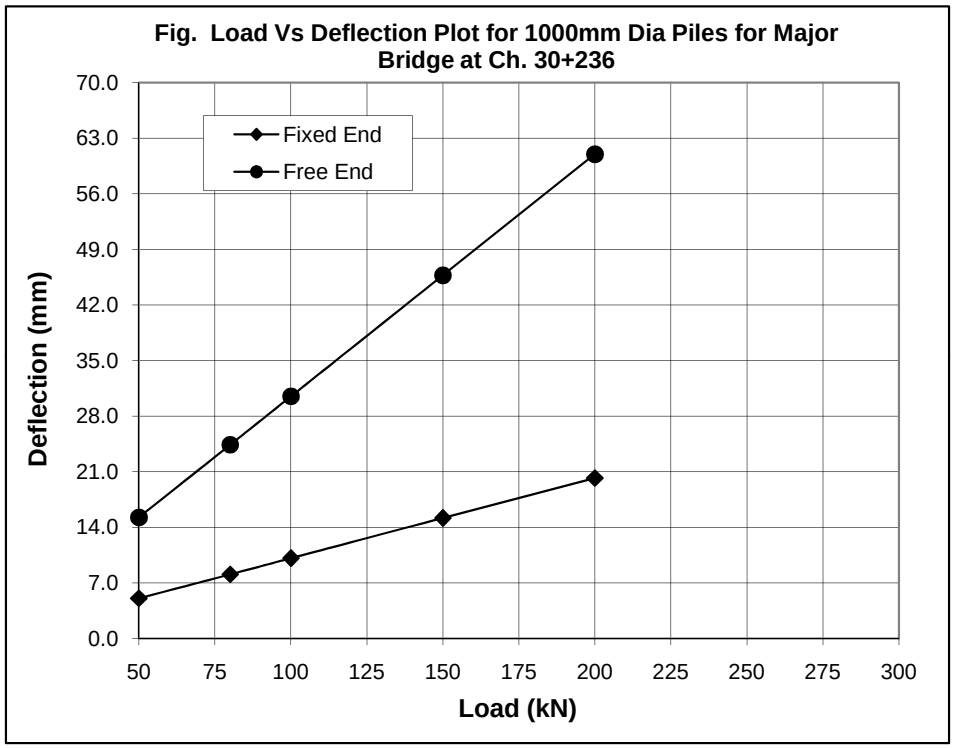
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 30+236 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.250	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	350.65	
L_f/T=	2.2	Fixed
L_f (Fixed)=	771.44	cm
L_f/T=	1.9	Free
L_f (Free)=	666.24	cm
L_1=	400	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	5.05	15.24
80	8.09	24.39
100	10.11	30.49
150	15.16	45.73
200	20.22	60.97



Hence lateral capacity (load corresponding to 16mm deflection)

= 150kN (for fixed head condition)
= 50 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 30+236 (IS: 2911 - PART-1/SEC-2-2010)

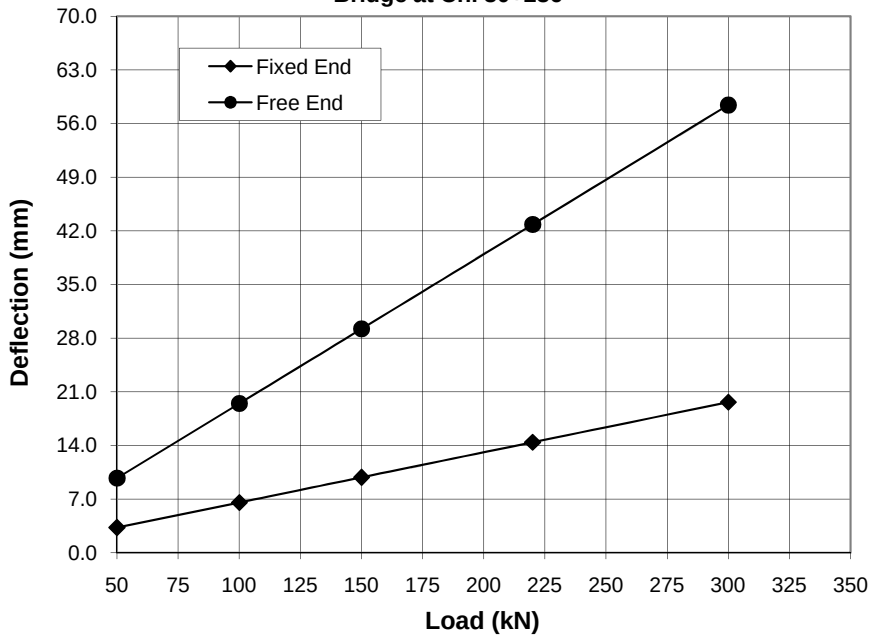
D=	**120**	cm
η_h=	0.250	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	405.72	
L_f/T=	2.2	Fixed
L_f (Fixed)=	892.58	cm
L_f/T=	1.9	Free
L_f (Free)=	770.86	cm
L_1=	400	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

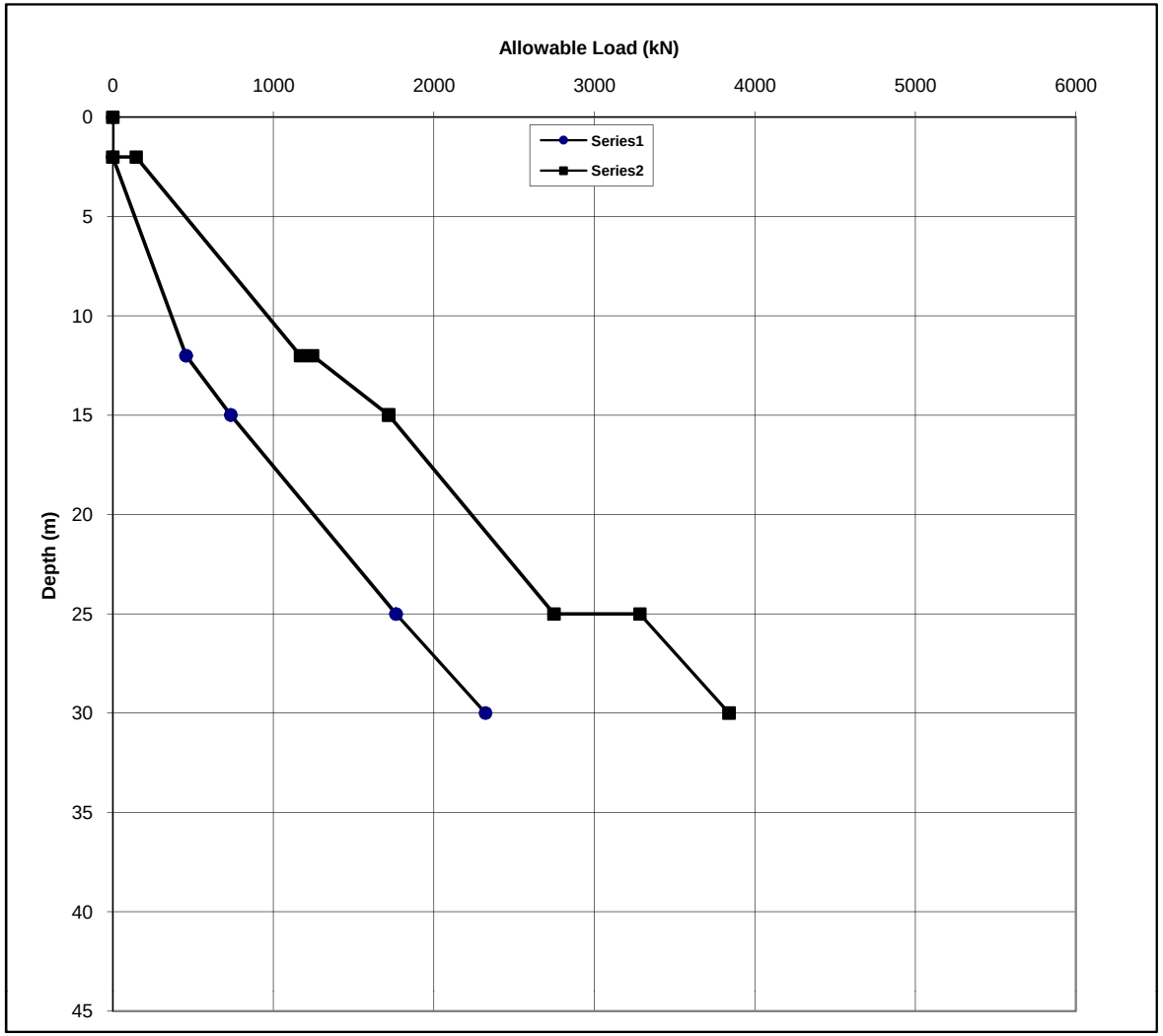
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	3.27	9.73
100	6.55	19.47
150	9.82	29.20
220	14.41	42.83
300	19.65	58.41

Hence lateral capacity (load corresponding to 18mm deflection)

Fig. Load Vs Deflection Plot for 1200mm Dia Piles for Major Bridge at Ch. 30+236

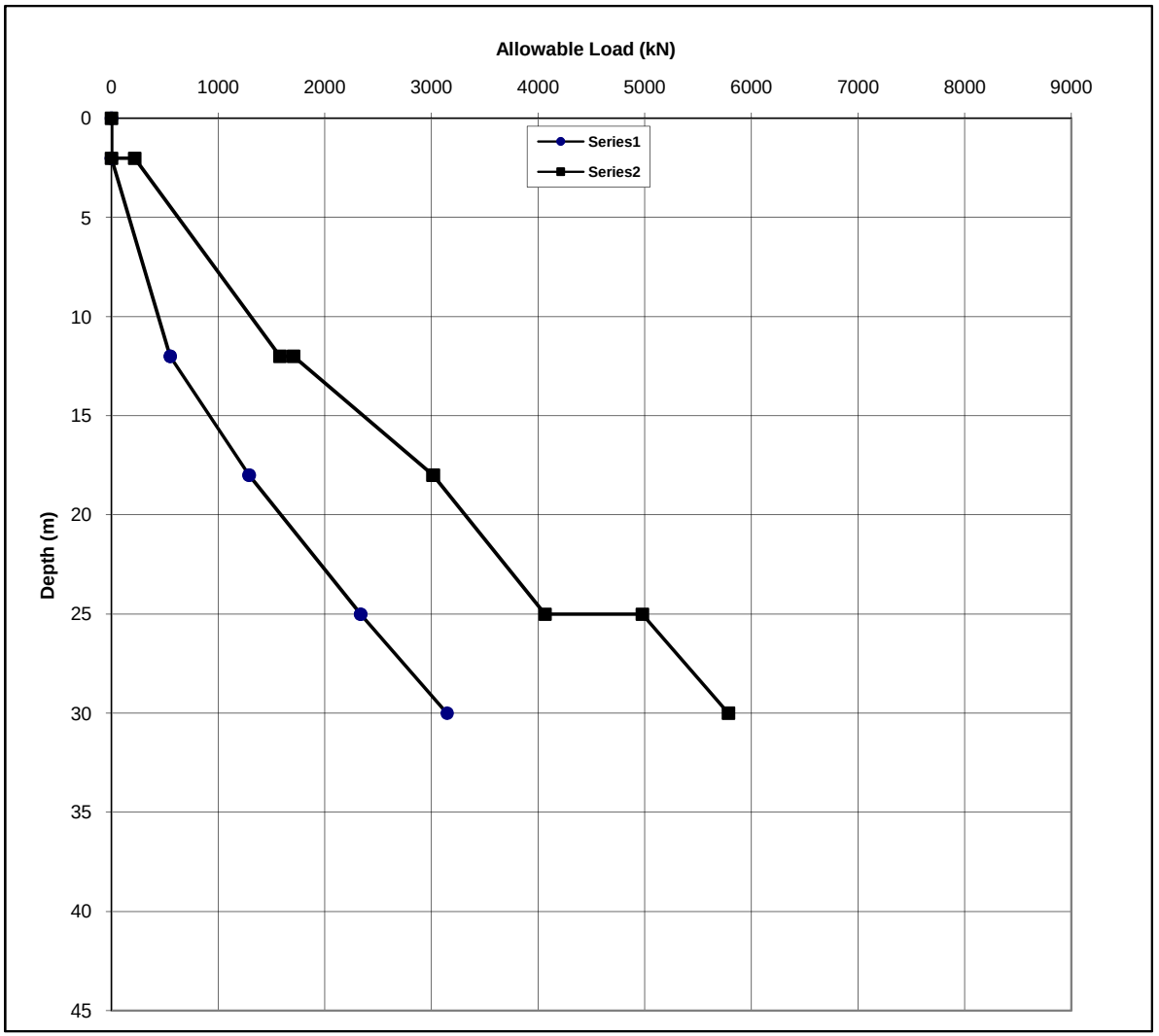


= 270kN (for fixed head condition)
= 90kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 31+820

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 31+820

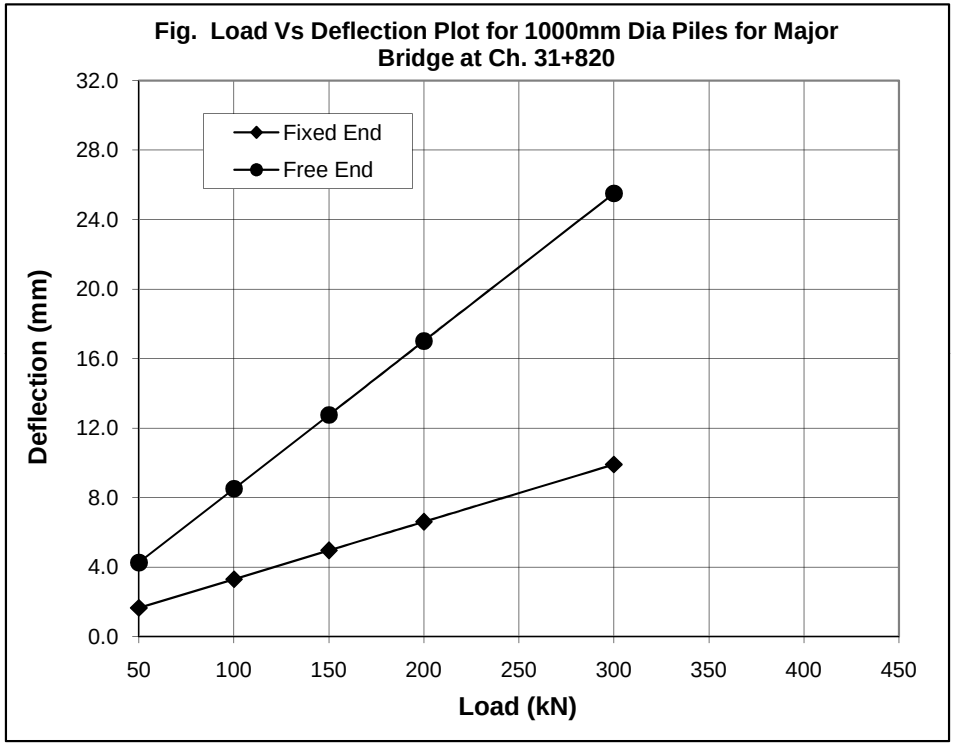
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 31+820 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	366.66	
L_f/T=	2.2	Fixed
L_f (Fixed)=	806.65	cm
L_f/T=	1.9	Free
L_f (Free)=	696.65	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.65	4.25
100	3.30	8.50
150	4.95	12.75
200	6.60	17.01
300	9.90	25.51



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 300kN (for fixed head condition)

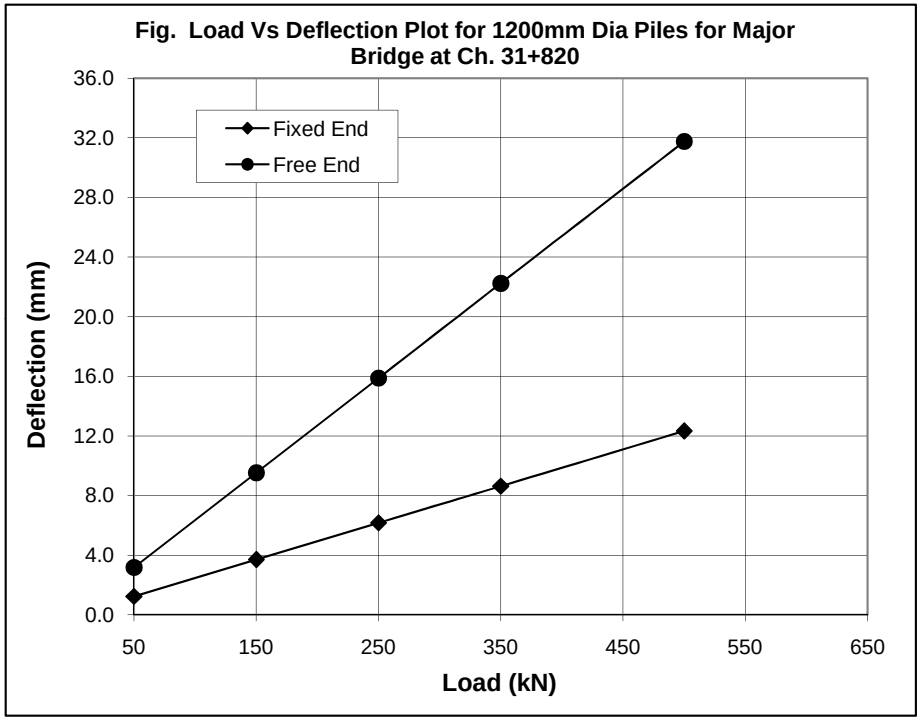
= 110 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 31+820 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	424.23	
L_f/T=	2.2	Fixed
L_f (Fixed)=	933.32	cm
L_f/T=	1.9	Free
L_f (Free)=	806.05	cm
L_1=	0	cm
d=	Q(L_1+L_f)^3/12EI	Fixed
	Q(L_1+L_f)^3/3EI	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.23	3.18
150	3.70	9.53
250	6.16	15.88
350	8.63	22.23
500	12.33	31.76



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

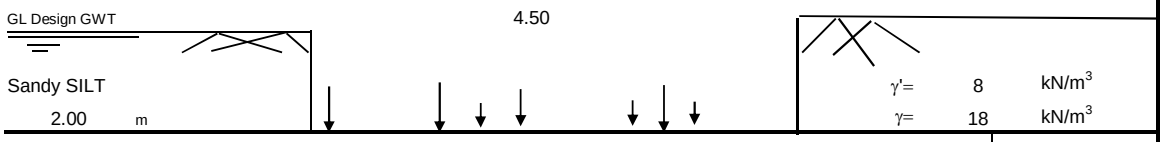
= 480kN (for fixed head condition)

= 190kN (for free head condition)

Calculation for Bearing Capacity at Minor Bridge CH 33+310 km

Footing Size: 5.5x4.5 m

Depth : 2.00 m



Layer - I		Sandy	SILT		Z_1
		N_{av}=	8		
		ϕ_{av}=	31	degree	
		c_{av}=	0	kPa	
		γ_{av}=	8	kN/m3	
5.00	m				
		Silty	SAND		
Layer - II		N_{av}=	20		……Z_2
		ϕ_{av}=	31	degree	
		c_{av}=	0	kPa	
12.00	m	γ_{av}=	9	kN/m3	

Safe Bearing Capacity from Shear Failure

Design ϕ= 31 degree

For Layer - I

As ϕ is 31° Intermediate Shear failure is considered

Q(safe)= $(cN_cs_cd_ci_c+(\gamma*D)(N_q-1)s_qd_qi_q+0.5B\gamma N_\gamma s_\gamma d_\gamma i_{\gamma W}/FS$

FS=	2.5			w=	0.5		
N_c=	33.34	N_q=	21.38		N_γ=	27.54	General shear failure
N_c=	17.19	N_q=	8.1		N_γ=	7.59	Local shear failure
N_c=	19.88	N_q=	10.31		N_γ=	10.92	Intermediate condition
S_c=	1.164	S_q=	1.164		S_γ=	0.67	
dc=	1+0.2*(D/B)*tan(45+φ/2)=			1.16			
dq=dγ=	1+0.1*(D/B)*tan(45+φ/2)			1.08			
ic=iq=	(1-α/90)^2=	1.00		ig=	(1-α/φ)^2=	1.00	α=0
Q_{safe-I}=		**139.0**	**kPa**				

Design Bearing Capacity= **135** **kPa**

Settlement for Layer - I

δ (mm) = $m_v*H*\Delta p*\mu_g*d_f$*Rigidity Factor (0.8) for clay

m_v= m2/kN μ_g=

δ (mm)= $[2.303*(H/C)*\log_{10}\{(p_o+\Delta p)/p_o\}]*d_f$*Rigidity Factor (0.8) for sand

C=1.5*(C_{kd}/p_o)= 214.3 C_{kd}/N= 250 KN/m2 1st layer I = 0.88

p_o= 14 p= 135.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_1 (mm)= 22.17

Settlement for Layer-II

δ (mm) = m_v*H*Δp*μ_g*d_f*Rigidity Factor (0.8) for clay

m_v= m2/kN μ_g=

δ (mm)= [2.303*(H/C)*$\log_{10}$(p_o+Δp)/p_o)]*d_f*Rigidity Factor (0.8) for sand IS:8009 (Part I)

C=1.5*(C_{kd}/p_o)= 125.9 C_{kd}/N= 300 KN/m^2 2nd layer I = 0.2

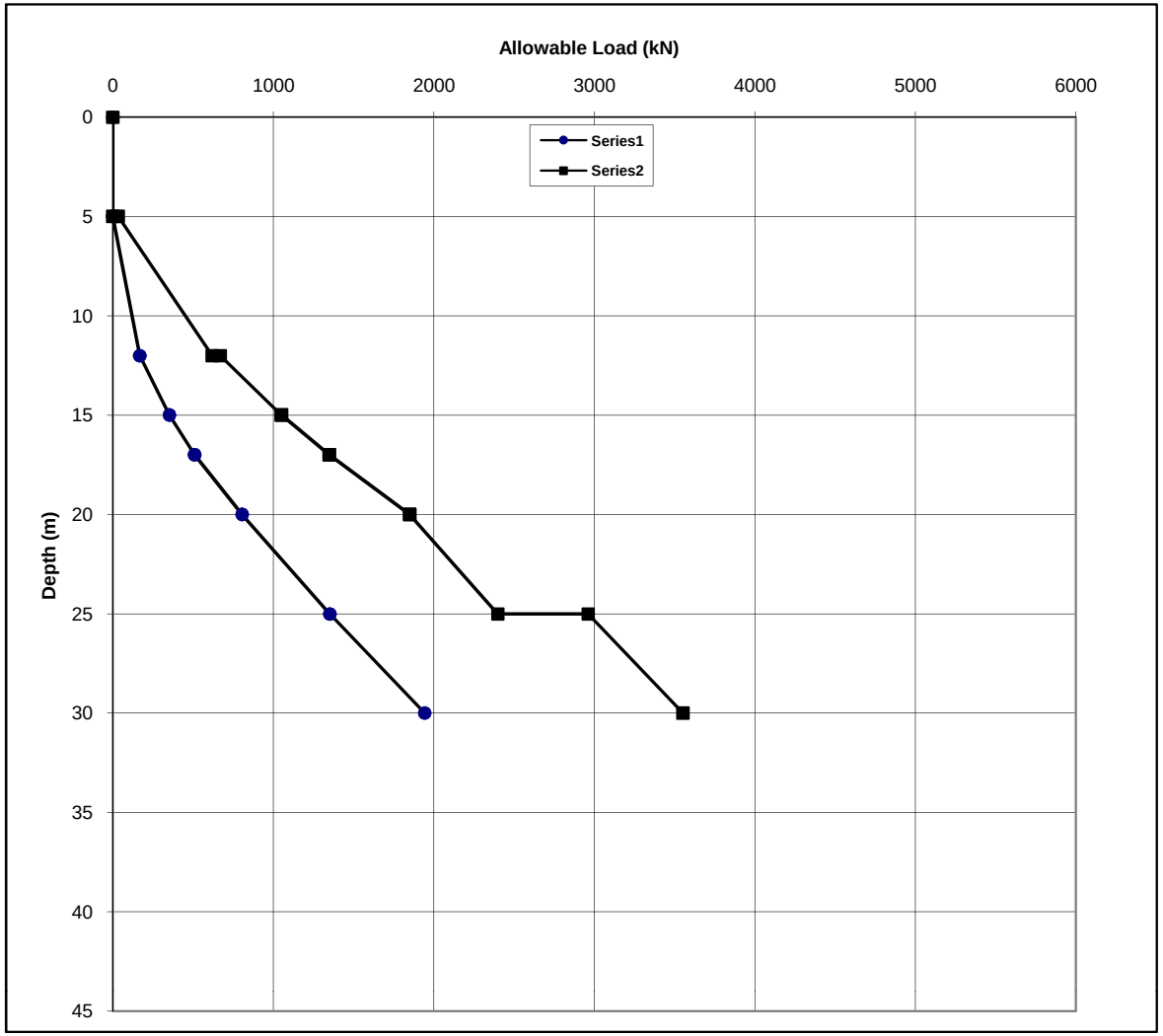
p_o= 71.5 p= 135.0 kPa

Rigidity factor= 0.8 Depth Factor, d_f= 0.88

δ_2 (mm)= 12.54

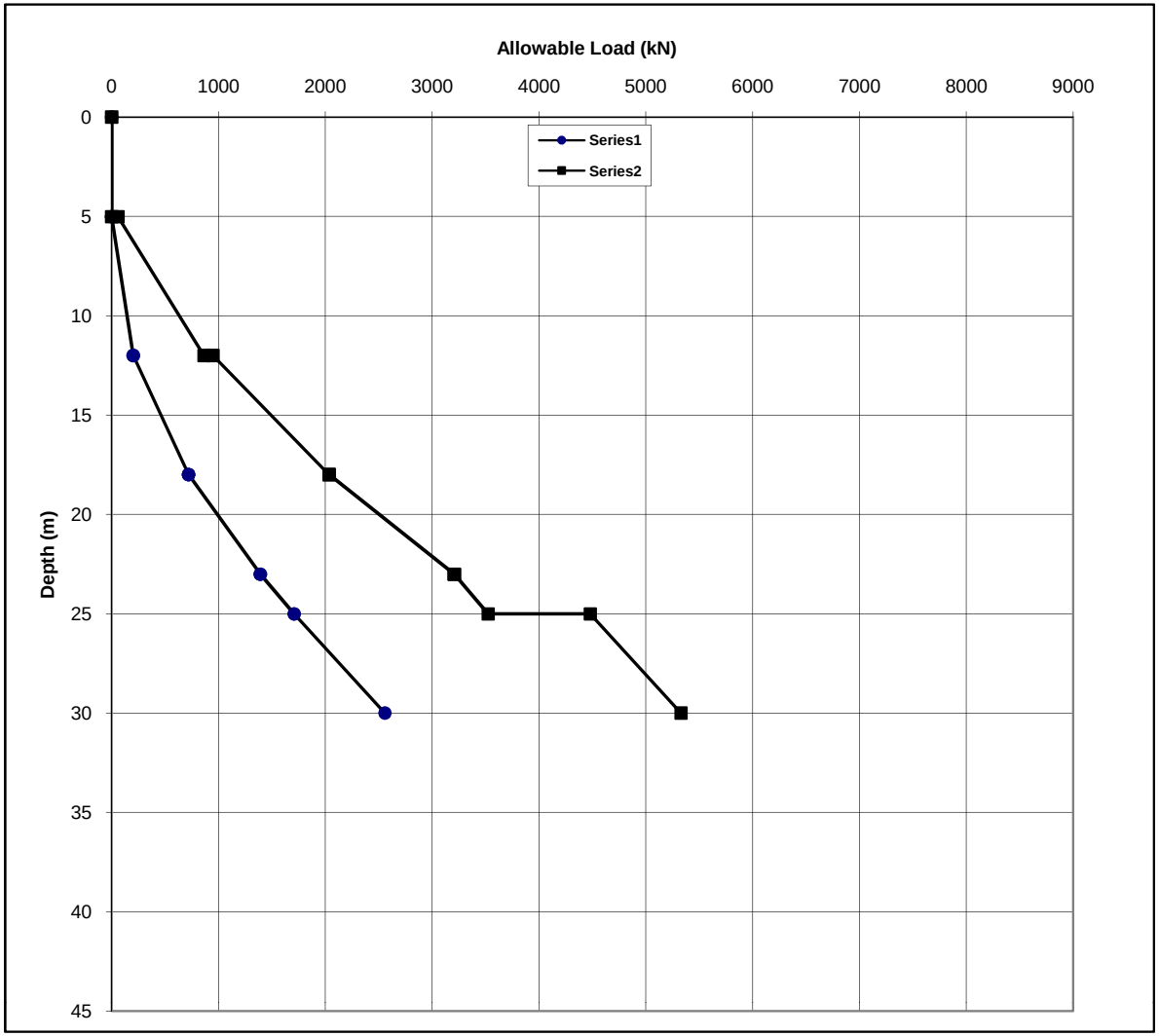
Total settlement = 34.72 mm

Allowable Bearing capacity for 25mm settlement= 100.1 KPa



Allowable Pile Capacity at Major Bridge Ch. 34+920

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 34+920

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 34+920 (IS: 2911 - PART-1/SEC-2-2010)

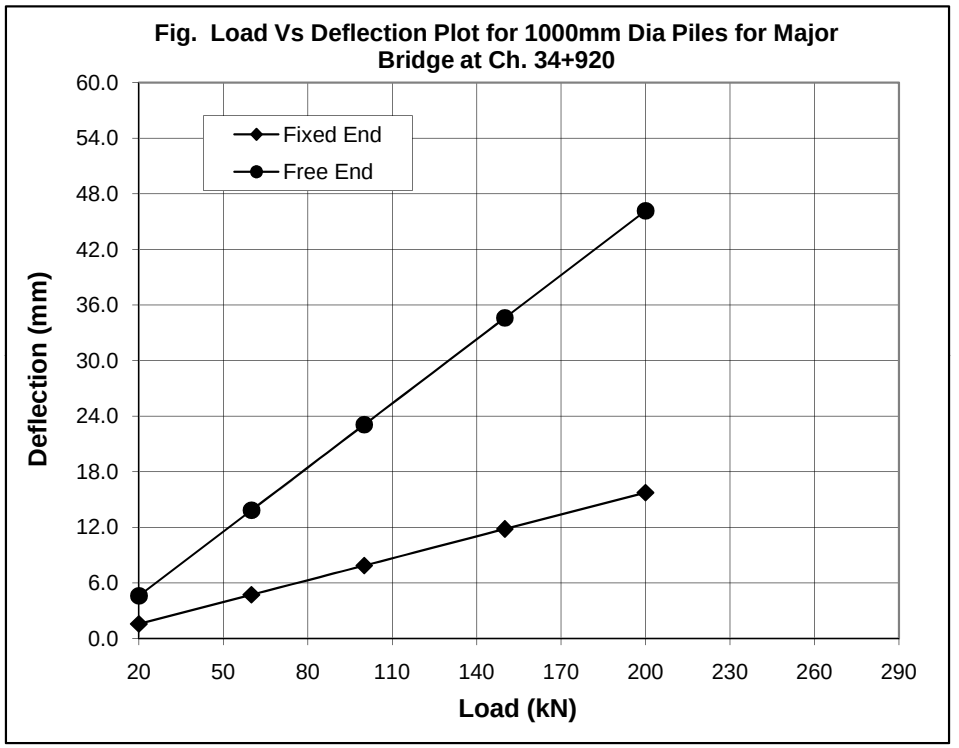
D=	**100**	cm
η_h=	0.240	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	353.53	
L_f/T=	2.2	Fixed
L_f (Fixed)=	777.76	cm
L_f/T=	1.9	Free
L_f (Free)=	671.70	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
20	1.57	4.62
60	4.72	13.85
100	7.87	23.08
150	11.81	34.61
200	15.74	46.15

Hence lateral capacity (load corresponding to 14mm deflection)

= 180kN (for fixed head condition)
= 60 kN (for free head condition)



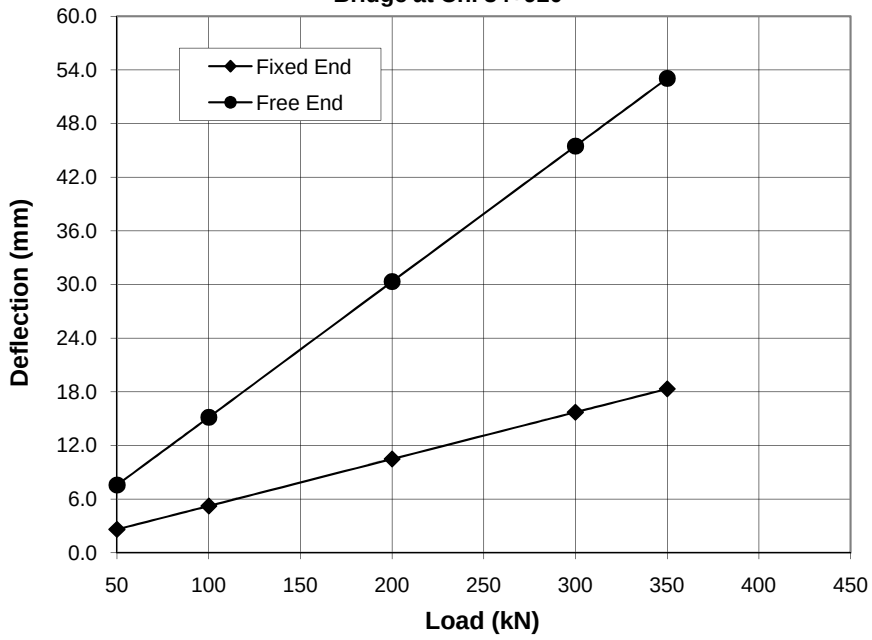
LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 34+920 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.240	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	409.04	
L_f/T=	2.2	Fixed
L_f (Fixed)=	899.90	cm
L_f/T=	1.9	Free
L_f (Free)=	777.18	cm
L_1=	300	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

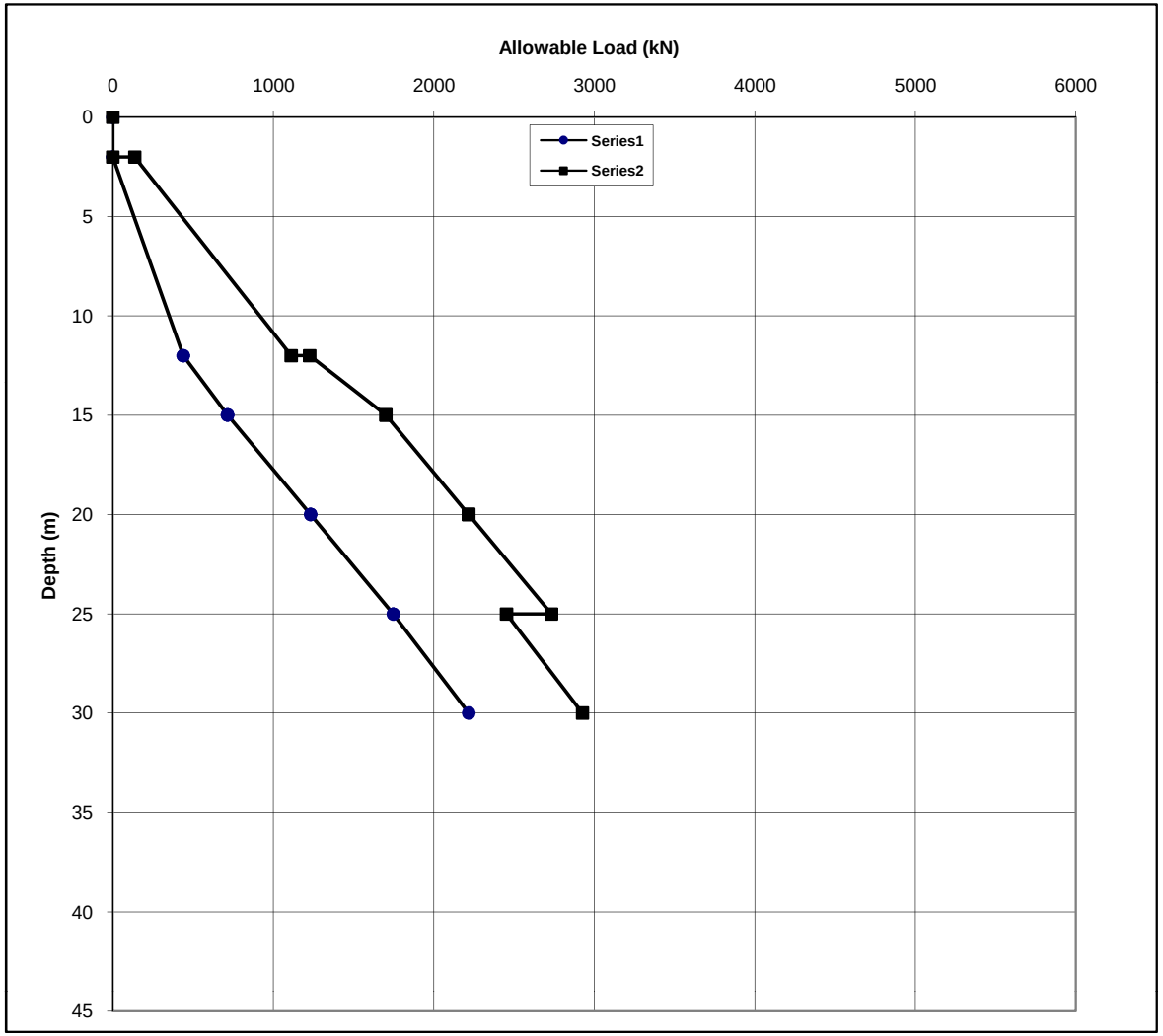
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	2.62	7.58
100	5.24	15.16
200	10.48	30.32
300	15.71	45.48
350	18.33	53.06

Fig. Load Vs Deflection Plot for 1200mm Dia Piles for Major Bridge at Ch. 34+920



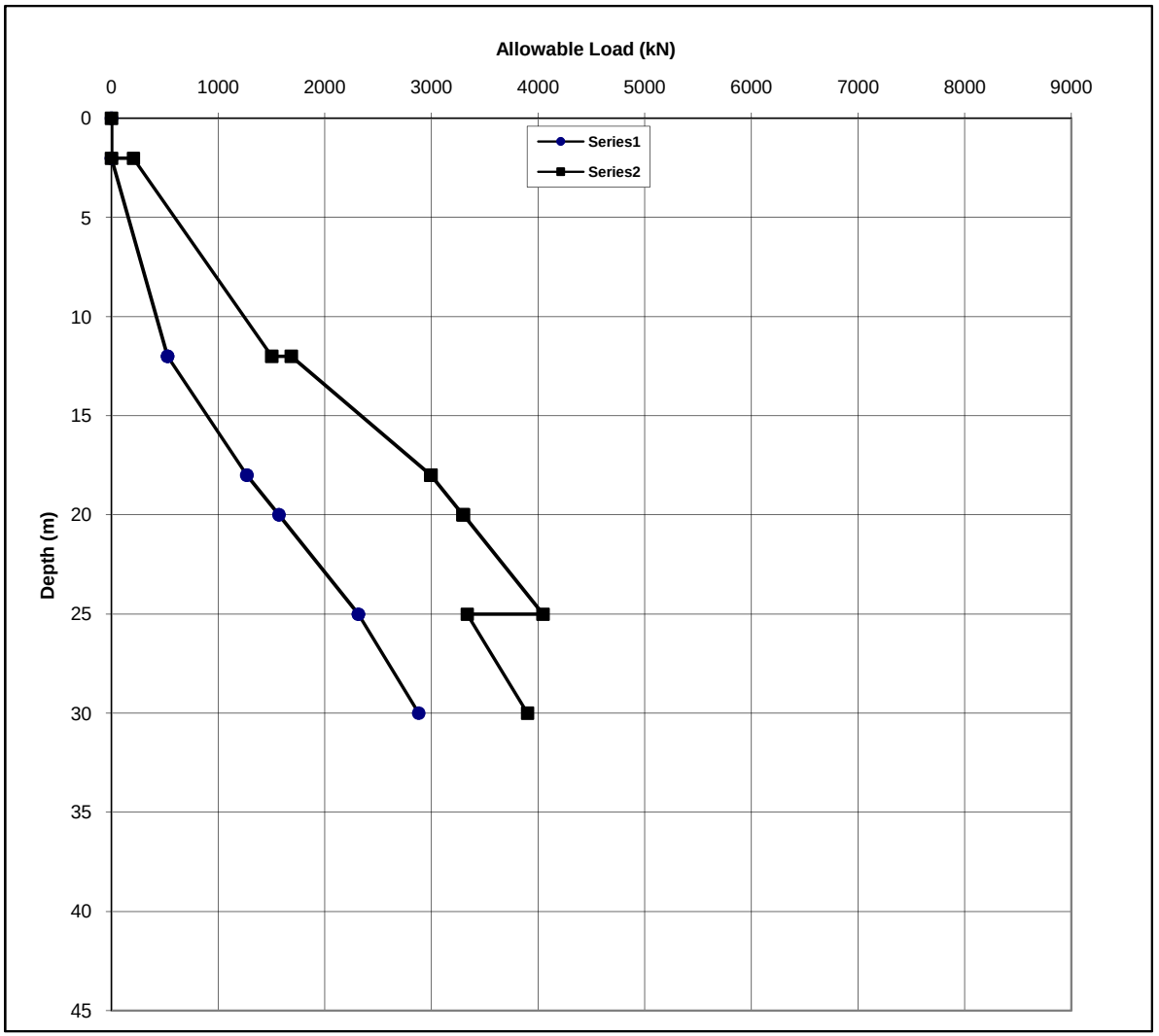
Hence lateral capacity (load corresponding to 16mm deflection)

= 300kN (for fixed head condition)
= 100kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 36+585

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 36+585

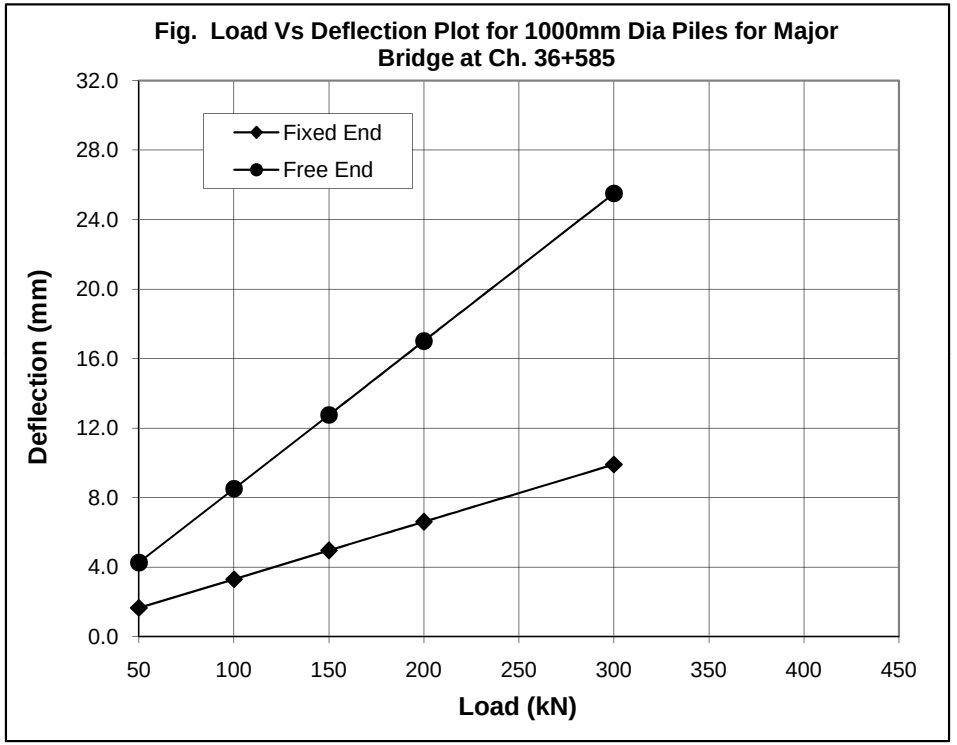
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 36+585 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	366.66	
L_f/T=	2.2	Fixed
L_f (Fixed)=	806.65	cm
L_f/T=	1.9	Free
L_f (Free)=	696.65	cm
L_1=	0	cm
d=	Q(L_1+L_f)^3/12EI	Fixed
	Q(L_1+L_f)^3/3EI	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.65	4.25
100	3.30	8.50
150	4.95	12.75
200	6.60	17.01
300	9.90	25.51



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 300kN (for fixed head condition)

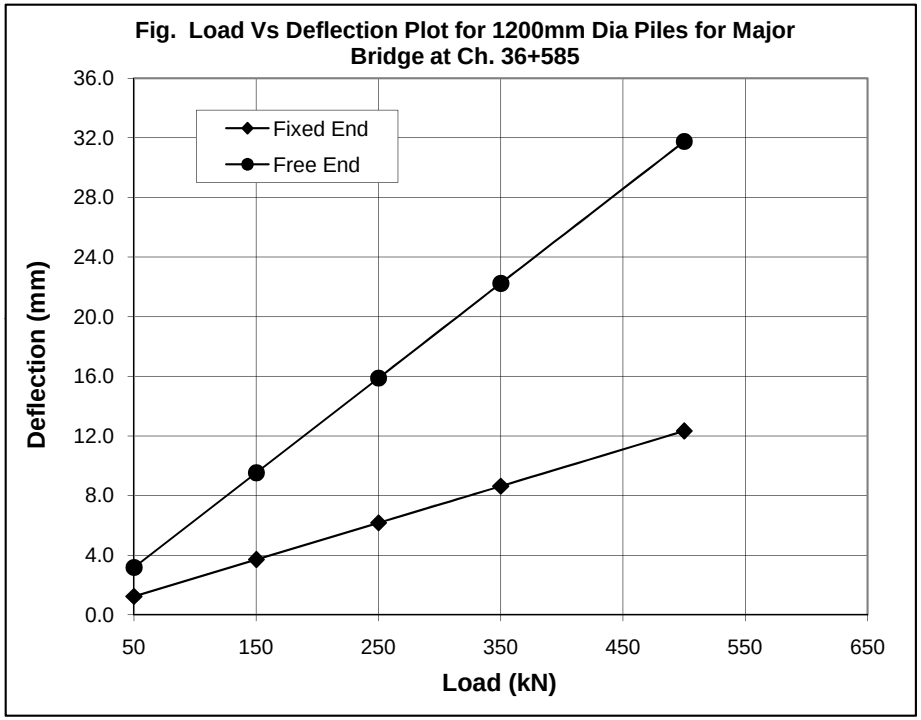
= 110 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 36+585 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.200	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	424.23	
L_f/T=	2.2	Fixed
L_f (Fixed)=	933.32	cm
L_f/T=	1.9	Free
L_f (Free)=	806.05	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

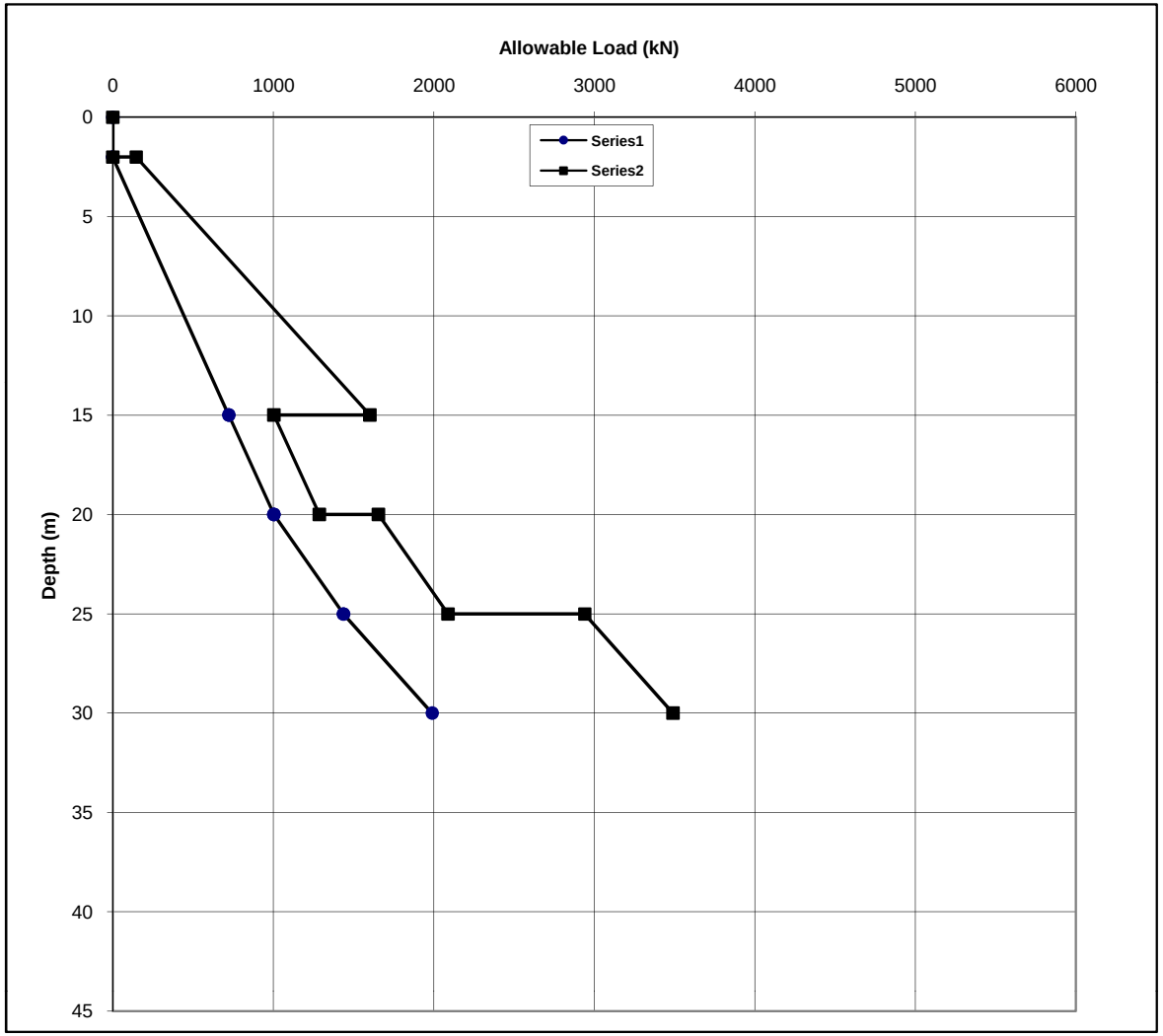
Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.23	3.18
150	3.70	9.53
250	6.16	15.88
350	8.63	22.23
500	12.33	31.76



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

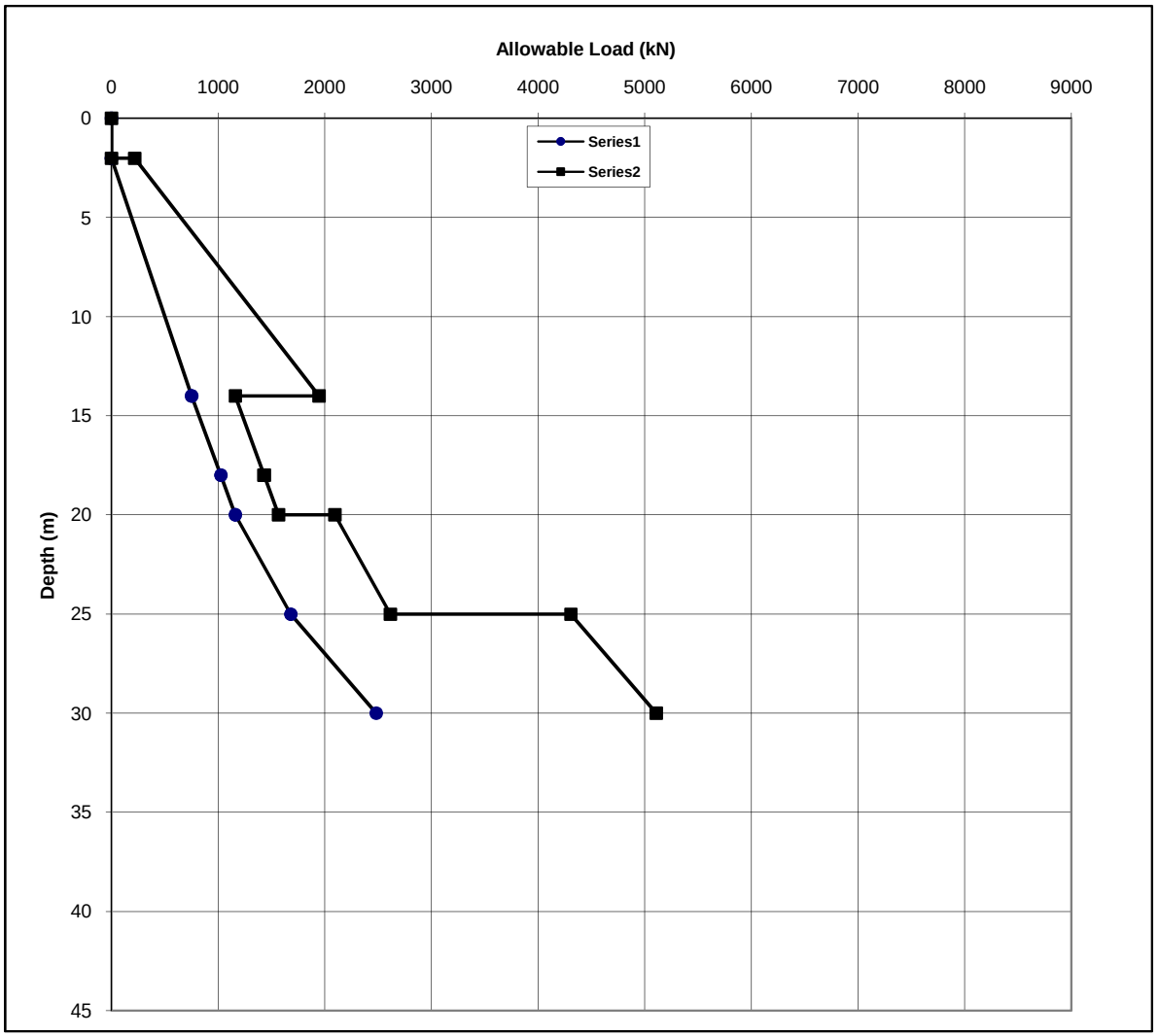
= 480kN (for fixed head condition)

= 190kN (for free head condition)



Allowable Pile Capacity at Major Bridge Ch. 38+930

Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1000**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**



Allowable Pile Capacity at Major Bridge Ch. 38+930

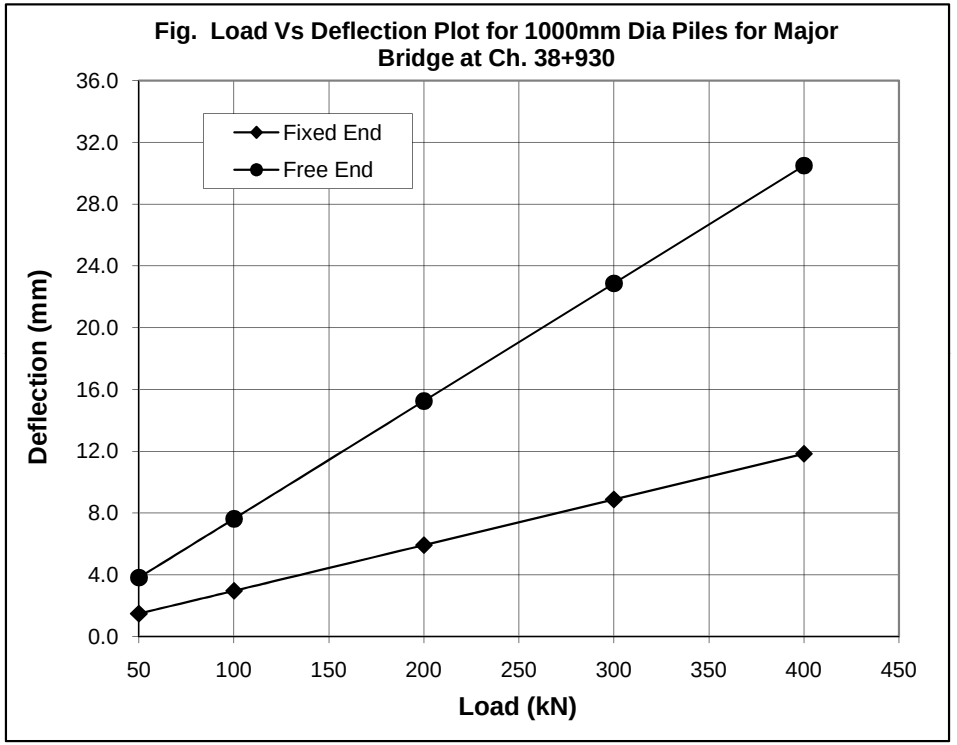
Pile Type=	**Bored**	**Factor of Safety**	
Pile Dia (mm)=	**1200**	**End Bearing =**	**2.5**
		Skin Friction =	**2.5**

LATERAL CAPACITY OF 1000 MM DIA BORED PILE FOR MAJOR BRIDGE AT CH 38+930 (IS: 2911 - PART-1/SEC-2-2010)

D=	**100**	cm
η_h=	0.240	kg/cm^3
E=	270000	kg/cm^2
I=	4908738.5	cm^4
EI=	1.32536E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	353.53	
L_f/T=	2.2	Fixed
L_f (Fixed)=	777.76	cm
L_f/T=	1.9	Free
L_f (Free)=	671.70	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.48	3.81
100	2.96	7.62
200	5.92	15.24
300	8.87	22.87
400	11.83	30.49



Hence lateral capacity (load corresponding to 1% of pile diameter=10mm deflection)

= 340kN (for fixed head condition)

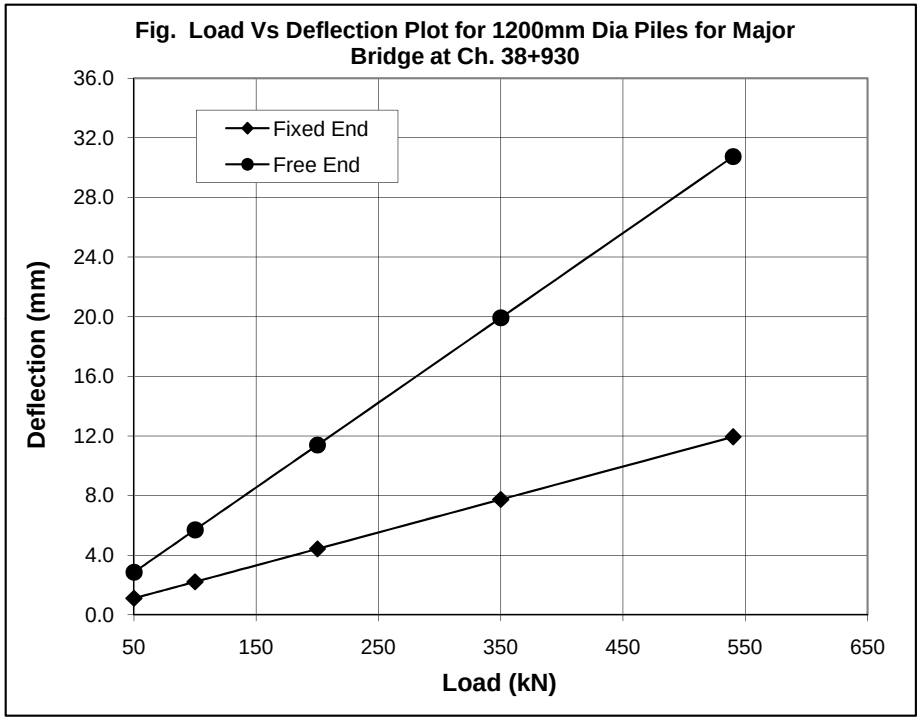
= 130 kN (for free head condition)

LATERAL CAPACITY OF 1200 MM DIA BORED PILE FOR MAJOR BRIDGE CH. 38+930 (IS: 2911 - PART-1/SEC-2-2010)

D=	**120**	cm
η_h=	0.240	kg/cm^3
E=	270000	kg/cm^2
I=	10178760.2	cm^4
EI=	2.74827E+12	kg-cm^2

T=	(EI/ηh)^0.2	
	409.04	
L_f/T=	2.2	Fixed
L_f (Fixed)=	899.90	cm
L_f/T=	1.9	Free
L_f (Free)=	777.18	cm
L_1=	0	cm
d=	$Q(L_1+L_f)^3/12EI$	Fixed
	$Q(L_1+L_f)^3/3EI$	Free

Q (kN)	d (mm) - Fixed	d (mm) - Free
50	1.10	2.85
100	2.21	5.69
200	4.42	11.39
350	7.73	19.93
540	11.93	30.75



Hence lateral capacity (load corresponding to 1% of pile diameter=12mm deflection)

= 540kN (for fixed head condition)

= 210kN (for free head condition)

ANNEXURE C –LAB TEST RESULTS

XPLORER

SUMMARY OF LABORATORY TEST RESULTS

CLIENT: SKYLARK DESIGNER AND ENGINEERS (P) LTD

PROJECT: Geotechnical Investigation Works For Muzaffarnagar to Saharanpur Section of DFCC Meerut

Job No. 1342

Test Report No: XPL/2015-16/02

SL.NO.	CHAINAGE/ BH NO.	Type of Sample	Depth (m)	Moisture Content %	Bulk Density g/cc	Dry Density g/cc	Grain size Analysis (%)				Atterberg Limit (%)			IS Classification	Permeability (cm/sec)	Specific Gravity	F.S.I. %	Modified Proctor		Standard Proctor		CBR Test %	Direct Shear Test		Triaxial Test		Consolidation Test				Swelling Pressure kpa	Shrinkage Limit %	Chemical Analysis *		
							Gravel	Sand	Fines									OMC%	MDD Mg/m³	OMC%	MDD Mg/m³		c kPa	Φ Degree	UU C kPa	UC C kPa	e_0	C_c	P_c	C_r			Sulphates mg/l	Chlorides mg/l	pH Value
									Silt	Clay	LL	PI.	PI																					
1	CH-2010, BH-1	SPT-1	1.50				0	31	66	3	29	NP		MI.									0	28.0										
2		UDS-3	8.00	24.6	1.94	1.58	7	7	75	11	34	22	12	CL		2.67									62								Nil	109.22	7.81
3		SPT-10	15.00				0	96	4					SP									0	32.1										
4		UDS-8	23.00	26.0	1.82	1.45	1	2	82	15	36	23	13	CI																				
5		UDS-9	26.00	30.1	2.07	1.59	0	2	76	22	45	23	22	CI											215									
6	CH-1980, BH-1	SPT-1	1.50				0	65	35		25	NP		SM									0	31.0										
7		UDS-3	8.00	25.0	1.84	1.47	0	2	89	9	32	NP		ML		2.64																	Nil	119.15	7.52
8		SPT-10	15.00				4	94	2					SP									0	33.0										
9		UDS-8	23.00	21.8	1.80	1.48	3	5	84	8	30	NP		ML																				
10		UDS-9	26.00	27.8	1.85	1.45	0	3	89	8	29	NP		ML									0	31.9										
11	CH-6550, BH-1	SPT-1	1.50				0	76	24		23	NP		SM									0	30.1										
12		SPT-6	9.00				0	82	18					SM		2.66							0	32.2									Nil	89.36	7.45
13		UDS-7	20.00	29.6	2.05	1.58	1	3	79	17	37	23	14	CI																				
14		SPT-19	28.50				0	14	78	8	31	NP		ML									0	32.0										
15	CH-6550, BH-2	SPT-1	1.50				0	89	11					SW-SM		2.64																		
16		SPT-6	9.00				2	6	80	12	34	22	12	CL																				
17		UDS-7	20.00	26.8	2.01	1.59	0	2	84	14	32	21	11	CL												78								
18		SPT-19	28.50				0	5	79	16	38	21	17	CI																				
19	CH-5322, BH-1	SPT-1	1.50				0	57	43					SM									0	29.7										
20		SPT-4	6.00				2	4	77	17	41	18	23	CI		2.65																		
21		UDS-4	11.00	22.1	1.89	1.55	0	6	82	12	30	20	10	CL											87								Nil	79.43	7.66
22																																		

Remark * Not in NABL Scope

* NP - Non Plastic

Checked by: KA

Date: 28/3/16

Authorised Signatory:

Date: 28/3/16

XPLORER

SUMMARY OF LABORATORY TEST RESULTS

CLIENT: SKYLARK DESIGNER AND ENGINEERS (P) LTD — Job No 1342

PROJECT: Geotechnical Investigation Works For Muzaffarnagar to Saharanpur Section of DFCC Meerut — Test Report No: XPL/2015-16/02

SL NO	CHAINAGE/ BH NO.	Type of Sample	Depth (m)	Moisture Content %	Bulk Density g/cc	Dry Density g/cc	Grain size Analysis (%)				Atterberg Limit (%)			IS Classification	Permeability (cm/sec)	Specific Gravity	F.S.I. %	Modified Proctor		Standard Proctor		CBR Test %	Direct Shear Test		Triaxial Test		Consolidation Test				Swelling Pressure kpa	Shrinkage Limit %	Chemical Analysis *		
							Gravel	Sand	Fines		LL	PL.	PI					OMC%	MDD Mg/m³	OMC%	MDD Mg/m³		c kPa	Φ Degree	UU C kPa	UC C kPa	e_0	C_c	P_c	C_r			Sulphates mg/l	Chlorides mg/l	pH Value
									Silt	Clay																								
1	CH-1790, BH-1	SPT-1	1.50				0	92	8					SW-SM									0	30.8										
2		UDS-4	11.00	28.2	2.02	1.57	1	4	80	15	37	22	15	CI		2.66									166								Nil	99.29	7.72
3		UDS-6	17.00	22.0	1.94	1.59	0	16	76	8	33	NP		ML																				
4		UDS-8	23.00	22.2	2.03	1.66																												
5		UDS-9	26.00	19.2	2.09	1.75																												
6		SPT-18	27.00				0	79	21					SM									0	34.4										
7	CH-1790, BH-2	SPT-1	1.50				0	83	17					SM									0	29.8										
8		UDS-4	11.00	25.6	2.17	1.73	0	12	84	4	29	NP		ML																				
9		UDS-6	17.00	20.1	2.02	1.68	0	44	56	0	25	NP		ML		2.69							0	30.9										
10		SPT-18	27.00				6	10	70	14	34	23	11	CL																				
11	CH-2286, BH-	SPT-1	1.50				0	55	45	0	23	NP		SM									0	29.9										
12		SPT-4	6.00				0	81	19					SM		2.65																	Nil	109.22	7.54
13		SPT-7	10.50				0	96	4					SP									0	32.5										
14	CH-3360,BH-	SPT-1	1.50				0	35	65	0	24	NP		ML		2.67							0	28.9										
15		SPT-4	6.00				0	67	33					SM																				
16		UDS-4	11.00	20.8	1.97	1.63	1	19	80	0	28	NP		ML									0	31.0									Nil	119.15	7.55
17	CH-8440, BH-	UDS-1	2.00	24.0	2.00	1.61	0	4	85	11	33	20	13	CL		2.64									50								Nil	109.22	7.81
18		SPT-4	6.00				1	11	83	6				ML																				
19		UDS-4	11.00	22.4	2.11	1.72	0	15	77	8	27	NP		ML																				
20	CH-11+753, BH-1	UDS-1	2.00	14.5	1.86	1.63	0	34	61	5		30	NP	ML		2.66							0	29.0										
21		SPT-8	12.00				1	97	2					SP																				
22		SPT-17	25.50				1	95	4					SP									0	34.0										

Remark * Not in NABL Scope
* NP - Non Plastic

Checked by: — Date: 28/3/16

Authorised Signatory: — Date: 28/3/16

XPLORER

SUMMARY OF LABORATORY TEST RESULTS

CLIENT: SKYLARK DESIGNER AND ENGINEERS (P) LTD

PROJECT: Geotechnical Investigation Works For Muzaffarnagar to Saharanpur Section of DFCC Meerut

Job No. 1342

Test Report No: XPL/2015-16/02

SL NO.	CHAINAGE/ BH NO.	Type of Sample	Depth (m)	Moisture Content %	Bulk Density g/cc	Dry Density g/cc	Grain size Analysis (%)				Atterberg Limit (%)			IS Classification	Permeability (cm/sec)	Specific Gravity	F.S.I. %	Modified Proctor		Standard Proctor		CBR Test %	Direct Shear Test		Triaxial Test		Consolidation Test				Swelling Pressure kpa	Shrinkage Limit %	Chemical Analysis *		
							Gravel	Sand	Fines		LL	PL	PI					OMC%	MDD Mg/m³	OMC%	MDD Mg/m³		c kPa	Φ Degree	UU C kPa	UC C kPa	e_0	C_c	P_c	C_r			Sulphates mg/l	Chlorides mg/l	pH Value
									Silt	Clay																								
1	CH-10+540, BH-1	SPT-1	1.50				0	89	11					SW-SM									0	30.1										
2		SPT-8	12.00				1	6	85	8	32	NP*		ML		2.68																Nil	89.36	7.45
3		SPT-17	25.50				2	73	25					SM																				
4	CH-15+800, BH-1	UDS-1	2.00	23.4	1.83	1.48	0	27	73	0	27	NP		ML		2.62							0	31.3										
5		SPT-8	12.00				1	89	10					SW-SM									0	29.1								Nil	109.22	7.50
6		SPT-17	25.50				0	93	7					SW-SM																				
7	CH-14+150, BH-1	UDS-1	2.00	16.4	1.91	1.64	0	33	61	6	31	NP		ML		2.63							0	32.6										
8		SPT-8	12.00				1	80	19					SM									0	30.0								Nil	79.43	7.25
9		SPT-17	25.50				0	96	4					SP																				
10	CH-13+260, BH-1	UDS-1	2.00	21.1	1.92	1.58	0	2	87	11	32	22	10	CL		2.67									104									
11		SPT-8	12.00				1	85	14					SM									0	32.0								Nil	99.29	7.65
12		SPT-17	25.50				6	74	20					SM																				
13	CH-17+790, BH-1	UDS-1	2.00	9.6	1.98	1.81	0	18	77	5	28	NP		ML		2.69							0	29.0										
14		SPT-8	12.00				1	86	13					SM																		Nil	119.15	7.21
15		UDS-8	23.00	22.0	2.03	1.66	0	12	88	0				ML									0	32.0										
16		UDS-9	26.00	18.2	2.09	1.76	1	8	85	6	31	NP		ML																				
17	CH-18+900, BH-1	UDS-1	2.00	18.7	1.93	1.63	0	2	87	11	33	20	13	CL												55.0								
18		UDS-2	5.00	29.1	2.08	1.61	1	14	73	12	34	21	13	CL		2.67																Nil	109.22	7.39
19		SPT-6	9.00				0	76	24					SM																				
20	CH-19+680, BH-1	SPT-1	1.50				0	46	54	0				ML									0	29.0										
21		UDS-2	5.00	19.7	1.91	1.60	1	10	86	3	29	NP		ML		2.64																Nil	129.07	7.10
22		SPT-6	9.00				0	84	16					SM									0	31.2										

Remark * Not in NABL Scope

* NP - Non Plastic

Checked by: RE

Date: 28/3/16

Authorised Signatory:

Date: 28/3/16

XPLORER

SUMMARY OF LABORATORY TEST RESULTS

CLIENT: SKYLARK DESIGNER AND ENGINEERS (P) LTD — Job No. 1342

PROJECT: Geotechnical Investigation Works For Muzaffarnagar to Saharanpur Section of DFCC Meerut — Test Report No. XPL/2015-16/02

Sl. NO.	CHAINAGE/ BH NO.	Type of Sample	Depth (m)	Moisture Content %	Bulk Density g/cc	Dry Density g/cc	Grain size Analysis (%)				Atterberg Limit (%)			IS Classification	Permeability (cm/sec)	Specific Gravity	F.S.L %	Modified Proctor		Standard Proctor		CBR Test %	Direct Shear Test		Triaxial Test		Consolidation Test				Swelling Pressure kpa	Shrinkage Limit %	Chemical Analysis *		
							Gravel	Sand	Fines		LL	PL	PI					OMC%	MDD Mg/m³	OMC%	MDD Mg/m³		c kPa	Φ Degree	UU C kPa	UC C kPa	e_0	C_c	P_c	C_r			Sulphates mg/l	Chlorides mg/l	pH Value
									Silt	Clay																									
1	CH-24+269, BH-1	UDS-1	2.00	10.2	1.81	1.64	0	23	74	3				ML		2.64							0	29.2									Nil	109.22	7.15
2		UDS-5	14.00	10.8	1.85	1.67	1	2	89	8	32	NP*		ML																					
3		SPT-17	25.50				0	93	7					SW-SM									0	34.3											
4	CH-20+960, BH-1	UDS-1	2.00	22.6	2.03	1.65	0	8	90	2	27	NP		ML		2.66							0	28.1									Nil	148.93	6.99
5		SPT-6	9.00				1	94	5					SW-SM									0	31.0											
6	CH-22+700, BH-1	UDS-1	2.00	8.4	1.85	1.71	0	11	89	0				ML		2.62							0	29.3									Nil	139.00	7.01
7		UDS-2	5.00	10.1	1.75	1.59	1	7	87	5	30	NP		ML																					
8		SPT-8	12.00				0	96	4					SP									0	31.1											
9	CH-25+880, BH-1	UDS-1	2.00	16.1	2.00	1.72	0	47	47	6	26	NP		ML		2.65							0	29.4									Nil	129.07	7.11
10		UDS-4	11.00	20.4	2.03	1.68																													
11		SPT-8	12.00				1	96	3					SP									0	30.4											
12		SPT-17	25.50				0	98	2					SP																					
13	CH-28+840, BH-1	UDS-1	2.00	9.7	1.87	1.71	0	4	82	14	34	22	12	CL		2.66										48							Nil	109.22	7.30
14		UDS-2	5.00	10.1	1.88	1.71	1	10	84	5	29	NP*		ML																					
15		UDS-5	14.00	11.0	1.87	1.69	2	26	72	0				ML									0	31.5											
16		SPT-17	25.50				0	97	3					SP									0	33.3											
17	CH-27+960, BH-1	UDS-1	2.00	9.4	1.90	1.73	0	12	80	8	30	NP*		ML		2.61							0	28.0									Nil	119.15	7.05
18		SPT-8	12.00				1	91	8					SW-SM																					
19		UDS-6	17.00	11.2	1.87	1.69	5	4	79	12	32	22	10	CL																					
20		SPT-17	25.50				0	96	4					SP									0	33.2											
21	CH-30+236, BH-1	UDS-1	2.00	9.3	1.87	1.71	0	40	60	0				ML		2.66							0	29.7									Nil	129.07	7.12
22		SPT-8	12.00				1	96	3					SP																					
23		UDS-5	14.00	21.5	1.86	1.53	0	6	89	5	29	NP*		ML									0	30.9											
24		SPT-17	25.50				1	91	8					SW-SM									0	33.7											

Remark * Not in NABL Scope
* NP - Non Plastic

Checked by: — Date: 28/3/16

Authorised Signatory: — Date: 28/3/16

XPLORER

SUMMARY OF LABORATORY TEST RESULTS

CLIENT: SKYLARK DESIGNER AND ENGINEERS (P) LTD — Job No. 1342

PROJECT: Geotechnical Investigation Works For Muzaffarnagar to Saharanpur Section of DFCC Meerut — Test Report No: XPL/2015-16/02

SL NO	CHAINAGE/ BH NO.	Type of Sample	Depth (m)	Moisture Content %	Bulk Density g/cc	Dry Density g/cc	Grain size Analysis (%)				Atterberg Limit (%)			IS Classification	Permeability (cm/sec)	Specific Gravity	F.S.I. %	Modified Proctor		Standard Proctor		CBR Test %	Direct Shear Test		Triaxial Test		Consolidation Test				Swelling Pressure kpa	Shrinkage Limit %	Chemical Analysis *		
							Gravel	Sand	Fines		LL	PL	PI					OMC%	MDD Mg/m³	OMC%	MDD Mg/m³		c kPa	Φ Degree	UU C kPa	UC C kPa	e_0	C_c	P_c	C_r			Sulphates mg/l	Chlorides mg/l	pH Value
									Silt	Clay																									
1	CH-31+820, BH-1	SPT-1	1.50				0	53	47	0	25	NP		SM		2.67							0	30.1									Nil	109.22	7.02
2		SPT-8	12.00				1	90	9					SW-SM																				
3		SPT-17	25.50				0	88	12					SW-SM									0	32.8										
4	CH-33+310, BH-1	UDS-1	2.00	20.7	1.78	1.47	0	9	91	0	25	NP		ML		2.64							0	28.7									Nil	119.15	7.14
5		SPT-6	9.00				1	86	13					SM									0	31.0										
6	CH-34+920, BH-1	UDS-1	2.00	7.8	1.86	1.73	0	4	91	5	29	NP		ML		2.67							0	27.3									Nil	158.86	7.26
7		SPT-8	12.00				1	93	6					SW-SM									0	32.5										
8		UDS-6	17.00	7.4	1.88	1.75	6	4	86	4	28	NP		ML																				
9		SPT-17	25.50				1	91	8					SW-SM									0	33.1										
10	CH-36+585, BH-1	SPT-1	1.50				0	61	39					SM		2.62							0	31.0									Nil	148.93	7.19
11		SPT-8	12.00				1	91	8					SW-SM									0	31.7										
12		UDS-8	23.00	11.7	1.83	1.64	1	31	62	6	32	NP		ML																				
13		SPT-17	25.50				0	11	77	12				CL																				
14	CH-36+585, BH-2	SPT-1	1.50				0	32	61	7	28	NP		ML									0	28.1									Nil	119.15	7.20
15		SPT-8	12.00				1	85	14					SM		2.61																		
16		UDS-7	20.00	17.4	1.89	1.61	0	14	81	5	29	NP		ML									0	30.5										
17		SPT-17	25.50				2	9	77	12				CL																				
18	Bridge NO. 53, BH-1	SPT-1	1.50				0	34	66	0	27	NP		ML		2.65							0	28.1									Nil	109.22	7.22
19		SPT-8	12.00				1	97	2					SP									0	31.0										
20		SPT-17	25.50				4	7	76	13	34	21	13	CL																				
21	Bridge NO. 53, BH-2	SPT-1	1.50				7	5	83	5	31	NP		ML									0	28.8									Nil	119.15	7.26
22		SPT-8	12.00				1	95	4					SP		2.66							0	31.2										
23		SPT-17	25.50				5	7	77	11	33	23	10	CL																				

Remark * Not in NABL Scope
* NP - Non Plastic

Checked by: RC
Date: 28/3/16

Authorised Signatory:
Date: 28/3/16

XPLORER

SUMMARY OF LABORATORY TEST RESULTS

CLIENT: SKYLARK DESIGNER AND ENGINEERS (P) LTD — Job No 1342

PROJECT: Geotechnical Investigation Works For Muzaffarnagar to Saharanpur Section of DFCC Meerut — Test Report No: XPL/2015-16/02

SL.NO.	CHAINAGE/ BH NO.	Type of Sample	Depth (m)	Moisture Content %	Bulk Density g/cc	Dry Density g/cc	Grain size Analysis (%)				Atterberg Limit (%)			IS Classification	Permeability (cm/sec)	Specific Gravity	F.S.I. %	Modified Proctor		Standard Proctor		CBR Test %	Direct Shear Test		Triaxial Test		Consolidation Test				Swelling Pressure kpa	Shrinkage Limit %	Chemical Analysis *		
							Gravel	Sand	Fines		LL	PL	PI					OMC%	MDD Mg/m³	OMC%	MDD Mg/m³		c kPa	Φ Degree	UU	UC	e_0	C_c	P_c	C_r			Sulphates mg/l	Chlorides mg/l	pH Value
									Silt	Clay															C kPa	C kPa									
1	CH-38+930, BH-1	UDS-1	2.00	11.7	1.76	1.58	1	5	91	3	29	NP		ML		2.62						10	29.9										Nil	188.65	7.33
2		UDS-4	11.00	26.3	1.84	1.45																													
3		UDS-5	14.00	28.0	1.82	1.42	1	3	84	12	33	21	12	CL											104										
4		SPT-17	25.50				0	91	9					SW-SM									0	32.1											
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Checked by: RE
Date: 28/3/16

Authorised Signatory:
Date: 28/3/16

XPLORER
CONSULTANCY SERVICES (P) LTD.

NABL ACCREDITATED LABORATORY
CERTIFICATE NO.T-1678

MOISTURE CONTENT & DENSITY TEST OF SOIL

IS: 2720-1973(Part-II) (Reaffirmed 2007)

PROJECT: Geotechnical Investigation Works For Hapur - Meerut Section of DFCC Meerut — JOB NO: 1342

SITE REF: Muzaffarnagar to Saharanpur — Test Report No: XPL/2015-16/02

MOISTURE CONTENT	**CH-2010**			**CH-1980**	
Borehole No./Pit no.	BH-1			BH-1	
Sample No.	UDS-3	UDS-8	UDS-9	UDS-3	UDS-8
Depth (m)	8.00	23.00	26.00	8.00	23.00
Oven No.	XPL/OV-2	XPL/OV-2	XPL/OV-2	XPL/OV-2	XPL/OV-1
Sample Extruder No.	XPL/SE-1	XPL/SE-1	XPL/SE-1	XPL/SE-1	XPL/SE-1
Balance No.	XPL/EB-06	XPL/EB-06	XPL/EB-06	XPL/EB-06	XPL/EB-06
Soil Type	Silty CLAY	Silty CLAY	Silty CLAY	Sandy SILT	Sandy SILT
Container No.	ST-133	ST-139	ST-274	ST-115	ST-160
Wt.Can. W1,g	24.60	27.15	21.12	20.72	20.01
Wt.Can.+ Wet Soil,(W2),g	50.6	64.03	52.28	50.01	57.11
Wt.Can.+ Dry Soil,(W3),g	45.47	56.43	45.07	44.16	50.47
Wt.Water (W2-W3),g	5.13	7.60	7.21	5.85	6.64
Wt.Dry Soil (W3-W1),g	20.87	29.28	23.95	23.44	30.46
Water Content, w, %= {(W2-W3)/(W3-W1)}x 100	**24.6**	**26.0**	**30.1**	**25.0**	**21.8**
IN-SITU DENSITY					
Balance No.	XPL/EB-04	XPL/EB-04	XPL/EB-04	XPL/EB-04	XPL/EB-04
Vernier Calliper No.	XPL/VC-1	XPL/VC-1	XPL/VC-1	XPL/VC-1	XPL/VC-1
Steel Tape No.	XPL/ST-1	XPL/ST-1	XPL/ST-1	XPL/ST-1	XPL/ST-1
Container No.	B-401	B-77	B-18	B-47	B-74
Wt. Tube+Soil, g	9821	10452	9864	5759	9808
Wt.of Tube	6845	6027	6284	4005	5985
Dia of Tube, g(Average) cm	10	10.5	10	8	10.5
Length of sample, cm	19.5	28.0	22.0	19.0	24.5
Wt Soil (W)	2976	4425	3580	1754	3823
Vol. Soil (V), cm^3	1532	2426	1729	955	2122
In-Situ Density, g_t =(W/V) g/cm^3	1.94	1.82	2.07	1.84	1.80
Dry Density, γd =[gt/(1+w)] g/cm^3	**1.56**	**1.45**	**1.59**	**1.47**	**1.48**

Tested by.	Cheked By	Authorised Signatory
Date: 15/3/2016	Date: 28/3/16	Date: 28/3/16