Uttar Pradesh Expressways Industrial Development Authority (UPEIDA)

Development of 'Ganga Expressway' From Meerut to Prayagraj, an Access Controlled Greenfield Expressway Project

PACKAGE III

Km 86.900 Village: Sakatpur Karanpur, District-Amroha
to
Km 137.600 Village: Jarenda, District-Budaun

DPR (Technical Data)

AUGUST 2020

M/s L N Malviya Infra Projects Pvt. Ltd., Highway Engineering Consultant and Infratech Civil Solutions (Consortium) T-10, 3rd Floor, City Centre, Plot No. 01, M.P. Nagar, Bhopal (M.P) 462024

TECHNICAL DATA

0.1 INTRODUCTION

Uttar Pradesh Expressways Industrial Development Authority (known by its acronym UPEIDA) was set up by the State Government under U.P. Industrial Areas Development Act 1976, in December 2007 for development of Expressways in Uttar Pradesh. This is a newly established Organization with lean and laborious employee base, on contract or on deputation basis from State Revenue Department/PWD, among them few are deployed on retainership basis or by service provider.

Govt. of Uttar Pradesh (GoUP) has successfully developed 165 km Noida to Agra 6 Lane Access Controlled Expressway (Yamuna Expressway). Rigid pavement has been constructed for the entire length of the expressway. The project was developed on Public Private Partnership (PPP) mode and is in operation since August 2012.

Fig. 0.1 - Yamuna Expressway

The work of linking this expressway with State Capital through another high speed six lane corridor namely "Agra to Lucknow Access Controlled Expressway (Green Field) Project" has also been successfully completed. It is India's largest 302 Km access controlled Greenfield expressway. The entire length of the project road is of flexible pavement type. This Expressway Project has been developed on EPC mode with Government funding.

Fig. 0.2 – Agra-Lucknow Expressway

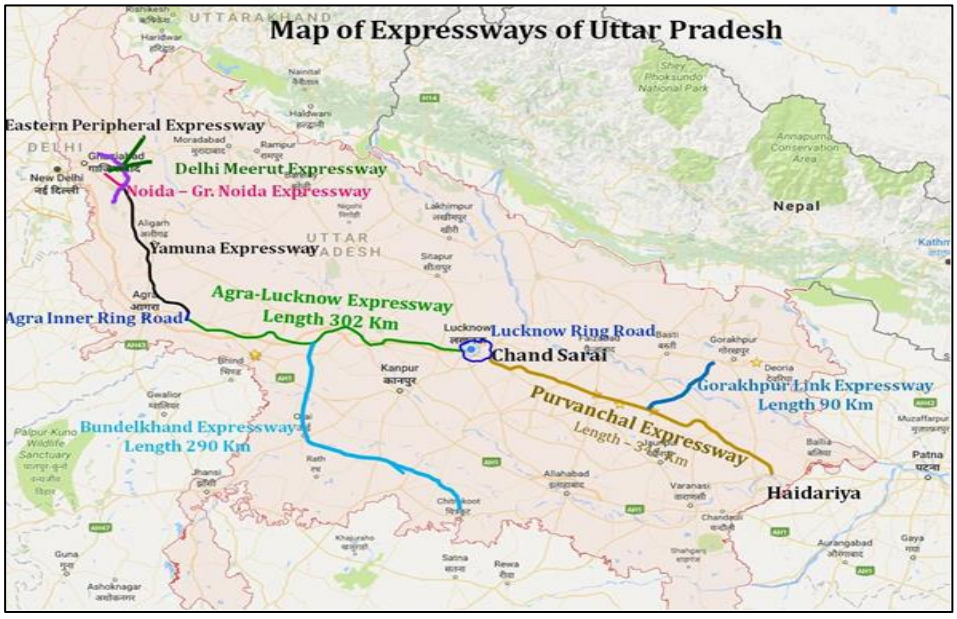
The Agra-Lucknow Expressway network starting from Noida area to Lucknow city will provide seamless travel between State Capital and National Capital.

The Authority is developing another 6 Lane Access Controlled Green Field Expressway "The Purvanchal Expressway" in EPC Mode, which will connect to outer Ring Road in Lucknow which in turn will be connected to "Agra-Lucknow Access Controlled Expressway (Green Field) Project" at Lucknow. This Expressway project shall create immense opportunities to the people of eastern region of the State and over all development of the State by providing high speed connectivity between East & West borders of the State and with national capital.

The construction for "Purvanchal Expressway Project" is in progress. This Expressway is expected to be ready by 2020.

Fig. 0.3 – Construction of Purvanchal Expressway

The Uttar Pradesh Government has decided to develop the "Ganga Expressway Project". UPEIDA is committed for the development of this expressway and has Entrusted M/s L N Malviya Infra Projects Pvt. Ltd., Highway Engineering Consultant and Intratech Civil Solutions (Consortium) to carry out the detailed project report to implement the project on EPC Mode and selection of developers through competitive bidding process.



The project will provide direct high speed connectivity from National Capital Region through proposed expressway to Meerut and then onwards to Prayagraj. It will facilitate construction of

all-weather high speed access controlled expressway, which will decongest the increasing traffic on existing road network. The expressway will also decrease travel time substantially.

The proposed Ganga Expressway starts from km 10+050 of Meerut-Bulandshahar NH-334 near village Hajipur (Dist. Meerut) **(CH 8+029)** & terminates at Prayagraj Bypass on NH-19 (Old NH-2) near village Judapur Dando (Dist. Prayagraj) **(CH 601+847)**. The proposed expressway has been divided into 12 packages. The chainage wise details of the packages has been given in Table-0.1 below:

Table-0.1

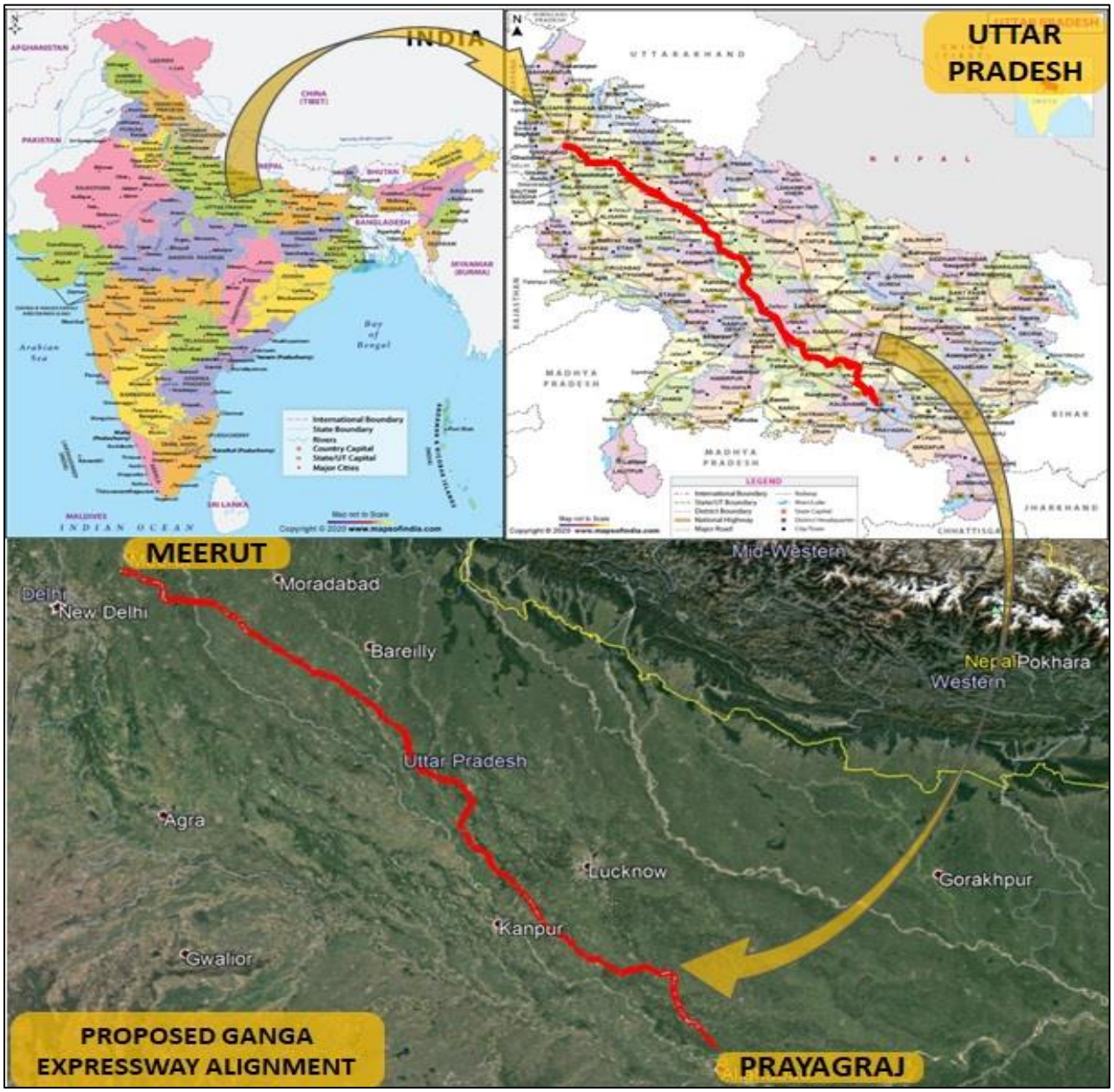
Package No.	Section Details	Chainage (km)		Length
		From	To	
I	From Hajipur (Dist. Meerut) to Village-Chandner (Dist. Hapur)	8.029	56.900	48.871
II	From Village-Chandner (Dist. Hapur) to Village-Mirzapur Dugar (Dist. Amroha)	56.900	87.000	30.100
III	From Mirzapur Dugar (Dist. Amroha) to Village-Nagla Barah/Jarenda (Dist. Budaun)	87.000	137.600	50.600
IV	From Village-Nagla Barah/Jarenda (Dist. Budaun) to Village-Binawar (Dist. Budaun)	137.600	189.700	52.100
V	From Binawar (Dist.Budaun) to Dari Gulau (Dist.Shahjahanpur)	189.700	236.400	46.700
VI	From Village- Dari Gulau (Dist.Shahjahanpur) to Village-Ubariya Khurd (Dist. Hardoi)	236.400	289.300	52.900
VII	From Village-Ubariya Khurd (Dist. Hardoi) to Village-Iksai (Dist. Hardoi)	289.300	341.700	52.400
VIII	From Village-Iksai (Dist. Hardoi) to Village-Raiyamau(Dist. Unnao)	341.700	391.900	50.200
IX	From Village- Raiyamau (Dist. Unnao) to Village-Sarso (Dist. Unnao)	391.900	445.000	53.100
X	From Village- Sarso (Dist. Unnao) to Village-Terukha (Dist. Raebareli)	445.000	496.800	51.800
XI	From Village-Terukha (Dist. Raebareli) to Village-Naudhiya (Dist. Pratapgarh)	496.800	548.800	52.000
XII	From Village- Naudhiya (Dist. Pratapgarh) to Village-Judapur Dando (Dist. Prayagraj)	548.800	601.847	53.047
Total				**593.818**

The Consultant has undertaken requisite surveys & studies for the project which includes costing to assess technical, environmental and social assessment studies, their analysis etc. As a part of the study to establish the viability, this Project Report has been prepared after carrying out engineering surveys and appropriate assessment of a preliminary design considering the engineering conditions, the present traffic and its growth, the environmental impact assessment as well as the social aspects along with cost assessment. This report among other aspects covers the details on finalization of alignment, grade separator interchanges and structures along the proposed Expressway, marking on the Khasra maps of ROW and marking of alignment on revenue maps, identification of Tourist spots, eco-friendly structures, water bodies etc. along the expressway.

0.2 APPROACH AND METHODOLOGY

Methodology adopted for the study was initially presented in Inception Report. The methodology adopted for the project is based on initial studies, secondary data, traffic analysis, topographic survey, revenue calculations and Cost Estimates. The project area social screening/RAP and Environment Impact Assessment are also completed for the detailed Engineering stage (DPR). The government policies about Land acquisition is also covered in the detailed Engineering stage (DPR). The methodology adopted is in line with the requirements of the ToR. The methodology adopted to arrive at detailed Engineering stage is covered in chapter 3. Detailed Engineering and field studies such as soil investigations, Environment Impact Analysis and design works are completed for the most preferred alignment Option-1.

The project Index Map is Shown below:



0.3 PROJECT ALIGNMENT DESCRIPTION (Package-3)

The project package under consideration is **Package-3**.

The Package 3 of Ganga Expressway starts from Mirzapur Dugar (Dist. Amroha) at km 87+000 of the proposed alignment and ends at km 137+600 near village Nagla Barah/Jarenda (Dist. Budaun).

The length of the Section is 50.600 km.

The Entire Expressway is access controlled with only entry/exit at Nodes (intersecting points of National Highway or State Highways or Major District Roads – crossing with the proposed Expressway Alignment), details of which has been described in Table-0.3.

0.3.1 Alignment & Structures

The expressway alignment is having 6 Lanes with Paved Shoulders Configuration with Service Roads, which is further expandable up to 8 Lanes. The alignment has been designed with the design speed of 120 km/h.

The key features of the project alignment are given in Table 0.2 below:

Table-0.2

S. No.	Particulars	Nos. / Length
1	Length (km)	50.600
2	Major Bridges	0
3	Minor Bridges	1
4	Culverts	67
5	ROB	1
6	VUP	2
7	LVUP	13
8	SVUP	22
9	Flyovers	1
10	Trumpet	0
11	Double Trumpet	1
12	Diamond Interchange	1
15	Way Side Amenities	1
16	Proposed Node Development	2

0.3.2 Node Development

The Expressway is access controlled with only entry/exit at Nodes (intersecting points of National Highway or State Highways or Major District Roads – crossing with the proposed Expressway Alignment). In view of the background and detailed discussions held with UPEIDA and other stake holders such as the Revenue Authorities, 17 locations were selected along the 593.818 km length of project corridor where Nodes would be developed and are lettered “A” to “Q”. Out of these, 2 nodes E & F fall under package-3 as listed in Table-0.3 below:

Table-0.3

Toll Nodes	Chainage	Details of the Intersecting Roads	Road No.	Type of Intersection
E	102+427	Anupshahr - Moradabad	ODR	Diamond
F	123+288	Babrala - Chandausi	NH 509	Diamond

0.4 RIGHT OF WAY

ROW has been taken as total 120 m (as per guidelines) for the proposed expressway except at Interchange Locations, Way Side Amenities, Toilet Block, Toll Plaza locations and at locations for training on the course of nallah/drain, where the ROW varies.

0.5 ABUTTING LAND USE PATTERN

The land use pattern on the both sides of the expressway in maximum section is agricultural.

0.6 TERRAIN

The terrain of this stretch can be termed as plain and flat throughout.

0.7 FOREST

No forest land observed along the road. However, the alignment passes through some stretches of Social Forestry.

0.8 ARCHEOLOGICAL/ANCIENT STRUCTURE

No such type of structure found along the project corridor.

0.9 TRAFFIC SURVEYS, ANALYSIS AND PROJECTIONS

The traffic surveys were mainly:

(a) Origin and destination surveys (which included willingness-to-pay "stated-preference" questions and, in one instance where this type of survey was possible, a "revealed-preference" survey – see below); and

(b) Classified Volume Count Surveys;

(c) Axle Load Surveys

All survey types were conducted in accordance with the guidelines specified in IRC 9-1972, IRC 102-1988 and IRC SP19-2001.

The surveys were conducted at points close to where the proposed Expressway would intersect with the National, State and other highways/district roads and other locations from which, traffic that may eventually use the Expressway either partly or entirely.

Table-0.5 Locations for Road-Side Origin and Destination (O-D) Surveys

OD. No.	Survey Location	Stretch & Road Name	Day & Date of O-D Survey
1	Siwaya Toll Booth	Muzaffarnagar - Meerut	Wednesday, 12thFebruary 2020
2	Nizampur	Meerut - Garhmukteshwar	Friday, 6th December 2019
3	Kurkawali	Hasanpur - Chandausi	Monday, 4th November 2019
5	Nagariya	Aligarh - Etah	Wednesday, 27th November 2019
6	Khankah e Niyaziya	Aliganj - Farrukhabad	Monday, 9th December 2019
7	Samdhan	Farrukhabad - Kannauj	Wednesday, 27th November 2019
8	Bilhaur	Kannauj - Kanpur	Monday, 2nd December 2019
9	Katohan Toll Booth	Fatehpur - Prayagraj	Monday, 16th February 2020
10	Agwanpur	Bijnor - Moradabad	Friday, 29th November 2019
11	Faridpur Toll Booth	Bareilly - Shahjahanpur	Monday, 2nd December 2019
12	Nawada	Chandausi - Budaun	Thursday, 28th November 2019
13	Usawan	Budaun - Farrukhabad	Thursday, 5th December 2019
14	Shahabad	Shahjahanpur - Hardoi	Friday, 29th November 2019
15	Safipur	Bangarmau - Unnao	Wednesday, 4th December 2019
16	Semari	Unnao - Lalganj	Friday, 6th December 2019
17	Andiyari	Unchahar - Prayagraj	Tuesday, 10th December 2019

Seven-day count using video coverage was undertaken on National Highways/State Highways/Major District Roads where Road Side Origin-Destination Surveys were carried out – results **(Average Daily Traffic - ADT**) are shown on Tables 4.6 and detailed counts at each location are provided in Appendix.

Table-0.6 Average Daily Traffic (ADT) on Existing Alternate Roads

Vehicle Classification			PCU Factor	Muzaffarnagar – Meerut	Aligarh - Etah	Aliganj - Farrukhabad	Farrukhabad – Kannauj	Kannauj - Kanpur	Budaun – Farrukhabad	Meerut – Garhmukteshwar	Hasanpur - Chandausi	Chandausi - Budaun	Bijnor - Moradabad	Bareilly – Shahjahanpur	Shahjahanpur - Hardoi	Bangarmau - Unnao	Unnao - Lalganj	Unchahar - Prayagraj	Fatehpur - Prayagraj
Passenger Vehicles	Two Wheeler		0.5	5380	1750	2813	3569	2723	1776	3683	2285	3453	7080	9565	3514	6026	2838	6245	3162
	Three Wheeler		1.5	877	605	124	658	415	87	695	254	212	934	1749	347	362	74	586	300
	Car/Van/ Jeep		1.0	12525	736	679	1921	2444	964	4879	855	2027	5179	5976	2476	2163	1282	4632	3094
	Mini Bus		1.5	21	4	18	9	35	7	11	8	7	39	21	19	31	3	52	32
	Bus		3.0	1253	541	37	75	249	244	430	202	278	581	578	197	191	210	490	469
Govt. & Other Vehicles	Tempo/ LCV		1.5	1048	346	226	344	795	315	842	510	707	745	1794	783	742	618	956	1274
	Commercial Vehicles	2 Axle	3.0	484	1061	73	85	853	430	599	164	456	263	1509	231	280	493	448	1033
		3 Axle	3.0	325	1066	50	90	877	438	561	176	447	283	1453	392	491	501	656	1062
		M-Axle	4.5	665	826	138	146	972	454	481	152	509	143	2375	467	606	778	1171	2464
Agricultural Vehicles	Tractor		1.5	20	26	17	17	20	31	48	26	50	43	26	28	38	20	34	13
	Tractor with Trailer		4.5	71	82	139	99	103	151	250	250	282	325	206	243	111	37	356	89
Passenger Vehicles	Cycle		0.5	42	152	950	357	239	286	385	82	500	125	527	835	500	570	501	151
	Cycle Rickshaw		2.0	11	2	0	0	0	9	23	3	7	26	0	0	0	0	0	11
Goods Vehicles	Animal Drawn	Bullock Cart	8.0	0	2	13	10	1	24	50	0	6	14	84	30	16	17	47	0
		Horse	8.0	0	3	0	0	0	35	0	0	24	11	0	0	0	0	0	0
	Hand Cart		3.0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
	Other (Pl. Specify)		2.0	24	10	0	3	6	17	28	7	14	42	29	31	1	9	3	16
Total Vehicles (Nos.)				**22749**	**7212**	**5277**	**7383**	**9733**	**5269**	**12966**	**4974**	**8980**	**15833**	**25892**	**9594**	**11558**	**7449**	**16178**	**13170**
Total Vehicles (PCUs)				**27761**	**15313**	**4975**	**7364**	**16617**	**9240**	**17867**	**6692**	**12859**	**17245**	**39371**	**12376**	**13428**	**11487**	**22484**	**26414**

0.10 PAVEMENT DESIGN

Flexible pavement has been adopted for new carriageways throughout the project length except at toll plaza/booth locations. In the toll plaza/booth area, rigid pavement has been adopted.

(a) New Flexible Pavement Design

The pavement design basically aims at determining the total thickness of the pavement structure as well as thickness of individual structural components. The following assumptions are considered for the preliminary pavement design. The basic assumptions considered while designing are as follows:

- Design life of 20 (after construction period) years has been considered for flexible pavement design.
- Sub grade CBR (for design) has been taken as 8%.
- Design life for Cement Concrete pavement has been assumed as 30 years.

Proposed Crust Composition for New Construction

Package No.	Section		Length (m)	Adopted MSA (20 Years)	Design CBR	Crust Composition (in mm)				
	From	To				Subgrade	GSB	WMM	DBM	BC
3	87.000	137.600	50.600	99.0	8%	500	200	150	135	50

(b) Service roads have been designed for 5 MSA with design CBR of 8%. The crust composition of service roads is given in Table below:

Proposed Crust For Service Road						
Design MSA	Design CBR	Crust Composition (in mm)				
		BC	DBM	WMM	GSB	Subgrade
5	8%	30	50	100	200	500

0.11 ROAD SIDE DRAINS

Package wise lengths and types of Drains is given in table below:

Package No.	Length of Drain (m)					Remarks
	Unlined Drain (LHS+RHS)	Lined Drain (LHS+RHS)	Median Drain	Covered Drain (LHS+RHS)	Chute Drain	
III	39283	61525	48410		45868	
Total Length (km)	**39.283**	**61.525**	**48.410**	**-**	**45.868**	

0.12 SERVICE ROADS

Detail of proposed Service Roads are as follows:

Package No.	Length (in km)

	3.75 m Service Road		7.0 m Service Road		10.0 m Service Road	
	LHS	RHS	LHS	RHS	LHS	RHS
III	45.252	25.587	0.400	0.4	0	0

0.13 AIR STRIPS

The Air Strips may allow military aircraft to continue operating even if their regular air bases, some of the most vulnerable targets in any war, are degraded or destroyed.

Air Strip has not been provided in this package.

0.14 GRADE SEPARATED STRUCTURES

Package wise count & details of Grade Separated structures are given in table below:

Package No.	ROB (Nos.)	VUP (Nos.)	LVUP (Nos.)	SVUP (Nos.)	Flyover (Nos.)	Trumpet (Nos.)	Double Trumpet (Nos.)	Diamond Interchange (Nos.)
Package-3	1	2	13	23	1	0	1	1

Table 0.12 (a) List of Road Over-bridge (ROB)

S. No.	Chainage	Type of Structure			Span Arrangement	Width of Structure (m)	Skew Angle, if any	Remarks
		Foundation	Sub Structure	Super Structure				
1	123+100	PILE	R.C.C.	STEEL	1X76.080 +2X15	4X12.5	16	Package-3

Table 0.12 (b) List of Vehicular Underpass (VUP)

S. No.	Chainage	Type of Crossing	Structure Type	Span Arrangement		Width of Structure (m)	Skew Angle, if any	Remarks
				Lateral Clearance (m)	Vertical Clearance (m)			
1	124+051	At Interchange	BOX	2X10	5.5	2x21.250	0	Package-3
2	125+300	WSA	BOX	2X10	5.5	2x21.250	0	Package-3

Table 0.12 (c) List of Light Vehicular Underpass (LVUP)

S. No.	Chainage	Type of Crossing	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
				Lateral Clearance (m)	Vertical Clearance (m)		
1	90+150	VR	BOX	12.00	4.5	2x21.250	Package-3
2	94+354	VR	BOX	12.00	4.5	2x21.250	Package-3
3	97+300	VR	BOX	12.00	4.5	2x21.250	Package-3
4	99+100	VR	BOX	12.00	4.5	2x21.250	Package-3
5	105+647	VR	BOX	12.00	4.5	2x21.250	Package-3

S. No.	Chainage	Type of Crossing	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
				Lateral Clearance (m)	Vertical Clearance (m)		
				(30^0 Skew)			
6	106+420	VR	BOX	12.00	4.5	2x21.250	Package-3
7	109+041	Road	BOX	12.00	4.5	2x21.250	Package-3
8	112+038	VR	BOX	12.00	4.5	2x21.250	Package-3
9	121+885	VR	BOX	12.00	4.5	2x21.250	Package-3
10	125+666	VR	BOX	12.00	4.5	2x21.250	Package-3
11	129+855	VR	BOX	12.00	4.5	2x21.250	Package-3
12	132+475	VR	BOX	12.00	4.5	2x21.250	Package-3
13	134+930	VR	BOX	12.00	4.5	2x21.250	Package-3

Table 0.12 (d) List of Smaller Dimension Vehicular Underpass (SVUP)

S. No.	Chainage	Type of Crossing	Type of Structure	Span Arrangement		Width of Structure	Remarks
				Lateral Clearance (m)	Vertical Clearance (m)		
1	87+300	VR	BOX	7.0	4.0	2x21.25	Package-3
2	88+540	VR	BOX	7.0	4.0	2x21.25	Package-3
3	91+027	VR	BOX	7.0	4.0	2x21.25	Package-3
4	92+382	VR	BOX	7.0	4.0	2x21.25	Package-3
5	93+160	VR	BOX	7.0	4.0	2x21.25	Package-3
6	95+548	VR	BOX	7.0	4.0	2x21.25	Package-3
7	96+728	VR	BOX	7.0	4.0	2x21.25	Package-3
8	100+740	VR	BOX	7.0	4.0	2x21.25	Package-3
9	101+648	VR	BOX	7.0	4.0	2x21.25	Package-3
10	103+454	VR	BOX	7.0	4.0	2x21.25	Package-3
11	104+662	VR	BOX	7.0	4.0	2x21.25	Package-3
12	107+262	VR	BOX	7.0	4.0	2x21.25	Package-3
13	110+935	VR	BOX	7.0	4.0	2x21.25	Package-3
14	114+595	VR	BOX	7.0	4.0	2x21.25	Package-3
15	117+505	VR	BOX	7.0	4.0	2x21.25	Package-3
16	119+611	VR	BOX	7.0	4.0	2x21.25	Package-3
17	124+110	VR	BOX	7.0	4.0	2x21.25	Package-3
18	127+166	VR	BOX	7.0	4.0	2x21.25	Package-3
19	128+341	VR	BOX	7.0	4.0	2x21.25	Package-3
20	131+323	VR	BOX	7.0	4.0	2x21.25	Package-3
21	133+437	VR	BOX	7.0	4.0	2x21.25	Package-3
22	136+700	VR	BOX	7.0	4.0	2x21.25	Package-3

Table 0.12 (e) List of Flyovers

S. No.	Chainage	Type of Crossing	Structure Type			Span Arrangement	Width of Structure	Remarks
			Foundation	Sub Structure	Super Structure			
1	115+751	SH-51	Pile	R.C.C.	PSC I Girder	2 X 32	2x21.25	Package-3

Table 0.12 (f) List of Trumpets

S. No.	Chainage	Type of Crossing	Structure Type			Span Arrangement	Width of Structure	Remarks
			Foundation	Sub Structure	Super Structure			
Nil								

Table 0.12 (g) List of Double Trumpets

S. No.	Chainage	Type of Crossing	Structure Type			Span Arrangement	Width of Structure	Remarks
			Foundation	Sub Structure	Super Structure			
1	123+288	NH509	Pile	R.C.C.	PSC I Girder	2 x 32	2x21.25	Package-3

Table 0.12 (h) List of Diamond Interchanges

S. No.	Chainage	Type of Crossing	Structure Type			Span Arrangement	Width of Structure	Remarks
			Foundation	Sub Structure	Super Structure			
1	102+427	ODR-BT	Pile	R.C.C.	PSC I Girder	2 x32	2x21.25	Package-3

0.15 CROSS DRAINAGE STRUCTURES

Package wise count of Major Bridges, Minor Bridges & culverts is given in table below:

Package No.	Major Bridges (Nos.)	Minor Bridges (Nos.)	Culverts (Nos.)
Package-3	0	1	62+5 = 67

Table-0.13 (a) List of Major Bridges

S. No.	Chainage	Type of Crossing	Type of Structure			Span Arrangement	Width of Structure	Skew Angle, if any	Remarks
			Foundation	Sub Structure	Super Structure				
Nil									

Table-0.13 (b) List of Minor Bridges

S. No.	Chainage	Type of Crossing	Type of Structure			Span Arrangement	Width of Structure	Skew Angle, if any	Remarks
			Found-ation	Sub Structure	Super Structure				
1	112+800	Canal+Road	Pile	-	-	2X18	2x21.25	50	Package-3

Table-0.13 (c) List of Culverts

S. No.	Chainage	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
			Lateral Clearance (m)	Vertical Clearance (m)		
1	87+750	Culvert	2.0	2.0	2x21.25	Package-3
2	88+160	Culvert	2.0	2.0	2x21.25	Package-3
3	89+170	Culvert	2.0	2.0	2x21.25	Package-3
4	89+734	Culvert	2.0	2.0	2x21.25	Package-3
5	90+610	Culvert	2.0	2.0	2x21.25	Package-3
6	91+515	Culvert	2.0	2.0	2x21.25	Package-3
7	92+100	Culvert	2.0	2.0	2x21.25	Package-3
8	92+789	Culvert	2.0	2.0	2x21.25	Package-3
9	93+333	Culvert	2.0	2.0	2x21.25	Package-3
10	94+000	Culvert	2.0	2.0	2x21.25	Package-3
11	94+610	Culvert	2.0	2.0	2x21.25	Package-3
12	95+095	Culvert	3.0	3.0	2x21.25	Package-3
13	95+795	Culvert	2.0	2.0	2x21.25	Package-3
14	96+300	Culvert	2.0	2.0	2x21.25	Package-3
15	96+905	Culvert	2.0	2.0	2x21.25	Package-3
16	97+800	Culvert	3.0	3.0	2x21.25	Package-3
17	98+624	Culvert	3.0	3.0	2x21.25	Package-3
18	99+630	Culvert	2.0	2.0	2x21.25	Package-3
19	100+310	Culvert	2.0	2.0	2x21.25	Package-3
20	101+148	Culvert	3.0	3.0	2x21.25	Package-3
21	101+430	Culvert	2.0	2.0	2x21.25	Package-3
22	103+300	Culvert	2.0	2.0	2x21.25	Package-3
23	103+705	Culvert	3.0	3.0	2x21.25	Package-3
24	104+215	Culvert	3.0	3.0	2x21.25	Package-3
25	105+197	Culvert	2.0	2.0	2x21.25	Package-3
26	106+200	Culvert	2.0	2.0	2x21.25	Package-3
27	106+903	Culvert	3.0	3.0	2x21.25	Package-3
28	107+640	Culvert	3.0	3.0	2x21.25	Package-3
29	108+190	Culvert	2.0	2.0	2x21.25	Package-3
30	109+495	Culvert	2.0	2.0	2x21.25	Package-3
31	110+025	Culvert	2.0	2.0	2x21.25	Package-3
32	110+560	Culvert	2.0	2.0	2x21.25	Package-3
33	111+556	Culvert	3.0	3.0	2x21.25	Package-3
34	112+310	Culvert	2.0	2.0	2x21.25	Package-3

S. No.	Chainage	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
			Lateral Clearance (m)	Vertical Clearance (m)		
35	113+279	Culvert	3.0	3.0	2x21.25	Package-3
36	113+510	Culvert	2.0	2.0	2x21.25	Package-3
37	114+176	Culvert	2.0	2.0	2x21.25	Package-3
38	115+160	Culvert	2.0	2.0	2x21.25	Package-3
39	116+600	Culvert	2.0	2.0	2x21.25	Package-3
40	117+166	Culvert	2.0	2.0	2x21.25	Package-3
41	118+208	Culvert	3.0	3.0	2x21.25	Package-3
42	119+180	Culvert	2.0	2.0	2x21.25	Package-3
43	120+278	Culvert	3.0	3.0	2x21.25	Package-3
44	120+750	Culvert	2.0	2.0	2x21.25	Package-3
45	121+315	Culvert	2.0	2.0	2x21.25	Package-3
46	122+310	Culvert	2.0	2.0	2x21.25	Package-3
47	124+806	Culvert	2.0	2.0	2x21.25	Package-3
48	126+345	Culvert	3.0	3.0	2x21.25	Package-3
49	127+620	Culvert	2.0	2.0	2x21.25	Package-3
50	128+100	Culvert	2.0	2.0	2x21.25	Package-3
51	128+788	Culvert	3.0	3.0	2x21.25	Package-3
52	129+162	Culvert	2.0	2.0	2x21.25	Package-3
53	130+639	Culvert	3.0	3.0	2x21.25	Package-3
54	131+626	Culvert	3.0	3.0	2x21.25	Package-3
55	132+165	Culvert	3.0	3.0	2x21.25	Package-3
56	132+948	Culvert	3.0	3.0	2x21.25	Package-3
57	133+840	Culvert	3.0	3.0	2x21.25	Package-3
58	134+626	Culvert	2.0	2.0	2x21.25	Package-3
59	135+783	Culvert	2.0	2.0	2x21.25	Package-3
60	136+180	Culvert	2.0	2.0	2x21.25	Package-3
61	136+600	Culvert	2.0	2.0	2x21.25	Package-3
62	137+402	Culvert	2.0	2.0	2x21.25	Package-3
63	102+427	Culverts @ Diamond Interchange	2x	2.0	2x21.25	Package-3
64	123+288	Culverts @ DoubleTrumpet	2x	2.0	2x21.25	Package-3
65	123+288	HPC @ Double Trumpet	1x1200		2x21.25	Package-3
66	125+300	HPC @ Way Side Amenities	1X1200		2x21.25	Package-3
67	125+300	HPC @ Way Side Amenities	1X1200		2x21.25	Package-3

0.16 RAILWAY TRACKS/CROSSINGS

There is 1 location where alignment of the package crosses railway line. 1 Road over Bridge (ROB) has been proposed at this location. Detail of which has already been attached above in Table-0.12 (a).

0.17 TOLL PLAZAS & RAMP PLAZAS

4 Ramp Plazas (at 2 Nodes) have been proposed along the project package. List of the same is attached below:

S. No.	Location		Remarks
1	102+427	Anupshahr - Moradabad	Ramp Plaza
2	123+288	Babrala - Chandausi	Ramp Plaza

The proposed Toll Plaza is having 16 Lanes (8+8) lane configuration whereas Toll Booths are having 4 Toll Lanes.

0.18 WAY SIDE AMENITIES

Way Side Amenities have been proposed along the project package.

S. No.	Chainage	LHS/RHS	Distance between WSA (km)
1	125+400	RHS	50.5

0.19 SOCIAL IMPACT ASSESSMENT (SIA) AND R&R POLICY

Social Impact Assessment will involve:

(i) Agricultural/Homestead/Commercial Land Impacts;
(ii) Loss of Structures (Residential/Commercial/Other);
(iii) Loss of livelihood due to loss of primary source of income;
(iv) Loss of community infrastructure/common property resources;
(v) Temporary Impacts on agricultural land due to plant site for contractor etc.;
(vi) Any unanticipated impacts due to the project will be documented and mitigated based on the spirit of the principle agreed upon in this policy framework.

R&R Policies:

The project being greenfield alignment will require acquisition of large area of agriculture/ private/ government land. However, it is kept in mind while finalizing the alignment that the impact to the structures is minimum.

The R&R policies for the impacts to the Land (agricultural/Private/Government), Structures, Persons, Livelihood & others will involve various kind of compensations involving financial assistance, compensation for land, land for land (if feasible), compensation for crops, rental accommodation etc., whichever applicable based on the policy norms.

0.20 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The major objective of EIA study is to establish present environmental condition along the project corridor through available data / information supported by field studies to evaluate the impacts on relevant environmental attributes due to the construction & operation of the proposed project; to recommend adequate mitigation measures to minimize / reduce adverse impacts and to prepare an Environmental Management Plan (EMP) for timely implementation of the mitigation measures to make the project environmentally sound and sustainable. An Environmental Impact Assessment (EIA) study basically includes:

- Establishment of the present environmental scenario
- Study of the specific activities related to the project
- Evaluation of the probable environmental impacts
- Recommendations of necessary environmental control measures.
- Preparation of Environmental Management Plan

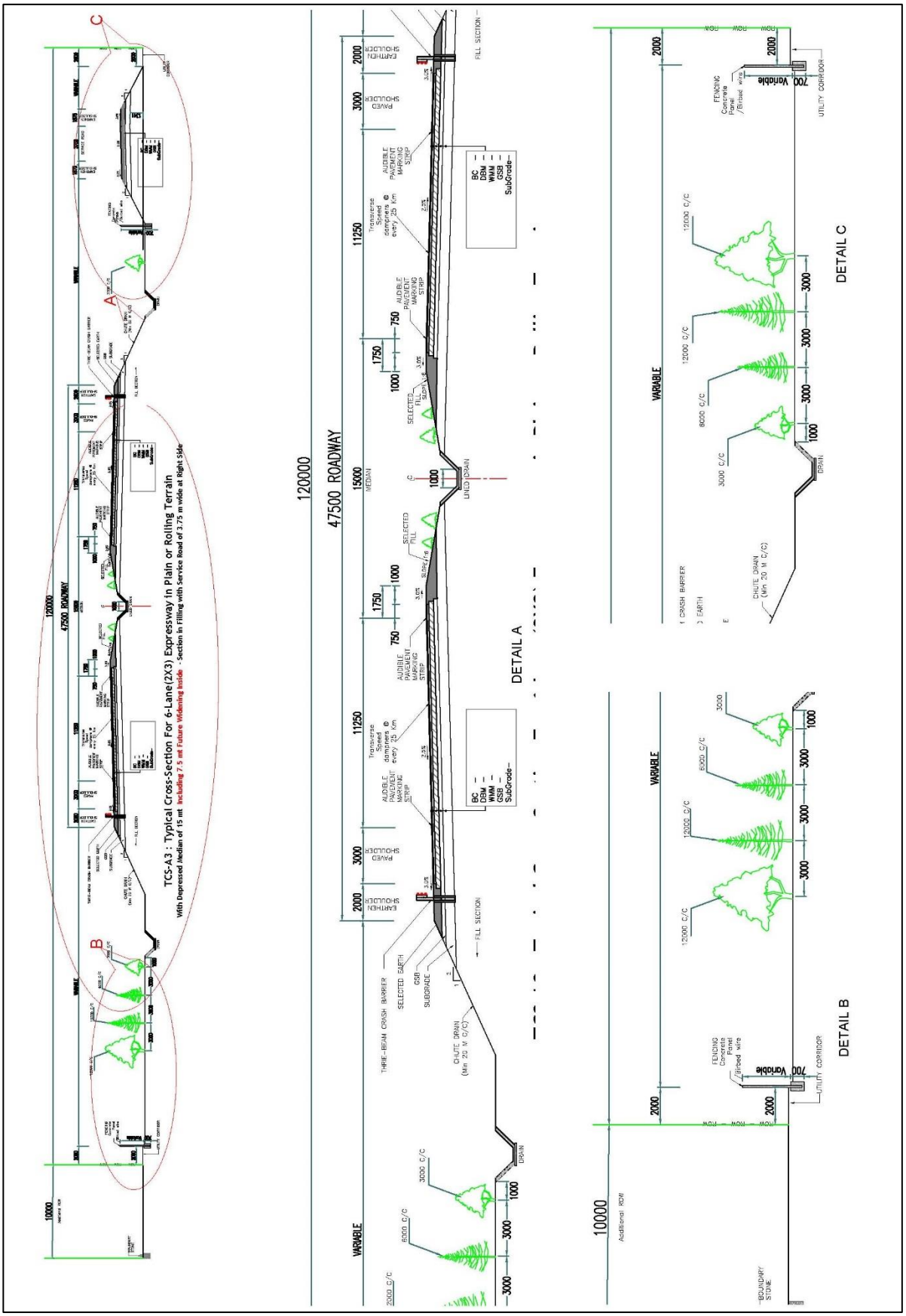
0.21 TCS SCHEDULE FOR THE PROJECT

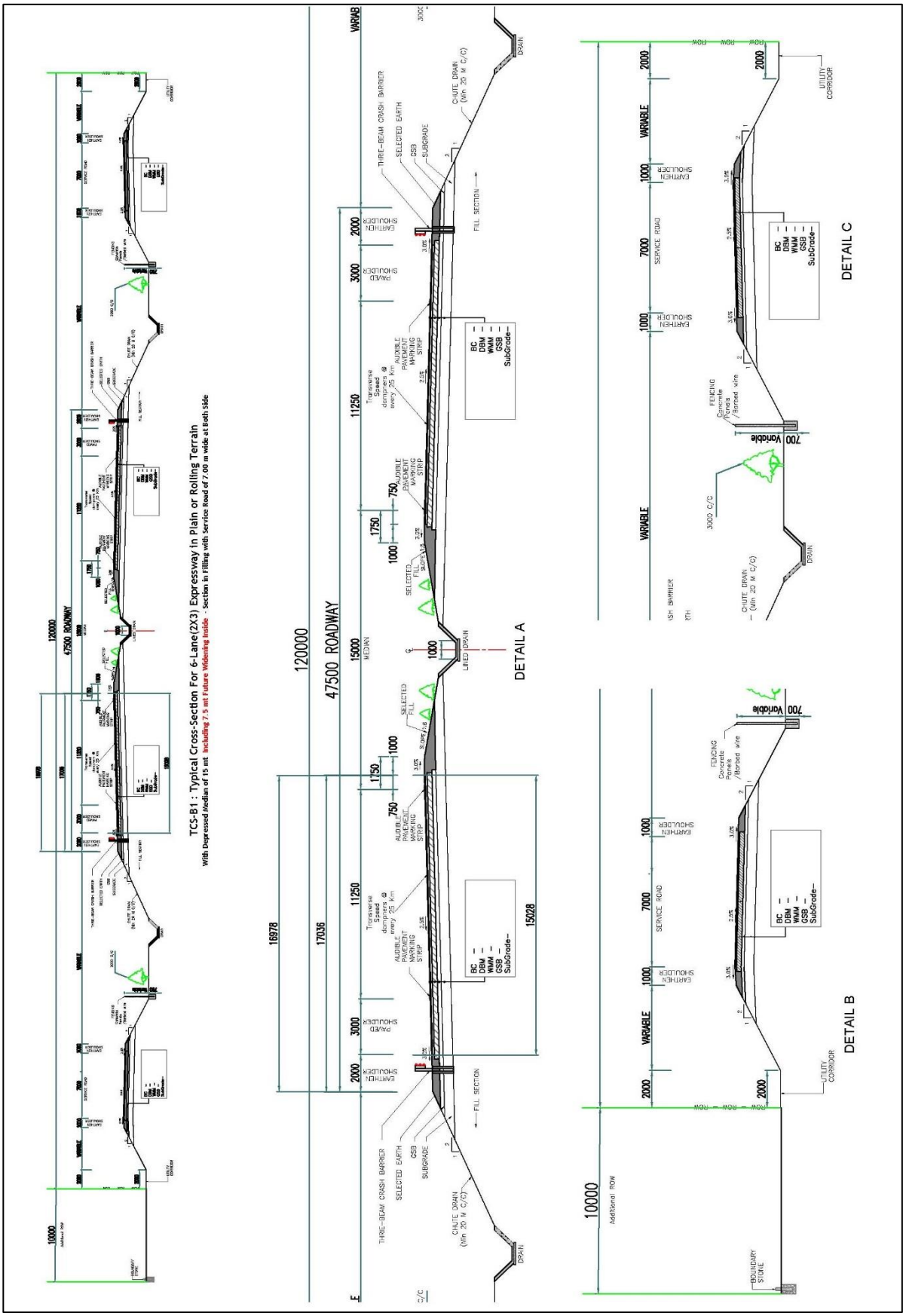
The chainage wise list of Typical Cross-sections applicable along the project is attached below:

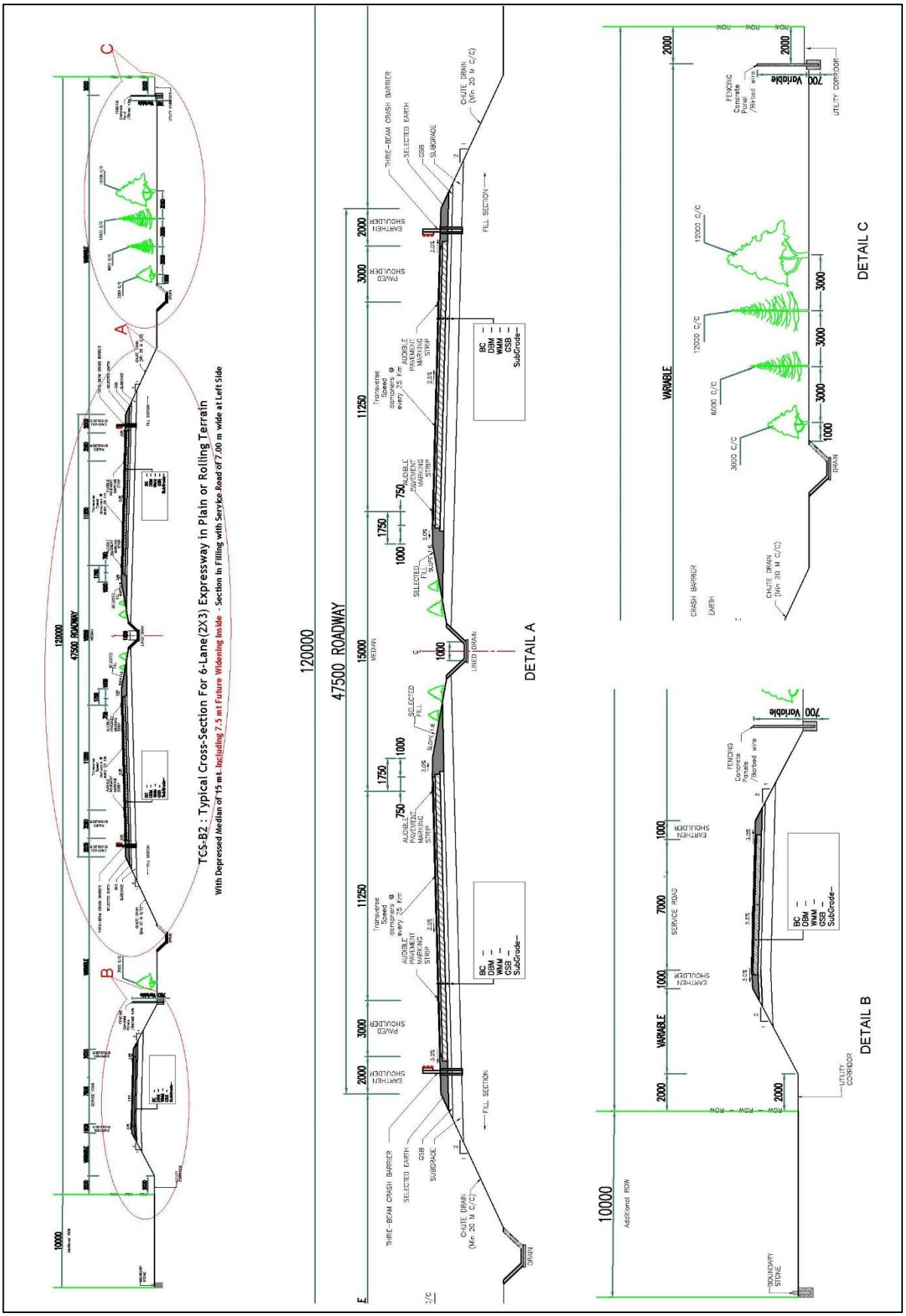
S. No.	Chainage		Length (Km)	Type of C/S	Package No.
	From	To			
1	86.900	87.300	0.400	B3	Package-3
2	87.300	88.100	0.800	B1	Package-3
3	88.100	88.540	0.440	B3	Package-3
4	88.540	95.540	7.000	B1	Package-3
5	95.540	96.010	0.470	B3	Package-3
6	96.010	97.300	1.290	B1	Package-3
7	97.300	97.810	0.510	B3	Package-3
8	97.810	99.100	1.290	B1	Package-3
9	99.100	99.355	0.255	B3	Package-3
10	99.355	101.150	1.795	B1	Package-3
11	101.150	102.427	1.277	B3	Package-3
12	102.427	102.948	0.521	B2	Package-3
13	102.948	104.215	1.267	B3	Package-3
14	104.215	105.715	1.500	B1	Package-3
15	105.715	105.900	0.185	B3	Package-3
16	105.900	107.262	1.362	B2	Package-3
17	107.262	107.790	0.528	B3	Package-3
18	107.790	109.041	1.251	B2	Package-3
19	109.041	112.600	3.559	B3	Package-3
20	112.600	113.000	0.400	A3	Package-3
21	113.000	114.595	1.595	B3	Package-3
22	114.595	115.550	0.955	B1	Package-3

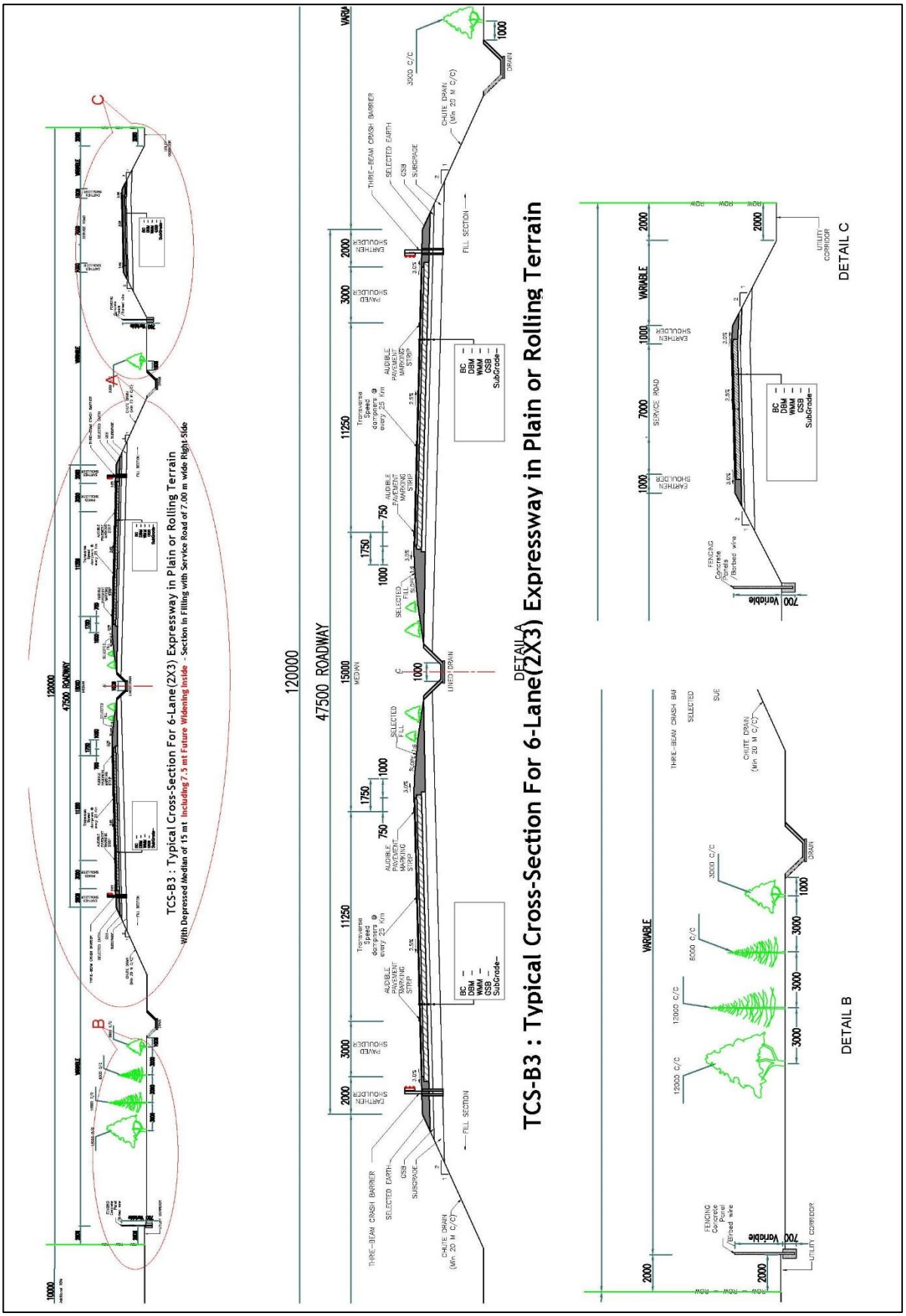
S. No.	Chainage		Length (Km)	Type of C/S	Package No.
	From	To			
23	115.550	115.810	0.260	B3	Package-3
24	115.810	117.505	1.695	B1	Package-3
25	117.505	118.200	0.695	B3	Package-3
26	118.200	119.611	1.411	B1	Package-3
27	119.611	120.290	0.679	B3	Package-3
28	120.290	121.550	1.260	B1	Package-3
29	121.550	122.146	0.596	B3	Package-3
30	122.146	123.135	0.989	C	Package-3
31	123.135	124.060	0.925	B2	Package-3
32	124.060	128.335	4.275	B3	Package-3
33	128.335	129.461	1.126	B1	Package-3
34	129.461	131.323	1.862	B3	Package-3
35	131.323	134.100	2.777	B2	Package-3
36	134.100	137.600	3.500	B3	Package-3

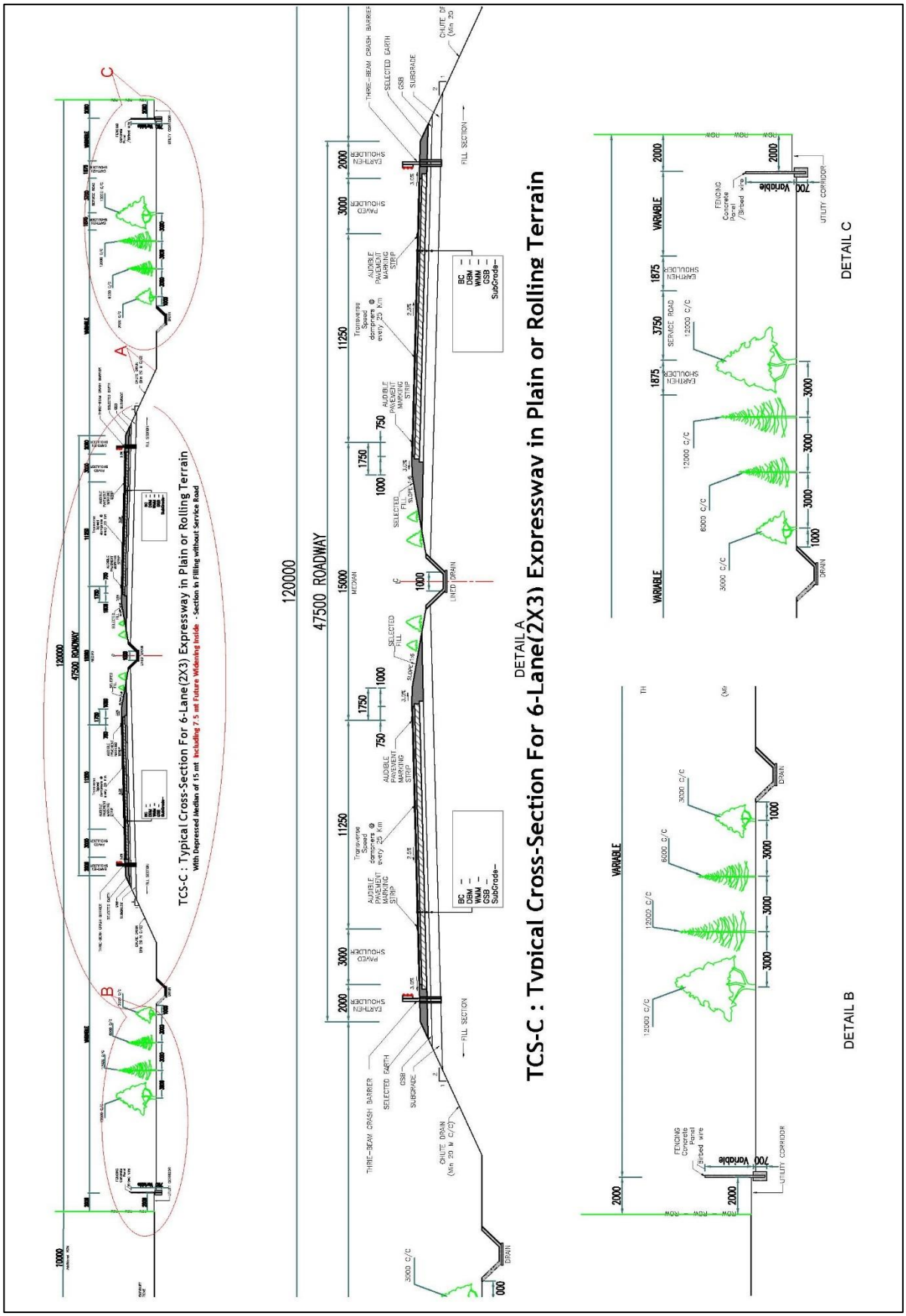
Typical cross-sections mentioned in the above table have been attached below:


TCS-A3 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 3.75 m wide at Right Side
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
VARIABLE
FILL SECTION
SELECTED FILL
SELECTED EARTH
GSB
SUBGRADE
THRIE-BEAM CRASH BARRIER
CHUTE DRAIN
(Min 20 M C/C)
DRAIN
UTILITY CORRIDOR
FENCING
BOUNDARY STONE
Additional ROW
700 Variable
3000 C/C
6000 C/C
12000 C/C


TCS-B1 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening inside - Section in Filling with Service Road of 7.00 m wide at Both side
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
SERVICE ROAD
UTILITY CORRIDOR
Additional ROW
BOUNDARY STONE
THREE-BEAM CRASH BARRIER
SELECTED EARTH
GSB
SUBGRADE
CHUTE DRAIN (Min 20 M C/C)
FILL SECTION
BC
DBM
WMM
GSB
SubGrade
Variable
700
3000 C/C


TCS-B2 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt- Including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 7.00 m wide at Left Side
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
VARIABLE
SERVICE ROAD
CRASH BARRIER
EARTH
CHUTE DRAIN
FENCING
UTILITY CORRIDOR
BOUNDARY STONE
Additional ROW


TCS-B3 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section In Filling with Service Road of 7.00 m wide Right Side
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
VARIABLE
SERVICE ROAD
FILL SECTION
CUT SECTION
THREE-BEAM CRASH BARRIER
CHUTE DRAIN
UTILITY CORRIDOR
FENCING


TCS-C : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
TCS-C : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section in Filling without Service Road
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
FILL SECTION
THREE-BEAM CRASH BARRIER
SELECTED EARTH
GSB
SUBGRADE
CHUTE DRAIN
(Min 25 M C/C)
EARTHEN SHOULDER
PAVED SHOULDER
MEDIAN
LINED DRAIN
AUDIBLE PAVEMENT MARKING STRIP
Transverse Grooves dampners @ every 25 Km
SELECTED FILL
BC
DBM
WMM
GSB
SubGrade
SERVICE ROAD
VARIABLE
FENCING Concrete Panel /Barbed wire
UTILITY CORRIDOR
Variable
700
12000 C/C
6000 C/C
3000 C/C
DRAIN

0.22 TOLLING STRATEGY

- The closed tolling system needs to be adopted and implemented for the primary reason of amassing the maximum toll fee from the maximum number of commuters in order to adequately recover the project costs.
- Further, closed tolling system is also a transparent and authentic way of tolling as the commuter pays toll fee based on the distance travelled.
- Moreover, in a closed tolling system, the commuter has an advantage of commuting with minimum halts at only two locations namely, ingress and egress; whereas in the open tolling system, the commuter might have to stop at multiple locations.
- Additionally, a closed tolling system will reduce the fuel consumption of the vehicles by eliminating conventional deceleration and acceleration and cost of travel.

0.23 COST ESTIMATES & RATE ANALYSIS

This being a Project Report, cost estimate is carried out based on preliminary design. The project cost estimates have been prepared considering various items of works associated with the identified proposals. Latest available Schedule of Rates (SOR) of concerned circle of State's Public Works Department has been adopted for determination of costs. For works not similar in nature to the Works to be executed, the cost of work has been derived on the basis of MORT&H Standard Data Book and the applicable schedule of rates for the relevant circle as published by the State Government. Civil cost of the package is approximately **Rs. 1622 crores** (Excluding GST).

0.24 ECONOMIC & FINANCIAL ANALYSIS

The Economic & Financial Analysis of the project expressway is under progress as per the latest Instructions received from the department.

0.25 HORIZONTAL ALIGNMENT REPORT

HIP / Curve No.	Deflection Angle			Element	Start	End	Length (m)	Bearing (dd mm ss)	Hand of Arc	Design Speed (KM/H)	Radius (m)	Superelevation (%)
	Deg	Min	Sec		Chainage (m)	Chainage (m)						
				Start	84346.481	87319.979	2973.498					
1	4	29	35.8	Arc	87319.979	88496.313	1176.334		Right	120	15000	2.50%
				Straight	88496.313	90824.127	2327.814	142 11 29.6				
2	329	1	18.5	Arc	90824.127	92986.813	2162.686		Left	120	-4000	2.50%
2	27	28	56.4	Straight	92986.813	96120.295	3133.482	111 12 48.1	Right	120		2.50%
3	20	38	5.6	Arc	96120.295	99001.470	2881.175		Right	120	8000	2.50%
				Straight	99001.47	102501.409	3499.939	131 50 53.7				
4	33	16	44.1	Arc	102501.409	104824.715	2323.306		Right	120	4000	2.50%
4	293	59	20.7	Straight	104824.715	105987.168	1162.453	165 7 37.8	Left	120		2.50%
5	347	48	13.7	Arc	105987.168	107690.077	1702.909		Left	120	-8000	2.50%
				Straight	107690.077	109919.608	2229.531	152 55 51.5				
6	314	24	53.6	Arc	109919.608	113897.659	3978.051		Left	120	-5000	2.50%
5	36	50	12.5	Straight	113897.659	116325.115	2427.456	107 20 45.1	Right	120		2.50%
7	23	56	52.1	Arc	116325.115	120922.763	4597.648		Right	120	11000	2.50%
7	300	16	22.2	Straight	120922.763	123997.891	3075.128	131 17 37.2	Left	120		2.50%
8	349	19	58.8	Arc	123997.891	125673.458	1675.567		Left	120	-9000	2.50%
7	325	33	22.4	Straight	125673.458	127469.991	1796.533	120 37 36.1	Left	120		2.50%
9	18	37	19.6	Arc	127469.991	130070.129	2600.138		Right	120	8000	2.50%
				Straight	130070.129	131903.586	1833.457	139 14 55.7				
10	330	1	46.4	Arc	131903.586	136088.248	4184.662		Left	120	-8000	2.50%
8	74	31	56.2	Straight	136088.248	137859.550	1771.302	109 16 42.1	Right	120		2.50%
10	31	21	59.8	Transition	137859.55	189722.035	200.000		Right	120	INFINITY	2.50%
11	27	5	31.5	Arc		190704.150	982.115	193 10 22.4	Right	120		2.50%

0.26 VERTICAL ALIGNMENT REPORT

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
1				Grade	84346.481	203.441	84390.000	203.310	-0.301				43.519
2	84490.000	203.009	0.606	Sag Curve	84390.000	203.310	84590.000	203.315		32991	0.303	329.913	200.000
3				Grade	84590.000	203.315	84727.545	203.735	0.305				137.545
4	84827.545	204.040	-0.605	Hog Curve	84727.545	203.735	84927.545	203.740		-33045	-0.303	330.447	200.000
5				Grade	84927.545	203.740	85263.800	202.732	-0.300				336.255
6	85363.800	202.432	1.186	Sag Curve	85263.800	202.732	85463.800	203.318		16864	0.593	168.640	200.000
7				Grade	85463.800	203.318	85630.517	204.795	0.886				166.717
8	85885.517	207.055	-1.885	Hog Curve	85630.517	204.795	86140.517	204.509		-27061	-0.370	270.607	510.000
9				Grade	86140.517	204.509	86220.580	203.709	-0.999				80.063
10	86328.080	202.636	1.485	Sag Curve	86220.580	203.709	86435.580	203.159		14478	0.691	144.781	215.000
11				Grade	86435.580	203.159	86998.018	205.895	0.486				562.438
12	87188.018	206.819	-1.368	Hog Curve	86998.018	205.895	87378.018	205.144		-27771	-0.360	277.708	380.000
13				Grade	87378.018	205.144	87587.048	203.300	-0.882				209.030
14	87677.048	202.507	1.249	Sag Curve	87587.048	203.300	87767.048	202.837		14416	0.694	144.157	180.000
15				Grade	87767.048	202.837	88528.770	205.631	0.367				761.722
16	88718.770	206.328	-1.332	Hog Curve	88528.770	205.631	88908.770	204.494		-28525	-0.351	285.258	380.000

17				Grade	88908.770	204.494	89071.602	202.922	-0.965				162.832
18	89121.602	202.439	0.638	Sag Curve	89071.602	202.922	89171.602	202.275		15672	0.638	156.723	100.000
19				Grade	89171.602	202.275	89390.793	201.558	-0.327				219.191
20	89540.793	201.067	1.327	Sag Curve	89390.793	201.558	89690.793	202.567		22603	0.442	226.024	300.000
21				Grade	89690.793	202.567	89890.000	204.559	1.000				199.207
22	90155.000	207.209	-2.000	Hog Curve	89890.000	204.559	90420.000	204.559		-26500	-0.377	264.999	530.000
23				Grade	90420.000	204.559	90478.792	203.971	-1.000				58.792
24	90588.792	202.871	1.604	Sag Curve	90478.792	203.971	90698.792	203.536		13714	0.729	137.135	220.000
25				Grade	90698.792	203.536	90830.515	204.332	0.604				131.723
26	91063.015	205.737	-1.770	Hog Curve	90830.515	204.332	91295.515	203.026		-26267	-0.381	262.674	465.000
27				Grade	91295.515	203.026	91316.110	202.786	-1.166				20.595
28	91376.110	202.086	0.867	Sag Curve	91316.110	202.786	91436.110	201.907		13839	0.723	138.385	120.000
29				Grade	91436.110	201.907	91804.491	200.806	-0.299				368.381
30	91894.491	200.537	1.299	Sag Curve	91804.491	200.806	91984.491	201.437		13858	0.722	138.581	180.000
31				Grade	91984.491	201.437	92115.945	202.751	1.000				131.454
32	92355.945	205.151	-1.760	Hog Curve	92115.945	202.751	92595.945	203.328		-27277	-0.367	272.769	480.000
33				Grade	92595.945	203.328	92710.265	202.459	-0.760				114.320
34	92835.265	201.510	1.867	Sag Curve	92710.265	202.459	92960.265	202.894		13390	0.747	133.896	250.000

35				Grade	92960.265	202.894	92993.403	203.261	1.107				33.138
36	93268.403	206.306	-2.116	Hog Curve	92993.403	203.261	93543.403	203.532		-25988	-0.385	259.882	550.000
37				Grade	93543.403	203.532	93717.893	201.771	-1.009				174.490
38	93847.893	200.459	2.009	Sag Curve	93717.893	201.771	93977.893	201.759		12942	0.773	129.421	260.000
39				Grade	93977.893	201.759	94123.048	203.211	1.000				145.155
40	94388.048	205.861	-2.000	Hog Curve	94123.048	203.211	94653.048	203.211		-26500	-0.377	264.999	530.000
41				Grade	94653.048	203.211	94737.598	202.366	-1.000				84.550
42	94887.598	200.866	1.800	Sag Curve	94737.598	202.366	95037.598	202.065		16667	0.600	166.667	300.000
43				Grade	95037.598	202.065	95312.979	204.269	0.800				275.381
44	95547.979	206.149	-1.800	Hog Curve	95312.979	204.269	95782.979	203.799		-26112	-0.383	261.117	470.000
45				Grade	95782.979	203.799	95882.440	202.804	-1.000				99.461
46	95957.440	202.054	0.697	Sag Curve	95882.440	202.804	96032.440	201.827		21522	0.465	215.216	150.000
47				Grade	96032.440	201.827	96220.694	201.257	-0.303				188.254
48	96320.694	200.954	1.355	Sag Curve	96220.694	201.257	96420.694	202.006		14756	0.678	147.558	200.000
49				Grade	96420.694	202.006	96508.872	202.934	1.052				88.178
50	96688.872	204.828	-1.371	Hog Curve	96508.872	202.934	96868.872	204.255		-26261	-0.381	262.612	360.000
51				Grade	96868.872	204.255	96966.213	203.945	-0.318				97.341
52	97041.213	203.707	0.787	Sag Curve	96966.213	203.945	97116.213	204.058		19052	0.525	190.516	150.000

53				Grade	97116.213	204.058	97183.306	204.373	0.469				67.093
54	97448.306	205.615	-1.469	Hog Curve	97183.306	204.373	97713.306	202.965		-36081	-0.277	360.815	530.000
55				Grade	97713.306	202.965	97832.237	201.776	-1.000				118.931
56	97932.237	200.776	1.301	Sag Curve	97832.237	201.776	98032.237	201.077		15373	0.650	153.730	200.000
57				Grade	98032.237	201.077	98798.498	203.383	0.301				766.261
58	98848.498	203.534	0.266	Sag Curve	98798.498	203.383	98898.498	203.817		37571	0.266	375.714	100.000
59				Grade	98898.498	203.817	99016.488	204.487	0.567				117.990
60	99181.488	205.422	-1.235	Hog Curve	99016.488	204.487	99346.488	204.320		-26716	-0.374	267.165	330.000
61				Grade	99346.488	204.320	99875.134	200.788	-0.668				528.646
62	100100.134	199.285	1.668	Sag Curve	99875.134	200.788	100325.134	201.535		26978	0.371	269.782	450.000
63				Grade	100325.134	201.535	100475.140	203.035	1.000				150.006
64	100740.140	205.685	-2.000	Hog Curve	100475.140	203.035	101005.140	203.035		-26500	-0.377	265.006	530.000
65				Grade	101005.140	203.035	101128.124	201.805	-1.000				122.984
66	101253.124	200.555	1.862	Sag Curve	101128.124	201.805	101378.124	201.632		13429	0.745	134.289	250.000
67				Grade	101378.124	201.632	101975.805	206.782	0.862				597.681
68	102150.805	208.290	-0.862	Hog Curve	101975.805	206.782	102325.805	208.290		-40620	-0.246	406.190	350.000
69				Grade	102325.805	208.290	102529.521	208.290	0.000				203.716
70	102679.521	208.290	-0.881	Hog Curve	102529.521	208.290	102829.521	206.969		-34059	-0.294	340.599	300.000

71				Grade	102829.521	206.969	102954.948	205.864	-0.881				125.427
72	103029.948	205.204	0.531	Sag Curve	102954.948	205.864	103104.948	204.941		28254	0.354	282.542	150.000
73				Grade	103104.948	204.941	103354.143	204.069	-0.350				249.195
74	103454.143	203.719	-0.650	Hog Curve	103354.143	204.069	103554.143	202.719		-30769	-0.325	307.692	200.000
75				Grade	103554.143	202.719	103731.277	200.948	-1.000				177.134
76	103881.277	199.448	1.821	Sag Curve	103731.277	200.948	104031.277	200.680		16474	0.607	164.742	300.000
77				Grade	104031.277	200.680	104265.344	202.602	0.821				234.067
78	104450.344	204.121	-1.331	Hog Curve	104265.344	202.602	104635.344	203.179		-27808	-0.360	278.079	370.000
79				Grade	104635.344	203.179	105108.679	200.767	-0.509				473.335
80	105208.679	200.258	1.509	Sag Curve	105108.679	200.767	105308.679	201.258		13250	0.755	132.501	200.000
81				Grade	105308.679	201.258	105397.057	202.142	1.000				88.378
82	105662.057	204.792	-2.000	Hog Curve	105397.057	202.142	105927.057	202.142		-26500	-0.377	264.999	530.000
83				Grade	105927.057	202.142	106005.137	201.361	-1.000				78.080
84	106055.137	200.861	0.693	Sag Curve	106005.137	201.361	106105.137	200.707		14435	0.693	144.350	100.000
85				Grade	106105.137	200.707	106674.762	198.957	-0.307				569.625
86	106774.762	198.650	1.278	Sag Curve	106674.762	198.957	106874.762	199.621		15648	0.639	156.477	200.000
87				Grade	106874.762	199.621	107013.705	200.970	0.971				138.943
88	107278.706	203.543	-1.971	Hog Curve	107013.705	200.970	107543.705	200.893		-26891	-0.372	268.911	530.000
89				Grade	107543.705	200.893	107693.858	199.391	-1.000				150.153
90	107793.858	198.391	1.311	Sag Curve	107693.858	199.391	107893.858	198.702		15254	0.656	152.541	200.000
91				Grade	107893.858	198.702	108015.848	199.082	0.311				121.990

92	108115.848	199.393	-0.622	Hog Curve	108015.848	199.082	108215.848	199.083		-32176	-0.311	321.761	200.000
93				Grade	108215.848	199.083	108377.400	198.581	-0.310				161.552
94	108492.400	198.224	1.310	Sag Curve	108377.400	198.581	108607.400	199.374		17551	0.570	175.512	230.000
95				Grade	108607.400	199.374	108776.000	201.060	1.000				168.600
96	109041.000	203.710	-2.000	Hog Curve	108776.000	201.060	109306.000	201.060		-26500	-0.377	264.999	530.000
97				Grade	109306.000	201.060	109477.310	199.347	-1.000				171.310
98	109567.310	198.447	1.300	Sag Curve	109477.310	199.347	109657.310	198.717		13846	0.722	138.464	180.000
99				Grade	109657.310	198.717	109939.186	199.562	0.300				281.876
100	110089.186	200.012	-0.606	Hog Curve	109939.186	199.562	110239.186	199.553		-49469	-0.202	494.682	300.000
101				Grade	110239.186	199.553	110333.798	199.263	-0.306				94.612
102	110433.798	198.956	0.946	Sag Curve	110333.798	199.263	110533.798	199.596		21131	0.473	211.314	200.000
103				Grade	110533.798	199.596	110736.632	200.894	0.640				202.834
104	110936.632	202.174	-1.533	Hog Curve	110736.632	200.894	111136.632	200.388		-26088	-0.383	260.879	400.000
105				Grade	111136.632	200.388	111303.512	198.897	-0.893				166.880
106	111403.512	198.004	1.403	Sag Curve	111303.512	198.897	111503.512	198.514		14253	0.702	142.533	200.000
107				Grade	111503.512	198.514	111964.882	200.866	0.510				461.370
108	112014.882	201.121	-0.152	Hog Curve	111964.882	200.866	112064.882	201.300		-65694	-0.152	656.944	100.000
109				Grade	112064.882	201.300	112665.907	203.450	0.358				601.025
110	112790.907	203.897	-0.808	Hog Curve	112665.907	203.450	112915.907	203.334		-30957	-0.323	309.569	250.000
111				Grade	112915.907	203.334	113045.811	202.750	-0.450				129.904
112	113185.811	202.120	-1.090	Hog Curve	113045.811	202.750	113325.811	199.964		-25687	-0.389	256.871	280.000
113				Grade	113325.811	199.964	113449.342	198.062	-1.540				123.531
114	113599.342	195.752	1.853	Sag Curve	113449.342	198.062	113749.342	196.222		16187	0.618	161.867	300.000

115				Grade	113749.342	196.222	114317.858	198.004	0.313				568.516
116	114367.858	198.160	0.396	Sag Curve	114317.858	198.004	114417.858	198.515		25237	0.396	252.372	100.000
117				Grade	114417.858	198.515	114441.767	198.685	0.710				23.909
118	114591.767	199.749	-1.006	Hog Curve	114441.767	198.685	114741.767	199.305		-29813	-0.335	298.125	300.000
119				Grade	114741.767	199.305	114812.527	199.095	-0.297				70.760
120	114937.527	198.724	1.297	Sag Curve	114812.527	199.095	115062.527	199.974		19281	0.519	192.808	250.000
121				Grade	115062.527	199.974	115448.659	203.835	1.000				386.132
122	115583.659	205.185	-1.000	Hog Curve	115448.659	203.835	115718.659	205.185		-27000	-0.370	270.000	270.000
123				Grade	115718.659	205.185	115785.269	205.185	0.000				66.610
124	115955.269	205.185	-1.278	Hog Curve	115785.269	205.185	116125.269	203.012		-26598	-0.376	265.979	340.000
125				Grade	116125.269	203.012	116566.084	197.377	-1.278				440.815
126	116766.084	194.820	1.981	Sag Curve	116566.084	197.377	116966.084	196.226		20193	0.495	201.930	400.000
127				Grade	116966.084	196.226	117280.560	198.435	0.703				314.476
128	117505.560	200.016	-1.707	Hog Curve	117280.560	198.435	117730.560	197.757		-26368	-0.379	263.685	450.000
129				Grade	117730.560	197.757	117874.556	196.311	-1.004				143.996
130	117989.556	195.156	1.351	Sag Curve	117874.556	196.311	118104.556	195.556		17022	0.587	170.216	230.000
131				Grade	118104.556	195.556	118287.545	196.191	0.347				182.989
132	118412.545	196.625	-0.704	Hog Curve	118287.545	196.191	118537.545	196.179		-35534	-0.281	355.341	250.000
133				Grade	118537.545	196.179	119066.963	194.293	-0.356				529.418
134	119166.963	193.936	1.356	Sag Curve	119066.963	194.293	119266.963	194.936		14745	0.678	147.453	200.000
135				Grade	119266.963	194.936	119344.954	195.716	1.000				77.991
136	119609.954	198.366	-2.000	Hog Curve	119344.954	195.716	119874.954	195.716		-26500	-0.377	264.999	530.000
137				Grade	119874.954	195.716	119971.463	194.751	-1.000				96.509

138	120061.463	193.851	1.313	Sag Curve	119971.463	194.751	120151.463	194.132		13714	0.729	137.137	180.000
139				Grade	120151.463	194.132	120229.731	194.377	0.313				78.268
140	120319.731	194.658	-0.623	Hog Curve	120229.731	194.377	120409.731	194.379		-28907	-0.346	289.067	180.000
141				Grade	120409.731	194.379	120728.398	193.391	-0.310				318.667
142	120803.398	193.158	0.610	Sag Curve	120728.398	193.391	120878.398	193.383		24585	0.407	245.851	150.000
143				Grade	120878.398	193.383	121013.523	193.789	0.300				135.125
144	121113.524	194.089	-0.610	Hog Curve	121013.523	193.789	121213.523	193.779		-32780	-0.305	327.804	200.000
145				Grade	121213.523	193.779	121264.916	193.619	-0.310				51.393
146	121354.916	193.340	1.310	Sag Curve	121264.916	193.619	121444.916	194.240		13739	0.728	137.391	180.000
147				Grade	121444.916	194.240	121684.638	196.637	1.000				239.722
148	121884.639	198.637	-1.500	Hog Curve	121684.638	196.637	122084.638	197.637		-26665	-0.375	266.652	400.000
149				Grade	122084.638	197.637	122212.706	196.997	-0.500				128.068
150	122312.706	196.497	1.500	Sag Curve	122212.706	196.997	122412.706	197.497		13332	0.750	133.321	200.000
151				Grade	122412.706	197.497	122775.000	201.120	1.000				362.294
152	122910.000	202.470	-1.000	Hog Curve	122775.000	201.120	123045.000	202.470		-26998	-0.370	269.986	270.000
153				Grade	123045.000	202.470	123155.000	202.470	0.000				110.000
154	123320.000	202.470	-1.250	Hog Curve	123155.000	202.470	123485.000	200.408		-26401	-0.379	264.005	330.000
155				Grade	123485.000	200.408	123686.394	197.890	-1.250				201.394
156	123796.394	196.515	1.562	Sag Curve	123686.394	197.890	123906.394	196.858		14086	0.710	140.859	220.000
157				Grade	123906.394	196.858	124000.874	197.153	0.312				94.480
158	124170.874	197.683	-1.230	Hog Curve	124000.874	197.153	124340.874	196.123		-27653	-0.362	276.533	340.000
159				Grade	124340.874	196.123	124653.255	193.257	-0.918				312.381
160	124778.255	192.109	1.927	Sag Curve	124653.255	193.257	124903.255	193.371		12974	0.771	129.740	250.000

161				Grade	124903.255	193.371	125091.313	195.269	1.009				188.058
162	125326.313	197.641	-1.778	Hog Curve	125091.313	195.269	125561.313	195.834		-26432	-0.378	264.326	470.000
163				Grade	125561.313	195.834	126033.107	192.207	-0.769				471.794
164	126133.107	191.438	1.069	Sag Curve	126033.107	192.207	126233.107	191.738		18712	0.534	187.119	200.000
165				Grade	126233.107	191.738	127028.135	194.123	0.300				795.028
166	127203.135	194.648	-0.969	Hog Curve	127028.135	194.123	127378.135	193.478		-36136	-0.277	361.363	350.000
167				Grade	127378.135	193.478	127762.534	190.908	-0.669				384.399
168	127862.534	190.239	1.669	Sag Curve	127762.534	190.908	127962.534	191.239		11986	0.834	119.864	200.000
169				Grade	127962.534	191.239	128076.000	192.374	1.000				113.466
170	128341.000	195.024	-2.000	Hog Curve	128076.000	192.374	128606.000	192.374		-26500	-0.377	265.006	530.000
171				Grade	128606.000	192.374	128772.993	190.704	-1.000				166.993
172	128872.993	189.704	1.309	Sag Curve	128772.993	190.704	128972.993	190.014		15274	0.655	152.737	200.000
173				Grade	128972.993	190.014	129287.550	190.987	0.309				314.557
174	129337.550	191.142	0.596	Sag Curve	129287.550	190.987	129387.550	191.595		16769	0.596	167.695	100.000
175				Grade	129387.550	191.595	129536.661	192.946	0.906				149.111
176	129801.660	195.346	-1.961	Hog Curve	129536.661	192.946	130066.661	192.549		-27026	-0.370	270.256	530.000
177				Grade	130066.661	192.549	130195.951	191.185	-1.055				129.290
178	130295.951	190.130	1.421	Sag Curve	130195.951	191.185	130395.951	190.496		14071	0.711	140.708	200.000
179				Grade	130395.951	190.496	130478.393	190.797	0.366				82.442
180	130568.393	191.127	-0.675	Hog Curve	130478.393	190.797	130658.393	190.849		-26667	-0.375	266.674	180.000
181				Grade	130658.393	190.849	130720.316	190.658	-0.309				61.923
182	130795.316	190.426	1.027	Sag Curve	130720.316	190.658	130870.316	190.964		14612	0.684	146.116	150.000
183				Grade	130870.316	190.964	131093.000	192.562	0.718				222.684

184	131323.000	194.213	-1.658	Hog Curve	131093.000	192.562	131553.000	192.050		-27741	-0.360	277.416	460.000
185				Grade	131553.000	192.050	131677.133	190.882	-0.941				124.133
186	131787.133	189.848	1.541	Sag Curve	131677.133	190.882	131897.133	190.508		14281	0.700	142.808	220.000
187				Grade	131897.133	190.508	132269.477	192.742	0.600				372.344
188	132469.477	193.942	-1.500	Hog Curve	132269.477	192.742	132669.477	192.142		-26667	-0.375	266.667	400.000
189				Grade	132669.477	192.142	132872.550	190.314	-0.900				203.073
190	133000.050	189.167	1.800	Sag Curve	132872.550	190.314	133127.550	190.314		14167	0.706	141.667	255.000
191				Grade	133127.550	190.314	133199.140	190.958	0.900				71.590
192	133434.140	193.073	-1.800	Hog Curve	133199.140	190.958	133669.140	190.958		-26111	-0.383	261.110	470.000
193				Grade	133669.140	190.958	133956.982	188.368	-0.900				287.842
194	134056.982	187.468	1.213	Sag Curve	133956.982	188.368	134156.982	187.780		16494	0.606	164.938	200.000
195				Grade	134156.982	187.780	134341.615	188.357	0.313				184.633
196	134391.615	188.514	0.687	Sag Curve	134341.615	188.357	134441.615	189.014		14547	0.687	145.469	100.000
197				Grade	134441.615	189.014	134675.461	191.352	1.000				233.846
198	134940.461	194.002	-2.000	Hog Curve	134675.461	191.352	135205.461	191.352		-26500	-0.377	264.999	530.000
199				Grade	135205.461	191.352	135358.060	189.826	-1.000				152.599
200	135458.060	188.826	0.657	Sag Curve	135358.060	189.826	135558.060	188.484		30421	0.329	304.210	200.000
201				Grade	135558.060	188.484	135971.555	187.067	-0.343				413.495
202	136021.555	186.896	0.657	Sag Curve	135971.555	187.067	136071.555	187.053		15213	0.657	152.133	100.000
203				Grade	136071.555	187.053	136247.395	187.607	0.315				175.840
204	136297.395	187.764	0.689	Sag Curve	136247.395	187.607	136347.395	188.266		14509	0.689	145.087	100.000
205				Grade	136347.395	188.266	136434.897	189.145	1.004				87.502
206	136699.897	191.805	-2.004	Hog Curve	136434.897	189.145	136964.897	189.155		-26447	-0.378	264.473	530.000

207				Grade	136964.897	189.155	137058.740	188.217	-1.000				93.843
208	137158.740	187.217	1.502	Sag Curve	137058.740	188.217	137258.740	187.719		13318	0.751	133.181	200.000
209				Grade	137258.740	187.719	137859.550	190.733	0.502				600.810
210				Grade	137859.550	190.733	0.000	0.000	0.502				-137859.550

Geotechnical investigation report

Name of Work: -Soil Investigation report for **Consultancy services for preparation of detailed project report for Ganga expressway (89+000 to 172+910 Km).**

Client: - Uttar Pradesh Expressway Industrial Development Authority

Consultant: M/S L. N. Malviya Infra Projects Pvt. Ltd.

Lab Report No: -PL/GIS/049/2019-20

PARIKSHAN
LABORATORY
MATERIAL TESTING SOLUTIONS

Address- 1 Ahilya Ashram Ujjain road Polo ground Indore (M.P)

Contact No: - 9754103778, 0731-4066973

CERTIFICATE

We here by certify that "**Soil Investigation report for Consultancy services for preparation of detailed project report for Ganga expressway (89+000 to 172+910 Km)** was completed as per technical specification.

The outcome &inference in Geo-technical investigation is presented as report herein. This report of 137 pages.

Date: 03.03.2020
Revision -00

For Parikshan Laboratory

Authorized Signatory

INDEX

1.0 INTRODUCTION

Geotechnical Investigation, which covers the field sampling and tests, necessary laboratory tests and finally analysing the sub soil characteristics and behaviour of the soil of the proposed site. The objective of the geotechnical investigation was to explore the sub soil profile up to predetermined depth and to work out the design capacity of the soil beneath at a required foundation depth for the proposed type of foundation. Computation and calculation of Safe Bearing Capacity considering the drilling, field testing, laboratory tastings of soil, and rock, water quality, water corrosion etc is of great importance to Structural Engineers who have to design foundations and structures.

Hence, Geotechnical investigation has been under taken at the proposed site.

The report presents the compiled data of the field and laboratory test results along with all necessary graphs, tables of the Geotechnical Investigation conducted at the site.

2.0 FIELD INVESTIGATION

2.1 Scope:

It has been planned to drill bore holes at the locations given by the official of the Client. During boring collection of disturbed/undisturbed/core samples, carrying out field test and laboratory test on undisturbed, disturbed and core samples and submission of report including recommendation for design of foundation for proposed structure.

2.2 Field Activities:

2.2.1 Boring

Bore holes were drilled by rotary drilling technique. Steel casing pipes provided (when required) to prevent side collapse. The details and description of Bore holes, Depth of bore hole, SPT, strata and the depth of water table are as given in following pages.

2.2.2 Standard Penetration Test (SPT)

These tests were Conducted at every 1.5 m intervals and every change of Strata or wherever Possible. The tests were Performed by driving into the soil (bore holes cleaned of any loose material) a standard split spoon sampler with the help of a standard hammer with a free fall of 75 cm on a driving head as described in IS: 2131. This head was attached to "A" drill rod to the other end of which the sampler was fitted. The number of blows needed to penetrate the first, second and third stage (each of 15 cms.) depth of the borehole data sheet is the numerical sum of blows counted during the second & third stage only i.e. for a depth of 30 cms.

2.2.3 Collection of samples

Undisturbed, disturbed and rock core samples were collected at regular intervals. The disturbed samples were kept in air tight bags and UDS samples are sealed with a paraffin wax at both sides, labelled depth wise and dispatched to the laboratory for testing.

3.0 LABORATORY INVESTIGATION

Based on the strata encountered at the site, following relevant laboratory tests and studies were conducted on the samples collected from the bore holes to classify them and to evaluate their Index and Engineering properties.

- **Atterberg's Limit**: -
  Liquid limit and Plastic limits are carried out for the determination of different characteristic of soil. The tests performed in accordance with I.S.2720 Part – 5-1985 by using Mechanical Liquid Limit Apparatus. About 120 g of the soil sample passing 425-micron IS Sieve shall be mixed thoroughly with distilled water in the evaporating dish or on the flat glass plate to form a uniform paste. The paste shall have a consistency that will require 30 to 35 drops of the cup to cause the required closure of the standard groove.
  Liquid limit and plastic limit of soils are both depend up on the amount and type of clay in a soil and form the basis for the soil classification system for cohesive soils based on the Plasticity index.

  For Plastic Limit, a soil sample weighing at least 20 gm of the soil sample passing 425 micron IS sieve is thoroughly mixed with water such that it can be easily moulded with fingers. A ball is formed with about 8gm of this soil and is rolled between the fingers and the glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter of 3mm throughout its length. The soil is kneaded to a uniform mass and rolled again. The process is continued until the thread crumbles. The pieces of crumbled soil thread are collected for moisture content determination and reported as plastic limit.

- **Particle Size Distribution**:-
  The sieve analysis is carried out in accordance with IS: 2720 (Pt. IV). The results are presented in the form of Grain size distribution curve.

  Representative soil sample is obtained from the bulk soil sample collected or received from site by method of coning and quartering. Quantity of soil taken will be dependent on the maximum size of particle size present in the soil. Sieve analysis is conducted in two parts:

1) Soil fraction retained on 4.75mm IS

Soil portion retained on 4.75 ISS is weighed. The sample is then separated into various fractions by sieving through the following sieves: 100, 75, 19 and 4.75 mm ISS

While sieving through each sieve, sieve is agitated so that sample rolls in irregular motion over the sieve, at no time the particles are pushed through; Care is also taken to see that no individual soil particles are broken, though particles adhering one another are rubbed by rubber pestle when required. Care is also taken not to over load the sieve beyond the permitted maximum load for respective sieve.

The mass of the material retained on each sieve is recorded The percentage of soil retained on each sieve is then calculated on the basis of the total mass of soil taken and from these results, the percentage passing through each sieve is calculated.

2) Soil fraction passing 4.75 ISS

The portion of the soil passing 4.75 mm ISS is oven dried at 105 to 110 c. The portion is coned & quartered to obtain required representative quantity of the material. The material is weighed and placed in tray/bucket filled with water for soaking and loosening the adhered cohesive materials. The soaked soil specimen is then washed on 75 micron IS Sieve until the water passing the sieve is almost clear. The material retained on 75 micron IS Sieve is then transferred in a tray, dried in oven. Sieve analysis is then conducted on a nest of sieves (viz. 2 mm, 425 and 75 micron ISS) either by hand or by using mechanical sieve shaker. The fraction retained on each of the sieves is weighed separately and masses recorded. Cumulative mass of soil fraction retained on each sieve is then calculated the weights are then converted into cumulative percentage retained and passing on the basis of the mass of the sample passing 4.75 ISS taken. The combined gradation on the basis of the total sample taken for analysis is finally calculated.

- **Specific Gravity**: -

  In order to determine specific gravity of soil particles these tests were conducted on selected samples in 50ml volumetric density bottle using procedure described in IS: 2720 Part III.

- **Free Swell test IS: 2720 (Part – XL):**
  In order to determine the swelling characteristics of the soil, differential free swell test is carried out. An oven dried soil sample, 10 gm passing through 425 micron is poured in two 100 ml graduated cylinder. One cylinder was filled with distilled water and in kerosene up to 100 ml mark. After the removal of entrapped air, sample was allowed sufficient time to attain equilibrium state of volume. The final volume of soil in each cylinder was recorded.
- **Shear by Tri-axial as per IS: 2720 (Part XII)-1981**:
  The test should be conducted in environment in which ambient temperature is constant. All valves are assumed to be closed and it is also assumed that the pedestal at the base of tri axial cell is covered with water. Gently slide one de- aired coarse porous stone on to the top of the pedestal and blow off any excess water from the pedestal. Place a filter paper disc on the stone and then place the soil sample on the disc. Place the second de-aired
  Disc and the coarse porous stone on top of the sample and the loading cap on top of the second porous stone. Ensure that the sample, the stones, the discs, and the loading cap are all concentrically placed on the pedestal.
- **Unconfined compressive strength of rock specimens:**
  As soon as the rock core samples were received in the laboratory, Core Recovery percentages and RQD percentages were determined. Then core samples which were longer than the diameter that was 54mm were selected for preparation of specific specimens as per IS: 9143-1979 in the ratio of length : diameter = 1:1 and correction factors applied (since limited intact rock core sampling was possible). Then the specimens were tested for unconfined compressive strength.

4.01 BORE LOG & SOIL PROFILE

Geotechnical Investigation for	M/S L.N Malviya Infra Projects Pvt. Ltd.	Bore Hole No.	BH-01
Chainage	102+427	Recorded by	Mr. Krishna
Coordinates	28.535829,78.511659		

Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 3.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	6		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	8		-	-	2.44	1.80	0.00	78.14	21.86	34.55	22.36	11	0.16	18
	SPT	3.00	4.50		4.50	7		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	12		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	14		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	15		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		9.00	10.50		10.50	18		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	15		-	-	2.45	1.80	0.00	80.22	19.78	-	-	-	0.14	20
		12.00	13.50		13.50	16		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	21		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	20		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	16.50	18.00		18.00	19	Water Table encountered at 3.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	21		-	-	2.45	1.81	0.00	79.34	20.66	-	-	-	0.21	17
		21.00	22.50		22.50	24		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	28		-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	26		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	27		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		27.00	28.50		28.50	29		-	-	2.46	1.80	-	-	-	-	-	-	0.22	16
		28.50	30.00		30.00	32		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	30		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	34		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	34		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.									Bore Hole No.		BH-02	
Chainage							102+427									Recorded by		Mr. Krishna	
Coordinates							28.535829,78.511659												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 3.10 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	4		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	5		-	-	2.43	1.79	0.00	77.02	22.98	28.40	20.11	-	0.18	17
	SPT	3.00	4.50		4.50	8		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	9		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	10		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	12		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		9.00	10.50		10.50	13		-	-	2.44	1.80	0.00	80.87	18.12	-	-	-	0.15	21
		10.50	12.00		12.00	14		-	-	-	-	-	-	-	-	-	-	-	-
		12.00	13.50		13.50	17		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	22		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	16.50	18.00		18.00	20	Water Table encountered at 3.10 meter	-	-	2.46	1.82	0.00	75.42	29.58	-	-	-	0.24	16
		18.00	19.50		19.50	21		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	23		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	25		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	26		-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	28		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	32		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		27.00	28.50		28.50	30		-	-	2.46	1.81	-	-	-	-	-	-	0.26	15
		28.50	30.00		30.00	34		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	38		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	40		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	43		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.									Bore Hole No.		BH-03	
Chainage							102+427									Recorded by		Mr. Krishna	
Coordinates							28.535829,78.511659												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 2.90 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	5		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	7		-	-	2.44	1.80	0.00	79.50	20.50	26.30	19.00	-	0.16	20
	SPT	3.00	4.50		4.50	9		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	10		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	12		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	14		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		9.00	10.50		10.50	18		-	-	2.44	1.80	0.00	75.59	24.41	-	-	-	0.19	18
		10.50	12.00		12.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		12.00	13.50		13.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	28		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	24		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	16.50	18.00		18.00	29	Water Table encountered at 2.90 meter	-	-	2.45	1.81	0.00	72.13	27.87	-	-	-	0.23	16
		18.00	19.50		19.50	32		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	35		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	37		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	39		-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	42		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	45		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		27.00	28.50		28.50	49		-	-	2.47	1.82	-	-	-	-	-	-	0.28	15
		28.50	30.00		30.00	47		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	45		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	51		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	50		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-01	
Chainage							112+800								Recorded by			Mr. Krishna	
Coordinates							28.458023,78.565438												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.50 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	4		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	5		-	-	2.48	1.81	0.00	83.19	16.81	34.50	23.65	12	0.08	21
	SPT	3.00	4.50		4.50	9		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	6		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	8		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	10		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		9.00	10.50		10.50	12		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	11		-	-	2.46	1.80	0.00	80.87	19.13	-	-	-	0.22	17
		12.00	13.50		13.50	14		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	15		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	16		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	16.50	18.00		18.00	18	Water Table encountered at 4.50 meter	-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	20		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	21		-	-	2.47	1.80	0.00	78.78	21.22	-	-	-	0.21	18
		21.00	22.50		22.50	23		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	25		-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	26		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	25		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		27.00	28.50		28.50	29		-	-	2.47	1.80	0.00	77.85	22.15	-	-	-	0.24	16
		28.50	30.00		30.00	30		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	32		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	34		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	37		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-02	
Chainage							112+800								Recorded by			Mr. Krishna	
Coordinates							28.458023,78.565438												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.20 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	3		-	-	2.48	1.82	0.00	81.09	18.91	-	-	-	0.10	17
	UDS	1.50	3.00		3.00	4		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	6		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	10		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	12		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	15		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		9.00	10.50		10.50	18		-	-	2.48	1.82	0.00	79.55	20.45	-	-	-	0.21	20
		10.50	12.00		12.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		12.00	13.50		13.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	21		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	25		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	16.50	18.00		18.00	29	Water Table encountered at 4.20 meter	-	-	2.49	1.82	0.00	75.36	24.64	-	-	-	0.22	18
		18.00	19.50		19.50	32		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	37		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	40		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	42		-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	37		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	39		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		27.00	28.50		28.50	41		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	45		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	48		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	51		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	51		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-03	
Chainage							112+800								Recorded by			Mr. Krishna	
Coordinates							28.458023,78.565438												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.50 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	5		-	-	2.50	1.82	-	-	-	-	-	-	0.12	15
	UDS	1.50	3.00		3.00	5		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	7		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	9		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	11		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	12		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		9.00	10.50		10.50	17		-	-	2.49	1.82	-	-	-	-	-	-	0.26	22
		10.50	12.00		12.00	22		-	-	-	-	-	-	-	-	-	-	-	-
		12.00	13.50		13.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	22		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	24		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	16.50	18.00		18.00	30	Water Table encountered at 4.50 meter	-	-	2.49	1.82	-	-	-	-	-	-	0.20	17
		18.00	19.50		19.50	32		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	34		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	45		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	48		-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	40		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	42		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		27.00	28.50		28.50	46		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	44		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	44		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	50		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	50		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-01	
Chainage							115+751								Recorded by			Mr. Krishna	
Coordinates							28.449366, 78.594384												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	5		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	4		-	-	2.46	1.80	1.38	83.20	15.40	35.11	20.24	11.3	0.20	17
	SPT	3.00	4.50		4.50	6		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	10		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	12		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	11		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		9.00	10.50		10.50	12		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	15		-	-	2.45	1.76	0.00	81.69	18.31	-	-	10.2	0.16	23
		12.00	13.50		13.50	18		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	22		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	21		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	16.50	18.00		18.00	20	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	26		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	30		-	-	2.46	1.75	0.00	80.23	19.77	-	-	-	0.20	18
		21.00	22.50		22.50	29		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	28		-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	31		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	35		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		27.00	28.50		28.50	34		-	-	2.46	1.76	0.00	79.63	20.37	-	-	-	0.19	21
		28.50	30.00		30.00	34		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	35		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	36		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	-		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE

Geotechnical Investigation for	M/S L.N Malviya Infra Projects Pvt. Ltd.	Bore Hole No.	BH-02
Chainage	115+751	Recorded by	Mr. Krishna
Coordinates	28.449366, 78.594384		

Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.50 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	7		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	6		-	-	2.45	1.78	0.00	85.10	14.90	35.54	23.01	10.3	0.21	17
	SPT	3.00	4.50		4.50	5		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	12		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	16		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	12		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		9.00	10.50		10.50	17		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	15		-	-	2.44	1.77	0.00	82.78	17.22	-	-	-	0.17	23
		12.00	13.50		13.50	16		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	22		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	16.50	18.00		18.00	23	Water Table encountered at 4.50 meter	-	-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	24		-	-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	24		-	-	2.45	1.78	0.00	89.93	10.07	-	-	-	0.23	16	
		21.00	22.50		22.50	25		-	-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	27		-	-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	30		-	-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	29		-	-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		27.00	28.50		28.50	31		-	-	2.46	1.76	0.00	79.63	20.37	-	-	-	0.20	22	
		28.50	30.00		30.00	34		-	-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	35		-	-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	38		-	-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	-		-	-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-03	
Chainage							115+751								Recorded by			Mr. Krishna	
Coordinates							28.449366, 78.594384												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.20 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	3		-	-	2.44	1.80	0.00	79.28	20.72	-	-	-	0.15	22
	UDS	1.50	3.00		3.00	5		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	6		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	8		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	10		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	11		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		9.00	10.50		10.50	16		-	-	2.44	1.81	0.00	75.43	24.57	-	-	-	0.20	19
		10.50	12.00		12.00	18		-	-	-	-	-	-	-	-	-	-	-	-
		12.00	13.50		13.50	20		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	21		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	23		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	16.50	18.00		18.00	25	Water Table encountered at 4.20 meter	-	-	2.45	1.80	0.00	72.66	27.34	-	-	-	0.26	16
		18.00	19.50		19.50	29		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	32		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	33		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	35		-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	38		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	39		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		27.00	28.50		28.50	41		-	-	2.46	1.82	0.00	70.33	29.67	-	-	-	0.28	15
		28.50	30.00		30.00	43		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	45		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	48		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	-		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-01	
Chainage							123+100								Recorded by			Mr. Krishna	
Coordinates							28.415836, 78.658008												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	4		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	8		-	-	2.44	1.81	0.00	78.30	21.70	34.33	21.25	10.5	0.18	22
	SPT	3.00	4.50		4.50	7		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	12		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt	DS	6.00	7.50		7.50	13		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	18		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	18		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	15		-	-	2.44	1.80	0.00	82.56	17.44	-	-	-	0.18	23
		12.00	13.50		13.50	20		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	13.50	15.00		15.00	17	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	19		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	23		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	21		-	-	2.43	1.79	0.00	80.63	18.63	-	-	11.0	0.22	19
		21.00	22.50		22.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	24		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		24.00	25.50		25.50	26		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	28		-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	27		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	31		-	-	2.43	1.76	0.00	85.64	14.36	-	-	-	0.20	18
		30.00	31.50		31.50	33		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	34		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	34.50		34.50	35		-	-	-	-	-	-	-	-	-	-	-	-
		34.50	36.00		36.00	37		-	-	-	-	-	-	-	-	-	-	-	-
		36.00	37.50		37.50	36		-	-	-	-	-	-	-	-	-	-	-	-
		37.50	39.00		39.00	35		-	-	-	-	-	-	-	-	-	-	-	-
		39.00	40.00		-	38		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-02	
Chainage							123+100								Recorded by			Mr. Krishna	
Coordinates							28.415836, 78.658008												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	3		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	5		-	-	2.46	1.84	0.00	79.45	20.55	35.40	22.74	11.5	0.17	22
	SPT	3.00	4.50		4.50	8		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	7		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt	DS	6.00	7.50		7.50	10		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	12		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	11		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	16		-	-	2.45	1.82	0.00	75.88	24.12	-	-	-	0.22	21
		12.00	13.50		13.50	12		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	13.50	15.00		15.00	17	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	20		-	-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	18		-	-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	21		-	-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	20		-	-	2.44	1.82	0.00	78.22	21.78	-	-	-	0.21	23	
		21.00	22.50		22.50	24		-	-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	26		-	-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		24.00	25.50		25.50	28		-	-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	30		-	-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	31		-	-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	38		-	-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	34		-	-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	35		-	-	-	-	-	-	-	-	-	-	-	-	-
		33.00	34.50		34.50	37		-	-	2.43	1.80	-	-	-	-	-	-	0.20	22	
		34.50	36.00		36.00	44		-	-	-	-	-	-	-	-	-	-	-	-	-
		36.00	37.50		37.50	38		-	-	-	-	-	-	-	-	-	-	-	-	-
		37.50	39.00		39.00	42		-	-	-	-	-	-	-	-	-	-	-	-	-
		39.00	40.00		-	-		-	-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-03	
Chainage							123+100								Recorded by			Mr. Krishna	
Coordinates							28.415836, 78.658008												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	4		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	5		-	-	2.45	1.82	0.00	75.92	24.10	34.11	21.24	10	0.23	20
	SPT	3.00	4.50		4.50	8		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	10		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt	DS	6.00	7.50		7.50	10		-	-	-	-	-	-	-	-	-	-	-	-
		7.50	9.00		9.00	15		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	14		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	13		-	-	2.45	1.81	0.00	79.53	20.47	-	-	-	0.20	23
		12.00	13.50		13.50	16		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	13.50	15.00		15.00	15	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	18		-	-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	21		-	-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	22		-	-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	20		-	-	2.44	1.80	0.00	80.71	19.29	-	-	-	0.20	24	
		21.00	22.50		22.50	22		-	-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	27		-	-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		24.00	25.50		25.50	26		-	-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	28		-	-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	30		-	-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	31		-	-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	34		-	-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	32		-	-	-	-	-	-	-	-	-	-	-	-	-
		33.00	34.50		34.50	31		-	-	2.46	1.79	-	-	-	-	-	-	0.19	23	
		34.50	36.00		36.00	33		-	-	-	-	-	-	-	-	-	-	-	-	-
		36.00	37.50		37.50	37		-	-	-	-	-	-	-	-	-	-	-	-	-
		37.50	39.00		39.00	38		-	-	-	-	-	-	-	-	-	-	-	-	-
		39.00	40.00		-	38		-	-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-04	
Chainage							123+100								Recorded by			Mr. Krishna	
Coordinates							28.415836, 78.658008												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.30 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	4		-	-	2.43	1.81	0.00	74.62	25.38	30.35	20.18	-	0.22	21
	UDS	1.50	3.00		3.00	5		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	8		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	10		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt	DS	6.00	7.50		7.50	10		-	-	2.45	1.81	0.00	70.25	29.75	-	-	-	0.24	20
		7.50	9.00		9.00	15		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	14		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	13		-	-										
		12.00	13.50		13.50	16		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil with silt	DS	13.50	15.00		15.00	15	Water Table encountered at 4.00 meter	-	-	2.45	1.82	0.00	67.50	32.50	-	-	-	0.27	19
		15.00	16.50		16.50	18		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	21		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	27		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		24.00	25.50		25.50	26		-	-	2.46	1.82	-	-	-	-	-	-	0.29	18
		25.50	27.00		27.00	28		-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	30		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	31		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	34		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	32		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	34.50		34.50	31		-	-	-	-	-	-	-	-	-	-	-	-
		34.50	36.00		36.00	33		-	-	-	-	-	-	-	-	-	-	-	-
		36.00	37.50		37.50	37		-	-	-	-	-	-	-	-	-	-	-	-
		37.50	39.00		39.00	38		-	-	-	-	-	-	-	-	-	-	-	-
		39.00	40.00		-	38		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.									Bore Hole No.		BH-01	
Chainage							123+288									Recorded by		Mr. Krishna	
Coordinates							28.414782, 78.659474												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.50 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	5		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	8		-	-	2.40	1.80	0.00	81.60	18.40	34.89	22.51	12	0.24	18
	SPT	3.00	4.50		4.50	6		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	9		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	11		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		7.50	9.00		9.00	12		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	13		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	14		-	-	2.44	1.82	0.00	80.02	19.98	-	-	-	0.22	21
		12.00	13.50		13.50	15		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	17		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil	DS	15.00	16.50		16.50	17		-	-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	22		-	-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	16		-	-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	20		-	-	2.44	1.79	0.00	83.25	16.75	-	-	-	0.17	23	
		21.00	22.50		22.50	21		-	-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	26		-	-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	26		-	-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		25.50	27.00		27.00	28		-	-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	30		-	-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	31		-	-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	33		-	-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	34		-	-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	36		-	-	2.46	1.80	-	-	-	-	-	-	0.16	25	

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-02	
Chainage							123+288								Recorded by			Mr. Krishna	
Coordinates							28.414782, 78.659474												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.50 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	4		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	5		-	-	2.47	1.85	0.00	75.63	24.37	35.39	23.15		0.28	19
	SPT	3.00	4.50		4.50	7		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	12		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	10		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		7.50	9.00		9.00	11		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	10		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	15		-	-	2.45	1.80	0.00	82.47	17.53	-	-	-	0.22	22
		12.00	13.50		13.50	13		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	17		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil	DS	15.00	16.50		16.50	18	Water Table encountered at 4.50 meter	-	-	-	-	-	-	-	-	-	-	-	-	
		16.50	18.00		18.00	15		-	-	-	-	-	-	-	-	-	-	-	-	
		18.00	19.50		19.50	20		-	-	-	-	-	-	-	-	-	-	-	-	
		19.50	21.00		21.00	22		-	-	2.44	1.80	0.00	81.44	18.56	-	-	-	0.20	24	
		21.00	22.50		22.50	24		-	-	-	-	-	-	-	-	-	-	-	-	
		22.50	24.00		24.00	26		-	-	-	-	-	-	-	-	-	-	-	-	
		24.00	25.50		25.50	28		-	-	-	-	-	-	-	-	-	-	-	-	
Brown Sandy Soil		25.50	27.00		27.00	30		-	-	-	-	-	-	-	-	-	-	-	-	
		27.00	28.50		28.50	31		-	-	-	-	-	-	-	-	-	-	-	-	
		28.50	30.00		30.00	31		-	-	-	-	-	-	-	-	-	-	-	-	
		30.00	31.50		31.50	35		-	-	-	-	-	-	-	-	-	-	-	-	
		31.50	33.00		33.00	34		-	-	-	-	-	-	-	-	-	-	-	-	
		33.00	35.00		34.50	36		-	-	2.45	1.81	-	-	-	-	-	-	0.19	24	

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-03	
Chainage							123+288								Recorded by			Mr. Krishna	
Coordinates							28.414782, 78.659474												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.40 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	4		-	-	2.47	1.84	0.00	74.62	25.38	31.03	22.00	-	0.27	18
	UDS	1.50	3.00		3.00	5		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	7		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	12		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	10		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy soil with silt		7.50	9.00		9.00	11		-	-	2.46	1.82	0.00	70.70	29.30	-	-	-	0.29	19
		9.00	10.50		10.50	10		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	15		-	-	-	-	-	-	-	-	-	-	-	-
		12.00	13.50		13.50	13		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	17		-	-	-	-	-	-	-	-	-	-	-	-

brown Stiff sandy soil	DS	15.00	16.50		16.50	18	Water Table encountered at 4.40 meter	-	-	2.45	1.82	0.00	69.64	30.36	-	-	-	0.32	17
		16.50	18.00		18.00	15		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	20		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	22		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	24		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	26		-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	28		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		25.50	27.00		27.00	30		-	-	2.45	1.82	-	-	-	-	-	-	0.30	18
		27.00	28.50		28.50	31		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	31		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	35		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	34		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	36		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-01	
Chainage							154+200								Recorded by			Mr. Krishna	
Coordinates							28.259873, 78.915266												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 5.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	5		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	8		-	-	2.46	1.85	0.00	80.20	19.80	34.89	23.63	12.5	0.20	20
	SPT	3.00	4.50		4.50	10		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	11		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	10		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	15		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	14		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	15		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		12.00	13.50		13.50	17		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	19		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	20		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	18		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	20		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	22		-	-	2.45	1.80	0.00	83.77	16.23	-	-	-	0.18	23

		21.00	22.50		22.50	26		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	28		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		24.00	25.50		25.50	30		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	31		-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	33		-	-	2.46	1.82	-	-	-	-	-	-	0.17	24
		28.50	30.00		30.00	34		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	35		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	37		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	-		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-02	
Chainage							154+200								Recorded by			Mr. Krishna	
Coordinates							28.259873, 78.915266												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.80 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	4		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	6		-	-	2.47	1.86	0.00	78.52	21.48	34.14	20.88		0.24	19
	SPT	3.00	4.50		4.50	5		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	10		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	12		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	18		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	16		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	12		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		12.00	13.50		13.50	12		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	14		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	22		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	24		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	26		-	-	2.45	1.80	0.00	80.62	19.38	-	-	-	0.20	21

		21.00	22.50		22.50	30		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	31		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		24.00	25.50		25.50	33		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	34		-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	37		-	-	2.44	1.79	-	-	-	-	-	-	0.20	22
		28.50	30.00		30.00	40		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	41		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	42		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	45		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-03	
Chainage							154+200								Recorded by			Mr. Krishna	
Coordinates							28.259873, 78.915266												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.60 meter	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	3		-	-	2.46	1.84	0.00	75.78	24.22	32.64	20.12	-	0.24	19
	UDS	1.50	3.00		3.00	5		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	7		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	8		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	10		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	12		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	15		-	-	-	-	-	-	-	-	-	-	-	-
		10.50	12.00		12.00	17		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		12.00	13.50		13.50	19		-	-	2.45	1.80	0.00	70.51	29.49	-	-	-	0.26	18
		13.50	15.00		15.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	24		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	28		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	32		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	35		-	-	-	-	-	-	-	-	-	-	-	-

		21.00	22.50		22.50	37		-	-	-	-	-	-	-	-	-	-	-	-
		22.50	24.00		24.00	39		-	-	-	-	-	-	-	-	-	-	-	-
Brown Sandy Soil		24.00	25.50		25.50	42		-	-	2.46	1.82	-	-	-	-	-	-	0.25	20
		25.50	27.00		27.00	47		-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	50		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	52		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	55		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	59		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	63		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE

Geotechnical Investigation for	M/S L.N Malviya Infra Projects Pvt. Ltd.	Bore Hole No.	BH-01
Chainage	157+356	Recorded by	Mr. Krishna
Coordinates	28.252265, 78.946318		

Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 3.50 meter	-	-	-	-	-	-	-	-	-	-	-	-
Brown and Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	3		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	4		-	-	2.45	1.83	0.00	77.60	22.40	33.71	25.58	12	0.28	18
	SPT	3.00	4.50		4.50	8		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	5		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	12		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	10		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	13		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		10.50	12.00		12.00	13		-	-	-	-	-	-	-	-	-	-	-	-
		12.00	13.50		13.50	15		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	18		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	20		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	21		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	22		-	-	2.43	1.79	0.00	81.11	18.89	-	-	-	0.22	20
		21.00	22.50		22.50	24		-	-	-	-	-	-	-	-	-	-	-	-

Brown Sandy Soil		22.50	24.00		24.00	26		-	-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	24		-	-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	38		-	-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	32		-	-	2.45	1.78	-	-	-	-	-	-	0.18	23	
		28.50	30.00		30.00	33		-	-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	34		-	-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	35		-	-	-	-	-	-	-	-	-	-	-	-	-
		33.00	34.50		34.50	37		-	-	-	-	-	-	-	-	-	-	-	-	-
		34.50	36.00		36.00	42		-	-	-	-	-	-	-	-	-	-	-	-	-
		36.00	37.50		37.50	40		-	-	-	-	-	-	-	-	-	-	-	-	-
		37.50	39.00		39.00	38		-	-	-	-	-	-	-	-	-	-	-	-	-
		39.00	40.00		-	-		-	-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE

Geotechnical Investigation for	M/S L.N Malviya Infra Projects Pvt. Ltd.	Bore Hole No.	BH-02
Chainage	157+356	Recorded by	Mr. Krishna
Coordinates	28.252265, 78.946318		

Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 3.50 meter	-	-	-	-	-	-	-	-	-	-	-	-
Brown and Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	3		-	-	2.46	1.80	0.00	75.57	24.43	32.08	21.42	-	0.26	18
	UDS	1.50	3.00		3.00	4		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	8		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	5		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	12		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	10		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	13		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		10.50	12.00		12.00	13		-	-	2.45	1.80	0.00	72.64	27.36	-	-	-	0.27	17
		12.00	13.50		13.50	15		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	18		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	20		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	21		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	22		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	24		-	-	-	-	-	-	-	-	-	-	-	-

Brown Sandy Soil		22.50	24.00		24.00	26		-	-	2.47	1.82	-	-	-	-	-	-	0.22	21
		24.00	25.50		25.50	24		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	38		-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	32		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	33		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	34		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	35		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	37		-	-	-	-	-	-	-	-	-	-	-	-
		34.50	36.00		36.00	42		-	-	-	-	-	-	-	-	-	-	-	-
		36.00	37.50		37.50	40		-	-	-	-	-	-	-	-	-	-	-	-
		37.50	39.00		39.00	38		-	-	-	-	-	-	-	-	-	-	-	-
		39.00	40.00		-	-		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE

Geotechnical Investigation for	M/S L.N Malviya Infra Projects Pvt. Ltd.	Bore Hole No.	BH-03
Chainage	157+356	Recorded by	Mr. Krishna
Coordinates	28.252265, 78.946318		

Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 3.70 meter	-	-	-	-	-	-	-	-	-	-	-	-
Brown and Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	5		-	-	2.47	1.80	-	-	-	-	-	-	0.27	19
	UDS	1.50	3.00		3.00	4		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	8		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	5		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	10		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	12		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	10		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		10.50	12.00		12.00	15		-	-	2.48	1.80	-	-	-	-	-	-	0.28	20
		12.00	13.50		13.50	19		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	22		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	21		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	28		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	29		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	30		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	23		-	-	-	-	-	-	-	-	-	-	-	-

Brown Sandy Soil		22.50	24.00		24.00	28		-	-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	32		-	-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	37		-	-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	34		-	-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	35		-	-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	39		-	-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	30		-	-	-	-	-	-	-	-	-	-	-	-	-
		33.00	34.50		34.50	32		-	-	-	-	-	-	-	-	-	-	-	-	-
		34.50	36.00		36.00	36		-	-	-	-	-	-	-	-	-	-	-	-	-
		36.00	37.50		37.50	40		-	-	-	-	-	-	-	-	-	-	-	-	-
		37.50	39.00		39.00	38		-	-	-	-	-	-	-	-	-	-	-	-	-
		39.00	40.00		-	-		-	-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE																			
Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.									Bore Hole No.		BH-04	
Chainage							157+356									Recorded by		Mr. Krishna	
Coordinates							28.252265, 78.946318												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 3.60 meter	-	-	-	-	-	-	-	-	-	-	-	-
Brown and Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	5		-	-	2.46	1.80	-	-	-	-	-	-	0.25	17
	UDS	1.50	3.00		3.00	8		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	12		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	13		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	15		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	18		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	20		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		10.50	12.00		12.00	22		-	-	2.45	1.82	-	-	-	-	-	-	0.20	19
		12.00	13.50		13.50	14		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	19		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	21		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	26		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	28		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	24		-	-	-	-	-	-	-	-	-	-	-	-

Brown Sandy Soil		22.50	24.00		24.00	26		-	-	-	-	-	-	-	-	-	-	-	-	-
		24.00	25.50		25.50	24		-	-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	38		-	-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	32		-	-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	33		-	-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	34		-	-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	35		-	-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	37		-	-	-	-	-	-	-	-	-	-	-	-	-
		34.50	36.00		36.00	40		-	-	-	-	-	-	-	-	-	-	-	-	-
		36.00	37.50		37.50	43		-	-	-	-	-	-	-	-	-	-	-	-	-
		37.50	39.00		39.00	38		-	-	-	-	-	-	-	-	-	-	-	-	-
		39.00	40.00		-	-		-	-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE

Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-01	
Chainage							166+070								Recorded by			Mr. Krishna	
Coordinates							28.1973,79.0061												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.50 meter	-	-	-	-	-	-	-	-	-	-	-	-
Brown and Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	2		-	-	2.45	1.82	0.00	74.23	25.77	30.95	19.50	-	0.13	17
	UDS	1.50	3.00		3.00	4		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	5		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	6		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	8		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	12		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	15		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		10.50	12.00		12.00	16		-	-	2.45	1.81	0.00	70.41	27.59	-	-	-	0.26	18
		12.00	13.50		13.50	18		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	23		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	26		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	28		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	30		-	-	-	-	-	-	-	-	-	-	-	-

Brown Sandy Soil		22.50	24.00		24.00	32		-	-	2.45	1.82	-	-	-	-	-	-	0.26	19
		24.00	25.50		25.50	35		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	38		-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	40		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	42		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	48		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	54		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	-		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE

Geotechnical Investigation for							M/S L.N Malviya Infra Projects Pvt. Ltd.								Bore Hole No.			BH-02	
Chainage							166+070								Recorded by			Mr. Krishna	
Coordinates							28.1973,79.0061												
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.40 meter	-	-	-	-	-	-	-	-	-	-	-	-
Brown and Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	5		-	-	2.45	1.82	0.00	74.32	25.68	29.85	19.56	-	0.12	16
	UDS	1.50	3.00		3.00	4		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	7		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	9		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	12		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	13		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	15		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		10.50	12.00		12.00	18		-	-	2.46	1.83	0.00	70.53	29.47	-	-	-	0.28	15
		12.00	13.50		13.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	26		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	28		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	30		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	32		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	35		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	40		-	-	-	-	-	-	-	-	-	-	-	-

Brown Sandy Soil		22.50	24.00		24.00	42		-	-	2.48	1.83	-	-	-	-	-	-	0.22	20
		24.00	25.50		25.50	46		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	48		-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	52		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	55		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	58		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	62		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	-		-	-	-	-	-	-	-	-	-	-	-	-

4.01 BORE LOG & SOIL PROFILE

Geotechnical Investigation for	M/S L.N Malviya Infra Projects Pvt. Ltd.	Bore Hole No.	BH-01
Chainage	172+910	Recorded by	Mr. Krishna
Coordinates	28.175765, 79.066400		

Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
Brown and Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	4		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	1.50	3.00		3.00	6		-	-	2.45	1.83	0.00	84.20	15.80	34.23	21.57	12	0.20	16
	SPT	3.00	4.50		4.50	8		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	5		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	15		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	12		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	16		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		10.50	12.00		12.00	15		-	-	-	-	-	-	-	-	-	-	-	-
		12.00	13.50		13.50	14		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	22		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	13		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	25		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	27		-	-	2.44	1.82	0.00	80.26	19.80	-	-	-	0.24	17
		21.00	22.50		22.50	28		-	-	-	-	-	-	-	-	-	-	-	-

Brown Sandy Soil		22.50	24.00		24.00	26		-	-	-	-	-	-	-	-	-	-	-	-	
		24.00	25.50		25.50	28		-	-	-	-	-	-	-	-	-	-	-	-	
		25.50	27.00		27.00	30		-	-	-	-	-	-	-	-	-	-	-	-	
		27.00	28.50		28.50	31		-	-	2.44	1.81	-	-	-	-	-	-	0.23	19	
		28.50	30.00		30.00	33		-	-	-	-	-	-	-	-	-	-	-	-	
		30.00	31.50		31.50	34		-	-	-	-	-	-	-	-	-	-	-	-	
		31.50	33.00		33.00	35		-	-	-	-	-	-	-	-	-	-	-	-	
		33.00	35.00		34.50	37		-	-	-	-	-	-	-	-	-	-	-	-	

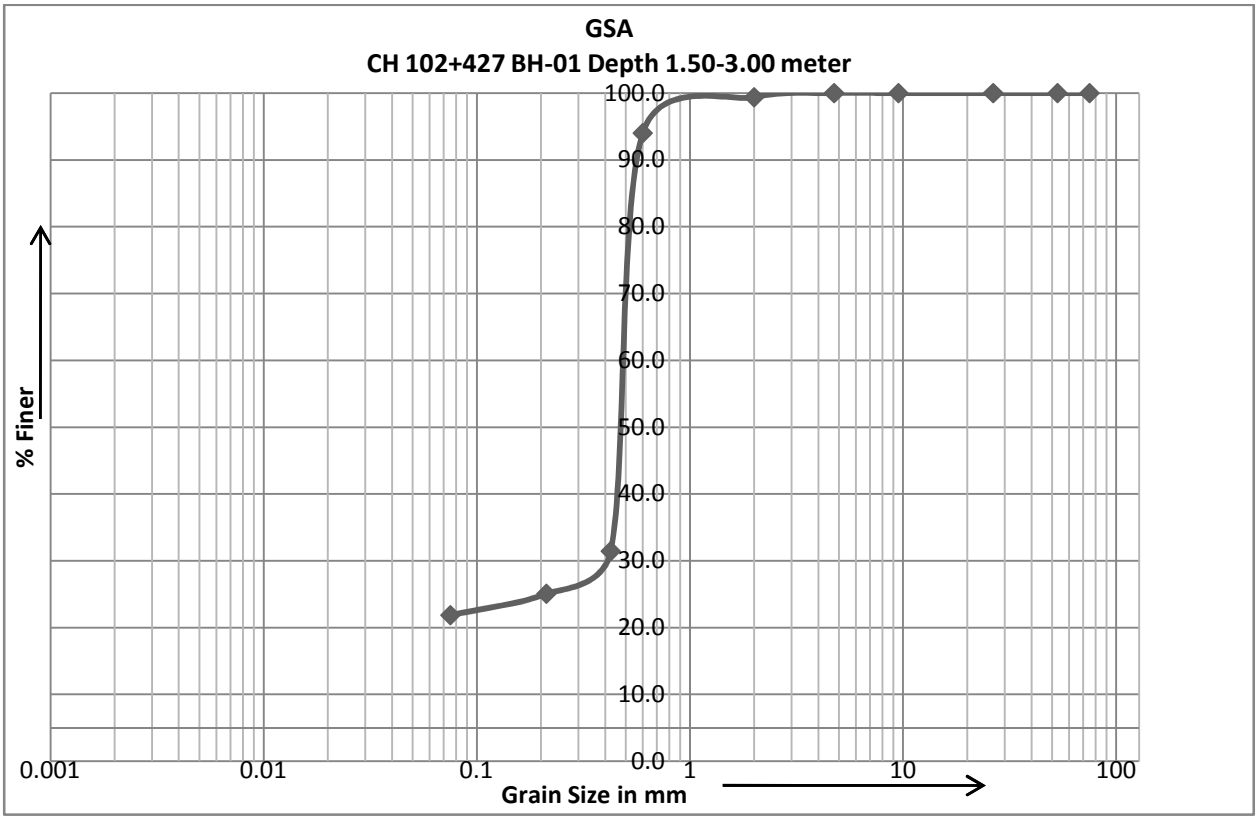
4.01 BORE LOG & SOIL PROFILE

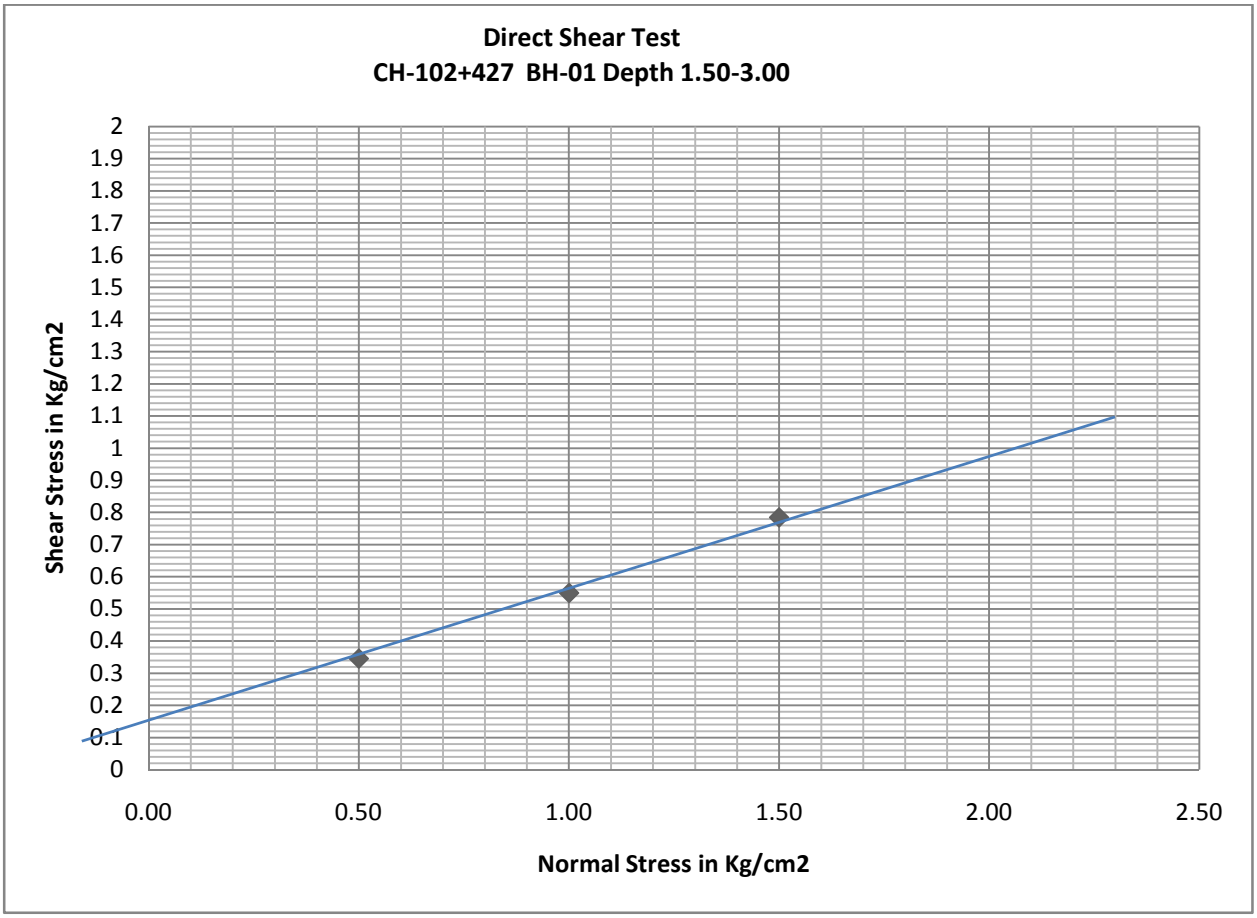
Geotechnical Investigation for	M/S L.N Malviya Infra Projects Pvt. Ltd.	Bore Hole No.	BH-02
Chainage	172+910	Recorded by	Mr. Krishna
Coordinates	28.175765, 79.066400		

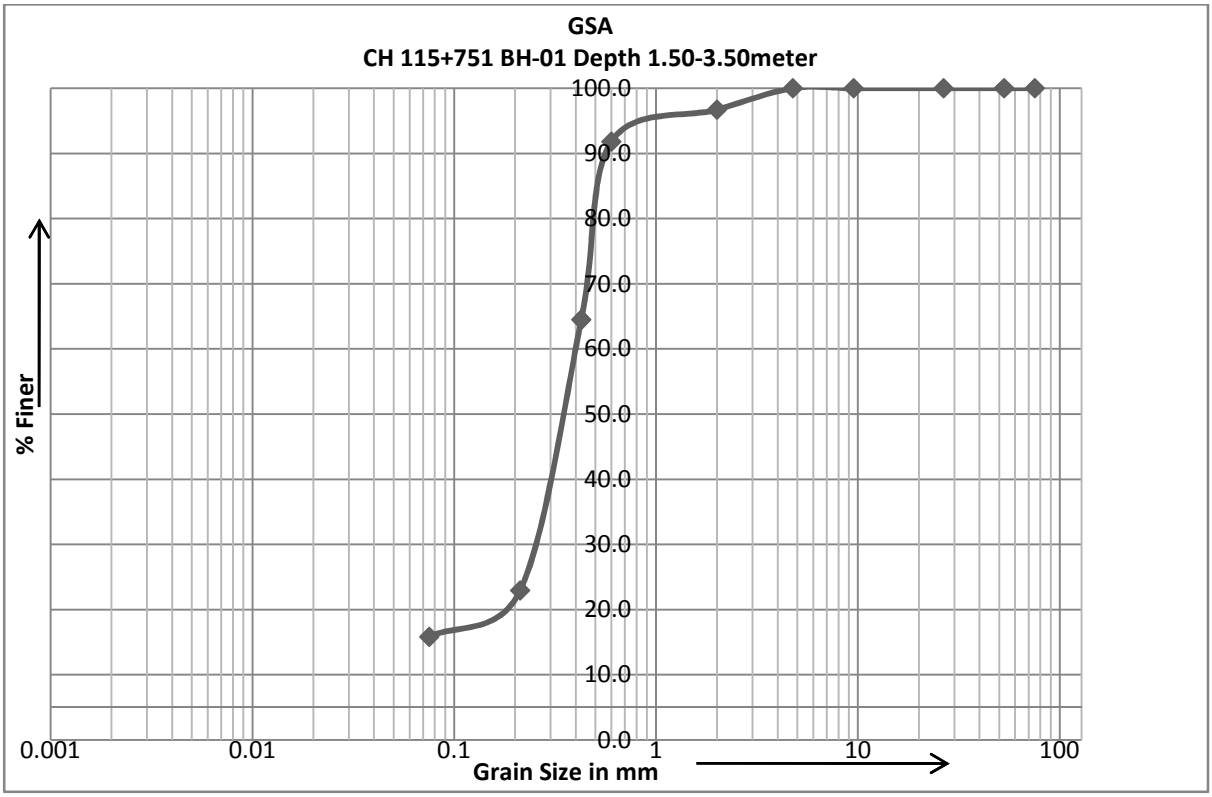
Strata Encountered	Nature of Sample	Depth of Drilling In meter		Symbolic Representation of Strata	SPT		Depth of Water table	% Core Recovery	RQD in %	Specific gravity of soil in gm/cc	Bulk Density in gm/cc	GSA			Atterbergs Limit		Free Swell Index %	Type of Test (UU)	
		From	To		Depth	No						% Gravel	% Sand	% Silt& Clay	Liquid limit in %	Plastic Limit in %		Cohesion in Kg/cm^2	Angle of Internal friction in Degree
Filled up Soil	DS	0.00	0.50		0.50	-	Water Table encountered at 4.00 meter	-	-	-	-	-	-	-	-	-	-	-	-
Brown and Yellow Sandy soil with silt	SPT	0.50	1.50		1.50	3		-	-	2.45	1.83	0.00	80.08	19.92	-	-	11	0.12	14
	UDS	1.50	3.00		3.00	4		-	-	-	-	-	-	-	-	-	-	-	-
	SPT	3.00	4.50		4.50	6		-	-	-	-	-	-	-	-	-	-	-	-
	UDS	4.50	6.00		6.00	7		-	-	-	-	-	-	-	-	-	-	-	-
	DS	6.00	7.50		7.50	9		-	-	-	-	-	-	-	-	-	-	-	-
	DS	7.50	9.00		9.00	11		-	-	-	-	-	-	-	-	-	-	-	-
		9.00	10.50		10.50	12		-	-	-	-	-	-	-	-	-	-	-	-
Brown stiff sandy soil		10.50	12.00		12.00	14		-	-	2.45	1.83	0.00	75.27	24.73	-	-	-	0.23	18
		12.00	13.50		13.50	13		-	-	-	-	-	-	-	-	-	-	-	-
		13.50	15.00		15.00	18		-	-	-	-	-	-	-	-	-	-	-	-
		15.00	16.50		16.50	19		-	-	-	-	-	-	-	-	-	-	-	-
		16.50	18.00		18.00	20		-	-	-	-	-	-	-	-	-	-	-	-
		18.00	19.50		19.50	22		-	-	-	-	-	-	-	-	-	-	-	-
		19.50	21.00		21.00	24		-	-	-	-	-	-	-	-	-	-	-	-
		21.00	22.50		22.50	26		-	-	-	-	-	-	-	-	-	-	-	-

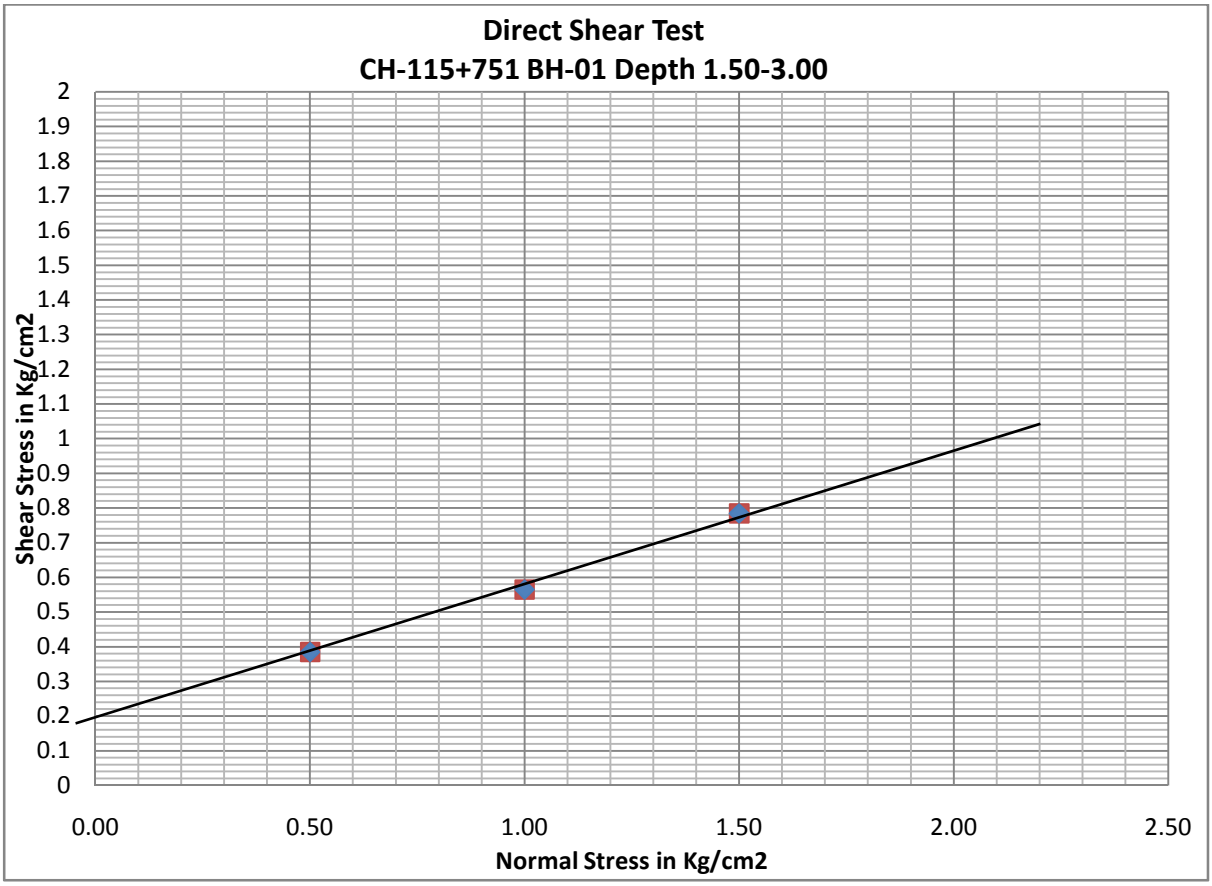
Brown Sandy Soil		22.50	24.00		24.00	28		-	-	2.47	1.82	-	-	-	-	-	-	0.24	17
		24.00	25.50		25.50	32		-	-	-	-	-	-	-	-	-	-	-	-
		25.50	27.00		27.00	35		-	-	-	-	-	-	-	-	-	-	-	-
		27.00	28.50		28.50	40		-	-	-	-	-	-	-	-	-	-	-	-
		28.50	30.00		30.00	42		-	-	-	-	-	-	-	-	-	-	-	-
		30.00	31.50		31.50	48		-	-	-	-	-	-	-	-	-	-	-	-
		31.50	33.00		33.00	52		-	-	-	-	-	-	-	-	-	-	-	-
		33.00	35.00		34.50	56		-	-	-	-	-	-	-	-	-	-	-	-

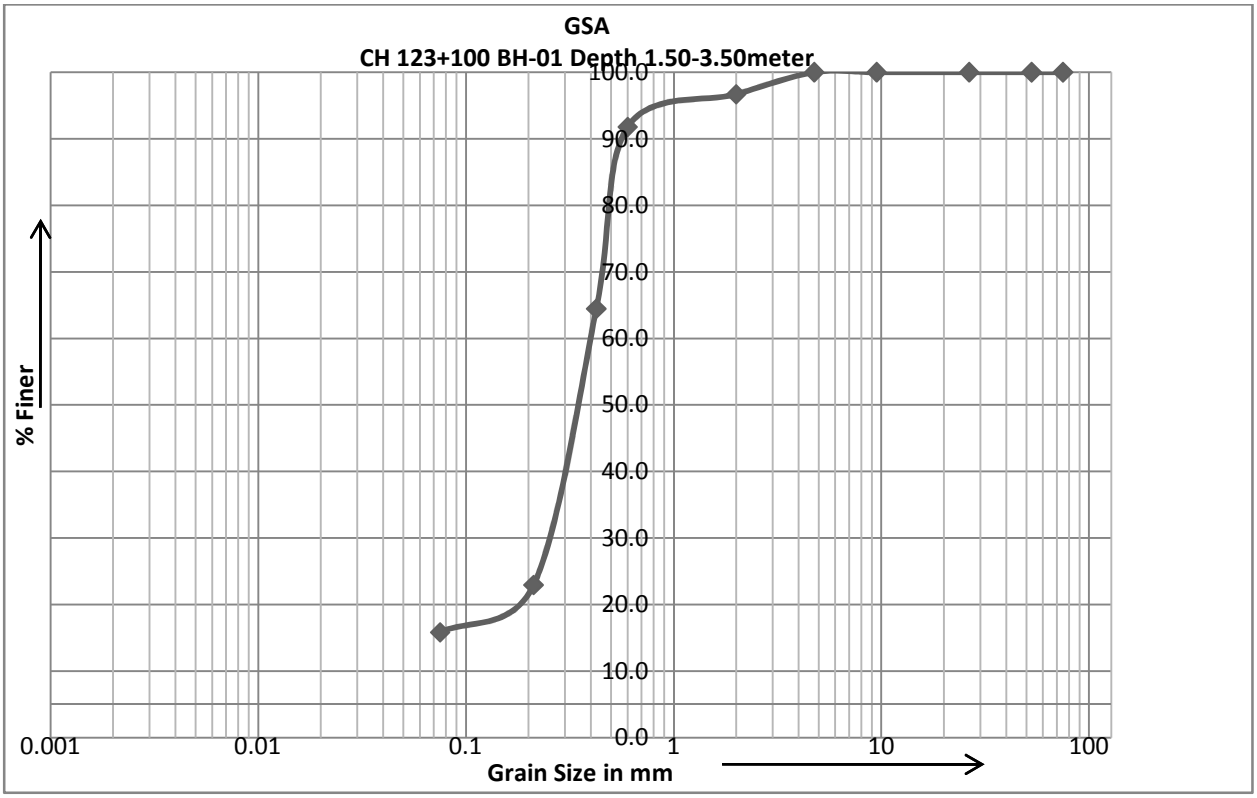
5.0Test Results Graphs






GSA
CH 115+751 BH-01 Depth 1.50-3.50meter
% Finer
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.001
0.01
0.1
1
10
100
Grain Size in mm


Direct Shear Test
CH-115+751 BH-01 Depth 1.50-3.00
Shear Stress in Kg/cm2
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
0.50
1.00
1.50
2.00
2.50
Normal Stress in Kg/cm2


GSA
CH 123+100 BH-01 Depth 1.50-3.50meter
% Finer
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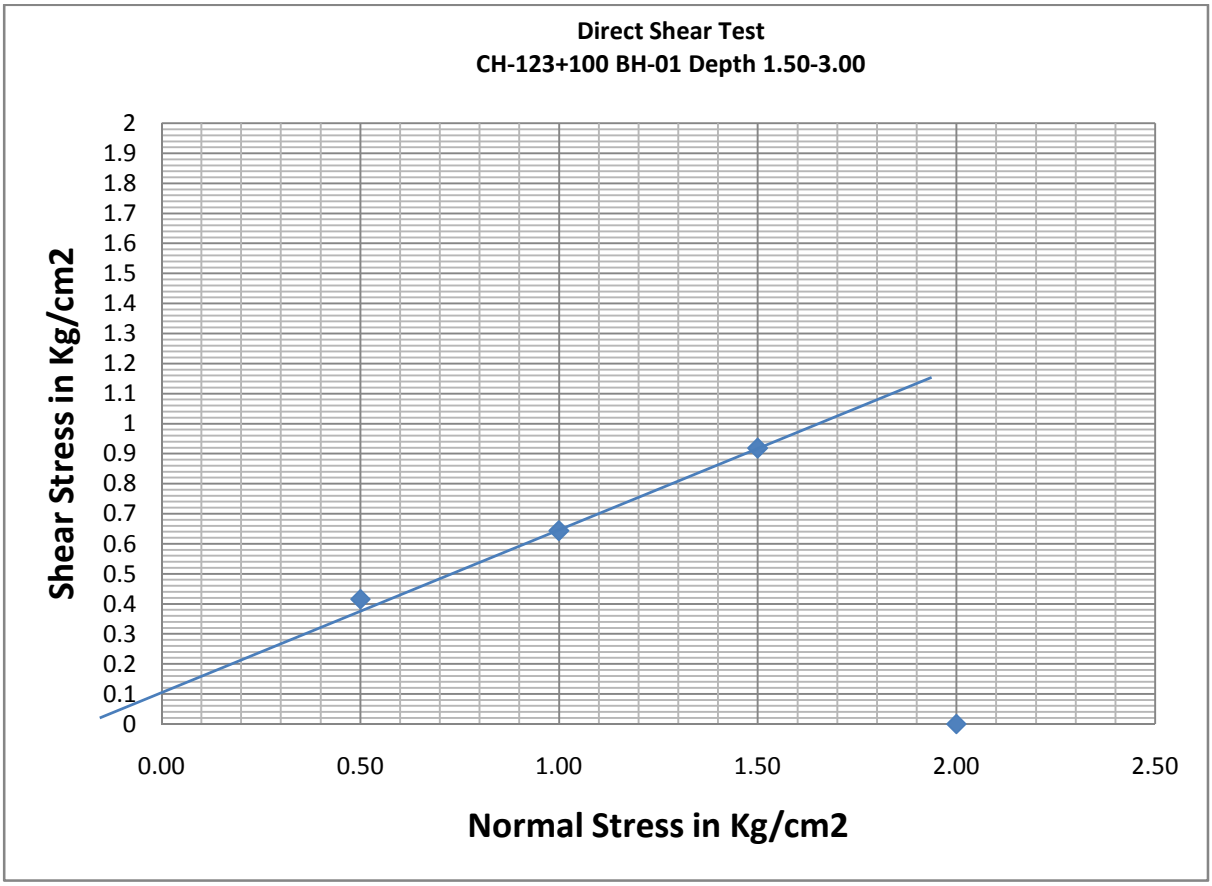
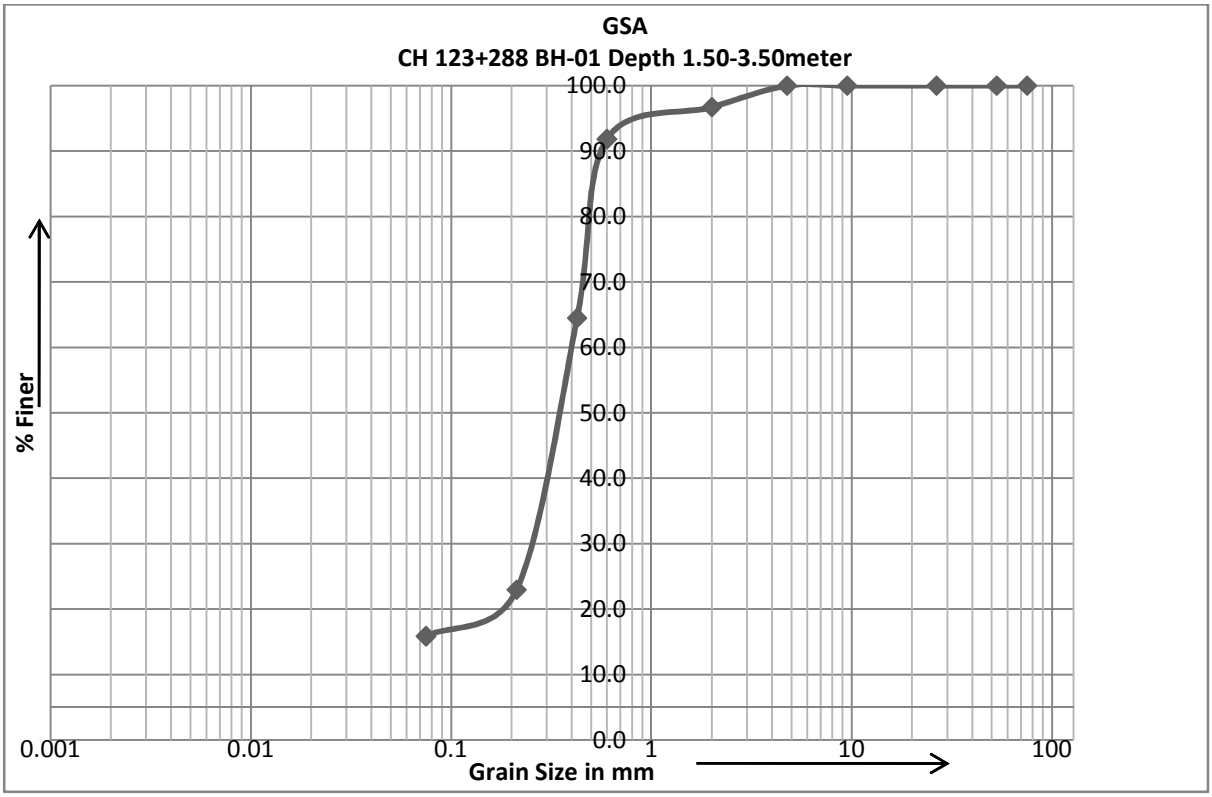
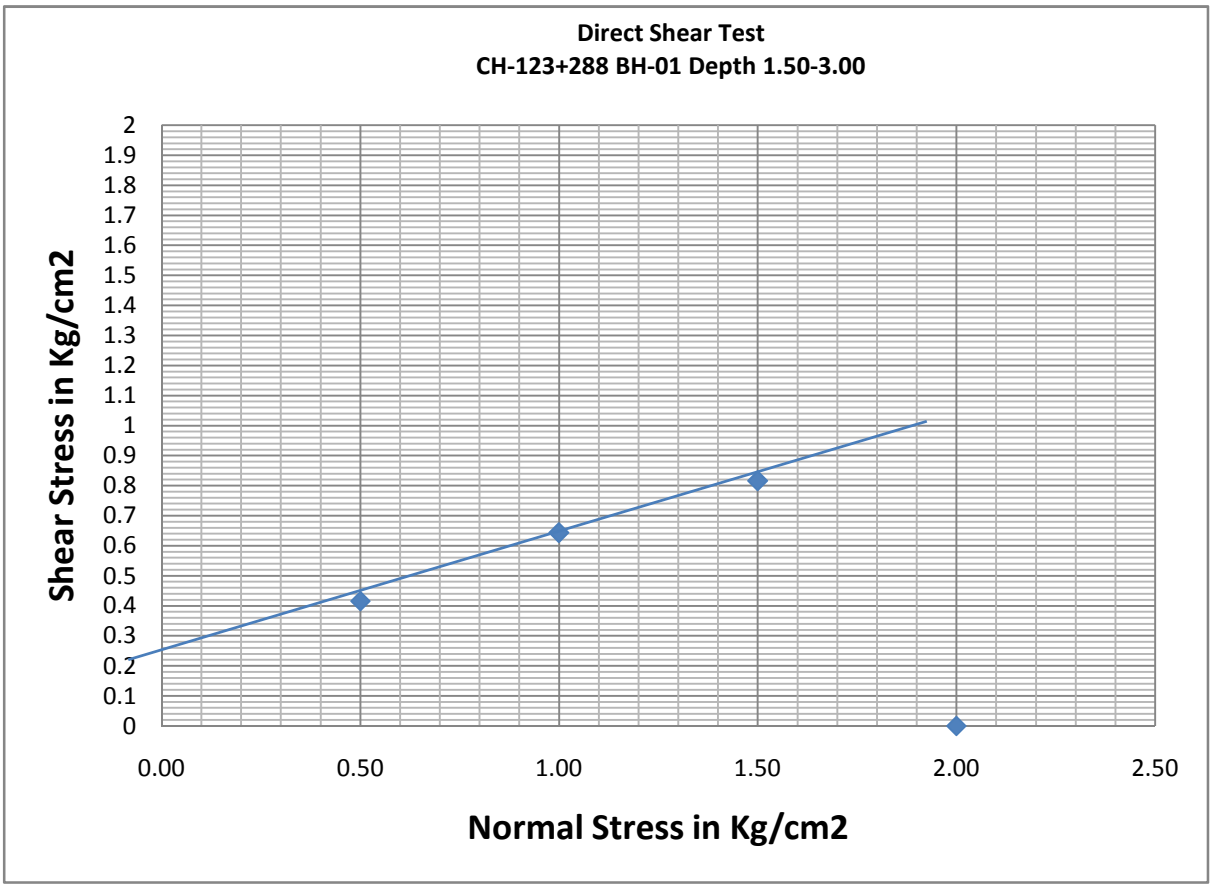
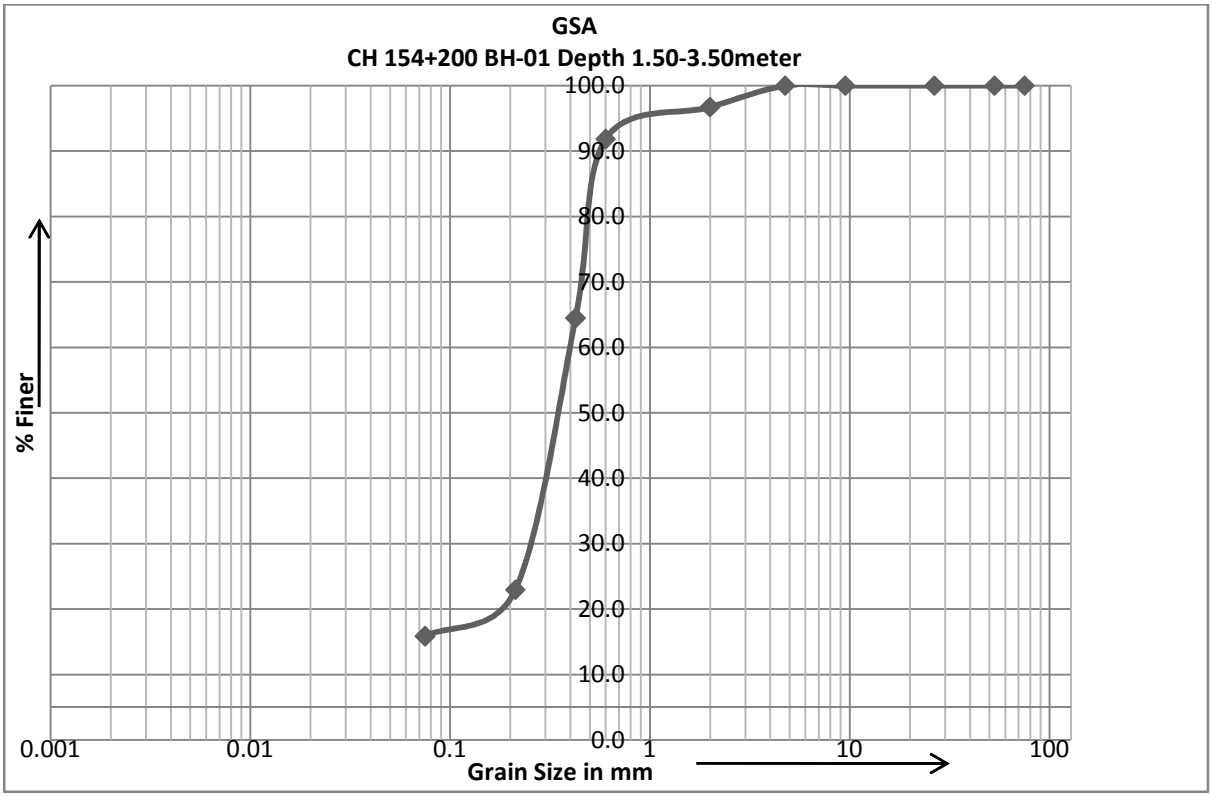
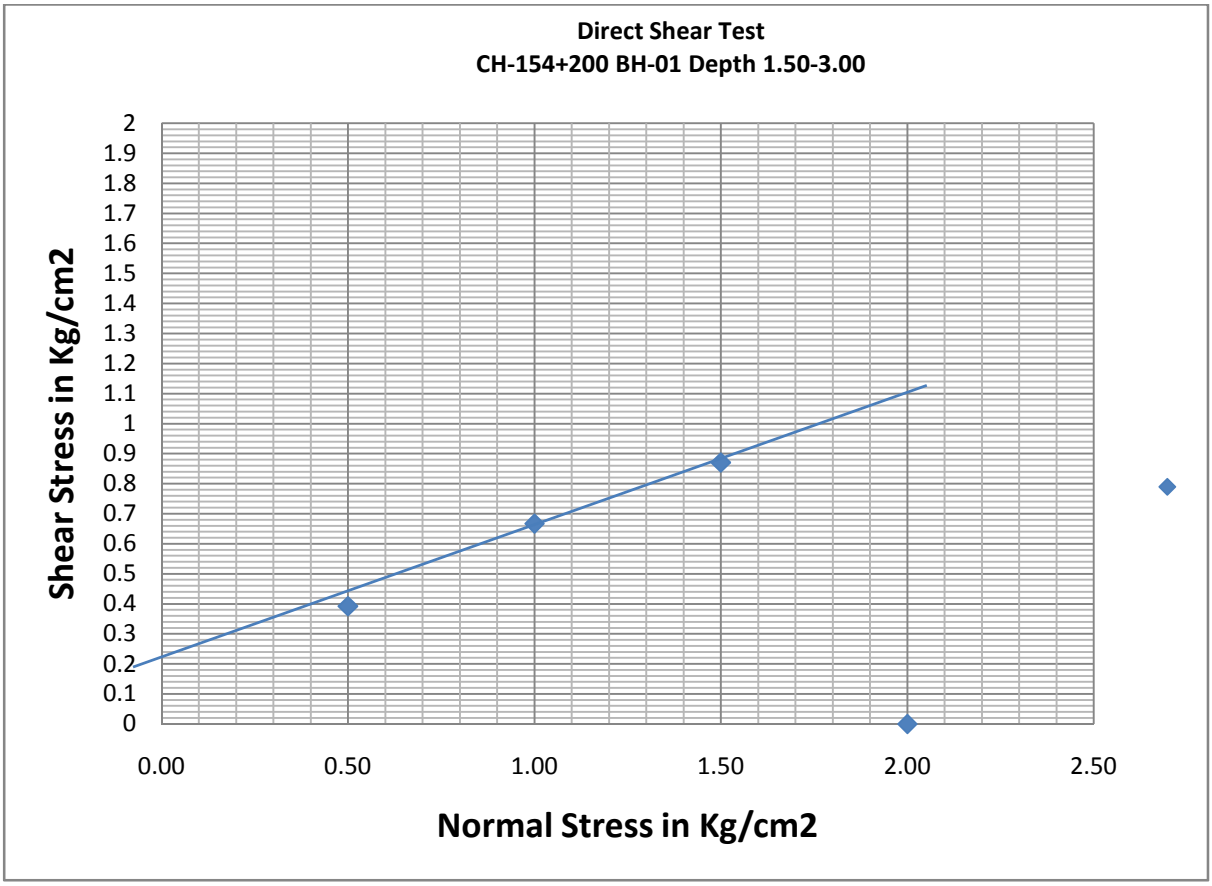
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.001
0.01
0.1
1
10
100
Grain Size in mm

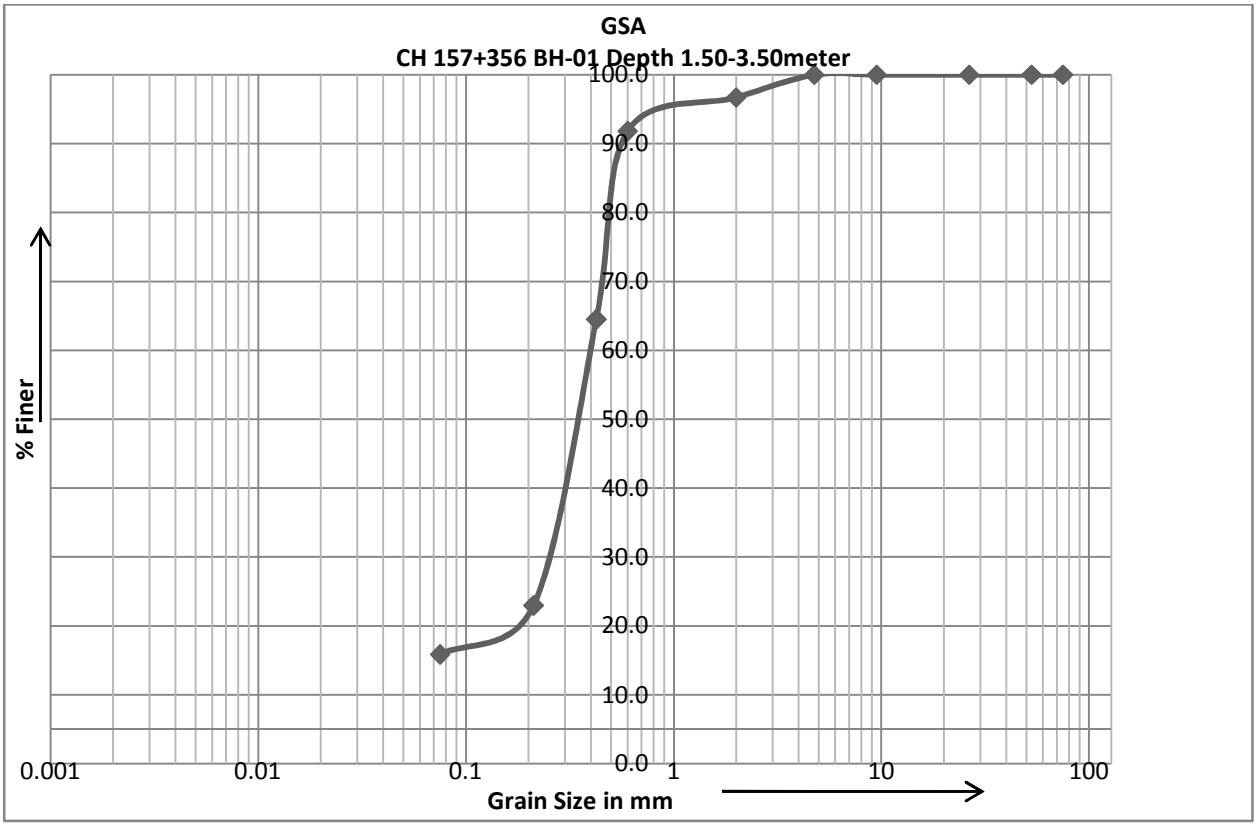

Direct Shear Test
CH-123+100 BH-01 Depth 1.50-3.00
Shear Stress in Kg/cm2
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
0.50
1.00
1.50
2.00
2.50
Normal Stress in Kg/cm2

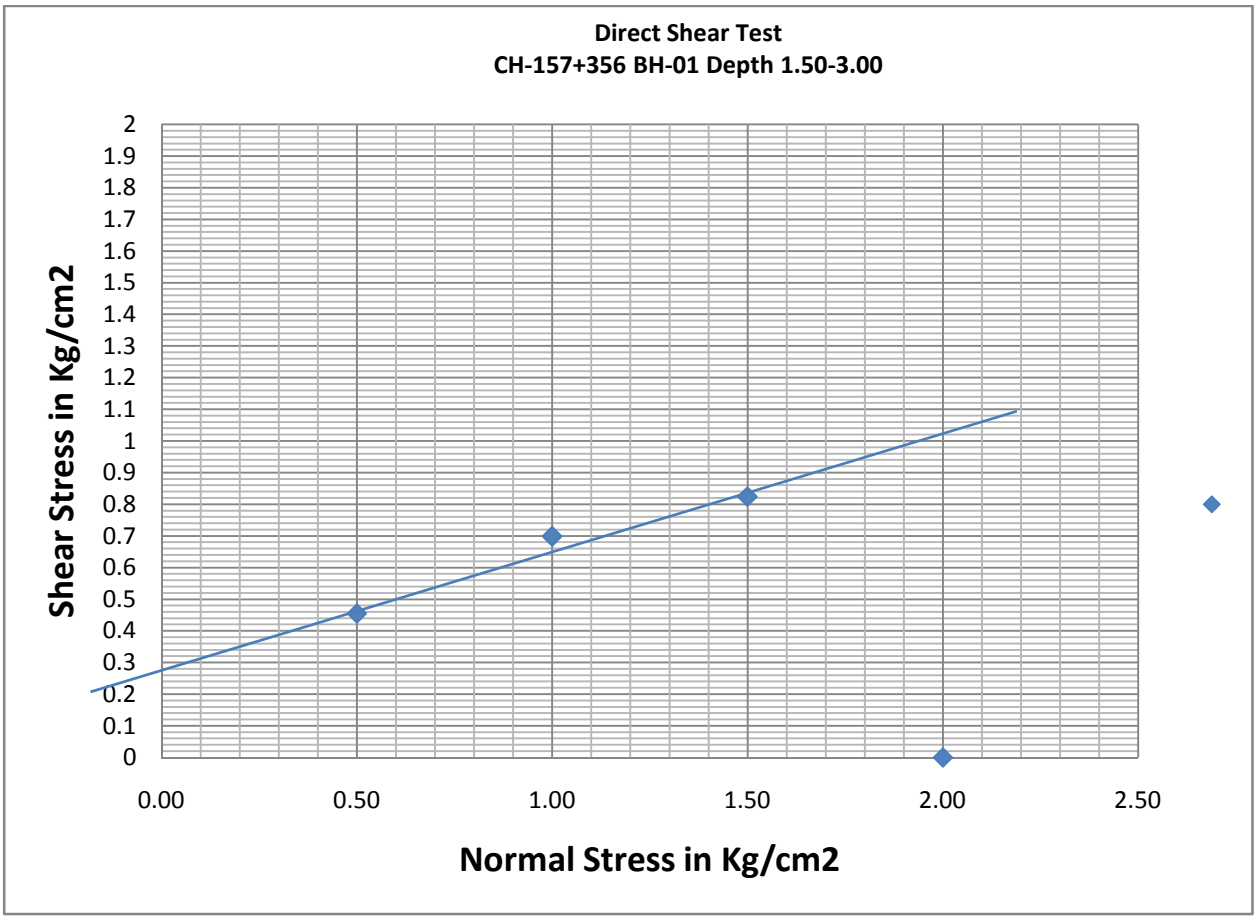

GSA
CH 123+288 BH-01 Depth 1.50-3.50meter
% Finer
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.001
0.01
0.1
1
10
100
Grain Size in mm

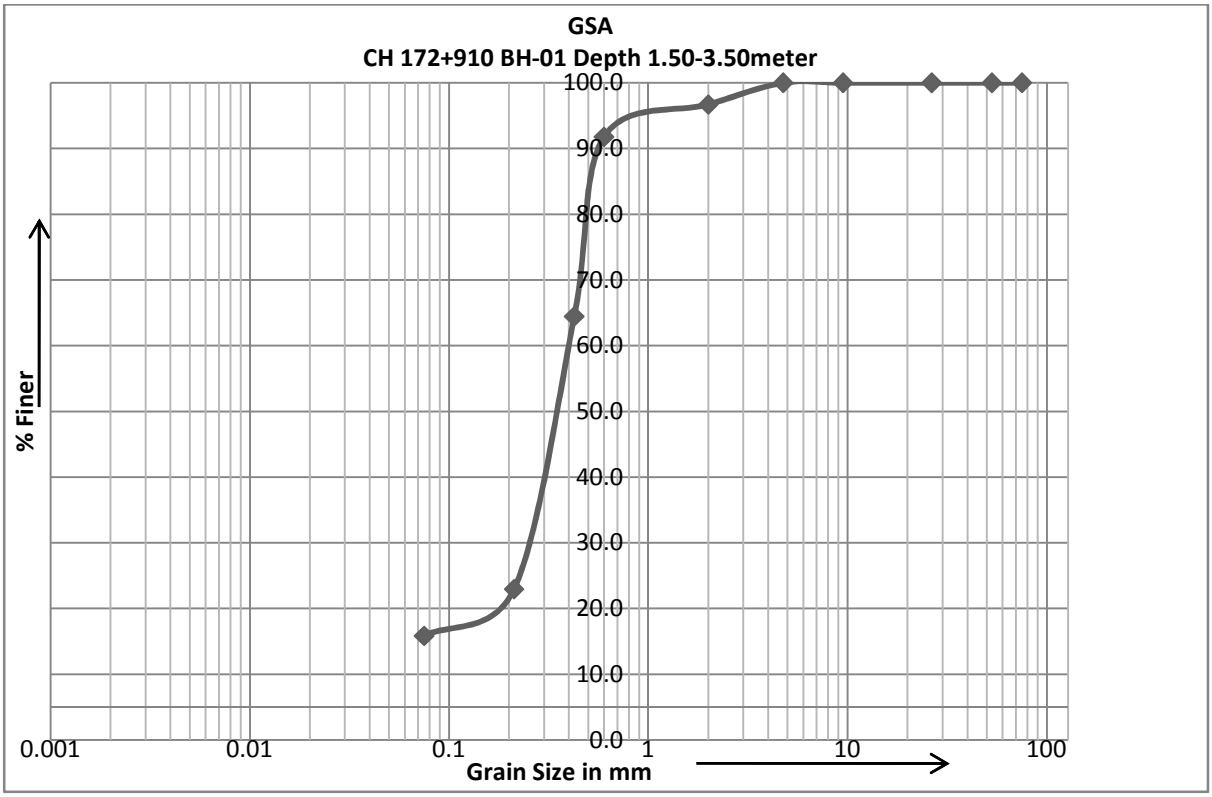

Direct Shear Test
CH-123+288 BH-01 Depth 1.50-3.00
Shear Stress in Kg/cm2
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
0.50
1.00
1.50
2.00
2.50
Normal Stress in Kg/cm2

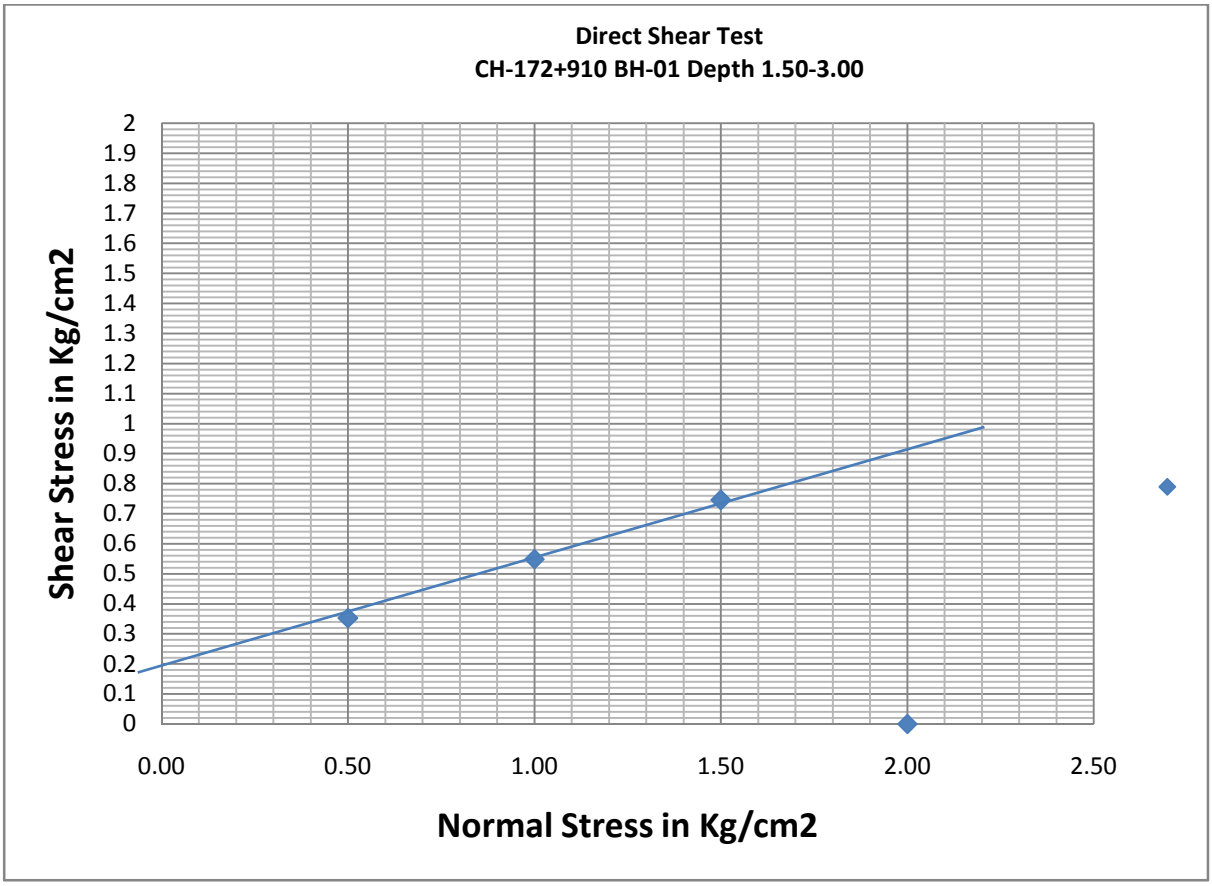

GSA
CH 154+200 BH-01 Depth 1.50-3.50meter
% Finer
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.001
0.01
0.1
1
10
100
Grain Size in mm


Direct Shear Test
CH-154+200 BH-01 Depth 1.50-3.00
Shear Stress in Kg/cm2
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
0.50
1.00
1.50
2.00
2.50
Normal Stress in Kg/cm2


GSA
CH 157+356 BH-01 Depth 1.50-3.50meter
% Finer
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.001
0.01
0.1
1
10
100
Grain Size in mm


Direct Shear Test
CH-157+356 BH-01 Depth 1.50-3.00
Shear Stress in Kg/cm2
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
0.50
1.00
1.50
2.00
2.50
Normal Stress in Kg/cm2


GSA
CH 172+910 BH-01 Depth 1.50-3.50meter
% Finer
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.001
0.01
0.1
1
10
100
Grain Size in mm


Direct Shear Test
CH-172+910 BH-01 Depth 1.50-3.00
Shear Stress in Kg/cm2
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
0.50
1.00
1.50
2.00
2.50
Normal Stress in Kg/cm2

6.0 Summery of Bearing capacity/Pile capacity of Bores

Sr. No	Chainage	Bore Hole No	Type of Foundation/ Size	Depth of Foundation	Bearing capacity /Vertical Pile Capacity/Well Capacity	Unit
1.	102+427	01	Pile/1.20 meter Diameter	25.00	325	Tons
				27.00	400	
				28.50	450	
		02		24.80	325	
				26.80	400	
				29.50	450	
		03		25.20	325	
				27.00	400	
				29.50	450	
2.	112+800	01	Raft (5*10 Meter)	1	15.48	Tons/m^2
				3	28.54	
		02		1	12.05	
				3	20.44	
		03		1	13.45	
				3	21.01	
3.	115+751	01	Pile/1.20 meter Diameter	25.00	325	Tons
				26.50	400	
				27.50	450	
		02		25.00	325	
				26.70	400	
				28.00	450	
		03		24.50	325	
				27.00	400	
				28.70	450	
4.	123+100	01	Pile/1.20 meter Diameter	22.50	325	Tons
				26.00	400	
				29.00	450	
		02		22.00	325	
				23.50	400	
				24.00	450	
		03		21.20	325	
				23.00	400	
				24.00	450	
		04		22.50	325	
				24.00	400	
				26.50	450	

Sr. No	Chainage	Bore Hole No	Type of Foundation/ Size	Depth of Foundation	Bearing capacity /Vertical Pile Capacity/Well Capacity		Unit
5.	123+288	01	Pile/1.20 meter Diameter	22.50	325		Tons
				24.00	400		
				25.00	450		
		02		22.00	325		
				23.50	400		
				24.50	450		
		03		21.50	325		
				23.50	400		
				25.50	450		
6.	154+200	01	Pile/1.20 meter Diameter	21.50	325		Tons
				22.50	400		
				23.50	450		
		02		21.50	325		
				22.70	400		
				23.50	450		
		03		21.60	325		
				22.80	400		
				23.60	450		
7.	157+356	01	Well	25.00	Well Dia	Capacity	T/m^2
					8.00	112.84	
					10.00	114.62	
				30.00	8.00	142.51	
					10.00	144.46	
				35.00	8.00	173.81	
					10.00	175.91	
		02		25.00	8.00	128.11	
					10.00	130.26	
				30.00	8.00	164.55	
					10.00	166.95	
				35.00	8.00	189.92	
					10.00	192.31	
		03		25.00	8.00	129.01	
					10.00	132.66	
				30.00	8.00	165.35	
					10.00	169.15	
				35.00	8.00	189.10	
					10.00	193.30	
		04		25.00	8.00	128.20	
					10.00	131.40	
				30.00	8.00	164.34	
					10.00	170.15	
				35.00	8.00	185.20	
					10.00	190.50	

Sr. No	Chainage	Bore Hole No	Type of Foundation/ Size	Depth of Foundation	Bearing capacity /Vertical Pile Capacity/Well Capacity	Unit
8.	166+070	01	Raft (5*10 Meter)	1.00	14.10	T/m^2
				3.00	22.70	
		02		1.00	13.41	
				3.00	21.54	
9.	172+910	01	Raft (5*10 Meter)	1.00	9.01	T/m^2
				3.00	13.16	
		02		1.00	10.29	
				3.00	11.12	

For Parikshan Laboratory

PARIKSHAN LABORATORY INDORE

Authorized Signatory

7.0Reference

Sr. No	IS CODE No.	TITLE OF CODE
1	IS 1892:1979	CODE OF PRACTICE FOR. SUBSURFACE INVESTIGATION FOR. FOUNDATIONS.
2	IS 2131:1981	METHOD FOR STANDARD PENETRATION TEST FOR SOILS.
3	IS 2132 : 1986	CODE OF PRACTICE FOR THIN-WALLED TUBE SAMPLING OF SOILS.
4	IS 2720 (Various Parts)	METHOD OF TEST OF SOIL.
5	IS 4078:1980	CODE OF PRACTICE FOR INDEXING AND STORAGE OF DRILL CORES.
6	IS 4464:1985	CODE OF PRACTICE FOR PRESENTATION OF DRILLING INFORMATION AND CORE DESCRIPTION IN FOUNDATION INVESTIGATION.
7	IS 6935:1973	METHOD FOR DETERMINATION OF WATER LEVEL IN A BORE HOLE.
8	IS 6926:1976	DIAMOND CORE DRILLING - SITE INVESTIGATION FOR RIVER VALLEY PROJECTS.
9	IS 6403:1981	CODE OF PRACTICE FOR DETERMINATION OF BEARING CAPACITY OF SHALLOW FOUNDATIONS.
10	IS 13365 (P-1):1998	QUANTITATIVE CLASSIFICATION SYSTEM OF ROCK MASSES.
11	IS 12070:1987	CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF SHALLOW FOUNDATIONS ON ROCKS.
12	IRC 78-2014	STANDARD SPECIFICATION AND CODE OF PRACTICE FOR ROAD AND BRIDGES.
13	IS-2911-2010 (Part-1)	DESIGN AND CONSTRUCTION OF PILE FOUNDATION

ANNEXURE-1

PILE/WELL CAPACITY CALULATION

CH- 102+427 BH- 1

1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-9	0.5	9.0	15.69	18	8	1	18	1
2		-9	-16.5	9.0	16.5	13.72	20	8	1	20	1
3		-16.5	-27	16.5	27.0	20.59	17	8.1	1	17	1
4		-27	-35	27.0	35.0	21.57	16	8	1	16	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-25.0	m
Depth from G.L.corresponding to F.L.	=	25.0	m
Pile Embedment length	=	24.5	m
Total Pile Length, L	=	24.5	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS

Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1	=	8.5	m
Pile embedment in the layer, h_1	=	8.5	m

Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$

Where, Reduction factor, α	=	1	
Cohesion, c_1	=	15.69	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil , γ_1	=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$	=	34	kN/m^2
Angle of wall friction, δ	=	18	deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$	=	32.028	m^2
Ultimate Skin Resistance, Q_{s1} = $(\alpha*c_1 + K*P_{d1}*\tan\delta) \times A_{s1}$	=	856.1495	kN

2.1.2 Layer-2:

Layer thickness, L_2	=	7.5	m
Pile embedment in the layer, h_1	=	7.5	m

Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$

Where, Reduction factor, α	=	1	
Cohesion, c_2	=	13.72	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_2	=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$	=	98	kN/m^2
Angle of wall friction, δ	=	20	deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$	=	28.26	m^2
Ultimate Skin Resistance, Q_{s2} = $(\alpha*c_2 + K*P_{d2}*\tan\delta) \times A_{s2}$	=	1395.181	kN

2.1.3 Layer-3:

Layer thickness, L_3	=	10.5	m
Pile embedment in the layer, h_3	=	8.5	m

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$

Where, Reduction factor, α	=	1	
Cohesion, c_3	=	20.59	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_3	=	8.1	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d3} $P_{d3} = P_{d2} + h_2/2 *\gamma_2 + h_3/2 *\gamma_3$	=	162.425	kN/m^2

	Angle of wall friction, δ	=	17	deg.
	Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	32.028	m^2
	Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$	=	2249.057	kN
2.1.4	Layer-4:			
	Layer thickness, L_4	=	8	m
	Pile embedment in the layer, h_4	=	-2	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	1	
	Cohesion, c_4	=	21.57	kN/m^2
	Coefficient of Lateral earth pressure, K	=	1	
	Unit weight of soil, γ_4	=	8	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$	=	188.85	kN/m^2
	Angle of wall friction, δ	=	16	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-7.536	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	-570	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	3930	kN
2.1.4	Layer-5:			
	Layer thickness, L_4	=	-35	m
	Pile embedment in the layer, h_4	=	0	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	0	
	Cohesion, c_4	=	25	kN/m^2
	Coefficient of Lateral earth pressure, K	=	0	
	Unit weight of soil, γ_4	=	0	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$	=	180.85	kN/m^2
	Angle of wall friction, δ	=	0	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	0	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	0	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	7574	kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c * N_c + P_d * N_q) * A_p$

Where,	Cohesion at Pile Toe, c	=	20.59	kN/m^2
	Bearing Capacity Factor, N_c	=	9	

	Effective overburden pressure at Pile tip, P_d			
	$P_d = P_{d6} + h_6/2 * \gamma_6$	=	180.85	kN/m^2
	Angle of internal friction at pile toe,ϕ	=	17	
	Bearing Capacity Factor, N_q	=	4	
	Area of Pile at toe, A_p	=	1.1304	m^2
	Ultimate End bearing Resistance, $Q_b = (c* N_c + P_d * N_q) * A_p$	=	1027	kN

2.3 Self Weight of the Pile, Wp

	Self weight of the Pile , $W_p = A_p * L * \gamma_p$			
	Where, Area of pile, A_p	=	1.1304	m^2
	Total Length of Pile , L	=	25	m
	Unit Weight of Pile material, γ_p	=	15	kN/m^3
	Self weight of the Pile , $W_p = A_p * L * \gamma_p$	=	415	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

	Where, Ultimate End Bearing, Qb	=	1027	kN
	Ultimate Skin Resistance, Qs	=	7574	kN
	Self weight of the Pile, Wp	=	415	kN
	Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$	=	8186	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

	Where, Ultimate Capacity of Pile, Q_{ult}	=	8186	kN
	Factor of Safety	=	2.5	
	Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS	=	3274	kN
			327.4395	Ton

3.0 Tension Capacity of Pile

	Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$			
	Where, Ultimate Skin Resistance, Qs	=	3930	kN
	Self weight of the Pile, Wp	=	415	kN
	Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$	=	3035	kN
	Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS			
	Where, FoS = Factor of Safety	=	2.5	
	Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS	=	1214	kN

4.0 Fixity Depth Calculation

	Pile fixity condition at top	=	fixed	
	Type of Soil in fixity zone	=	Sand	
	Modulus of subgrade reaction at fixity zone, K	=	5000	kN/m3
	Elastic modulus of concrete, Ec = 5000 * SQRT(fck)			
	Where, fck = Characteristic strength of concrete	=	35	N/mm^2

Elastic modulus of concrete, Ec = 5000 * SQRT(fck)	=	29580.4	N/mm^2
	=	29580399	kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4			
where, D = Diameter of the pile	=	1.2	m
Moment of inertia of Pile, I = 3.14 /64 *D^4	=	0.102	m^4
Relative Stiffness factor, T = (EI/K)^(1/5)	=	3.597	m
Unsupported length of pile, L1	=	0.0	m
Ratio of L1/T or L1/R	=	0	
Lf/T or Lf /R =	=	2.15	
Therefore, Fixity Depth , Lf =	=	7.7	m
Fixity depth, in terms of diameter of pile	=	6.44	times the dia

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin	=	> 4T	
Where, T = Relative stiffness factor	=	3.60	m
Let us consider a minimum length of pile , Lmin = 4.5 times T	=	16.2	m

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top	=	fixed	
The horizontal capacity, H	=	12*E*I*y / (L1+Lf)^3	
Where, y = Diaplacement of pile at head	=	0.005	m
E = Elastic modulus of pile material	=	29580399	kN/m^2
I = Moment of inertia	=	0.102	m^4
L1 = Unsupported length of pile	=	0.00	m
Lf = Fixity length of pile	=	7.73	m
The horizontal capacity, H = 12*E*I*y / (L1+Lf)^3	=	390.49	kN

7.0 Summary of Calculations

Pile Diameter	=	1.20	m
Pile Cut-off level	=	-0.5	m
Pile Founding Level	=	-25.0	m
Safe Vertical Capacity	=	3274	kN
Safe Tension Capacity	=	1214	kN
Pile head Condition	=	fixed	
Grade of Concrete	=	35.00	N/mm2
Horizontal capacity for a Displacement of 5.0 mm	=	390	kN
Minimum Pile length for Lateral Capacity	=	16.2	m
Fixity Depth, Lf	=	7.7	m

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1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-9	0.5	9.0	7.84	21	8.1	1	21	1
2		-9	-16.5	9.0	16.5	21.57	17	8	1	17	1
3		-16.5	-27	16.5	27.0	20.59	18	8	1	18	1
4		-27	-35	27.0	35.0	23.53	16	8	1	16	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-25.0	m
Depth from G.L.corresponding to F.L.	=	25.0	m
Pile Embedment length	=	24.5	m
Total Pile Length, L	=	24.5	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp
Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile
Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1 = 8.5 m

Pile embedment in the layer, h_1		=	8.5	m
Ultimate Skin Resistance, Q_{s1} =	$(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$			
Where, Reduction factor, α		=	1	
Cohesion, c_1		=	7.84	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil , γ_1		=	8.1	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$		=	34.425	kN/m^2
Angle of wall friction, δ		=	21	deg.
Surface area of Pile in layer 1, A_{s1} = pi * D * h_1		=	32.028	m^2
Ultimate Skin Resistance, Q_{s1} =	$(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$	=	674.0991	kN

2.1.2 Layer-2:

Layer thickness, L_2		=	7.5	m
Pile embedment in the layer, h_1		=	7.5	m
Ultimate Skin Resistance, Q_{s2} =	$(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$			
Where, Reduction factor, α		=	1	
Cohesion, c_2		=	21.57	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil, γ_2		=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$		=	98.85	kN/m^2
Angle of wall friction, δ		=	17	deg.
Surface area of Pile in layer 2, A_{s2} = pi * D * h_2		=	28.26	m^2
Ultimate Skin Resistance, Q_{s2} =	$(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$	=	1463.168	kN

2.1.3 Layer-3:

Layer thickness, L_3		=	10.5	m
Pile embedment in the layer, h_3		=	8.5	m
Ultimate Skin Resistance, Q_{s3} =	$(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$			
Where, Reduction factor, α		=	1	
Cohesion, c_3		=	20.59	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil, γ_3		=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d3} $P_{d3} = P_{d2} + h_2/2 *\gamma_2 + h_3/2 *\gamma_3$		=	162.85	kN/m^2
Angle of wall friction, δ		=	18	deg.
Surface area of Pile in layer 3, A_{s3} = pi * D * h_3		=	32.028	m^2

	Ultimate Skin Resistance, Q_{s3} =	$(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$	=	2353.241	kN
2.1.4	Layer-4:				
	Layer thickness, L_4		=	8	m
	Pile embedment in the layer, h_4		=	-2	m
	Ultimate Skin Resistance, Q_{s4} =	$(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α		=	1	
	Cohesion, c_4		=	23.53	kN/m^2
	Coefficient of Lateral earth pressure, K		=	1	
	Unit weight of soil, γ_4		=	8	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}				
	$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$		=	188.85	kN/m^2
	Angle of wall friction, δ		=	16	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$		=	-7.536	m^2
	Ultimate Skin Resistance, Q_{s4} =	$(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	-585	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$		=	3905	kN
2.1.4	Layer-5:				
	Layer thickness, L_4		=	-35	m
	Pile embedment in the layer, h_4		=	0	m
	Ultimate Skin Resistance, Q_{s4} =	$(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α		=	0	
	Cohesion, c_4		=	25	kN/m^2
	Coefficient of Lateral earth pressure, K		=	0	
	Unit weight of soil, γ_4		=	0	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}				
	$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$		=	180.85	kN/m^2
	Angle of wall friction, δ		=	0	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$		=	0	m^2
	Ultimate Skin Resistance, Q_{s4} =	$(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	0	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$		=	7722	kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c * N_c + P_d * N_q) * A_p$

Where,	Cohesion at Pile Toe, c	=	20.59	kN/m^2
	Bearing Capacity Factor, N_c	=	9	
	Effective overburden pressure at Pile tip, P_d			

$P_d = P_{d6} + h_6/2 * \gamma_6$	=	180.85	kN/m^2
Angle of internal friction at pile toe,ϕ	=	18	
Bearing Capacity Factor, N_q	=	4	
Area of Pile at toe, A_p	=	1.1304	m^2
Ultimate End bearing Resistance, $Q_b = (c* N_c + P_d * N_q) * A_p$	=	1027	kN

2.3 Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$			
Where, Area of pile, A_p	=	1.1304	m^2
Total Length of Pile , L	=	25	m
Unit Weight of Pile material, γ_p	=	15	kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$	=	415	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb	=	1027	kN
Ultimate Skin Resistance, Qs	=	7722	kN
Self weight of the Pile, Wp	=	415	kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$	=	8334	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

Where, Ultimate Capacity of Pile, Q_{ult}	=	8334	kN
Factor of Safety	=	2.5	
Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS	=	3333	kN
		333.3403	Ton

3.0 Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$			
Where, Ultimate Skin Resistance, Qs	=	3905	kN
Self weight of the Pile, Wp	=	415	kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$	=	3019	kN
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS			
Where, FoS = Factor of Safety	=	2.5	
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS	=	1208	kN

4.0 Fixity Depth Calculation

Pile fixity condition at top	=	fixed	
Type of Soil in fixity zone	=	Sand	
Modulus of subgrade reaction at fixity zone, K	=	5000	kN/m3
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)			

Where, fck = Characteristic strength of concrete		=	35	N/mm^2
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)		=	29580.4	N/mm^2
		=	29580399	kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4				
where, D = Diameter of the pile		=	1.2	m
Moment of inertia of Pile, I = 3.14 /64 *D^4		=	0.102	m^4
Relative Stiffness factor, T = (EI/K)^(1/5)		=	3.597	m
Unsupported length of pile, L1		=	0.0	m
Ratio of L1/T or L1/R		=	0	
Lf/T or Lf /R =		=	2.16	
Therefore, Fixity Depth , Lf =		=	7.8	m
Fixity depth, in terms of diameter of pile		=	6.47	times the dia

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin		=	> 4T	
Where, T = Relative stiffness factor		=	3.60	m
Let us consider a minimum length of pile , Lmin =	4.5 times T	=	16.2	m

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top	=	fixed	
The horizontal capacity, H	=	12*E*I*y / (L1+Lf)^3	
Where, y = Diaplacement of pile at head	=	0.005	m
E = Elastic modulus of pile material	=	29580399	kN/m^2
I = Moment of inertia	=	0.102	m^4
L1 = Unsupported length of pile	=	0.00	m
Lf = Fixity length of pile	=	7.77	m
The horizontal capacity, H = 12*E*I*y / (L1+Lf)^3	=	385.09	kN

7.0 Summary of Calculations

Pile Diameter		=	1.20	m
Pile Cut-off level		=	-0.5	m
Pile Founding Level		=	-25.0	m
Safe Vertical Capacity		=	3333	kN
Safe Tension Capacity		=	1208	kN
Pile head Condition		=	fixed	
Grade of Concrete		=	35.00	N/mm2
Horizontal capacity for a Displacement of	5.0 mm	=	385	kN
Minimum Pile length for Lateral Capacity		=	16.2	m
Fixity Depth, Lf		=	7.8	m

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1.0Input

1.1Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-9	0.5	9.0	19.61	17	8	1	17	1
2		-9	-16.5	9.0	16.5	15.69	23	7.6	1	23	1
3		-16.5	-27	16.5	27.0	19.61	18	7.5	1	18	1
4		-27	-35	27.0	35.0	18.63	21	7.6	1	21	1

1.2Pile Details

Existing ground level	=	0m
Pile Diameter, D	=	1.2m
Pile Cut-off level	=	-0.5m
Dredge level	=	-0.5m
Scour level	=	-0.5m
Pile Founding level	=	-24.5m
Depth from G.L.corresponding to F.L.	=	24.5m
Pile Embedment length	=	24.0m
Total Pile Length, L	=	24.0m
Pile Density	=	25.0kN/m^3
Factor of Safety	=	2.5
Pile Fixity condition at top	=	fixed(Fixed or Free)
Grade of Concrete	=	35N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000kN/m3
Type of soil in fixity zone	=	Sand(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0mm

2.0Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1	=	8.5m
Pile embedment in the layer, h_1	=	8.5m

Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$

Where, Reduction factor, α	=	1
Cohesion, c_1	=	19.61kN/m^2
Coefficient of Lateral earth pressure, K	=	1
Unit weight of soil , γ_1	=	8kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1}		
$P_{d1} = h_1/2 * \gamma_1$	=	34kN/m^2
Angle of wall friction, δ	=	17deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$	=	32.028m^2
Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$	=	960.816kN

2.1.2 Layer-2:

Layer thickness, L_2	=	7.5m
Pile embedment in the layer, h_1	=	7.5m

Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$

Where, Reduction factor, α	=	1
Cohesion, c_2	=	15.69kN/m^2
Coefficient of Lateral earth pressure, K	=	1
Unit weight of soil, γ_2	=	7.6kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2}		
$P_{d2} = P_{d1} + h_1/2 * \gamma_1 + h_2/2 * \gamma_2$	=	96.5kN/m^2
Angle of wall friction, δ	=	23deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$	=	28.26m^2
Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$	=	1600.326kN

2.1.3 Layer-3:

Layer thickness, L_3	=	10.5m
Pile embedment in the layer, h_3	=	8m

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$

Where, Reduction factor, α	=	1
Cohesion, c_3	=	19.61kN/m^2
Coefficient of Lateral earth pressure, K	=	1
Unit weight of soil, γ_3	=	7.5kN/m^3
Effective Overburden Pressure at middle of layer, P_{d3}		
$P_{d3} = P_{d2} + h_2/2 * \gamma_2 + h_3/2 * \gamma_3$	=	155kN/m^2
Angle of wall friction, δ	=	18deg.
Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	30.144m^2

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$ = 2108.43kN

2.1.4 Layer-4:

Layer thickness, L_4 = 8m

Pile embedment in the layer, h_4 = -2.5m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α = 1

Cohesion, c_4 = 18.63kN/m^2

Coefficient of Lateral earth pressure, K = 1

Unit weight of soil, γ_4 = 7.6kN/m^3

Effective Overburden Pressure at middle of layer, P_{d4}

$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$ = 175.5kN/m^2

Angle of wall friction, δ = 21deg.

Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$ = -9.42m^2

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$ = -810kN

Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$ = 3860kN

2.1.4 Layer-5:

Layer thickness, L_4 = -35m

Pile embedment in the layer, h_4 = 0m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α = 0

Cohesion, c_4 = 25kN/m^2

Coefficient of Lateral earth pressure, K = 0

Unit weight of soil, γ_4 = 0kN/m^3

Effective Overburden Pressure at middle of layer, P_{d4}

$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$ = 166kN/m^2

Angle of wall friction, δ = 0deg.

Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$ = 0m^2

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$ = 0kN

Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$ = 7569kN

2.2Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c * N_c + P_d * N_q) * A_p$

Where, Cohesion at Pile Toe, c = 19.61kN/m^2

Bearing Capacity Factor, N_c = 9

Effective overburden pressure at Pile tip, P_d

$P_d = P_{d6} + h_6/2 * \gamma_6$ = 166kN/m^2

Angle of internal friction at pile toe,ϕ = 18

Bearing Capacity Factor, N_q	=	4
Area of Pile at toe, A_p	=	1.1304m^2
Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$	=	950kN

2.3Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$		
Where, Area of pile, A_p	=	1.1304m^2
Total Length of Pile , L	=	24m
Unit Weight of Pile material, γ_p	=	15kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$	=	407kN

2.4Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb	=	950kN
Ultimate Skin Resistance, Qs	=	7569kN
Self weight of the Pile, Wp	=	407kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$	=	8112kN

2.5Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

Where, Ultimate Capacity of Pile, Q_{ult}	=	8112kN
Factor of Safety	=	2.5
Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS	=	3245kN 324.4689Ton

3.0Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$		
Where, Ultimate Skin Resistance, Qs	=	3860kN
Self weight of the Pile, Wp	=	407kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$	=	2980kN
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS		
Where, FoS = Factor of Safety	=	2.5
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS	=	1192kN

4.0Fixity Depth Calculation

Pile fixity condition at top	=	fixed
Type of Soil in fixity zone	=	Sand
Modulus of subgrade reaction at fixity zone, K	=	5000kN/m3
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)		
Where, fck = Characteristic strength of concrete	=	35N/mm^2
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)	=	29580.4N/mm^2
	=	29580399kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4		
where, D = Diameter of the pile	=	1.2m

Moment of inertia of Pile, I = 3.14 /64 *D^4		=	0.102m^4
Relative Stiffness factor, T = (EI/K)^(1/5)		=	3.597m
Unsupported length of pile, L1		=	0.0m
Ratio of L1/T or L1/R		=	0
Lf/T or Lf /R =		=	2.15
Therefore, Fixity Depth , Lf =		=	7.7m
Fixity depth, in terms of diameter of pile		=	6.44times the dia

5.0Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin		=	> 4T
Where, T = Relative stiffness factor		=	3.60m
Let us consider a minimum length of pile , Lmin =	4.5 times T	=	16.2m

6.0Horizontal Capacity of the Pile

Pile fixity condition at top		=	fixed
The horizontal capacity, H		=	12*E*I*y / (L1+Lf)^3
Where, y = Diaplacement of pile at head		=	0.005m
E = Elastic modulus of pile material		=	29580399kN/m^2
I = Moment of inertia		=	0.102m^4
L1 = Unsupported length of pile		=	0.00m
Lf = Fixity length of pile		=	7.73m
The horizontal capacity, H =	12*E*I*y / (L1+Lf)^3	=	390.49kN

7.0Summary of Calculations

Pile Diameter		=	1.20m
Pile Cut-off level		=	-0.5m
Pile Founding Level		=	-24.5m
Safe Vertical Capacity		=	3245kN
Safe Tension Capacity		=	1192kN
Pile head Condition		=	fixed
Grade of Concrete		=	35.00N/mm2
Horizontal capacity for a Displacement of	5.0mm	=	390kN
Minimum Pile length for Lateral Capacity		=	16.2m
Fixity Depth, Lf		=	7.7m

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1.0Input

1.1Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-9	0.5	9.0	19.61	17	8	1	17	1
2		-9	-16.5	9.0	16.5	15.69	23	7.6	1	23	1
3		-16.5	-27	16.5	27.0	19.61	18	7.5	1	18	1
4		-27	-35	27.0	35.0	18.63	21	7.6	1	21	1

1.2Pile Details

Existing ground level	=	0m
Pile Diameter, D	=	1.2m
Pile Cut-off level	=	-0.5m
Dredge level	=	-0.5m
Scour level	=	-0.5m
Pile Founding level	=	-24.5m
Depth from G.L.corresponding to F.L.	=	24.5m
Pile Embedment length	=	24.0m
Total Pile Length, L	=	24.0m
Pile Density	=	25.0kN/m^3
Factor of Safety	=	2.5
Pile Fixity condition at top	=	fixed(Fixed or Free)
Grade of Concrete	=	35N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000kN/m3
Type of soil in fixity zone	=	Sand(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0mm

2.0Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1	=	8.5m
Pile embedment in the layer, h_1	=	8.5m

Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$

Where, Reduction factor, α	=	1
Cohesion, c_1	=	19.61kN/m^2
Coefficient of Lateral earth pressure, K	=	1
Unit weight of soil , γ_1	=	8kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1}		
$P_{d1} = h_1/2 * \gamma_1$	=	34kN/m^2
Angle of wall friction, δ	=	17deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$	=	32.028m^2
Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$	=	960.816kN

2.1.2 Layer-2:

Layer thickness, L_2	=	7.5m
Pile embedment in the layer, h_1	=	7.5m

Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$

Where, Reduction factor, α	=	1
Cohesion, c_2	=	15.69kN/m^2
Coefficient of Lateral earth pressure, K	=	1
Unit weight of soil, γ_2	=	7.6kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2}		
$P_{d2} = P_{d1} + h_1/2 * \gamma_1 + h_2/2 * \gamma_2$	=	96.5kN/m^2
Angle of wall friction, δ	=	23deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$	=	28.26m^2
Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$	=	1600.326kN

2.1.3 Layer-3:

Layer thickness, L_3	=	10.5m
Pile embedment in the layer, h_3	=	8m

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$

Where, Reduction factor, α	=	1
Cohesion, c_3	=	19.61kN/m^2
Coefficient of Lateral earth pressure, K	=	1
Unit weight of soil, γ_3	=	7.5kN/m^3
Effective Overburden Pressure at middle of layer, P_{d3}		
$P_{d3} = P_{d2} + h_2/2 * \gamma_2 + h_3/2 * \gamma_3$	=	155kN/m^2
Angle of wall friction, δ	=	18deg.
Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	30.144m^2

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$ = 2108.43kN

2.1.4 Layer-4:

Layer thickness, L_4 = 8m

Pile embedment in the layer, h_4 = -2.5m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α = 1

Cohesion, c_4 = 18.63kN/m^2

Coefficient of Lateral earth pressure, K = 1

Unit weight of soil, γ_4 = 7.6kN/m^3

Effective Overburden Pressure at middle of layer, P_{d4}

$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$ = 175.5kN/m^2

Angle of wall friction, δ = 21deg.

Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$ = -9.42m^2

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$ = -810kN

Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$ = 3860kN

2.1.4 Layer-5:

Layer thickness, L_4 = -35m

Pile embedment in the layer, h_4 = 0m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α = 0

Cohesion, c_4 = 25kN/m^2

Coefficient of Lateral earth pressure, K = 0

Unit weight of soil, γ_4 = 0kN/m^3

Effective Overburden Pressure at middle of layer, P_{d4}

$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$ = 166kN/m^2

Angle of wall friction, δ = 0deg.

Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$ = 0m^2

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$ = 0kN

Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$ = 7569kN

2.2Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c * N_c + P_d * N_q) * A_p$

Where, Cohesion at Pile Toe, c = 19.61kN/m^2

Bearing Capacity Factor, N_c = 9

Effective overburden pressure at Pile tip, P_d

$P_d = P_{d6} + h_6/2 * \gamma_6$	=	166kN/m^2
Angle of internal friction at pile toe,ϕ	=	18
Bearing Capacity Factor, N_q	=	4
Area of Pile at toe, A_p	=	1.1304m^2
Ultimate End bearing Resistance, $Q_b = (c* N_c + P_d * N_q) * A_p$	=	950kN

2.3Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$

Where, Area of pile, A_p	=	1.1304m^2
Total Length of Pile , L	=	24m
Unit Weight of Pile material, γ_p	=	15kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$	=	407kN

2.4Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb	=	950kN
Ultimate Skin Resistance, Qs	=	7569kN
Self weight of the Pile, Wp	=	407kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$	=	8112kN

2.5Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

Where, Ultimate Capacity of Pile, Q_{ult}	=	8112kN
Factor of Safety	=	2.5
Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS	=	3245kN 324.4689Ton

3.0Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$

Where, Ultimate Skin Resistance, Qs	=	3860kN
Self weight of the Pile, Wp	=	407kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$	=	2980kN

Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS

Where, FoS = Factor of Safety	=	2.5
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS	=	1192kN

4.0Fixity Depth Calculation

Pile fixity condition at top	=	fixed
Type of Soil in fixity zone	=	Sand
Modulus of subgrade reaction at fixity zone, K	=	5000kN/m3
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)		
Where, fck = Characteristic strength of concrete	=	35N/mm^2

Elastic modulus of concrete, Ec = 5000 * SQRT(fck)		=	29580.4N/mm^2
		=	29580399kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4			
where, D = Diameter of the pile		=	1.2m
Moment of inertia of Pile, I = 3.14 /64 *D^4		=	0.102m^4
Relative Stiffness factor, T = (EI/K)^(1/5)		=	3.597m
Unsupported length of pile, L1		=	0.0m
Ratio of L1/T or L1/R		=	0
Lf/T or Lf /R =		=	2.15
Therefore, Fixity Depth , Lf =		=	7.7m
Fixity depth, in terms of diameter of pile		=	6.44times the dia

5.0Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin		=	> 4T
Where, T = Relative stiffness factor		=	3.60m
Let us consider a minimum length of pile , Lmin =	4.5 times T	=	16.2m

6.0Horizontal Capacity of the Pile

Pile fixity condition at top		=	fixed
The horizontal capacity, H		=	12*E*I*y / (L1+Lf)^3
Where, y = Diaplacement of pile at head		=	0.005m
E = Elastic modulus of pile material		=	29580399kN/m^2
I = Moment of inertia		=	0.102m^4
L1 = Unsupported length of pile		=	0.00m
Lf = Fixity length of pile		=	7.73m
The horizontal capacity, H =	12*E*I*y / (L1+Lf)^3	=	390.49kN

7.0Summary of Calculations

Pile Diameter		=	1.20m
Pile Cut-off level		=	-0.5m
Pile Founding Level		=	-24.5m
Safe Vertical Capacity		=	3245kN
Safe Tension Capacity		=	1192kN
Pile head Condition		=	fixed
Grade of Concrete		=	35.00N/mm2
Horizontal capacity for a Displacement of	5.0mm	=	390kN
Minimum Pile length for Lateral Capacity		=	16.2m
Fixity Depth, Lf		=	7.7m

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1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-9	0.5	9.0	20.59	17	7.8	1	17	1
2		-9	-16.5	9.0	16.5	16.67	23	7.7	1	23	1
3		-16.5	-27	16.5	27.0	22.55	16	7.8	1	16	1
4		-27	-35	27.0	35.0	19.61	22	7.6	1	22	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-25.0	m
Depth from G.L.corresponding to F.L.	=	25.0	m
Pile Embedment length	=	24.5	m
Total Pile Length, L	=	24.5	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1		=	8.5	m
Pile embedment in the layer, h_1		=	8.5	m
Ultimate Skin Resistance, Q_{s1} =	$(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$			
Where, Reduction factor, α		=	1	
Cohesion, c_1		=	20.59	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil , γ_1		=	7.8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$		=	33.15	kN/m^2
Angle of wall friction, δ		=	17	deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$		=	32.028	m^2
Ultimate Skin Resistance, Q_{s1} =	$(\alpha*c_1 + K*P_{d1}*\tan\delta) \times A_{s1}$	=	983.8848	kN

2.1.2 Layer-2:

Layer thickness, L_2		=	7.5	m
Pile embedment in the layer, h_1		=	7.5	m
Ultimate Skin Resistance, Q_{s2} =	$(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$			
Where, Reduction factor, α		=	1	
Cohesion, c_2		=	16.67	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil, γ_2		=	7.7	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$		=	95.175	kN/m^2
Angle of wall friction, δ		=	23	deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$		=	28.26	m^2
Ultimate Skin Resistance, Q_{s2} =	$(\alpha*c_2 + K*P_{d2}*\tan\delta) \times A_{s2}$	=	1612.135	kN

2.1.3 Layer-3:

Layer thickness, L_3		=	10.5	m
Pile embedment in the layer, h_3		=	8.5	m
Ultimate Skin Resistance, Q_{s3} =	$(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$			
Where, Reduction factor, α		=	1	
Cohesion, c_3		=	22.55	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil, γ_3		=	7.8	kN/m^3

	Effective Overburden Pressure at middle of layer, P_{d3}			
	$P_{d3} = P_{d2} + h_2/2 * \gamma_2 + h_3/2 * \gamma_3$	=	157.2	kN/m^2
	Angle of wall friction, δ	=	16	deg.
	Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	32.028	m^2
	Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$	=	2165.166	kN
2.1.4	Layer-4:			
	Layer thickness, L_4	=	8	m
	Pile embedment in the layer, h_4	=	-2	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	1	
	Cohesion, c_4	=	19.61	kN/m^2
	Coefficient of Lateral earth pressure, K	=	1	
	Unit weight of soil, γ_4	=	7.6	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$	=	182.75	kN/m^2
	Angle of wall friction, δ	=	22	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-7.536	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	-704	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	4057	kN
2.1.4	Layer-5:			
	Layer thickness, L_4	=	-35	m
	Pile embedment in the layer, h_4	=	0	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	0	
	Cohesion, c_4	=	25	kN/m^2
	Coefficient of Lateral earth pressure, K	=	0	
	Unit weight of soil, γ_4	=	0	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$	=	175.15	kN/m^2
	Angle of wall friction, δ	=	0	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	0	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	0	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	7835	kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$

Where,	Cohesion at Pile Toe, c	=	22.55	kN/m^2
	Bearing Capacity Factor, N_c	=	9	
	Effective overburden pressure at Pile tip, P_d			
	$P_d = P_{d6} + h_6/2 * \gamma_6$	=	175.15	kN/m^2
	Angle of internal friction at pile toe,ϕ	=	16	
	Bearing Capacity Factor, N_q	=	4	
	Area of Pile at toe, A_p	=	1.1304	m^2
Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$		=	1021	kN

2.3 Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$

Where,	Area of pile, A_p	=	1.1304	m^2
	Total Length of Pile , L	=	25	m
	Unit Weight of Pile material, γ_p	=	15	kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$		=	415	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where,	Ultimate End Bearing, Qb	=	1021	kN
	Ultimate Skin Resistance, Qs	=	7835	kN
	Self weight of the Pile, Wp	=	415	kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$		=	8441	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

Where,	Ultimate Capacity of Pile, Q_{ult}	=	8441	kN
	Factor of Safety	=	2.5	
Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS		=	3376	kN

3.0 Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$

Where,	Ultimate Skin Resistance, Qs	=	4057	kN
	Self weight of the Pile, Wp	=	415	kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$		=	3120	kN

Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS

Where,	FoS = Factor of Safety	=	2.5	
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS		=	1248	kN

4.0 Fixity Depth Calculation

Pile fixity condition at top	=	fixed	
Type of Soil in fixity zone	=	Sand	
Modulus of subgrade reaction at fixity zone, K	=	5000	kN/m3

Elastic modulus of concrete, Ec = 5000 * SQRT(fck)				
Where, fck = Characteristic strength of concrete		=	35	N/mm^2
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)		=	29580.4	N/mm^2
		=	29580399	kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4				
where, D = Diameter of the pile		=	1.2	m
Moment of inertia of Pile, I = 3.14 /64 *D^4		=	0.102	m^4
Relative Stiffness factor, T = (EI/K)^(1/5)		=	3.597	m
Unsupported length of pile, L1		=	0.0	m
Ratio of L1/T or L1/R		=	0	
Lf/T or Lf /R =		=	2.14	
Therefore, Fixity Depth , Lf =		=	7.7	m
Fixity depth, in terms of diameter of pile		=	6.41	times the dia

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin		=	> 4T	
Where, T = Relative stiffness factor		=	3.60	m
Let us consider a minimum length of pile , Lmin =	4.5 times T	=	16.2	m

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top		=	fixed	
The horizontal capacity, H		=	12*E*I*y / (L1+Lf)^3	
Where, y = Diaplacement of pile at head		=	0.005	m
E = Elastic modulus of pile material		=	29580399	kN/m^2
I = Moment of inertia		=	0.102	m^4
L1 = Unsupported length of pile		=	0.00	m
Lf = Fixity length of pile		=	7.70	m
The horizontal capacity, H =	12*E*I*y / (L1+Lf)^3	=	395.99	kN

7.0 Summary of Calculations

Pile Diameter	=	1.20	m
Pile Cut-off level	=	-0.5	m
Pile Founding Level	=	-25.0	m
Safe Vertical Capacity	=	3376	kN
Safe Tension Capacity	=	1248	kN

Pile head Condition			=	fixed	
Grade of Concrete			=	35.00	N/mm2
Horizontal capacity for a Displacement of	5.0	mm	=	396	kN
Minimum Pile length for Lateral Capacity			=	16.2	m
Fixity Depth, Lf			=	7.7	m

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1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-6	0.5	6.0	17.65	22	8.1	1	22	1
2		-6	-13.5	6.0	13.5	17.65	23	8	1	23	1
3		-13.5	-24	13.5	24.0	21.57	19	7.9	1	19	1
4		-24	-40	24.0	40.0	19.61	18	7.6	1	18	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-22.5	m
Depth from G.L.corresponding to F.L.	=	22.5	m
Pile Embedment length	=	22.0	m
Total Pile Length, L	=	22.0	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1	=	5.5	m
Pile embedment in the layer, h_1	=	5.5	m

Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$

Where, Reduction factor, α	=	1	
Cohesion, c_1	=	17.65	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil , γ_1	=	8.1	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$	=	22.275	kN/m^2
Angle of wall friction, δ	=	22	deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$	=	20.724	m^2
Ultimate Skin Resistance, Q_{s1} = $(\alpha*c_1 + K*P_{d1}*\tan\delta) \times A_{s1}$	=	552.1835	kN

2.1.2 Layer-2:

Layer thickness, L_2	=	7.5	m
Pile embedment in the layer, h_1	=	7.5	m

Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$

Where, Reduction factor, α	=	1	
Cohesion, c_2	=	17.65	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_2	=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$	=	74.55	kN/m^2
Angle of wall friction, δ	=	23	deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$	=	28.26	m^2
Ultimate Skin Resistance, Q_{s2} = $(\alpha*c_2 + K*P_{d2}*\tan\delta) \times A_{s2}$	=	1392.559	kN

2.1.3 Layer-3:

Layer thickness, L_3	=	10.5	m
Pile embedment in the layer, h_3	=	9	m

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$

Where, Reduction factor, α	=	1	
Cohesion, c_3	=	21.57	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_3	=	7.9	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d3} $P_{d3} = P_{d2} + h_2/2 *\gamma_2 + h_3/2 *\gamma_3$	=	140.1	kN/m^2
Angle of wall friction, δ	=	19	deg.
Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	33.912	m^2

Ultimate Skin Resistance, Q_{s3} =	$(\alpha^*c_3 + K^*P_{d3}^*\tan\delta) \times A_{s3}$	=	2366.513	kN

2.1.4 Layer-4:

Layer thickness, L_4	=	16	m
Pile embedment in the layer, h_4	=	-1.5	m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α	=	1	
Cohesion, c_4	=	19.61	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_4	=	7.6	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d4}			
$P_{d4} = P_{d3} + h_3/2 *\gamma_3 + h_4/2 *\gamma_4$	=	169.95	kN/m^2
Angle of wall friction, δ	=	18	deg.
Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-5.652	m^2

Ultimate Skin Resistance, Q_{s4} = $(\alpha^*c_4 + K^*P_{d4}^*\tan\delta) \times A_{s4}$	=	-423	kN
Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	3888	kN

2.1.4 Layer-5:

Layer thickness, L_4	=	-40	m
Pile embedment in the layer, h_4	=	0	m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α	=	0	
Cohesion, c_4	=	25	kN/m^2
Coefficient of Lateral earth pressure, K	=	0	
Unit weight of soil, γ_4	=	0	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d4}			
$P_{d5} = P_{d4} + h_4/2 *\gamma_4 + h_5/2 *\gamma_5$	=	164.25	kN/m^2
Angle of wall friction, δ	=	0	deg.
Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	0	m^2

Ultimate Skin Resistance, Q_{s4} = $(\alpha^*c_4 + K^*P_{d4}^*\tan\delta) \times A_{s4}$	=	0	kN
Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	7648	kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$

Where,	Cohesion at Pile Toe, c	=	21.57	kN/m^2
	Bearing Capacity Factor, N_c	=	9	
	Effective overburden pressure at Pile tip, P_d			
	$P_d = P_{d6} + h_6/2 *\gamma_6$	=	164.25	kN/m^2

Angle of internal friction at pile toe,ϕ	=	19	
Bearing Capacity Factor, N_q	=	4	
Area of Pile at toe, A_p	=	1.1304	m^2
Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$	=	962	kN

2.3 Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$			
Where, Area of pile, A_p	=	1.1304	m^2
Total Length of Pile , L	=	22	m
Unit Weight of Pile material, γ_p	=	15	kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$	=	373	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb	=	962	kN
Ultimate Skin Resistance, Qs	=	7648	kN
Self weight of the Pile, Wp	=	373	kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$	=	8237	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult} / FOS$

Where, Ultimate Capacity of Pile, Q_{ult}	=	8237	kN
Factor of Safety	=	2.5	
Safe Capacity of Pile, $Q_{safe} = Q_{ult} / FOS$	=	3295	kN
		329.4658	Ton

3.0 Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$			
Where, Ultimate Skin Resistance, Qs	=	3888	kN
Self weight of the Pile, Wp	=	373	kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$	=	2965	kN
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)} / FoS$			
Where, FoS = Factor of Safety	=	2.5	
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)} / FoS$	=	1186	kN

4.0 Fixity Depth Calculation

Pile fixity condition at top	=	fixed	
Type of Soil in fixity zone	=	Sand	
Modulus of subgrade reaction at fixity zone, K	=	5000	kN/m3
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)			
Where, fck = Characteristic strength of concrete	=	35	N/mm^2
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)	=	29580.4	N/mm^2
	=	29580399	kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4			
where, D = Diameter of the pile	=	1.2	m

Moment of inertia of Pile, I = 3.14 /64 *D^4	=	0.102	m^4	
Relative Stiffness factor, T = (EI/K)^(1/5)	=	3.597	m	
Unsupported length of pile, L1	=	0.0	m	
Ratio of L1/T or L1/R	=	0		
Lf/T or Lf /R =	=	2.16		
Therefore, Fixity Depth , Lf =	=	7.8	m	
Fixity depth, in terms of diameter of pile	=	6.47	times the dia	

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin	=	> 4T		
Where, T = Relative stiffness factor	=	3.60	m	
Let us consider a minimum length of pile , Lmin = 4.5 times T	=	16.2	m	

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top	=	fixed		
The horizontal capacity, H	=	12*E*I*y / (L1+Lf)^3		
Where, y = Diaplacement of pile at head	=	0.005	m	
E = Elastic modulus of pile material	=	29580399	kN/m^2	
I = Moment of inertia	=	0.102	m^4	
L1 = Unsupported length of pile	=	0.00	m	
Lf = Fixity length of pile	=	7.77	m	
The horizontal capacity, H = 12*E*I*y / (L1+Lf)^3	=	385.09	kN	

7.0 Summary of Calculations

Pile Diameter	=	1.20	m	
Pile Cut-off level	=	-0.5	m	
Pile Founding Level	=	-22.5	m	
Safe Vertical Capacity	=	3295	kN	
Safe Tension Capacity	=	1186	kN	
Pile head Condition	=	fixed		
Grade of Concrete	=	35.00	N/mm2	
Horizontal capacity for a Displacement of 5.0 mm	=	385	kN	
Minimum Pile length for Lateral Capacity	=	16.2	m	
Fixity Depth, Lf	=	7.8	m	

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1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-6	0.5	6.0	17.67	22	8.4	1	22	1
2		-6	-13.5	6.0	13.5	21.57	21	8.2	1	21	1
3		-13.5	-24	13.5	24.0	20.59	23	8.2	1	23	1
4		-24	-40	24.0	40.0	19.61	22	80	1	22	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-22.0	m
Depth from G.L.corresponding to F.L.	=	22.0	m
Pile Embedment length	=	21.5	m
Total Pile Length, L	=	21.5	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1		=	5.5	m
Pile embedment in the layer, h_1		=	5.5	m
Ultimate Skin Resistance, Q_{s1} =	$(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$			
Where, Reduction factor, α		=	1	
Cohesion, c_1		=	17.67	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil , γ_1		=	8.4	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$		=	23.1	kN/m^2
Angle of wall friction, δ		=	22	deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$		=	20.724	m^2
Ultimate Skin Resistance, Q_{s1} =	$(\alpha*c_1 + K*P_{d1}*\tan\delta) \times A_{s1}$	=	559.5019	kN

2.1.2 Layer-2:

Layer thickness, L_2		=	7.5	m
Pile embedment in the layer, h_1		=	7.5	m
Ultimate Skin Resistance, Q_{s2} =	$(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$			
Where, Reduction factor, α		=	1	
Cohesion, c_2		=	21.57	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil, γ_2		=	8.2	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$		=	76.95	kN/m^2
Angle of wall friction, δ		=	21	deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$		=	28.26	m^2
Ultimate Skin Resistance, Q_{s2} =	$(\alpha*c_2 + K*P_{d2}*\tan\delta) \times A_{s2}$	=	1443.858	kN

2.1.3 Layer-3:

Layer thickness, L_3		=	10.5	m
Pile embedment in the layer, h_3		=	8.5	m
Ultimate Skin Resistance, Q_{s3} =	$(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$			
Where, Reduction factor, α		=	1	
Cohesion, c_3		=	20.59	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil, γ_3		=	8.2	kN/m^3

Effective Overburden Pressure at middle of layer, P_{d3}

$P_{d3} = P_{d2} + h_2/2 * \gamma_2 + h_3/2 * \gamma_3$	=	142.55	kN/m^2
Angle of wall friction, δ	=	23	deg.
Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	32.028	m^2

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$ = 2596.339 kN

2.1.4 Layer-4:

Layer thickness, L_4	=	16	m
Pile embedment in the layer, h_4	=	-2	m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α	=	1	
Cohesion, c_4	=	19.61	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_4	=	80	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d4}			
$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$	=	97.4	kN/m^2
Angle of wall friction, δ	=	22	deg.
Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-7.536	m^2

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$ = -444 kN

Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$ = 4156 kN

2.1.4 Layer-5:

Layer thickness, L_4	=	-40	m
Pile embedment in the layer, h_4	=	0	m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α	=	0	
Cohesion, c_4	=	25	kN/m^2
Coefficient of Lateral earth pressure, K	=	0	
Unit weight of soil, γ_4	=	0	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d4}			
$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$	=	17.4	kN/m^2
Angle of wall friction, δ	=	0	deg.
Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	0	m^2

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$ = 0 kN

Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$ = 8196 kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$

Where,	Cohesion at Pile Toe, c	=	20.59	kN/m^2
	Bearing Capacity Factor, N_c	=	9	
	Effective overburden pressure at Pile tip, P_d			
	$P_d = P_{d6} + h_6/2 * \gamma_6$	=	17.4	kN/m^2
	Angle of internal friction at pile toe,ϕ	=	23	
	Bearing Capacity Factor, N_q	=	6.5	
	Area of Pile at toe, A_p	=	1.1304	m^2
Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$		=	337	kN

2.3 Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$

Where, Area of pile, A_p		=	1.1304	m^2
	Total Length of Pile , L	=	22	m
	Unit Weight of Pile material, γ_p	=	15	kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$		=	365	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb		=	337	kN
	Ultimate Skin Resistance, Qs	=	8196	kN
	Self weight of the Pile, Wp	=	365	kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$		=	8168	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

Where, Ultimate Capacity of Pile, Q_{ult}		=	8168	kN
	Factor of Safety	=	2.5	
Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS		=	3267	kN
			326.7397	Ton

3.0 Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$

Where, Ultimate Skin Resistance, Qs		=	4156	kN
	Self weight of the Pile, Wp	=	365	kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$		=	3135	kN

Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS

Where, FoS = Factor of Safety		=	2.5	
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS		=	1254	kN

4.0 Fixity Depth Calculation

Pile fixity condition at top		=	fixed	
Type of Soil in fixity zone		=	Sand	
Modulus of subgrade reaction at fixity zone, K		=	5000	kN/m3
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)				
Where, fck = Characteristic strength of concrete		=	35	N/mm^2
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)		=	29580.4	N/mm^2
		=	29580399	kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4				
where, D = Diameter of the pile		=	1.2	m
Moment of inertia of Pile, I = 3.14 /64 *D^4		=	0.102	m^4
Relative Stiffness factor, T = (EI/K)^(1/5)		=	3.597	m
Unsupported length of pile, L1		=	0.0	m
Ratio of L1/T or L1/R		=	0	
Lf/T or Lf /R =		=	2.16	
Therefore, Fixity Depth , Lf =		=	7.8	m
Fixity depth, in terms of diameter of pile		=	6.47	times the dia

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin		=	> 4T	
Where, T = Relative stiffness factor		=	3.60	m
Let us consider a minimum length of pile , Lmin =	4.5 times T	=	16.2	m

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top	=	fixed	
The horizontal capacity, H	=	12*E*I*y / (L1+Lf)^3	
Where, y = Diaplacement of pile at head	=	0.005	m
E = Elastic modulus of pile material	=	29580399	kN/m^2
I = Moment of inertia	=	0.102	m^4
L1 = Unsupported length of pile	=	0.00	m
Lf = Fixity length of pile	=	7.77	m
The horizontal capacity, H = 12*E*I*y / (L1+Lf)^3	=	385.09	kN

7.0 Summary of Calculations

Pile Diameter	=	1.20	m
Pile Cut-off level	=	-0.5	m
Pile Founding Level	=	-22.0	m
Safe Vertical Capacity	=	3267	kN
Safe Tension Capacity	=	1254	kN
Pile head Condition	=	fixed	
Grade of Concrete	=	35.00	N/mm2
Horizontal capacity for a Displacement of 5.0 mm	=	385	kN
Minimum Pile length for Lateral Capacity	=	16.2	m
Fixity Depth, Lf	=	7.8	M

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1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-6	0.5	6.0	22.55	22	8.2	1	22	1
2		-6	-13.5	6.0	13.5	19.61	23	8.1	1	23	1
3		-13.5	-24	13.5	24.0	19.61	24	8	1	24	1
4		-24	-40	24.0	40.0	18.63	23	7.9	1	23	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-21.2	m
Depth from G.L.corresponding to F.L.	=	21.2	m
Pile Embedment length	=	20.7	m
Total Pile Length, L	=	20.7	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1		=	5.5	m
Pile embedment in the layer, h_1		=	5.5	m
Ultimate Skin Resistance, Q_{s1} =	$(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$			
Where, Reduction factor, α		=	1	
Cohesion, c_1		=	22.55	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil , γ_1		=	8.2	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$		=	22.55	kN/m^2
Angle of wall friction, δ		=	22	deg.
Surface area of Pile in layer 1, A_{s1} = pi * D * h_1		=	20.724	m^2
Ultimate Skin Resistance, Q_{s1} =	$(\alpha*c_1 + K*P_{d1}*\tan\delta) \times A_{s1}$	=	656.0324	kN

2.1.2 Layer-2:

Layer thickness, L_2		=	7.5	m
Pile embedment in the layer, h_1		=	7.5	m
Ultimate Skin Resistance, Q_{s2} =	$(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$			
Where, Reduction factor, α		=	1	
Cohesion, c_2		=	19.61	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil, γ_2		=	8.1	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$		=	75.475	kN/m^2
Angle of wall friction, δ		=	23	deg.
Surface area of Pile in layer 2, A_{s2} = pi * D * h_2		=	28.26	m^2
Ultimate Skin Resistance, Q_{s2} =	$(\alpha*c_2 + K*P_{d2}*\tan\delta) \times A_{s2}$	=	1459.039	kN

2.1.3 Layer-3:

Layer thickness, L_3		=	10.5	m
Pile embedment in the layer, h_3		=	7.7	m
Ultimate Skin Resistance, Q_{s3} =	$(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$			
Where, Reduction factor, α		=	1	
Cohesion, c_3		=	19.61	kN/m^2
Coefficient of Lateral earth pressure, K		=	1	
Unit weight of soil, γ_3		=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d3} $P_{d3} = P_{d2} + h_2/2 *\gamma_2 + h_3/2 *\gamma_3$		=	136.65	kN/m^2
Angle of wall friction, δ		=	24	deg.
Surface area of Pile in layer 3, A_{s3} = pi * D * h_3		=	29.0136	m^2
Ultimate Skin Resistance, Q_{s3} =	$(\alpha*c_3 + K*P_{d3}*\tan\delta) \times A_{s3}$	=	2333.15	kN

2.1.4 Layer-4:

Layer thickness, L_4	=	16	m
Pile embedment in the layer, h_4	=	-2.8	m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α	=	1	
Cohesion, c_4	=	18.63	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_4	=	7.9	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d4}			
$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$	=	156.39	kN/m^2
Angle of wall friction, δ	=	23	deg.
Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-10.5504	m^2
Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	-897	kN
Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	3552	kN

2.1.4 Layer-5:

Layer thickness, L_4	=	-40	m
Pile embedment in the layer, h_4	=	0	m

Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$

Where, Reduction factor, α	=	0	
Cohesion, c_4	=	25	kN/m^2
Coefficient of Lateral earth pressure, K	=	0	
Unit weight of soil, γ_4	=	0	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d4}			
$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$	=	145.33	kN/m^2
Angle of wall friction, δ	=	0	deg.
Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	0	m^2
Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	0	kN
Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	7344	kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c * N_c + P_d * N_q) * A_p$

Where, Cohesion at Pile Toe, c	=	19.61	kN/m^2
Bearing Capacity Factor, N_c	=	9	
Effective overburden pressure at Pile tip, P_d			
$P_d = P_{d6} + h_6/2 * \gamma_6$	=	145.33	kN/m^2
Angle of internal friction at pile toe, ϕ	=	24	
Bearing Capacity Factor, N_q	=	6.5	
Area of Pile at toe, A_p	=	1.1304	m^2

Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$	=	1267	kN

2.3 Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$			
Where, Area of pile, A_p	=	1.1304	m^2
Total Length of Pile , L	=	21	m
Unit Weight of Pile material, γ_p	=	15	kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$	=	351	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb	=	1267	kN
Ultimate Skin Resistance, Qs	=	7344	kN
Self weight of the Pile, Wp	=	351	kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$	=	8260	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

Where, Ultimate Capacity of Pile, Q_{ult}	=	8260	kN
Factor of Safety	=	2.5	
Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS	=	3304	kN
		330.4088	Ton

3.0 Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$			
Where, Ultimate Skin Resistance, Qs	=	3552	kN
Self weight of the Pile, Wp	=	351	kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$	=	2719	kN
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS			
Where, FoS = Factor of Safety	=	2.5	
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS	=	1088	kN

4.0 Fixity Depth Calculation

Pile fixity condition at top	=	fixed	
Type of Soil in fixity zone	=	Sand	
Modulus of subgrade reaction at fixity zone, K	=	5000	kN/m3
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)			
Where, fck = Characteristic strength of concrete	=	35	N/mm^2
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)	=	29580.4	N/mm^2
	=	29580399	kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4			
where, D = Diameter of the pile	=	1.2	m
Moment of inertia of Pile, I = 3.14 /64 *D^4	=	0.102	m^4
Relative Stiffness factor, T = (EI/K)^(1/5)	=	3.597	m

Unsupported length of pile, L1	=	0.0	m	
Ratio of L1/T or L1/R	=	0		
Lf/T or Lf /R =	=	2.15		
Therefore, Fixity Depth , Lf =	=	7.7	m	
Fixity depth, in terms of diameter of pile	=	6.44	times the dia	

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin	=	> 4T	
Where, T = Relative stiffness factor	=	3.60	m
Let us consider a minimum length of pile , Lmin = 4.5 times T	=	16.2	m

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top	=	fixed	
The horizontal capacity, H	=	12*E*I*y / (L1+Lf)^3	
Where, y = Diaplacement of pile at head	=	0.005	m
E = Elastic modulus of pile material	=	29580399	kN/m^2
I = Moment of inertia	=	0.102	m^4
L1 = Unsupported length of pile	=	0.00	m
Lf = Fixity length of pile	=	7.73	m
The horizontal capacity, H = 12*E*I*y / (L1+Lf)^3	=	390.49	kN

7.0 Summary of Calculations

Pile Diameter	=	1.20	m
Pile Cut-off level	=	-0.5	m
Pile Founding Level	=	-21.2	m
Safe Vertical Capacity	=	3304	kN
Safe Tension Capacity	=	1088	kN
Pile head Condition	=	fixed	
Grade of Concrete	=	35.00	N/mm2
Horizontal capacity for a Displacement of 5.0 mm	=	390	kN
Minimum Pile length for Lateral Capacity	=	16.2	m
Fixity Depth, Lf	=	7.7	m

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1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-7.5	0.5	7.5	23.53	18	8.2	1	18	1
2		-7.5	-15	7.5	15.0	21.57	21	8.1	1	21	1
3		-15	-25.5	15.0	25.5	16.67	23	8	1	23	1
4		-25.5	-35	25.5	35.0	15.67	25	7.9	1	25	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-22.5	m
Depth from G.L.corresponding to F.L.	=	22.5	m
Pile Embedment length	=	22.0	m
Total Pile Length, L	=	22.0	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1	=	7	m
Pile embedment in the layer, h_1	=	7	m

Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$

Where, Reduction factor, α	=	1	
Cohesion, c_1	=	23.53	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil , γ_1	=	8.2	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$	=	28.7	kN/m^2
Angle of wall friction, δ	=	18	deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$	=	26.376	m^2
Ultimate Skin Resistance, Q_{s1} = $(\alpha*c_1 + K*P_{d1}*\tan\delta) \times A_{s1}$	=	866.4553	kN

2.1.2 Layer-2:

Layer thickness, L_2	=	7.5	m
Pile embedment in the layer, h_1	=	7.5	m

Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$

Where, Reduction factor, α	=	1	
Cohesion, c_2	=	21.57	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_2	=	8.1	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$	=	87.775	kN/m^2
Angle of wall friction, δ	=	21	deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$	=	28.26	m^2
Ultimate Skin Resistance, Q_{s2} = $(\alpha*c_2 + K*P_{d2}*\tan\delta) \times A_{s2}$	=	1561.222	kN

2.1.3 Layer-3:

Layer thickness, L_3	=	10.5	m
Pile embedment in the layer, h_3	=	7.5	m

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$

Where, Reduction factor, α	=	1	
Cohesion, c_3	=	16.67	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_3	=	8	kN/m^3

	Effective Overburden Pressure at middle of layer, P_{d3}			
	$P_{d3} = P_{d2} + h_2/2 * \gamma_2 + h_3/2 * \gamma_3$	=	148.15	kN/m^2
	Angle of wall friction, δ	=	23	deg.
	Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	28.26	m^2
	Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$	=	2247.246	kN
2.1.4	Layer-4:			
	Layer thickness, L_4	=	9.5	m
	Pile embedment in the layer, h_4	=	-3	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	1	
	Cohesion, c_4	=	15.67	kN/m^2
	Coefficient of Lateral earth pressure, K	=	1	
	Unit weight of soil, γ_4	=	7.9	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$	=	166.3	kN/m^2
	Angle of wall friction, δ	=	25	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-11.304	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	-1053	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	3622	kN
2.1.4	Layer-5:			
	Layer thickness, L_4	=	-35	m
	Pile embedment in the layer, h_4	=	0	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	0	
	Cohesion, c_4	=	25	kN/m^2
	Coefficient of Lateral earth pressure, K	=	0	
	Unit weight of soil, γ_4	=	0	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$	=	154.45	kN/m^2
	Angle of wall friction, δ	=	0	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	0	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	0	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	7430	kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$

Where,	Cohesion at Pile Toe, c	=	16.67	kN/m^2
	Bearing Capacity Factor, N_c	=	9	
	Effective overburden pressure at Pile tip, P_d			
	$P_d = P_{d6} + h_6/2 * \gamma_6$	=	154.45	kN/m^2
	Angle of internal friction at pile toe,ϕ	=	23	
	Bearing Capacity Factor, N_q	=	6.5	
	Area of Pile at toe, A_p	=	1.1304	m^2
Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$		=	1304	kN

2.3 Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$

Where, Area of pile, A_p		=	1.1304	m^2
	Total Length of Pile , L	=	22	m
	Unit Weight of Pile material, γ_p	=	15	kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$		=	373	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb		=	1304	kN
	Ultimate Skin Resistance, Qs	=	7430	kN
	Self weight of the Pile, Wp	=	373	kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$		=	8362	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult} / FOS$

Where, Ultimate Capacity of Pile, Q_{ult}		=	8362	kN
	Factor of Safety	=	2.5	
Safe Capacity of Pile, $Q_{safe} = Q_{ult} / FOS$		=	3345	kN

3.0 Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$

Where, Ultimate Skin Resistance, Qs		=	3622	kN
	Self weight of the Pile, Wp	=	373	kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$		=	2788	kN

Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)} / FoS$

Where, FoS = Factor of Safety		=	2.5	
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)} / FoS$		=	1115	kN

4.0 Fixity Depth Calculation

Pile fixity condition at top	=	fixed	
Type of Soil in fixity zone	=	Sand	

Modulus of subgrade reaction at fixity zone, K	=	5000	kN/m3
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)			
Where, fck = Characteristic strength of concrete	=	35	N/mm^2
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)	=	29580.4	N/mm^2
	=	29580399	kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4			
where, D = Diameter of the pile	=	1.2	m
Moment of inertia of Pile, I = 3.14 /64 *D^4	=	0.102	m^4
Relative Stiffness factor, T = (EI/K)^(1/5)	=	3.597	m
Unsupported length of pile, L1	=	0.0	m
Ratio of L1/T or L1/R	=	0	
Lf/T or Lf /R =	=	2.15	
Therefore, Fixity Depth , Lf =	=	7.7	m
Fixity depth, in terms of diameter of pile	=	6.44	times the dia

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin	=	> 4T	
Where, T = Relative stiffness factor	=	3.60	m
Let us consider a minimum length of pile , Lmin = 4.5 times T	=	16.2	m

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top	=	fixed	
The horizontal capacity, H	=	12*E*I*y / (L1+Lf)^3	
Where, y = Diaplacement of pile at head	=	0.005	m
E = Elastic modulus of pile material	=	29580399	kN/m^2
I = Moment of inertia	=	0.102	m^4
L1 = Unsupported length of pile	=	0.00	m
Lf = Fixity length of pile	=	7.73	m
The horizontal capacity, H = 12*E*I*y / (L1+Lf)^3	=	390.49	kN

7.0 Summary of Calculations

Pile Diameter	=	1.20	m
Pile Cut-off level	=	-0.5	m
Pile Founding Level	=	-22.5	m
Safe Vertical Capacity	=	3345	kN
Safe Tension Capacity	=	1115	kN
Pile head Condition	=	fixed	
Grade of Concrete	=	35.00	N/mm2
Horizontal capacity for a Displacement of 5.0 mm	=	390	kN
Minimum Pile length for Lateral Capacity	=	16.2	m
Fixity Depth, Lf	=	7.7	m

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1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-7.5	0.5	7.5	27.45	19	8.5	1	19	1
2		-7.5	-15	7.5	15.0	21.57	22	8	1	22	1
3		-15	-25.5	15.0	25.5	19.61	24	8	1	24	1
4		-25.5	-35	25.5	35.0	18.63	24	8.1	1	24	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-22.0	m
Depth from G.L.corresponding to F.L.	=	22.0	m
Pile Embedment length	=	21.5	m
Total Pile Length, L	=	21.5	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1	=	7	m
Pile embedment in the layer, h_1	=	7	m

Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$

Where, Reduction factor, α	=	1	
Cohesion, c_1	=	27.45	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil , γ_1	=	8.5	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$	=	29.75	kN/m^2
Angle of wall friction, δ	=	19	deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$	=	26.376	m^2
Ultimate Skin Resistance, Q_{s1} = $(\alpha*c_1 + K*P_{d1}*\tan\delta) \times A_{s1}$	=	994.0627	kN

2.1.2 Layer-2:

Layer thickness, L_2	=	7.5	m
Pile embedment in the layer, h_1	=	7.5	m

Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$

Where, Reduction factor, α	=	1	
Cohesion, c_2	=	21.57	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_2	=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$	=	89.5	kN/m^2
Angle of wall friction, δ	=	22	deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$	=	28.26	m^2
Ultimate Skin Resistance, Q_{s2} = $(\alpha*c_2 + K*P_{d2}*\tan\delta) \times A_{s2}$	=	1630.887	kN

2.1.3 Layer-3:

Layer thickness, L_3	=	10.5	m
Pile embedment in the layer, h_3	=	7	m

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$

Where, Reduction factor, α	=	1	
Cohesion, c_3	=	19.61	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_3	=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d3} $P_{d3} = P_{d2} + h_2/2 *\gamma_2 + h_3/2 *\gamma_3$	=	147.5	kN/m^2
Angle of wall friction, δ	=	24	deg.
Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	26.376	m^2

Ultimate Skin Resistance, Q_{s3} =	$(\alpha^*c_3 + K^*P_{d3}^*\tan\delta) \times A_{s3}$	=	2248.388	kN

2.1.4 Layer-4:

Layer thickness, L_4	=	9.5	m
Pile embedment in the layer, h_4	=	-3.5	m
Ultimate Skin Resistance, Q_{s4} =	$(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$		
Where, Reduction factor, α	=	1	
Cohesion, c_4	=	18.63	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_4	=	8.1	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d4}			
$P_{d4} = P_{d3} + h_3/2 *\gamma_3 + h_4/2 *\gamma_4$	=	161.325	kN/m^2
Angle of wall friction, δ	=	24	deg.
Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-13.188	m^2
Ultimate Skin Resistance, Q_{s4} =	$(\alpha^*c_4 + K^*P_{d4}^*\tan\delta) \times A_{s4}$	=	-1192	kN
Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	3681	kN

2.1.4 Layer-5:

Layer thickness, L_4	=	-35	m
Pile embedment in the layer, h_4	=	0	m
Ultimate Skin Resistance, Q_{s4} =	$(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$		
Where, Reduction factor, α	=	0	
Cohesion, c_4	=	25	kN/m^2
Coefficient of Lateral earth pressure, K	=	0	
Unit weight of soil, γ_4	=	0	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d4}			
$P_{d5} = P_{d4} + h_4/2 *\gamma_4 + h_5/2 *\gamma_5$	=	147.15	kN/m^2
Angle of wall friction, δ	=	0	deg.
Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	0	m^2
Ultimate Skin Resistance, Q_{s4} =	$(\alpha^*c_4 + K^*P_{d4}^*\tan\delta) \times A_{s4}$	=	0	kN
Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	7560	kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$

Where,	Cohesion at Pile Toe, c	=	19.61	kN/m^2
	Bearing Capacity Factor, N_c	=	9	
	Effective overburden pressure at Pile tip, P_d			
	$P_d = P_{d6} + h_6/2 *\gamma_6$	=	147.15	kN/m^2

Angle of internal friction at pile toe,ϕ	=	24	
Bearing Capacity Factor, N_q	=	6.5	
Area of Pile at toe, A_p	=	1.1304	m^2
Ultimate End bearing Resistance, $Q_b = (c^* N_c + P_d * N_q) * A_p$	=	1281	kN

2.3 Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$			
Where, Area of pile, A_p	=	1.1304	m^2
Total Length of Pile , L	=	22	m
Unit Weight of Pile material, γ_p	=	15	kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$	=	365	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb	=	1281	kN
Ultimate Skin Resistance, Qs	=	7560	kN
Self weight of the Pile, Wp	=	365	kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$	=	8476	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

Where, Ultimate Capacity of Pile, Q_{ult}	=	8476	kN
Factor of Safety	=	2.5	
Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS	=	3391	kN
		339.0545	Ton

3.0 Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$			
Where, Ultimate Skin Resistance, Qs	=	3681	kN
Self weight of the Pile, Wp	=	365	kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$	=	2819	kN
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS			
Where, FoS = Factor of Safety	=	2.5	
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS	=	1127	kN

4.0 Fixity Depth Calculation

Pile fixity condition at top	=	fixed	
Type of Soil in fixity zone	=	Sand	
Modulus of subgrade reaction at fixity zone, K	=	5000	kN/m3
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)			
Where, fck = Characteristic strength of concrete	=	35	N/mm^2
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)	=	29580.4	N/mm^2
	=	29580399	kN/m^2

Moment of inertia of Pile, I = 3.14 /64 *D^4

where, D = Diameter of the pile			=	1.2	m
Moment of inertia of Pile, I = 3.14 /64 *D^4			=	0.102	m^4
Relative Stiffness factor, T = (EI/K)^(1/5)			=	3.597	m
Unsupported length of pile, L1			=	0.0	m
Ratio of L1/T or L1/R			=	0	
Lf/T or Lf /R =			=	2.16	
Therefore, Fixity Depth , Lf =			=	7.8	m
Fixity depth, in terms of diameter of pile			=	6.47	times the dia

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin			=	> 4T	
Where, T = Relative stiffness factor			=	3.60	m
Let us consider a minimum length of pile , Lmin =	4.5 times T		=	16.2	m

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top			=	fixed	
The horizontal capacity, H			=	12*E*I*y / (L1+Lf)^3	
Where, y = Diaplacement of pile at head			=	0.005	m
E = Elastic modulus of pile material			=	29580399	kN/m^2
I = Moment of inertia			=	0.102	m^4
L1 = Unsupported length of pile			=	0.00	m
Lf = Fixity length of pile			=	7.77	m
The horizontal capacity, H =	12*E*I*y / (L1+Lf)^3		=	385.09	kN

7.0 Summary of Calculations

Pile Diameter			=	1.20	m
Pile Cut-off level			=	-0.5	m
Pile Founding Level			=	-22.0	m
Safe Vertical Capacity			=	3391	kN
Safe Tension Capacity			=	1127	kN
Pile head Condition			=	fixed	
Grade of Concrete			=	35.00	N/mm2
Horizontal capacity for a Displacement of	5.0	mm	=	385	kN
Minimum Pile length for Lateral Capacity			=	16.2	m
Fixity Depth, Lf			=	7.8	m

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1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-12	0.5	12.0	19.61	20	8.8	1	20	1
2		-12	-24	12.0	24.0	17.65	23	8	1	23	1
3		-24	-35	24.0	35.0	16.67	24	8.2	1	24	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-21.5	m
Depth from G.L.corresponding to F.L.	=	21.5	m
Pile Embedment length	=	21.0	m
Total Pile Length, L	=	21.0	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1	=	11.5	m
Pile embedment in the layer, h_1	=	11.5	m

Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$

Where, Reduction factor, α	=	1	
Cohesion, c_1	=	19.61	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil , γ_1	=	8.8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$	=	50.6	kN/m^2
Angle of wall friction, δ	=	20	deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$	=	43.332	m^2
Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$	=	1647.342	kN

2.1.2 Layer-2:

Layer thickness, L_2	=	12	m
Pile embedment in the layer, h_1	=	9.5	m

Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$

Where, Reduction factor, α	=	1	
Cohesion, c_2	=	17.65	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_2	=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$	=	139.2	kN/m^2
Angle of wall friction, δ	=	23	deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$	=	35.796	m^2
Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$	=	2745.677	kN

2.1.3 Layer-3:

Layer thickness, L_3	=	11	m
Pile embedment in the layer, h_3	=	-2.5	m

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$

Where, Reduction factor, α	=	1	
Cohesion, c_3	=	16.67	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_3	=	8.2	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d3}			

	$P_{d3} = P_{d2} + h_2/2 * \gamma_2 + h_3/2 * \gamma_3$	=	166.95	kN/m^2
	Angle of wall friction, δ	=	24	deg.
	Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	-9.42	m^2
	Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$	=	-856.829	kN
2.1.4	Layer-4:			
	Layer thickness, L_4	=	-35	m
	Pile embedment in the layer, h_4	=	-35	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	1	
	Cohesion, c_4	=	0	kN/m^2
	Coefficient of Lateral earth pressure, K	=	1	
	Unit weight of soil, γ_4	=	0	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$	=	156.7	kN/m^2
	Angle of wall friction, δ	=	0	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-131.88	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	0	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	3536	kN
2.1.4	Layer-5:			
	Layer thickness, L_4	=	0	m
	Pile embedment in the layer, h_4	=	-35	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	0	
	Cohesion, c_4	=	25	kN/m^2
	Coefficient of Lateral earth pressure, K	=	0	
	Unit weight of soil, γ_4	=	0	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$	=	156.7	kN/m^2
	Angle of wall friction, δ	=	0	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-131.88	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	0	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	5425	kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c * N_c + P_d * N_q) * A_p$

Where,	Cohesion at Pile Toe, c	=	15	kN/m^2
	Bearing Capacity Factor, N_c	=	9	
	Effective overburden pressure at Pile tip, P_d			
	$P_d = P_{d6} + h_6/2 * \gamma_6$	=	156.7	kN/m^2
	Angle of internal friction at pile toe,ϕ	=	29	
	Bearing Capacity Factor, N_q	=	18	
	Area of Pile at toe, A_p	=	1.1304	m^2
Ultimate End bearing Resistance, $Q_b = (c* N_c + P_d * N_q) * A_p$		=	3341	kN

2.3 Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$				
Where, Area of pile, A_p		=	1.1304	m^2
	Total Length of Pile , L	=	21	m
	Unit Weight of Pile material, γ_p	=	15	kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$		=	356	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb		=	3341	kN
	Ultimate Skin Resistance, Qs	=	5425	kN
	Self weight of the Pile, Wp	=	356	kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$		=	8410	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

Where, Ultimate Capacity of Pile, Q_{ult}		=	8410	kN
	Factor of Safety	=	2.5	
Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS		=	3364	kN
			336.3989	Ton

3.0 Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$				
Where, Ultimate Skin Resistance, Qs		=	3536	kN
	Self weight of the Pile, Wp	=	356	kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$		=	2714	kN
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS				
Where, FoS = Factor of Safety		=	2.5	
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS		=	1085	kN

4.0 Fixity Depth Calculation

Pile fixity condition at top	=	fixed	
Type of Soil in fixity zone	=	Sand	
Modulus of subgrade reaction at fixity zone, K	=	5000	kN/m3

Elastic modulus of concrete, Ec = 5000 * SQRT(fck)				
Where, fck = Characteristic strength of concrete		=	35	N/mm^2
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)		=	29580.4	N/mm^2
		=	29580399	kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4				
where, D = Diameter of the pile		=	1.2	m
Moment of inertia of Pile, I = 3.14 /64 *D^4		=	0.102	m^4
Relative Stiffness factor, T = (EI/K)^(1/5)		=	3.597	m
Unsupported length of pile, L1		=	0.0	m
Ratio of L1/T or L1/R		=	0	
Lf/T or Lf /R =		=	2.15	
Therefore, Fixity Depth , Lf =		=	7.7	m
Fixity depth, in terms of diameter of pile		=	6.44	times the dia

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin		=	> 4T	
Where, T = Relative stiffness factor		=	3.60	m
Let us consider a minimum length of pile , Lmin =	4.5 times T	=	16.2	m

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top		=	fixed	
The horizontal capacity, H		=	12*E*I*y / (L1+Lf)^3	
Where, y = Diaplacement of pile at head		=	0.005	m
E = Elastic modulus of pile material		=	29580399	kN/m^2
I = Moment of inertia		=	0.102	m^4
L1 = Unsupported length of pile		=	0.00	m
Lf = Fixity length of pile		=	7.73	m
The horizontal capacity, H =	12*E*I*y / (L1+Lf)^3	=	390.49	kN

7.0 Summary of Calculations

Pile Diameter		=	1.20	m
Pile Cut-off level		=	-0.5	m
Pile Founding Level		=	-21.5	m
Safe Vertical Capacity		=	3364	kN
Safe Tension Capacity		=	1085	kN
Pile head Condition		=	fixed	
Grade of Concrete		=	35.00	N/mm2
Horizontal capacity for a Displacement of	5.0 mm	=	390	kN
Minimum Pile length for Lateral Capacity		=	16.2	m
Fixity Depth, Lf		=	7.7	m

CH- 154+200 BH- 2

1.0 Input

1.1 Design Soil Parameters

Sl.No.	Description	Reduced Level		Depth of layer from ground		Soil Parameters			Interaction Parameters		
						c	ϕ	γ_{Sub}	k	δ	α
		From	To	From	To	kN/m^2	deg.	kN/m^3		deg.	
1	From Bore hole data	-0.5	-12	0.5	12.0	23.53	19	8.6	1	19	1
2		-12	-24	12.0	24.0	19.61	21	8	1	21	1
3		-24	-35	24.0	35.0	19.61	22	7.9	1	22	1

1.2 Pile Details

Existing ground level	=	0	m
Pile Diameter, D	=	1.2	m
Pile Cut-off level	=	-0.5	m
Dredge level	=	-0.5	m
Scour level	=	-0.5	m
Pile Founding level	=	-22.7	m
Depth from G.L.corresponding to F.L.	=	22.7	m
Pile Embedment length	=	22.2	m
Total Pile Length, L	=	22.2	m
Pile Density	=	25.0	kN/m^3
Factor of Safety	=	2.5	
Pile Fixity condition at top	=	fixed	(Fixed or Free)
Grade of Concrete	=	35	N/mm^2
Modulus of subgrade reaction at fixity zone	=	5000	kN/m3
Type of soil in fixity zone	=	Sand	(Sand or Clay)
Unsupported Length of Pile, L1	=	0.0	m
Allowable displacement of pile at head (For Horizontal capacity)	=	5.0	mm

2.0 Calculation of Vertical Capacity

Ultimate Capacity of Pile , Qult = Qb + Qs - Wp

Whetre, Qb = Ultimate End Bearing
Qs = Ultimate Skin Resistance
Wp = Self weight of Pile

Qsafe = Qult / FOS
Where, FOS = Factor of Safety

2.1 Calculation of Skin Resistances

2.1.1 Layer-1:

Layer thickness, L_1	=	11.5	m
Pile embedment in the layer, h_1	=	11.5	m

Ultimate Skin Resistance, Q_{s1} = $(\alpha * c_1 + K * P_{d1} * \tan\delta) \times A_{s1}$

Where, Reduction factor, α	=	1	
Cohesion, c_1	=	23.53	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil , γ_1	=	8.6	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d1} $P_{d1} = h_1/2 *\gamma_1$	=	49.45	kN/m^2
Angle of wall friction, δ	=	19	deg.
Surface area of Pile in layer 1, $A_{s1} = pi * D * h_1$	=	43.332	m^2
Ultimate Skin Resistance, Q_{s1} = $(\alpha*c_1 + K*P_{d1}*\tan\delta) \times A_{s1}$	=	1757.013	kN

2.1.2 Layer-2:

Layer thickness, L_2	=	12	m
Pile embedment in the layer, h_1	=	10.7	m

Ultimate Skin Resistance, Q_{s2} = $(\alpha * c_2 + K * P_{d2} * \tan\delta) \times A_{s2}$

Where, Reduction factor, α	=	1	
Cohesion, c_2	=	19.61	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_2	=	8	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d2} $P_{d2} = P_{d1} + h_1/2 *\gamma_1 + h_2/2 *\gamma_2$	=	141.7	kN/m^2
Angle of wall friction, δ	=	21	deg.
Surface area of Pile in layer 2, $A_{s2} = pi * D * h_2$	=	40.3176	m^2
Ultimate Skin Resistance, Q_{s2} = $(\alpha*c_2 + K*P_{d2}*\tan\delta) \times A_{s2}$	=	2982.427	kN

2.1.3 Layer-3:

Layer thickness, L_3	=	11	m
Pile embedment in the layer, h_3	=	-1.3	m

Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$

Where, Reduction factor, α	=	1	
Cohesion, c_3	=	19.61	kN/m^2
Coefficient of Lateral earth pressure, K	=	1	
Unit weight of soil, γ_3	=	7.9	kN/m^3
Effective Overburden Pressure at middle of layer, P_{d3} $P_{d3} = P_{d2} + h_2/2 *\gamma_2 + h_3/2 *\gamma_3$	=	179.365	kN/m^2

	Angle of wall friction, δ	=	22	deg.
	Surface area of Pile in layer 3, $A_{s3} = pi * D * h_3$	=	-4.8984	m^2
	Ultimate Skin Resistance, Q_{s3} = $(\alpha * c_3 + K * P_{d3} * \tan\delta) \times A_{s3}$	=	-450.837	kN
2.1.4	Layer-4:			
	Layer thickness, L_4	=	-35	m
	Pile embedment in the layer, h_4	=	-35	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	1	
	Cohesion, c_4	=	0	kN/m^2
	Coefficient of Lateral earth pressure, K	=	1	
	Unit weight of soil, γ_4	=	0	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d4} = P_{d3} + h_3/2 * \gamma_3 + h_4/2 * \gamma_4$	=	174.23	kN/m^2
	Angle of wall friction, δ	=	0	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-131.88	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	0	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	4289	kN
2.1.4	Layer-5:			
	Layer thickness, L_4	=	0	m
	Pile embedment in the layer, h_4	=	-35	m
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$			
	Where, Reduction factor, α	=	0	
	Cohesion, c_4	=	25	kN/m^2
	Coefficient of Lateral earth pressure, K	=	0	
	Unit weight of soil, γ_4	=	0	kN/m^3
	Effective Overburden Pressure at middle of layer, P_{d4}			
	$P_{d5} = P_{d4} + h_4/2 * \gamma_4 + h_5/2 * \gamma_5$	=	174.23	kN/m^2
	Angle of wall friction, δ	=	0	deg.
	Surface area of Pile in layer 4, $A_{s4} = pi * D * h_4$	=	-131.88	m^2
	Ultimate Skin Resistance, Q_{s4} = $(\alpha * c_4 + K * P_{d4} * \tan\delta) \times A_{s4}$	=	0	kN
	Total Ultimate Skin resistance, $Qs = Q_{s1} + Q_{s2} + Q_{s3} + \ldots + Q_{sn}$	=	6820	kN

2.2 Ultimate End Bearing Resistance

Ultimate End bearing Resistance, $Q_b = (c * N_c + P_d * N_q) * A_p$

Where,	Cohesion at Pile Toe, c	=	15	kN/m^2
	Bearing Capacity Factor, N_c	=	9	

Effective overburden pressure at Pile tip, P_d			
$P_d = P_{d6} + h_6/2 * \gamma_6$	=	174.23	kN/m^2
Angle of internal friction at pile toe,ϕ	=	29	
Bearing Capacity Factor, N_q	=	18	
Area of Pile at toe, A_p	=	1.1304	m^2
Ultimate End bearing Resistance, $Q_b = (c* N_c + P_d * N_q) * A_p$	=	3698	kN

2.3 Self Weight of the Pile, Wp

Self weight of the Pile , $W_p = A_p * L * \gamma_p$			
Where, Area of pile, A_p	=	1.1304	m^2
Total Length of Pile , L	=	22	m
Unit Weight of Pile material, γ_p	=	15	kN/m^3
Self weight of the Pile , $W_p = A_p * L * \gamma_p$	=	376	kN

2.4 Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$

Where, Ultimate End Bearing, Qb	=	3698	kN
Ultimate Skin Resistance, Qs	=	6820	kN
Self weight of the Pile, Wp	=	376	kN
Ultimate Capacity of the Pile , $Q_{ult} = Q_b + Q_s - W_p$	=	10141	kN

2.5 Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS

Where, Ultimate Capacity of Pile, Q_{ult}	=	10141	kN
Factor of Safety	=	2.5	
Safe Capacity of Pile, $Q_{safe} = Q_{ult}$ / FOS	=	4057	kN
		405.6587	Ton

3.0 Tension Capacity of Pile

Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$			
Where, Ultimate Skin Resistance, Qs	=	4289	kN
Self weight of the Pile, Wp	=	376	kN
Ultimate Tension Capacity of the Pile , $Q_{ult(T)} = 2/3 \times Q_s + W_p$	=	3235	kN
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS			
Where, FoS = Factor of Safety	=	2.5	
Safe Tension Capacity of the Pile , $Q_{safe(T)} = Q_{ult(T)}$ / FoS	=	1294	kN

4.0 Fixity Depth Calculation

Pile fixity condition at top	=	fixed	
Type of Soil in fixity zone	=	Sand	
Modulus of subgrade reaction at fixity zone, K	=	5000	kN/m3
Elastic modulus of concrete, Ec = 5000 * SQRT(fck)			
Where, fck = Characteristic strength of concrete	=	35	N/mm^2

Elastic modulus of concrete, Ec = 5000 * SQRT(fck)			=	29580.4	N/mm^2
			=	29580399	kN/m^2
Moment of inertia of Pile, I = 3.14 /64 *D^4					
where, D = Diameter of the pile			=	1.2	m
Moment of inertia of Pile, I = 3.14 /64 *D^4			=	0.102	m^4
Relative Stiffness factor, T = (EI/K)^(1/5)			=	3.597	m
Unsupported length of pile, L1			=	0.0	m
Ratio of L1/T or L1/R			=	0	
Lf/T or Lf /R =			=	2.15	
Therefore, Fixity Depth , Lf =			=	7.7	m
Fixity depth, in terms of diameter of pile			=	6.44	times the dia

5.0 Minimum Pile Length for lateral Capacity

Minimum Pile Length for flexible pile, Lmin		=	> 4T	
Where, T = Relative stiffness factor		=	3.60	m
Let us consider a minimum length of pile , Lmin =	4.5 times T	=	16.2	m

6.0 Horizontal Capacity of the Pile

Pile fixity condition at top		=	fixed	
The horizontal capacity, H		=	12*E*I*y / (L1+Lf)^3	
Where, y = Diaplacement of pile at head		=	0.005	m
E = Elastic modulus of pile material		=	29580399	kN/m^2
I = Moment of inertia		=	0.102	m^4
L1 = Unsupported length of pile		=	0.00	m
Lf = Fixity length of pile		=	7.73	m
The horizontal capacity, H =	12*E*I*y / (L1+Lf)^3	=	390.49	kN

7.0 Summary of Calculations

Pile Diameter		=	1.20	m
Pile Cut-off level		=	-0.5	m
Pile Founding Level		=	-22.7	m
Safe Vertical Capacity		=	4057	kN
Safe Tension Capacity		=	1294	kN
Pile head Condition		=	fixed	
Grade of Concrete		=	35.00	N/mm 2
Horizontal capacity for a Displacement of	5.0 mm	=	390	kN
Minimum Pile length for Lateral Capacity		=	16.2	m
Fixity Depth, Lf		=	7.7	m

Bearing capacity of wells at CH-157+356 BH-01

IS 3955 recommends the following empirical formulae for allowable bearing pressure for sands based on its N value for safety against shear failure.

$$qu = \left[5.4\, N^2 B + 16 \left(100 + N^2 \right) D \right] kg/m^2$$

Where,

qu = Safe bearing capacity in kg/m^2

N = Corrected SPT value

B = Smaller dimension of well

D = Depth of well foundation below scour level.

The allowable bearing pressure under the well foundation is as follows based on the Data of B.H. No.1:

S.N.	Well dia (m)	Depth (below the existing B.H. level)	Allowable bearing capacity Ton/m^2
1	8.00	35.00	173.81
2	10.00	35.00	175.91
3	8.00	30.00	142.51
4	10.00	30.00	144.46
5	8.00	25.00	112.84
6	10.00	25.00	114.62

CALCULATION OF SAFE BEARING CAPACITY OF SOIL

- Based on IS: 6403

CH-166+070 **BH-** **1**

Shape of footing	Square			
Depth of footing, D	*1.00*		Cohesion, C, kg/sq.cm	*0.130*
Width of footing, B	*5.00*		Angle of Int.Friction, ϕ	*17*
Length of footing, L	*10.00*		Specific Gravity, g	*2.450*
			Bulk Density, Y_d, gm/cc	*1.820*
Depth of Water Table,m	*1*		Sat. Density, Ysat, gm/cc	*2.077*
Ratio d/B	*0.000*		Sub. Density, Y', gm/cc	*1.077*
Water Table Factor	*0.50*		Inclination Angle α	*0*
Effective Surcharge over EGL, m	*2.50*	*m*	Factor of Safety	*2.5*
Dry Density, Y_d, gm/cc	1.820		Surcharge Density Assumed, gm/cc	*1.780*
Overburden Pressure,	*1.82*	t/m^2		

Void Ratio, e_o = $\frac{G \times Y_w}{Y_d}$ - *1*

= *0.346*

Mode of Failure = ***General Shear Failure***

for general shear failure i.e. Void Ratio < 0.55

$qu = cNcScdcic + q(Nq-1)\,Sqdqiq + 0.5\,B\gamma N\gamma S\gamma d\gamma i\gamma\ W'$

= ***35.25*** ***qs =*** ***14.10*** t/m^2