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Assessment of Some Engineering Geological Aspects of the Sub-soil of Ganakbari, Dhaka, Bangladesh

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Abstract

The Madhupur Clay soil of the studied area is composed predominantly of silt size particles with small amount sand and clay. Three stratigraphic units have been identified namely unit A, unit B and unit C. The lowermost unit (unit A) is mainly a sandy non cohesive unit. This unit is light reddish yellow or pale reddish yellow in colour, dense to very dense in nature. Unit B is mainly a silty sand unit which is mottled, light reddish yellow or pale reddish yellow in colour and medium dense to dense. The topmost unit (unit C) is mainly a clay unit which is pale grayish to light reddish yellow in colour, mainly medium to stiff in nature and show medium plasticity. The SPT value of study area ranges from 4 to 60 in the area and increases with increasing depth in all the bore holes. The layer of the cohesive clay soil (Unit C), extending to the depth of 0-28 feet, usually has the consistency that varies from medium to stiff. Further below, the non cohesive silty and sandy layers (Unit B & A respectively), extending to the depth of about 28-65 ft, usually have been found in a medium dense to very dense state. The sand percentages are increasing with increasing depth whereas the silt and clay percentages are decreasing with increasing depth. The obtained values of the Cu and Cg suggest that the studied samples are uniformly graded to well graded soil. The upper soil is suitable for light and moderate load bearing structures (up to 35 feet) whereas the lower soil is very much suitable for heavy structures (below 35 feet depth).

Keywords: *Geology, engineering, borehole stratigraphy, SPT, grain size.*

Introduction

The aim of the engineering geological investigation is to determine the subsurface condition and soil strength that helps to develop structure or foundation in an area. A geotechnical investigation has been carried out at Ganakbari, Savar, Dhaka by the detailed subsurface investigation programme which includes nine borings, execution of the Standard Penetration Test (SPT), collection of the disturbed samples and performance of laboratory tests. Ganakbari and its adjoining areas are the recently developed part of Dhaka city. The investigated area is composed of yellowish brown to grey, mottled, sticky clay. It is important to know the engineering geological properties of the area in order to use the result in the design and analysis the geo-engineering and environmental problems in the region.

The study area comprises the northern extremity of Dhaka District and located within longitude $91^{\circ}35'E$ to $91^{\circ}17'E$ and latitude $23^{\circ}54'N$ to $23^{\circ}58'N$ (Figure 1). Because of rapid urbanization and huge population and nearest to the Export Processing Zone (EPZ), the study area is very much important and familiar to the people. It is expected that more construction work will be done in near future in the study area. It confirms the importance and utility of this research.

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This paper deals with the engineering geological behaviour of the soil samples of the investigated area which include the subsurface stratigraphic characters, particle distribution and strength of the soil.

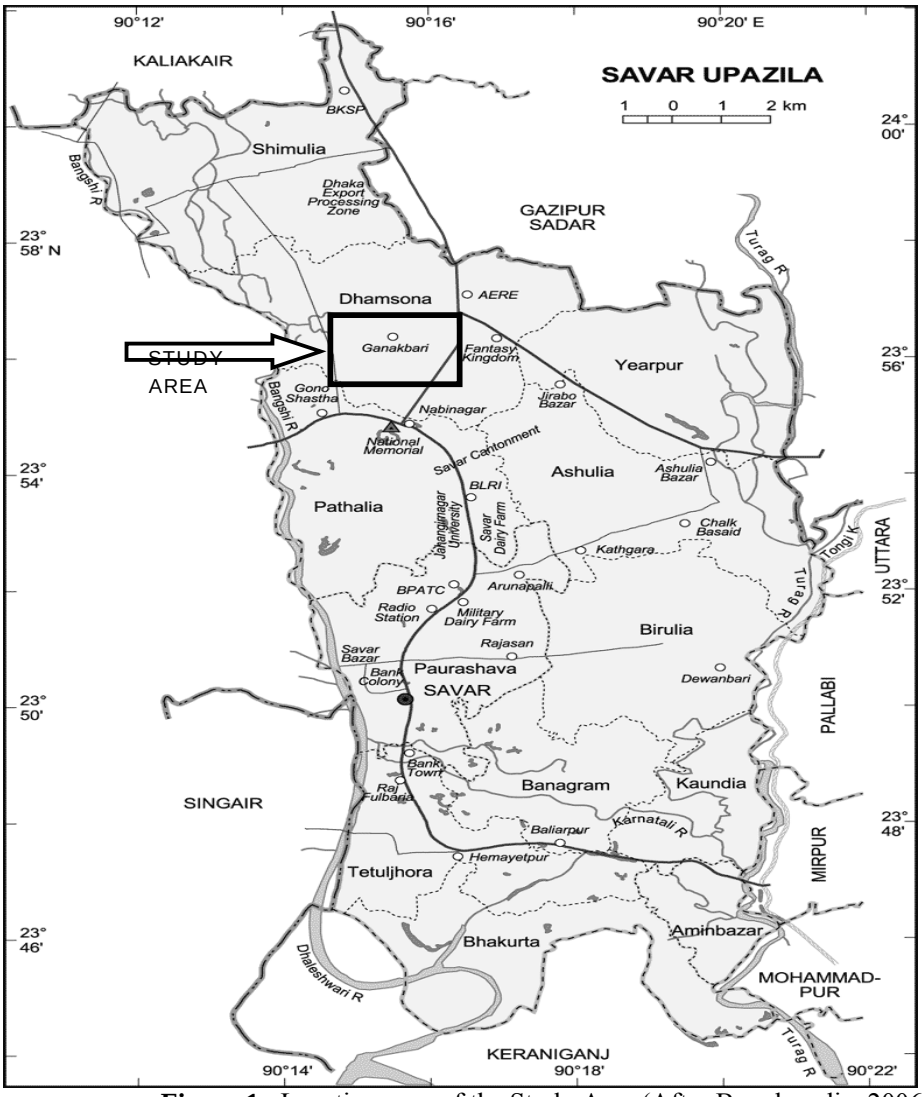

Figure 1. Location map of the Study Area (After Banglapedia, 2006)

Materials and Methods

A detailed field investigation of the study area has been carried out in order to know the topography, soil surface and the nature of soils of the area. The experimental data were obtained from the proper authority of the Housing and Building Research Institute. In the studied area, nine

(9) borings, each extending 65 feet depth, have been selected and executed as per direction of the proper authority. The method of wash boring technique was used as a means of advancing the borehole to enable the tube samples to be taken.

The soil samples, in the disturbed state, usually have been collected after 5′-0′′ intervals up to depth of investigation for each borehole. The above soil samples have been collected simultaneously by using split spoon sampler with the performance of the standard penetration test (SPT). The geotechnical parameters were determined in the soil test laboratory in the Housing and Building Research Institute (HBRI), according to ASTM Standards (1974). The data generated by the Housing and Building Research Institute (HBRI) were collected for this research work.

Results and Discussion

The study area comprises Madhupur Clay soils. During field investigation, different types of soil (grey to red in colour) were found in different soil-geomorphic units.

Borehole Stratigraphy

Stratigraphy of the study area has been revealed from the soils/rocks exposed as well as the soils/rocks encountered in the wells bored. The variety of soils has been developed because of difference in the degree of weathering in different boreholes of the study area. The stratigraphic succession of the study area is given in the table 1 based on the bore log data.

Table 1: The Stratigraphic Succession of the study area

Unit	Rock Type	Lithologic Description	Depth (ft)	Thickness (ft)
C	Clay	Pale grayish ash to light reddish, yellow ash or pale yellowish ash to light reddish yellow ash, mottled, medium plastic and medium stiff to stiff clay.	0-28	28
B	Silty sand	Light reddish yellow ash, mottled low plastic, stiff silt, little fine sand or pale reddish yellow, medium dense to dense, silty fine sand.	28-50	22
A	Sand	Light reddish yellow, dense to very dense, fine sand or pale reddish yellow and yellow, dense fine sand, with some/ little silt.	50-65	15

Individual rock unit has different lithology of the study area from nine boreholes and other characteristics that are described below:

UNIT A: Unit A is mainly a non cohesive sandy unit. This unit is light reddish yellow or pale reddish yellow in colour, dense to very dense in nature, and fine to very fine grained sand. Some or little silt is also present in this unit. The thickness is around 15 feet and depth ranges from 50 to 65 feet in all the bore holes.

UNIT B: Unit B is mainly a silty sand unit. Unit B overlies the unit A in this section. This unit is mottled, light reddish yellow or pale reddish yellow in colour and medium dense to dense in nature. The thickness is around 22 feet and depth ranges from 28 to 50 feet in all the bore holes.

UNIT C: Unit C is mainly a clay unit which overlies the unit B in this area. This unit is pale grayish to light reddish yellow or pale yellowish in colour, mainly medium to stiff in nature and show medium plasticity. Some or little silt is also present in this unit. The thickness is around 28 feet and depth ranges from 0 to 28 feet in all the bore holes.

Standard Penetration Test

The standard penetration test (SPT) is performed during the advancement of a soil boring to obtain an approximate measure of the dynamic soil resistance and remains today as the most common in-situ test worldwide. The procedures for the SPT are detailed in ASTM 1974. In the study area observed SPT values with respect to depth in different boreholes are given in Table 2. The SPT value of study area ranges from 4 to 60 in the area and shows that the values are high at greater depth and low at the near surface.

Table 2: SPT values of different boreholes with respect to depth

Depth (ft)	SPT Values								
	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6	BH-7	BH-8	BH-9
5	7	6	4	4	6	4	6	7	4
10	8	9	6	5	9	10	8	8	11
15	9	9	9	11	11	11	12	10	12
20	9	12	9	11	10	9	11	9	11
25	11	9	11	12	10	8	12	10	11
30	23	19	17	12	12	16	17	14	15
35	26	33	23	28	24	30	30	29	30
40	41	46	29	33	33	35	38	37	37
45	46	43	44	47	33	46	41	40	41
50	51	44	46	48	36	55	36	38	47
55	53	42	49	51	41	54	44	37	47
60	57	41	46	56	46	50	58	40	55
65	56	43	59	60	49	51	56	45	54

In borehole-1 the SPT value ranges from 7 to 57. In borehole-2 the SPT value ranges from 6 to 46. In borehole-3 the SPT value ranges from 4 to 59. In borehole-4 the SPT value ranges from 4 to 60. In borehole-5 the SPT value ranges from 6 to 49. In borehole-6 the SPT value ranges from 4 to 55. In borehole-7 the SPT value ranges from 6 to 58. In borehole-8 the SPT value ranges from 7 to 45. In borehole-9 the SPT value ranges from 4 to 55.

The term consistency of the cohesive soil is generally used on the basis of the SPT values (N) in the following way (Table 3).

Table 3: Soil classification based on SPT (after Terzaghi and Peck, 1967)

Cohesive Soil		
SPT Value	Type	Remarks
0-2	Very soft	Not suitable for civil structures, good for park.
2-4	Soft	
4-8	Medium	Good for very light structure using proper methods.
8-15	Stiff	Good for low load bearing structures.
15-30	Very Stiff	Good for moderate load bearing structures.
>30	Hard	Good for high load bearing structures.

The term relative density for the Non-cohesive soil is based on the SPT values (N) in the following way (Table 4).

Table 4: Soil classification based on SPT (after BS 5930, 1981)

Non-Cohesive Soil		
SPT Value	Type	Remarks
0-4	Very loose	Not suitable for civil structures, good for park.
4-10	Loose	Good for very light structure using proper methods.
10-30	Medium dense	Good for low to moderate load bearing structures.
30-50	Dense	Good for moderate to high load bearing structures.
>50	Very dense	Good for high load bearing structures.

The SPT values increase with increasing depth in all the bore holes (Figure 2). The layer of the cohesive clay soil (Unit C), extending to the depth of 0-28 feet, usually has the consistency that varies from medium to stiff. The top most part of this layer shows medium consistency (depth ranges from 0-10 ft) where as the lower part shows stiff consistency (depth ranges from 10-28 ft). Further below, the non cohesive silty and sandy layers (Unit B & A respectively), extending to the depth of about 28-65 ft, usually have been found in a medium dense to very dense state.

The SPT values suggested that the upper soil (up to 35 ft depth) is suitable for only light to medium load bearing structures with proper methods and the lower soil i.e. below 35 ft depth is suitable for constructions of medium to high load bearing structures.

Grain size analysis

Grain size analysis is one of the most suitable criteria of soil which is universally used in engineering classification of soils. The influence of size range of different particles on geotechnical parameters are well known to all over the world. The grain size results are shown in table 5. The particles generally tend to occur in somewhat different size range. The variation of sand, silt and clay fractions are shown in Figure 3.

The sand percentage ranges from 2% to 81%, silt from 19% to 83% and clay from 7% to 26%. The sand percentage is very much higher at greater depth (50 ft). The sand percentages are increasing with increasing depth whereas silt and clay percentages are decreasing with increasing depth (Figure 3). The clay percentage is abruptly lower at 28ft depth whereas the silt and sand percentages are high. This variation of grain size especially the clay fraction may be due to the

effect of binding agent in the clay, due to the effect of reagent used and especially, due to the effect of heating prior to the grinding of the materials (Gidigasu, 1976). The obtained results are closely related to the findings of Haque (1994), Islam (1997) and Nairuzzaman (2000), but slightly inconsistent with Serajuddin and Ahmed (1967), Salahuddin (1991), WASA (1991) and Ahammed *et al.* (2006).

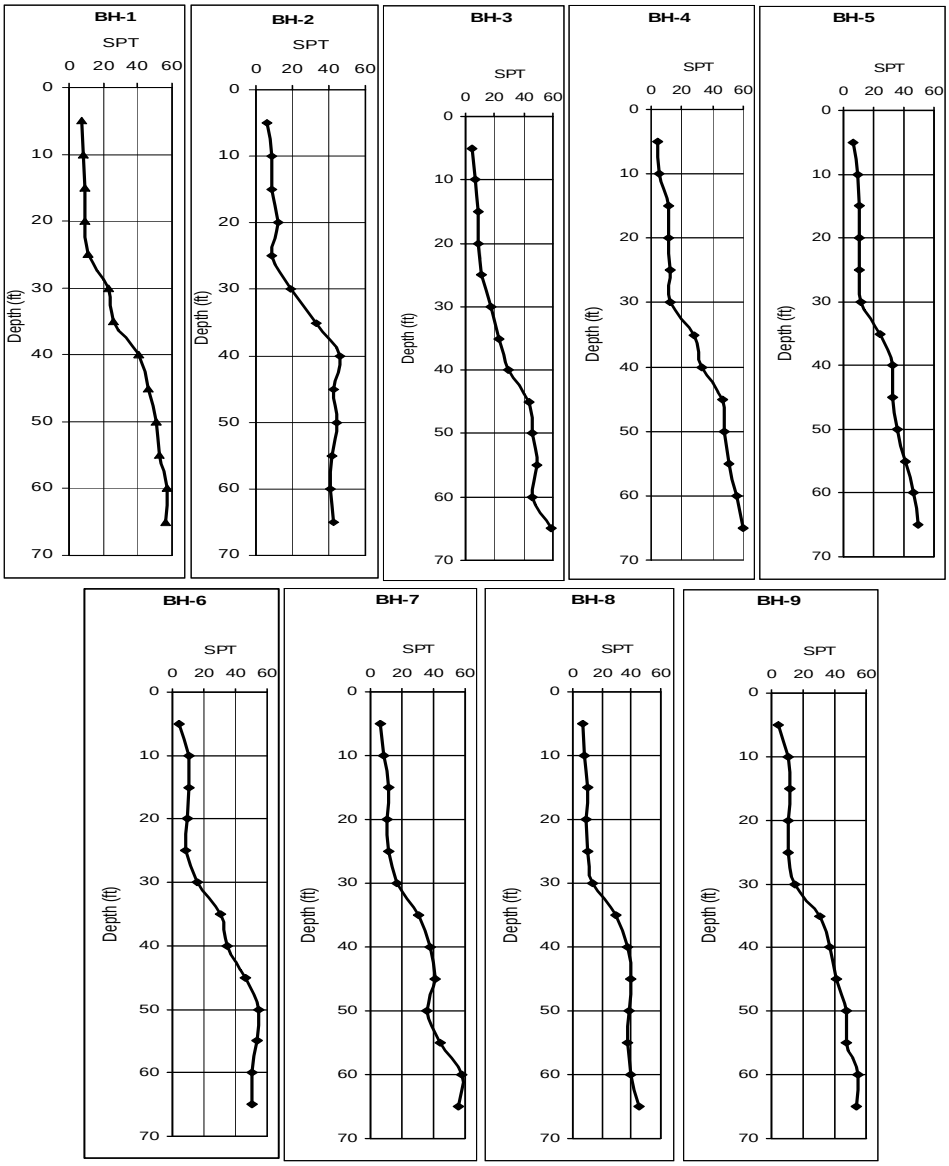

Figure 2. Variation of SPT values with respect to the depth for the boreholes

In most cases the soil is much better and suggested as suitable for construction of low to moderate structures up to 35 feet depth. The sandy soil below this depth is much more suitable for heavy load bearing structures. The co-efficient of uniformity (Cu) and co-efficient of gradation (Cg) have been determined and the values are presented in the table 5. The value of co-efficient of uniformity ranges from 2.40 to 24.29 and the values of co-efficient of gradation ranges from 0.14 to 2.26. Smith (1990) mentioned that if Cu<4, then the soil is uniformly graded and Cu>4 represents well graded. But according to Whitlow (1990), Cu<3 represents uniform graded soil and Cu>5 represents well graded soil. Whitlow (1990) also mentioned that most well graded soils will have the values of Cg between 0.5 and 2. The obtained values of Cu and Cg suggest that the analyzed soil is uniformly graded to well graded according to Smith (1990) and Whitlow (1990). Thus, the grading properties suggest that the soil may be suitable for civil constructions.

Table 5: Grain size and grading properties with Depth in Different Borehole

Location	Borehole No.	Sample No.	Depth (ft)	Grain Percent			Grading Properties	
				Sand (%)	Silt (%)	Clay (%)	Cu	Cg
Ganakbari	BH-1	UD-1	8.5	3	76	21	21.25	1.24
		D-7	35	59	41	00	3.45	1.46
		D-13	65	81	19	00	2.40	1.07
	BH-2	D-2	10	4	74	22	18.75	1.33
		D-6	30	43	57	00	6.15	1.54
		D-12	60	78	22	00	2.60	0.98
	BH-3	UD-1	8.5	2	76	22	15.00	1.28
		D-4	20	7	81	12	12.35	1.37
		D-13	65	78	22	00	2.40	1.13
	BH-4	UD-1	8.5	3	75	22	24.29	1.63
		D-5	25	10	83	7	9.63	1.42
		D-12	60	75	25	00	3.40	1.50
	BH-5	UD-2	13.5	3	71	26	17.14	1.07
		D-5	25	18	82	00	5.71	1.43
		D-10	50	76	24	00	3.05	1.25
	BH-6	UD-1	8.5	4	72	24	2.46	0.14
		D-6	30	41	59	00	6.82	1.48
		D-9	45	64	36	00	4.40	1.54
	BH-7	D-1	5	3	75	22	20.63	1.21
		D-7	35	48	52	00	6.67	1.58
		D-10	50	63	37	00	5.50	1.69
	BH-8	UD-1	8.5	3	75	22	20.00	0.99
		D-7	35	20	80	00	6.57	1.24
		D-11	55	80	20	00	3.00	1.33
	BH-9	UD-2	13.5	4	76	20	15.45	1.13
		D-6	30	38	62	00	10.71	1.19
		D-10	50	64	36	00	6.47	2.26

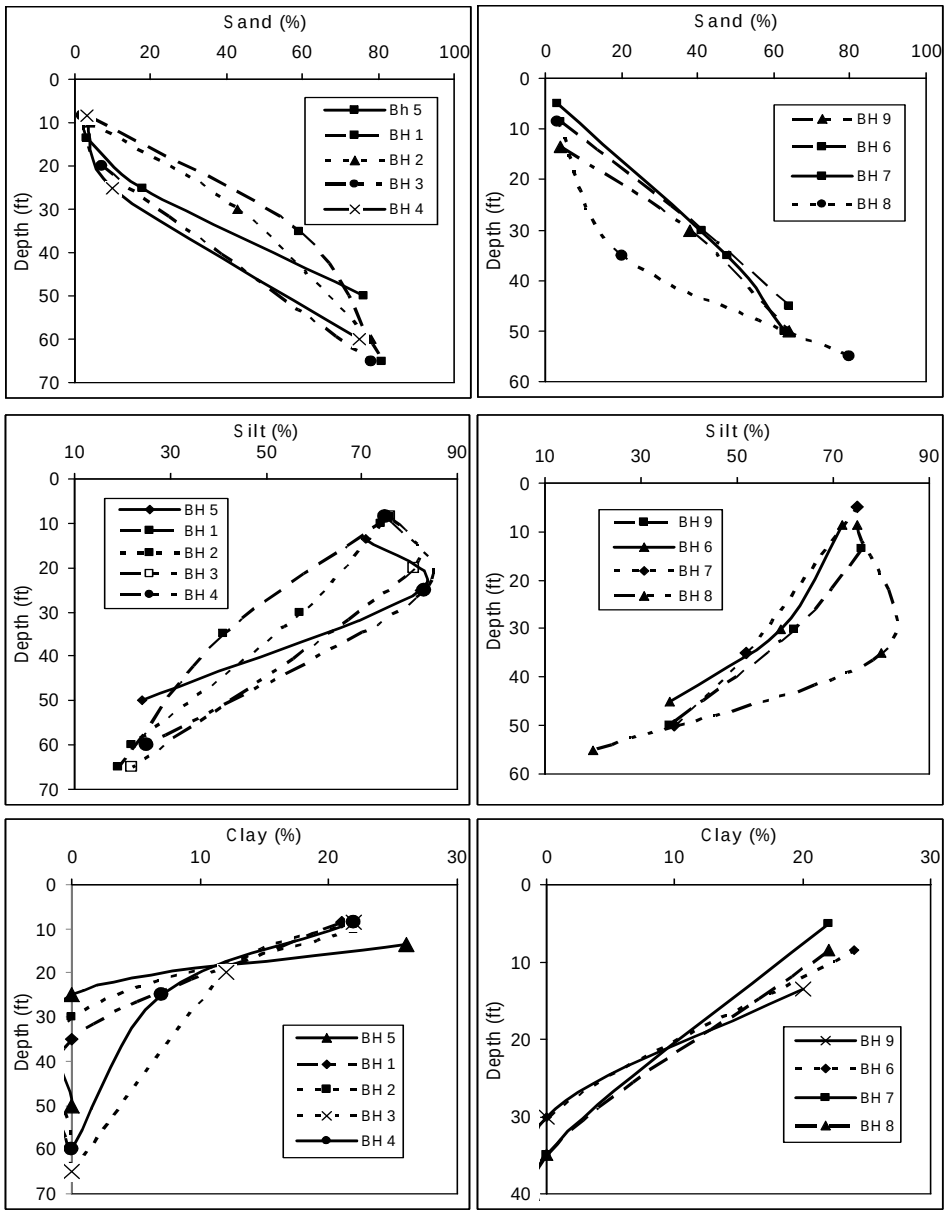

Figure 3. Variations of grain size in different boreholes with respect to depth

Conclusion

In this paper some engineering parameters and characteristics of some soil samples have been evaluated and interpreted. From the bore log data three stratigraphic units have been identified namely unit A, unit B and unit C. The lowermost unit (Unit A) is mainly a sandy non cohesive

unit. This unit is light reddish yellow or pale reddish yellow in colour and dense to very dense in nature. Unit B is mainly a silty sand unit. This unit is mottled, light reddish yellow or pale reddish yellow in colour and medium dense to dense in nature. The top most unit (Unit C) is mainly a clay unit. This unit is pale grayish to light reddish yellow or pale yellowish in colour, mainly medium to stiff in nature and show medium plasticity.

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The sand percentage ranges from 2% to 81%, silt from 19% to 83% and clay from 7% to 26%. In all boreholes the sand percentages are increasing with increasing depth but silt and clay percentages are decreasing with increasing depth. The value of co-efficient of uniformity ranges from 2.40 to 24.29 and the values of co-efficient of gradation ranges from 0.14 to 2.26. The obtained values of Cu and Cg suggest that the analyzed soil is uniformly graded to well graded in nature.

From the engineering geological investigation it can be said that upper soil is suitable for light and moderate load bearing structures (up to 35 feet) whereas the lower soil is very much suitable for heavy structures (below 35 feet depth).

Acknowledgement

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