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GEOTECHNICAL ENGINEERING REPORT FOR UPPER PUZUNTAUNG ROAD

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Abstract: *Upper Puzuntaung road exists Satsan quarter, Tarmwe Township, Yangon Division, in Myanmar. The proposed building is two stories RC building. Geotechnical engineering report is very important for foundation engineering and structural engineering. It depends on the right data from site investigation and laboratory test results. In this paper include interpretation of site investigation results (soil profile) with Standard Penetration Test(SPT) and laboratory test results for geotechnical engineering and related pile capacities. Subsoil stratification, groundwater level, very soft /soft Soil at the project site, Geotechnical capacity of the pile, soil profile types based on UBC97, Settlement of driving piles, conclusion, and reference books are described in this paper. Unified soil classification system is used to find soil classification. Type of soil are ML, CL, SM and soft soil layers exist up to 10 to 15m. Then stiff/hard and dense /very dense soil layers exist. The groundwater level was measured with respect to ground level. That is 1.2 to 2m. Recommended safe bearing capacity values for the shallow foundation is not adequate to support the proposed structures. To have a higher safe bearing capacity, pile foundation shall be considered. Pile capacities based on SPT are only described in this paper. Pile length is 30,32,34,36 m and pile width varies 30x30 cm^2, 35x35 cm^2 ,40x40 cm^2. Allowable Pile -end resistance (KN) is 104 kN to 550 kN, Allowable Pile -side resistance is 128 to 547 kN for all boreholes in various conditions with factor of safety is 3. According to UBC 97, all boreholes have soft soil profile type S_E .The settlement is 9mm to 13 mm respectively.*

Key Words: *site investigation, laboratory test results, Standard Penetration Test, pile capacities, Settlements.*

1. INTRODUCTION:

To be a sustainable building, there are needed a right site investigation, laboratory test and related net allowable bearing capacity of shallow foundations and pile foundations. But some area of constructions such as buildings, transmission towers is built without actual soil data. There are major problems in the constructions site to be sustainable. There is essential work to be aware of geotechnical engineering in all state holders. That causes the reduction of dangerous construction in Myanmar. This paper will provide awareness of geotechnical engineering.

2. LITERATURE REVIEW:

Unified soil classification system is preferred to geotechnical engineering. There are many different types of pile capacity equations based on soil parameters and standard penetration Test. In this paper, pile capacity related to the standard penetration test is described.

2.1 *Equation for estimating of pile capacity*

The ultimate load-carry capacity Q_u of a pile is given by the equation

$$Q_u=Q_{p+}Q_s$$

Where
Q_p=load –carrying capacity of the pile point
Q_s=frictional resistance (skin friction) derived from the soil-pile interface

2.2 ***Using Penetration Test Data for Pile Point Resistance, Q_p***

For standard penetration test (SPT) data Meyerhof (1956, 1976) proposed

$$\mathrm{Qp} = \mathrm{P_{pu}} = \mathrm{A_p}(40\mathrm{N})\frac{\mathrm{L_b}}{\mathrm{B}} \leq \mathrm{A_p}(380\mathrm{N}) \qquad (\mathrm{KN})$$

Where
N= statistical average of the SPT N_{55} numbers in a zone of about 10B above to 5 B below the pile point

B= width or diameter of pile point
L_b = pile penetration depth into a point –bearing stratum
L_b/B=average depth ratio of a point into point –bearing stratum

2.3. *Frictional Resistance, Q_s*

The frictional,or skin resistance of a pile may be written as

$$Q_s = \sum p\, \Delta L\, f$$

Where
p = perimeter of the pile section
ΔL = incremental pile length over which p and f are taken to be constant
f = unit friction resistance at any depth z

Using Penetration Test Data for Skin Resistance, Q_s
Shioi and Fukui (1982) suggest the following:
` For driven piles: $f_s = 2N_{s,\ 55for}$ sand, $f_s = 10N_{c,\ 55}$ for clay (kPa)
For bored piles :$f_s = 1N_{s,55}$ for sand, $f_s = 5N_{c,55}$ for clay (kPa)
Where
$N_{i,55}$= average blow count in the material indicated for the pile or pile segment length

2.4 *Calculation of settlement of pile capacity*

$S_t = S_s + S_p + S_{ps}$
S_t= total pile top settlement for a single pile
S_s= settlement due to axial deformation of a pile shaft or elastic settlement of pile
S_p = settlement of pile base or point caused by load transmitted at the base
S_{ps} =settlement of pile caused by load transmitted along the pile shaft

$$S_s = (Q_{Pa} + \alpha_s\ Q_{fa})L/(A_P\, E_P)$$
$$S_P = \frac{C_P\, Q_{Pa}}{B q_P}$$
$$S_{ps} = C_s\, Q_{fa}\,/(D_f\, q_p)$$

3. METHODOLOGY: Following steps are conducted to the geotechnical report of upperpuzontaung road.

- To obtain site investigation results data
- To obtain laboratory test results
- To classify soil type using USCS
- To describe soil consistency and stiffness
- To describe groundwater table
- To show difficult soil layers
- To find pile capacities
- To find settlement

4. RESULTS AND DISCUSSION

4.1 *Site Location*

The project site is located the upperpuzundaung road, Mingalartaungnyunt Township, Yangon Division, Myanmar. Figure 4.1 represents the site location and borehole locations. Then stiff/hard and dense /very dense soil layers exist.

All Boreholes have soft subsoil condition up to10 to 15 m depth below the existing grade. Maximum depths of boreholes are 44 m, 47m, 45.5m, 44 m respectively.

In Soil stratification includes soil layers, soil types, SPT number and soil consistency/soil stiffness. There are describe in table 4.1.

Figure 4.1 Site Location and Location of Borehole on Google Earth Map

Table 4.1 Subsoil Stratification

BH No.	***Layer***	***Depth(m)***	***Subsoil Type***	***SPT Range***	***Average SPT Value***	***Description***
BH 1	I	0-1.0				Top Soil
	II	1.0-3.0	ML	2 , 6,6	5	Soft
	III	3.0-6.0	ML	1 , 5	3	Soft
	IV	6.0-8.0	ML	1 , 2	1	Very Soft
	V	8.0-10.5	ML	2	2	soft
	VI	10.5-12.0	ML	5	5	Soft
	VII	12.0-16.5	ML	2 ,4,7	4	Soft
	VIII	16.5-25.5	CL	8 ,9,10,14	9	Stiff
	IX	25.5-30.0	SM	15,16,18	16	Dense
	X	30.0-34.5	ML	19,51,56	42	Hard
	XI	34.5-37.5	ML,SM	48,36	42	Dense
	XII	37.5-42.0	SM	37,59,64	>50	Dense
	XIII	42.0- 44.0	SM	69,64	>50	Dense
BH 2	I	0-1.0				Top Soil
	II	1.0-3.0	ML	2,3,4	3	Soft
	III	3.0-4.5	ML	2	2	Very Soft
	IV	4.5-6.5	CL	1,2	1	Very Soft
	V	6.5-8.0	ML	4	4	Soft
BH No.	***Layer***	***Depth(m)***	***Subsoil Type***	***SPT Range***	***Average SPT Value***	***Description***
BH 2	VI	8.0-12.0	ML,CL	2,7	4	Soft
	VII	12.0-13.5	CL	7	7	medium
	VIII	13.5-15.0	CL	6	6	medium
	IX	15.0-16.5	CL	9	9	stiff
	X	16.5-18.0	CL	10	10	stiff
	XI	18-19.5	CL	10	10	stiff
	XII	19.5-21	CL	8	8	stiff

	XIII	21-22.5	CL	11	11	stiff
	XIV	22.5-24.0	CL	12	12	stiff
	XV	24.00-25.5	CL	14	14	stiff
	XVI	25.5-28.5	SM	15,16	15	Medium
	XVII	28.5- 33.0	SM	15,17,16	16	Medium
	XVIII	33.0- 39.0	ML	13,14,	13	stiff
	XIX	39.0-40.5	ML	18	18	very stiff
	XX	40.5- 42.0	ML	28	28	very stiff
	XXI	42.0- 43.5	ML	63	63	Hard
	XXII	43.5-45.0	ML	59	59	Hard
	XXIII	45.0-46.5	SM	53	53	Dense
	XXIV	46.5-47.0	SM	88	88	Dense
BH 3	I	0-1.0		nil		Top Soil
	II	1.0-3.00	CL	2	2	Very Soft
	III	3.0-10.5	CL,ML	3,1,3,2,2,	2	Very Soft
	IV	10.5-13.50	CL,SM	2,11	6	medium
	V	13.5-16.5	SM, ML	17, 5	11	stiff
	VI	16.5-19.5	ML	7,11	9	stiff
	VII	19.5-22.5	ML	13, 12	12	stiff
BH No.	***Layer***	***Depth(m)***	***Subsoil Type***	***SPT Range***	***Average SPT Value***	***Description***
	VIII	22.5-30	ML	10 to 14	12	stiff
	IX	30.0-34.5	ML	12,15,16	14	stiff
	X	34.5-36.0	ML	18	18	Very stiff
	XI	36.0-39.0	ML	15, 14	14	Very stiff
	XII	39.0-40.5	ML	16	16	Very stiff
	XIII	40.5- 43.5	ML,SM	57,71	>50	Dense
	XIV	43.5-45.5	SM	71,76	>50	Dense
BH 4	I	0-1.0				Top Soil
	II	1.0-3.0	CL	2,2,6	3	Soft
	III	3.0-4.5	CL	5	5	Soft
	IV	4.5-7.50	CL	2,3	2	Very Soft
	V	7.5-10.50	CL	2	2	Very Soft
	VI	10.5-13.50	CL	3,2	2	Very Soft
	VII	13.5-15.0	ML	3	3	Soft
	VIII	15.0-18.0	ML,CL	10	10	Stiff
	IX	18-24.0	CL	8-12	10	Stiff
	X	24.00-33.0	CL	10 -14	12	Stiff
	XI	33.0- 34.5	CL	11	11	Stiff
	XII	34.5-36.0	ML	16	16	Very Stiff
	XIII	36.0-44.0	ML, SM	22 -79	>50	Dense

4.2 *Ground Water Level*

The groundwater level was measured with respect to ground level, the measuring time is 3 days, up to the termination of boreholes. The average measurement of groundwater levels was tabulated below:

Table 4.2 Ground Water Level

BH No.	***Ground Water Table(m)(BGL)***	***Termination Depth(m)***	***Remark***
BH 1	1.5	44.00	Min: 0.00 m, max: 2.8 m depth BGL
BH 2	1.2	47.00	Min: 1.00 m, max: 1.4 m depth BGL
BH 3	2.12	45.50	Min: 0.30 m, max: 4.2 m depth BGL
BH 4	1.15	44.00	Min: 1.00 m, max: 1.6 m depth BGL

4.3 *Very Soft / Soft Soil at the Project Site*

Table 4.3. Thickness of Soft soils layers

BH No.	***layer***	***Depth of very soft to soft soil***	***Thickness (m)***	***Soil Type***	***SPT-N***	***Avg. SPT-N***	***Description***
BH 1	I	0-1.0					Top Soil
	II	1.0-3.0	2	ML	2 , 6,6	5	Soft
	III	3.0-6.0	3	ML	1 , 5	3	Soft
	IV	6.0-8.0	2	ML	1 , 2	1	Very Soft
	V	8.0-10.5	2.5	ML	2	2	soft
	VI	10.5-12.0	1.5	ML	5	5	Soft
	VII	12.0-16.5	4.5	ML	2 ,4,7	4	Soft
BH 2	II	1.0-3.0	2.0	ML	2,3,4	3	Soft
	III	3.0-4.5	1.4	ML	2	2	Very Soft
	IV	4.5-6.5	2.0	CL	1,2	1	Very Soft
	V	6.5-8.0	1.5	ML	4	4	Soft
	VI	8.0-12.0	4.0	ML,CL	2,7	4	Soft
BH 3	II	1.0-3.00	2.0	CL	2	2	Very Soft
	III	3.0-10.5	7.5	CL,ML	3,1,3,2,2,	2	Very Soft
BH 4	II	1.0-3.0	2	CL	2,2,6	3	Soft
	III	3.0-4.5	1.5	CL	5	5	Soft
	IV	4.5-7.50	3	CL	2,3	2	Very Soft
	V	7.5-10.50	3	CL	2	2	Very Soft
	VI	10.5-13.50	3	CL	3,2	2	Very Soft

4.4 *Geotechnical Capacity of Piles*

Recommended safe bearing capacity values for shallow foundation or appropriate soil improvement placed on the existing soil is not adequate to support the proposed structures. To have the higher safe bearing capacity, pile foundation shall be considered.

Ultimate and Allowable Load Carrying Capacity of Piles are shown in table 4.4.

Table 4.4 Ultimate and Allowable Load Carrying Capacity of Piles

BH No.	***Pile Length (m)***	***Pile size: (cm)***	***WP for Pile***	***Ultimate Pile -end resistance (kN)***	***Ultimate Pile -side resistance (kN)***	***Allowable Pile -end resistance (KN)***	***Allowable Pile -side resistance***	***Factor of safety***
BH-1	30	30x30	63.66	679.03	1143.62	226.34	381.21	3
	30	35x35	86.65	853.13	1231.59	284.38	410.53	3
	30	40x40	113.18	1114.30	1407.53	371.43	469.18	3
BH 1	32	30x30	67.91	940.19	1385.54	313.40	461.85	3
	32	35x35	92.43	1137.51	1436.86	379.17	478.95	3
	32	40x40	120.79	1485.73	1642.12	495.24	547.37	3
BH 1	34	30x30	72.1548	932.09	1387.01	310.70	462.34	3
	34	35x35	98.21	1253.40	1618.18	417.80	539.39	3
	34	40x40	128.27	1637.09	1765.28	545.70	588.43	3
BH 1	36	30x30	76.399	916.68	1261.83	305.56	420.61	3
	36	35x35	103.98	1247.71	1472.14	415.90	490.71	3

	36	40x40	135.8	1650.55	1583.48	550.18	527.83	3
BH 2	30	30x30	63.66	417.86	527.83	139.29	175.94	3
	30	35x35	86.65	568.76	615.80	189.59	205.27	3
	30	40x40	113.18	742.87	703.77	247.62	234.59	3
BH2	32	30x30	67.91	391.75	604.80	130.58	201.60	3
	32	35x35	92.43	533.21	705.60	177.74	235.20	3
	32	40x40	120.79	696.44	806.40	232.15	268.80	3
BH 2	34	30x30	72.1548	391.75	714.76	130.58	238.25	3
	34	35x35	98.21	533.21	833.89	177.74	277.96	3
	34	40x40	128.27	696.44	953.02	232.15	317.67	3
BH 2	36	30x30	76.399	365.63	769.75	121.88	256.58	3
	36	35x35	103.98	497.66	898.04	165.89	299.35	3
	36	40x40	135.8	650.01	1026.33	216.67	342.11	3
BH3	30	30x30	63.66	313.40	439.85	104.47	146.62	3
	30	35x35	86.65	426.57	513.16	142.19	171.05	3
	30	40x40	113.18	557.15	586.47	185.72	195.49	3
BH 3	32	30x30	67.91	339.51	571.81	113.17	190.60	3
	32	35x35	92.43	462.11	667.11	154.04	222.37	3
	32	40x40	120.79	603.58	762.41	201.19	254.14	3
BH 3	34	30x30	72.1548	391.75	769.75	130.58	256.58	3
	34	35x35	98.21	497.66	838.17	165.89	279.39	3
	34	40x40	128.27	650.01	957.91	216.67	319.30	3
BH 3	36	30x30	76.399	391.75	879.71	130.58	293.24	3
	36	35x35	103.98	533.21	1026.33	177.74	342.11	3
	36	40x40	135.8	696.44	1172.95	232.15	390.98	3
BH 4 BH 4	30	30x30	63.66	313.40	384.87	104.47	128.29	3
	30	35x35	86.65	426.57	449.02	142.19	149.67	3
	30	40x40	113.18	557.15	513.16	185.72	171.05	3
BH 4	32	30x30	67.91	287.28	453.60	95.76	151.20	3
	32	35x35	92.43	391.02	529.20	130.34	176.40	3
	32	40x40	120.79	510.72	604.80	170.24	201.60	3
BH 4	34	30x30	72.1548	365.63	705.60	121.88	235.20	3
	34	35x35	98.21	462.11	764.40	154.04	254.80	3
	34	40x40	128.27	603.58	873.60	201.19	291.20	3
BH 4	36	30x30	76.399	548.44	1250.84	182.81	416.95	3
	36	35x35	103.98	533.21	1042.36	177.74	347.45	3
	36	40x40	135.8	696.44	1191.27	232.15	397.09	3

4.5 *Soil Profile Types Base on UBC97*

According to UBC 97, all boreholes have soil profile type S_E.

Table ES-5. Soil Profile Type Base on UBC 97

BH No.	*Avg. N (blows/ft)*	*Soil Profile Type*	*Soil Profile Name*	*Remark*
BH-1	4	S_E	Soft Soil Profile	<15
BH-2	4	S_E	Soft Soil Profile	<15
BH-3	4	S_E	Soft Soil Profile	<15
BH-4	4	S_E	Soft Soil Profile	<15

4.6 *Settlement of Driven Piles*

All settlements (short- term settlement*)* are 7 mm to 13.45 mm respectively.

BH No.	*Pile Length (m)*	*Pile size: (cm)*	*Ultimate Pile -end resistance (KN)*	*Ultimate Pile -side resistance (KN)*	F_S	Area of Pile $A_p(m^2)$	E_p kN/m^2	**Settlement (mm)*
BH-1	30	30x30	679.03	1143.62	3	0.0900	22.9x10^6	10.71
	30	35x35	853.13	1231.59	3	0.1225	22.9x10^6	10.65
	30	40x40	1114.30	1407.53	3	0.1600	22.9x10^6	11.16
BH 1	32	30x30	940.19	1385.54	3	0.0900	22.9x10^6	12.8
	32	35x35	1137.51	1436.86	3	0.1225	22.9x10^6	12.13
	32	40x40	1485.73	1642.12	3	0.1600	22.9x10^6	12.52
BH 1	34	30x30	932.09	1387.01	3	0.0900	22.9x10^6	13.22
	34	35x35	1253.40	1618.18	3	0.1225	22.9x10^6	13.35
	34	40x40	1637.09	1765.28	3	0.1600	22.9x10^6	13.45
BH 1	36	30x30	916.68	1261.83	3	0.0900	22.9x10^6	13.13
	36	35x35	1247.71	1472.14	3	0.1225	22.9x10^6	13.3
	36	40x40	1650.55	1583.48	3	0.1600	22.9x10^6	13.38
BH 2	30	30x30	417.86	527.83	3	0.0900	22.9x10^6	8.56
	30	35x35	568.76	615.80	3	0.1225	22.9x10^6	9.25
	30	40x40	742.87	703.77	3	0.1600	22.9x10^6	10
BH2	32	30x30	391.75	604.80	3	0.0900	22.9x10^6	9.03
	32	35x35	533.21	705.60	3	0.1225	22.9x10^6	9.71
	32	40x40	696.44	806.40	3	0.1600	22.9x10^6	10.44
BH 2	34	30x30	391.75	714.76	3	0.0900	22.9x10^6	9.72
	34	35x35	533.21	833.89	3	0.1225	22.9x10^6	10.37
	34	40x40	696.44	953.02	3	0.1600	22.9x10^6	11.08
BH 2	36	30x30	365.63	769.75	3	0.0900	22.9x10^6	10.12
	36	35x35	497.66	898.04	3	0.1225	22.9x10^6	10.76
	36	40x40	650.01	1026.33	3	0.1600	22.9x10^6	11.46
BH3	30	30x30	313.40	439.85	3	0.0900	22.9x10^6	7.98
	30	35x35	426.57	513.16	3	0.1225	22.9x10^6	8.72

	30	40x40	557.15	586.47	3	0.1600	$22.9x10^6$	9.5
BH 3	32	30x30	339.51	571.81	3	0.0900	$22.9x10^6$	8.8
	32	35x35	462.11	667.11	3	0.1225	$22.9x10^6$	9.51
	32	40x40	603.58	762.41	3	0.1600	$22.9x10^6$	10.27
BH 3	34	30x30	391.75	769.75	3	0.0900	$22.9x10^6$	10
	34	35x35	497.66	838.17	3	0.1225	$22.9x10^6$	10.38
	34	40x40	650.01	957.91	3	0.1600	$22.9x10^6$	11.18
BH 3	36	30x30	391.75	879.71	3	0.0900	$22.9x10^6$	10.7
	36	35x35	533.21	1026.33	3	0.1225	$22.9x10^6$	11.31
	36	40x40	696.44	1172.95	3	0.1600	$22.9x10^6$	12
BH 4	30	30x30	313.40	384.87	3	0.0900	$22.9x10^6$	6.65
	30	35x35	426.57	449.02	3	0.1225	$22.9x10^6$	7.21
	30	40x40	557.15	513.16	3	0.1600	$22.9x10^6$	7.81
BH 4	32	30x30	287.28	453.60	3	0.0900	$22.9x10^6$	7.1
	32	35x35	391.02	529.20	3	0.1225	$22.9x10^6$	7.67
	32	40x40	510.72	604.80	3	0.1600	$22.9x10^6$	8.29
BH 4	34	30x30	365.63	705.60	3	0.0900	$22.9x10^6$	8.61
	34	35x35	462.11	764.40	3	0.1225	$22.9x10^6$	8.84
	34	40x40	603.58	873.60	3	0.1600	$22.9x10^6$	9.42
BH 4	36	30x30	548.44	1250.84	3	0.0900	$22.9x10^6$	11.69
	36	35x35	533.21	1042.36	3	0.1225	$22.9x10^6$	10.18
	36	40x40	696.44	1191.27	3	0.1600	$22.9x10^6$	10.69

5. CONCLUSION AND RECOMMENDATION:

Soft soil layers exist up to 10 to 15m. Recommended safe bearing capacity values for the shallow foundation is not adequate to support the proposed structures. To have a higher safe bearing capacity, pile foundation shall be considered. Pile capacities based on SPT are only described in this paper. Pile length is 30,32,34,36 m and pile width varies 30x30 cm^2, 35x35 cm^2 ,40x40 cm^2. Allowable Pile -end resistance (KN) is 104 kN to 550 kN, Allowable Pile - side resistance is 128 to 547 kN for all boreholes in various conditions with factor of safety is 3. According to UBC 97, all boreholes have soft soil profile type S_E. The settlement is 9mm to 13 mm respectively.

Pile depth is deep. Therefore ordinary precast piles are not suitable.

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