CV3301 - Foundation Engineering (2012-2013) S1

1. a) Key Objectives are:

I) To evaluate surface site conditions and variability of subsoil conditions.

II) To identify potential geotechnical hazards.

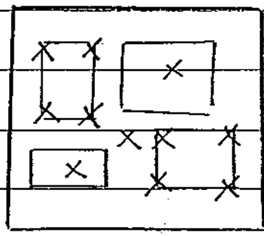
III) To establish soil profile and designed soil parameters.

Site Investigation can be easily affected by the nature of the project such as building with high loading or sensitive to settlement that may affect the safety factor in design the foundation. Local geology also affect the existing soil profile and local practise of foundation design will also affect the cost of foundation.

b) Method: Percussion Wash boring (for the top 4 layer).

Rotary Wash boring (for weathered rock).

• 11 boring are used.



11 boring.

c) Soil type.	Insitu Test	Soil Sampling Method.
Sand fill	CPT	thin wall sampler
Upper Marine Clay	CPT	thin wall sampler
Silty Sand	CPT	thin wall sampler
lower Marine Clay	CPT	thin wall sampler.
Weathered sandstone.	FVT	triple tube core barrel.

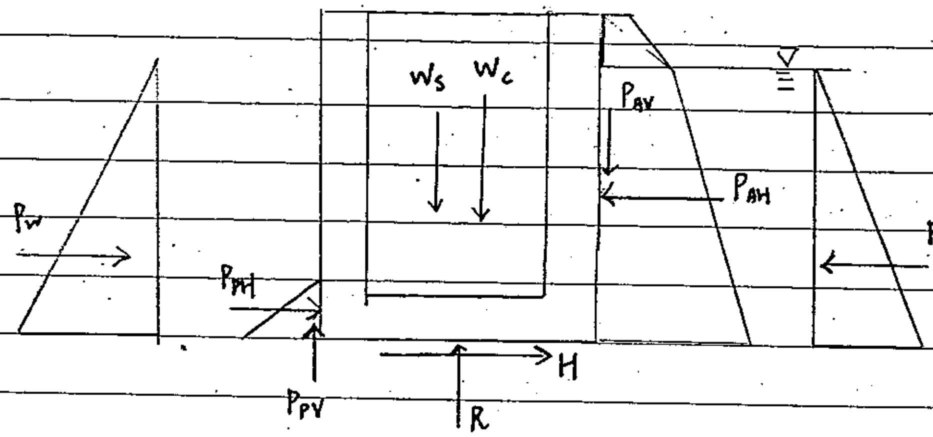
• The drilling of the borehole is terminated after 5m of weathered sandstone is encomtered.

d) Soil Type.	lab tests	Purpose.
Sand Fill	Sieve analysis, Fines content	Soil Strength Parameters: ϕ, γ, E
Upper Marine Clay	Density, Water Content, Atterberg limit, UU, CU, CD, Consolidation.	Soil strength Parameters: ϕ', γ', E, PI, Cu
Silty Sand	Sieve analysis, Fines content	Soil Strength Parameters: ϕ, γ, E.
lower Marine Clay	Density, Water Content, Atterberg limit, UU, CU, CD, Consolidation.	Soil Strength Parameters and consolidation: Cc, Cr, mv,
Weathered sandstone.	RQD	Soil Strength Parameters

e) We can use SPT test to obtain a continuous profile of change in soil stratigraphy.

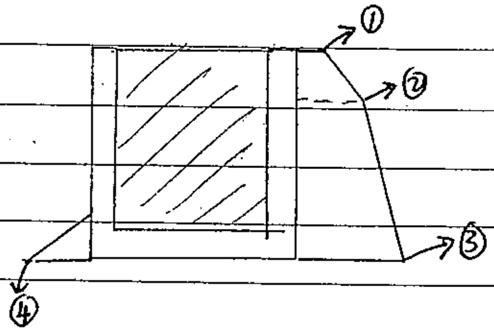
From SPT, we can get the N value and it can correlate to the soil strength and properties parameters.

2a) i)



ii) $\frac{\delta}{\phi_1} = \frac{20}{30}$

$= 0.667$



$K_{AH} = 0.28$, $K_{PH} = 5.0$ (from table)

①: $\sigma_{z1}' = 20$ kPa

$\sigma_{x1}' = K_{AH}\,\sigma_{z1}'$

$= 0.28(20)$

$= 5.6$ kPa

②: $\sigma_{z2}' = 20 + 1\times18$

$= 38$ kPa

$\sigma_{x2}' = K_{AH}\,\sigma_{z2}'$

$= 0.28(38)$

$= 10.64$ kPa

③: $\sigma_{z3}' = 20 + 1\times18 + 4\times(20-10)$

$= 78$ kPa

$\sigma_{x3}' = K_{AH}\,\sigma_{z3}'$

$= 0.28(78)$

$= 21.84$ kPa

④: $\sigma_{z4}' = 1\times(20-10)$

$= 10$ kPa

$\sigma_{x4}' = K_{PH}\,\sigma_{z4}'$

$= 5(10)$

$= 50$ kPa

$P_{AH} = \frac{1}{2}(5.6 + 10.64)(1) + \frac{1}{2}(10.64 + 21.84)(4)$

$= 73.08$ kN

$P_{PH} = \frac{1}{2}(1)(50)$

$= 25$ kN

iii) $H = C_a \times 3$

$= 3\times75$

$= 225$ kPa

FS (sliding) $= \frac{225+25}{73.08}$

$= 3.42$

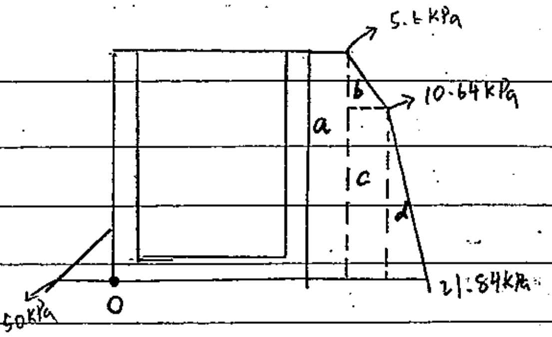
→ use $\gamma_s = 18$ (because is unfavourable value for the FS)

iv) $W_s = (18)(3 - 2\times0.4)(5-0.4)$

$= 182.16\ kN$

$W_c = (2\times0.4\times5 + 3\times0.4)(24)$

$= 124.8\ kN$



$a = 5.6\times5$ $\quad b = \frac{1}{2}(1)(10.64-5.6)$

$= 28\ kN$ $\quad = 2.52\ kN$

$c = (10.64-5.6)\times4$ $\quad d = \frac{1}{2}(4)(21.84-10.64)$

$= 20.16\ kN$ $\quad = 22.4\ kN$

$$FS(\text{overturning}) = \frac{\sout{P_{PH}\times\frac{1}{3} + (W_s+W_c)(1.5)}}{a\times2.5 + b\times(4+\frac{1}{3}) + c(2) + d(\frac{1}{3})(4)}$$

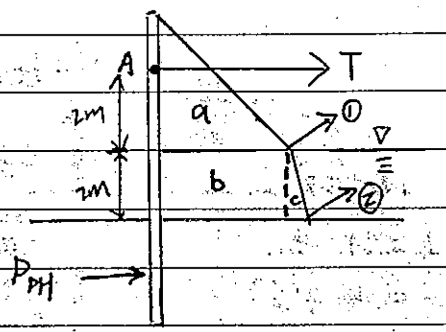
$$= \frac{25\times\frac{1}{3} + (182.16+124.8)(1.5)}{28(2.5) + 2.52(\frac{13}{3}) + 20.16(2) + 22.4(\frac{1}{3})(4)}$$

$$= \frac{468.77}{151.11}$$

$$= 3.10$$

b) $\frac{\delta_m}{\phi'_m} = \frac{20°}{30°}$

$= 0.667$



$K_{AH} = 0.28$ $\quad k_{PH} = 5.0$ (from chart)

①: $\sigma'_{z1} = 3(18)$ $\quad$ ②: $\sigma'_{z2} = 3(18) + 2(20-10)$

$= 54\ kPa$ $\quad = 74\ kPa$

$\sigma'_{x1} = 0.28(54)$ $\quad \sigma'_{x2} = 74(0.28)$

$= 15.12\ kPa$ $\quad = 20.72\ kPa$

$a = \frac{1}{2}(15.12)(3)$ $\quad b = (15.12)(2)$ $\quad c = \frac{1}{2}(20.72-15.12)(2)$

$= 22.68\ kN$ $\quad = 30.24\ kN$ $\quad = 5.6\ kN$

take moment at point A,

$\Sigma M_A = 0$

$a(1) + b(3) + c(2 + 2\times\frac{2}{3}) = P_{PH}(4+1.5)$

$5.5P_{PH} = 22.68(1) + 30.24(3) + 5.6(\frac{10}{3})$

$5.5P_{PH} = 132.067$

$P_{PH} = 24.01\ kN$

$q_n = q_1 - q_2$

$= 3(18) + 2(20) - 2(10)$

$= 74$ kPa

$5.29 C_{wm} - q_n = 5.29(30) - 74$

$= 84.7$ kPa

$P_{PH,Rd} = 84.7(3)$

$= 254.1$

FS (toe kick-out) $= \frac{254.1}{24.01}$

$= 10.54$

3. Assume $B < 2.2m$, $\frac{D}{B} \leq 1$, $\phi = 0$

$N_c = 5.14$, $N_q = 1$, $N_\gamma = 0$

$S_c = 1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$ $\quad$ $S_q = 1 + \left(\frac{B}{L}\right)\tan\phi'$

$= 1 + 1\left(\frac{1}{5.14}\right)$ $\quad$ $= 1 + 1(0)$

$= 1.195$ $\quad$ $= 1$

For $\frac{D}{B} \leq 1$, $k = \frac{D}{B}$

$d_c = 1 + 0.4k$ $\quad$ $d_q = 1 + 2k\tan\phi'(1 - \sin\phi')^2$

$= 1 + 0.4\left(\frac{D}{B}\right)$ $\quad$ $= 1$

$q_{ult}' = cN_c s_c d_c + \sigma_{zD}' N_q S_q d_q \Rightarrow q_{ult} = cN_c s_c d_c + \sigma_{zD}' N_q S_q d_q + u_D$

$q_{ult} = 28(5.14)(1.195)(1 + 0.4\frac{D}{B}) + (\sigma_{zD} - u_D) + u_D$

$= 171.98(1 + 0.4\frac{D}{B}) + \sigma_{zD}$

$q_{ult} - \sigma_{zD} = 171.98(1 + 0.4\frac{D}{B})$

$q_{ult\_net} = 171.98(1 + 0.4\frac{D}{B})$

$= 171.98\left(1 + \frac{0.4 \times 0.8}{B}\right)$

$q_a = \frac{120 + 0.8(B^2)(24)}{B^2}$

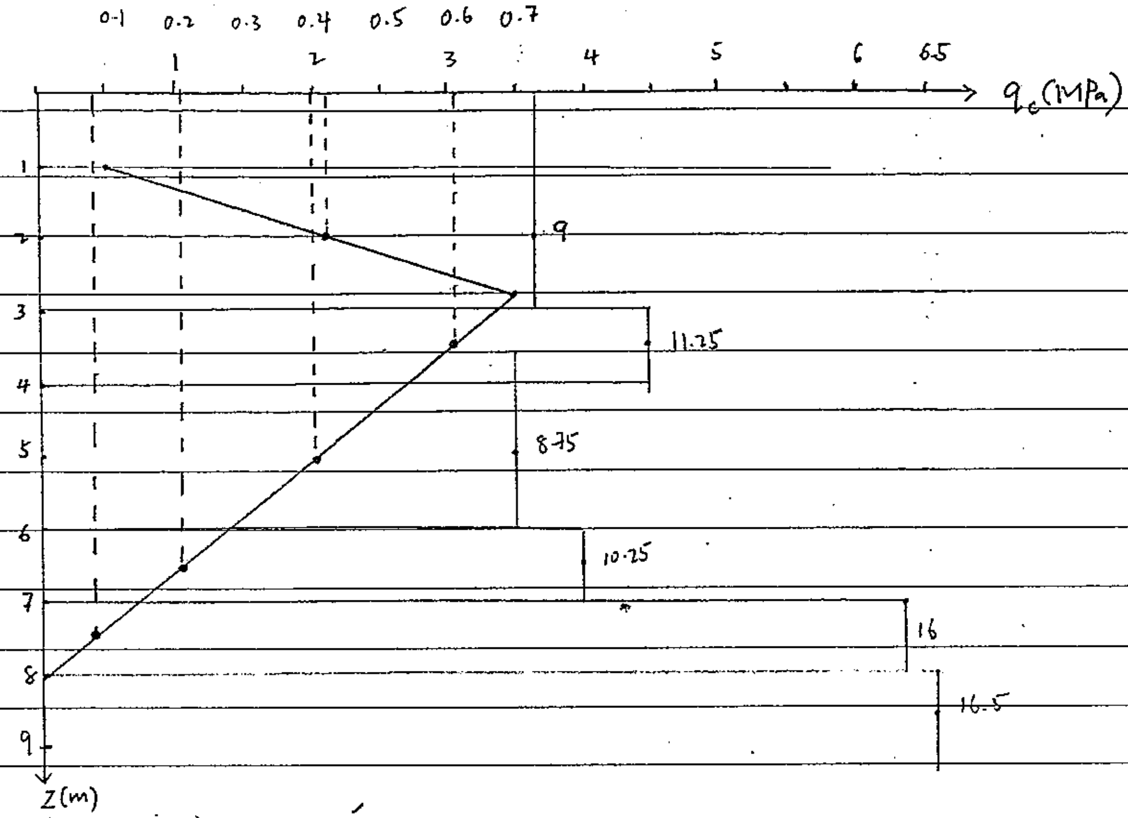
$= \frac{120}{B^2} + 0.8(24)$

$= \frac{120}{B^2} + 19.2$

$q_{a\_net} = q_a - \sigma_{zD}$

$= \frac{120}{B^2} + 19.2 - 0.8(18) = \frac{120}{B^2} + 4.8$

b)



$\sigma_{vp}' = 2.75(16.5) - 0.75(10)$

$= 37.875$ kPa

$I_z = 0.5 + 0.1\left(\frac{\Delta p}{\sigma'_{vp}}\right)^{0.5}$

$= 0.5 + 0.1\left(\frac{150}{37.875}\right)^{0.5}$

$= 0.7$

z	q_c	$E = 2.5 q_c$
2	3.6	9
3.5	4.5	11.25
5	3.5	8.75
6.5	4.1	10.25
7	6.4	16
8.5	6.6	16.5

z	H	I	E	$\frac{IH}{E}$
	2	0.42	9	0.093
	1	0.61	11.25	0.053
	2	0.4	8.75	0.091
	1	0.21	10.25	0.02
	1	0.9	16	0.056
			$\sum \frac{IH}{E}$	0.313

$C_1 = 1 - 0.5\left(\frac{16.5}{150}\right)$

$= 0.945$

$C_2 = 1 + 0.2\log\frac{0}{0.1}$ or $C_2 = 1 + 0.2\log\frac{30}{0.1}$

$= 1$ $\quad = 1.495$

$C_3 = 1.03 - 0.03\left(\frac{3.5}{3.5}\right)$

$= 1$

$\delta_d = C_1 C_2 C_3 \Delta q \sum \frac{IH}{E}$

$= 0.945(1)(1)(150)(0.313)$

$= 44.37$ mm

$\delta(30\text{ years}) = C_1 C_2 C_3 q \sum \frac{IH}{E}$

$= 0.945(1.495)(1)(150)(0.313)$

$= 66.33$ mm

$q_{a\_net} = \dfrac{q_{ult\_net}}{F.S.}$

$\dfrac{120}{B^2} + 4.8 = \dfrac{171.98(1 + \frac{0.32}{B})}{2.5}$

$\dfrac{120}{B^2} + 4.8 = 68.79(1 + \frac{0.32}{B})$

$(\dfrac{120}{B^2} + 4.8 = 68.79 + \dfrac{22.01}{B}) \times B^2$

$120 + 4.8B^2 = 68.79B^2 + 22.01B$

$63.99B^2 + 22.01B - 120 = 0$

$B = 1.208$ or $B = -1.55$

(suitable)

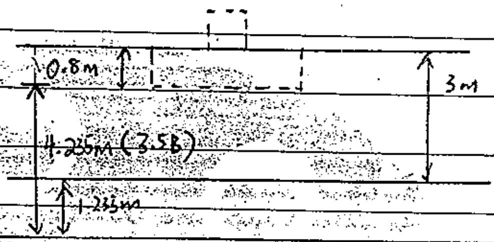
use $B = 1.21m$

ii) Eurocode 7 and Approach 1.

iii) $q - \sigma_{zD} = \dfrac{120}{B^2} + 4.8 = q_{a\_net}$

$= \dfrac{120}{1.21^2} + 4.8$

$= 86.76$ kPa



$\dfrac{D}{B} = \dfrac{0.8}{1.21}$ $I_1 = 0.95$

$= 0.66$

$\dfrac{Z_u}{B} = \infty$, $I_2 = 0.7$

$E_{u_1} = 200(28)$ $E_{u_2} = 200(40)$

$= 5600$ $= 8000$

$E_{u,ave} = \dfrac{3}{4.235}(5600) + \dfrac{1.235}{4.235}(8000)$

$= 6299.9$

$\delta_d = \dfrac{(q - \sigma_{zD}) B I_1 I_2}{E_u}$

$= \dfrac{86.76(1.21)(0.95)(0.7)}{6299.9}$

$= 0.011\ m$

4 a) Shallow fomdation: Depth of fondation is less than 3 m or $D/B < 1$.

Deep fomdation: Depth of the fondation is greater than 3 m or $D/B > 1$.

Since, the deep of embedment is deeper, the load carrying mode of deep fomdation usually depends on the side frictions of the piles rather than the end bearing capacity of the soil.

b) i) $P_a = \frac{30 \times 10^3}{4} \times 0.2^2$

$= 300$ kN

ii)

P	S	$\frac{S}{P}$ (10^{-3})
100	0.31	3.1
200	0.45	2.25
300	0.89	2.967
400	1.36	3.4
500	2.23	4.46
600	4.81	8.017
700	7.66	10.94
800	16.0	20
900	28.1	31.22

slope $= \frac{31.22 - 2.25}{28.1 - 0.45} \times 10^{-3}$

$= 1.048 \times 10^{-3}$

$P_{ult} = \frac{1}{slope}$

$= \frac{1}{1.048 \times 10^{-3}}$

$= 954.2$ kN

iii) $P_a = \frac{P_{ult}}{3.5}$

$= \frac{954.2}{3.5}$

$= 272.63$ kN

iv) $\eta N P_a > 1000$

$0.9N (272.63) > 1000$

$N > 4.08$

$\therefore N = 5$.

v) The pile load test has a quite good reliability. Since, it is depends on the actual load and settlement that the piles experienced when conducting the test. By controlling the rate of loading, we can have different set of loading to the installed pile. Thus, it has a quite good reliability and it is usually act as a test pile for the checking of pile capacity.

vi) It will cause the clay to undergo settlement. As there is changes in surcharge /loading, there is a changes of effective stress, thus settlement take places. The settlement of the medium clay will cause a downdrag force on the installed piles. Thus, reduce the pile capacity and may cause geotechnical failure of the foundation.