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CV3013 - Foundation Engineering

Semester 1 2019 - 2020

1(a) To obtain sufficient information of the ground to enable safe & economical foundation design & avoid difficulties during construction.

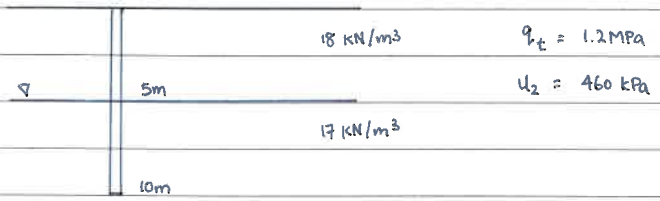
1(b) Mechanical disturbance → during sampling

Changes in chemical contents → contamination by drilling fluid

Changes in stresses → when soil is removed

Changes in moisture content / void ratio → when water escapes from the sample

1(c)



1(c)(i) $\sigma_{vo} = (18)(5) + (17)(5) = 175$

$\sigma_{vo}' = 175 - 5(9.81) = 125.95$

$u_0 = 5(9.81) = 49.05$

$$Q_t = \frac{q_t - \sigma_{vo}}{\sigma_{vo}'} = \frac{(1.2\times10^3) - 175}{125.95} = 8.14$$

$$B_q = \frac{u_2 - u_0}{q_t - \sigma_{vo}} = \frac{460 - 49.05}{1.2\times10^3 - 175} = 0.4$$

using the chart, soil behaviour type is clays - clay to silty clay

1(c)(ii) $$\phi'_{max} \geq 29.5\,(0.4)^{0.121}\left[0.256 + 0.366(0.4) + \log\left(\frac{1.2\times10^3 - 175}{125.95}\right)\right]$$

$\geq 34.7^\circ$

1(c)(iii) $$C_u = \frac{1.2\times10^3 - 175}{14} = 73.2\ \text{kPa}$$

1(c)(iv) $$k_o = 0.1\left(\frac{1.2\times10^3 - 175}{125.95}\right) = 0.814$$

Submitted by : Ye Xun

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2(a) Characteristic values are based on results from laboratory & field tests, complimented by well-established experience, which serves as a cautious estimate of the soil parameter.

2(b) DA1, combination 1

$\gamma_\gamma = 1.0$ $\gamma_K = 17\ kN/m^3$

$\gamma_{cu} = 1.0$ $C_{u,K} = 35kPa$ $\sigma_q = 17(1.0) = 17\ kN/m^2$

$C_{u,d} = \frac{35}{1.0} = 35$, $\gamma_{,d} = \frac{17}{1.0} = 17$

$S_c = 1 + 0.2\left(\frac{2}{2}\right) = 1.2$

$q_f = (1.2)(2+\pi)(35) + 17$

$= 232.95$

DA1, combination 2

$\gamma_\gamma = 1.0$ $\gamma_{,d} = 17\ kN/m^3$

$\gamma_{cu} = 1.4$ $C_{u,d} = \frac{35}{1.4} = 25kPa$ $\sigma_q = 17(1.0) = 17\ kN/m^2$

$q_f = (1.2)(2+\pi)(25) + 17$

$= 171.25$

Taking the lower value, $R_d = 171.25(2\times2) = 685\ kN$

To satisfy DA1, $Q_d < R_d$

$Q_d = (1.0)(110) + (1.3)(50) = 175$

Since $175 < 685$, footing is satisfactory

2(c) $L/B = \frac{25}{2} = 12.5 \geq 10$ $\sigma'_p = (15-9.81)(1+2) = 15.57$ @ $z_{fp} = 2$

use $z_{fo} = 4B = 4(2) = 8$

$z_{fp} = B = 2$

$I_{zp} = 0.5 + 0.1\left(\frac{75}{15.57}\right)^{0.5}$

$= 0.719$

Layer	Δz (m)	q_c (MPa)	$E = 3.5q_c$ (MPa)	I_z	$\frac{I_z}{E}\Delta z$
1	2	4	14	0.46	0.0657
2	6	8	28	0.36	0.0771
					Σ 0.1428

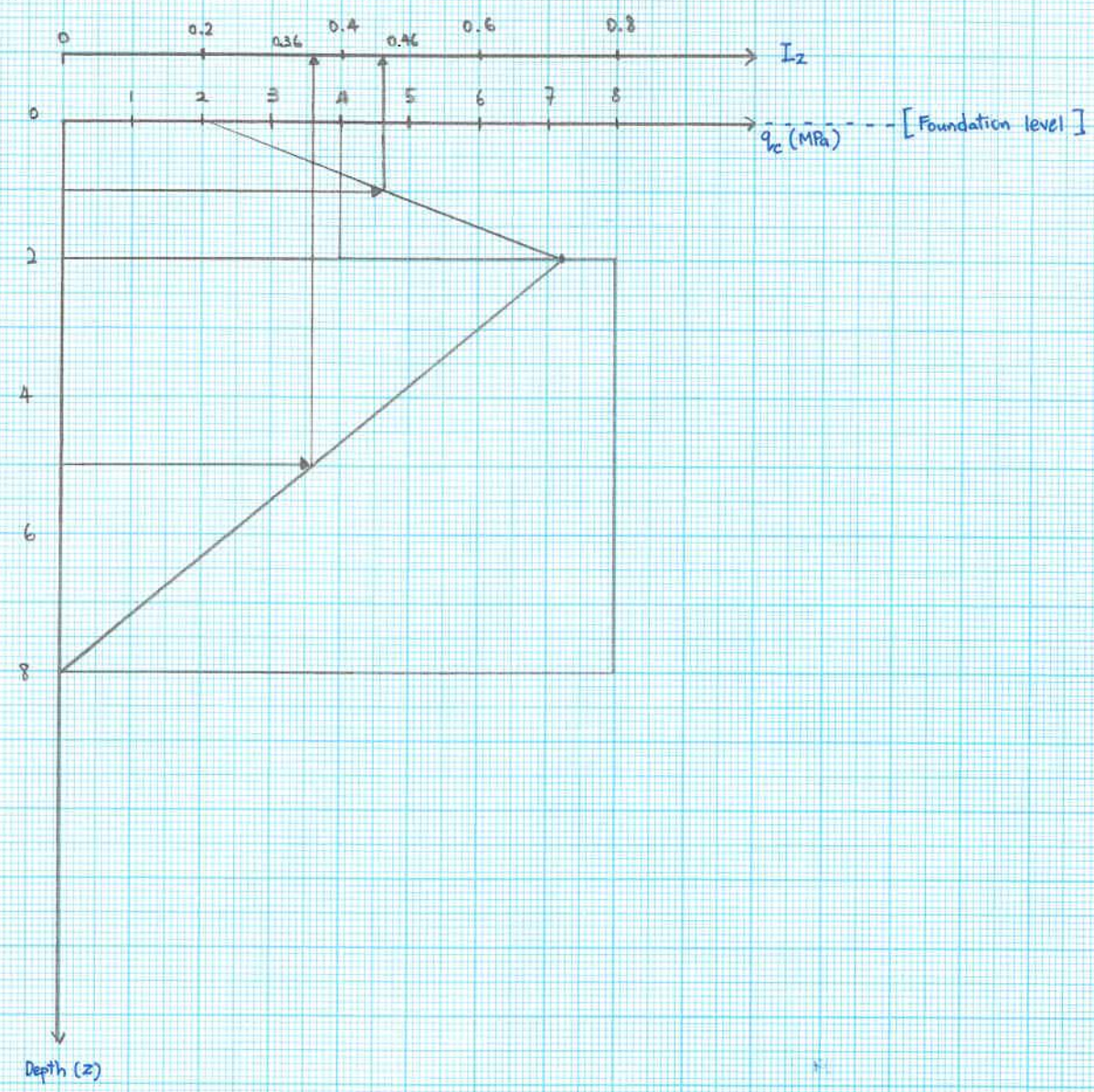
$\sigma_q' = (17-9.81) \times 1.0 = 7.19$

$C_1 = 1 - 0.5\left(\frac{7.19}{75}\right) = 0.952$

$C_2 = 1$ (immediate) $C_2 = 1 + 0.2\log\left(\frac{30}{0.1}\right) = 1.495$ (30 years)

immediate $= (1)(0.952)(75)(0.1428) = 10.2mm$

30 years $= (1.495)(0.952)(75)(0.1428) = 15.2mm$


0
0.2
0.36
0.4
0.46
0.6
0.8
I_z
0
1
2
3
4
5
6
7
8
q_c (MPa)
[Foundation level]
2
4
6
8
Depth (z)

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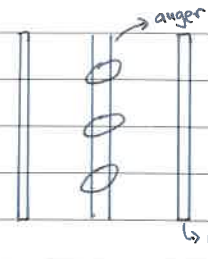
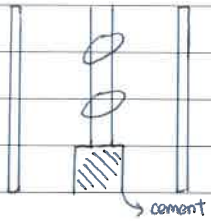
3(a) 1)



Drill into soil using hollow stem auger

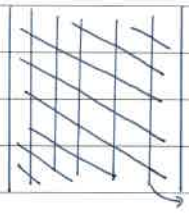
Install casing to prevent soil from caving in

2)



Withdraw auger while injecting cement grout

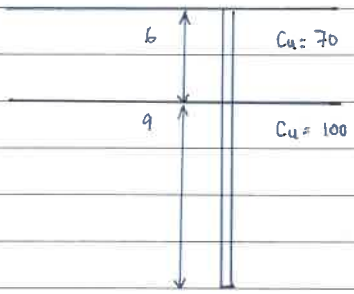
3)



Install steel reinforcements

Remove casing

3(b)



Design Approach 1 , combination 2

$\gamma_g = 1.0$, diameter = 1.0m , Length of pile = 15m

$\gamma_{cu} = 1.0$

$Cu,d = \frac{70}{1.0} = 70$, $Cu,d = \frac{100}{1.0} = 100$, $\gamma_d = \frac{18}{1.0} = 18$

$Nc = (2+\pi)\left(1 + 0.27\sqrt{\frac{9}{1.0}}\right) \leq 9.0 = 9$

$Q_{bu} = \frac{A_p(N_c C_u + \sigma_q)}{1.55} = \frac{\pi(1.0)^2}{4}(9(100) + 18(15))\frac{1}{1.55} = 592.85\ kN$

For non-displacement piles , $C_u = 70$, $\alpha = 1.16 - \left(\frac{70}{185}\right) = 0.782$

$C_u = 100$, $\alpha = 1.16 - \left(\frac{100}{185}\right) = 0.619$

$Q_{su} = \pi(1.0)\left[\frac{6(0.782)(70) + 9(0.619)(100)}{1.55}\right] = 1794.84\ kN$

$R_d = \frac{592.85 + 1794.84}{2} = 1193.85$ OR $R_d = \frac{592.85}{2} + \frac{1794.84}{1.6} = 1418.2$

$\therefore R_d = 1193.85\ kN$

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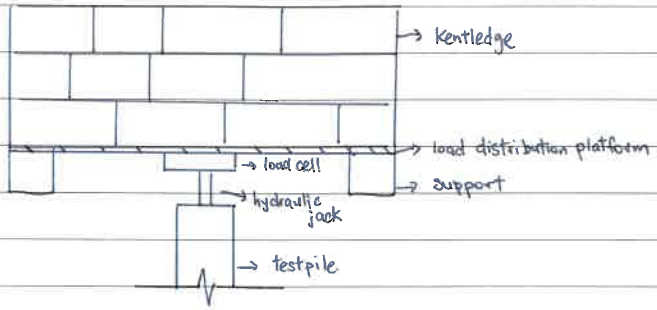
3(c)



kentledge load supported solely by the test pile. As the pile moves into the soil, the support at the sides acts as safety. weight must be at least equal to the maximum load. Test pile tested to ULS.

3(d)

$R_k = \min\left[\frac{R_{avg}}{1.38}, \frac{R_{min}}{1.15}\right]$, for $n = 4$

$R_{avg} = \frac{1}{4}(950 + 1020 + 990 + 1060) = 1005$

$R_k = \min\left[\frac{1005}{1.38}, \frac{950}{1.15}\right]$

$= \min[728.26, 826.09] = 728.26$ kN

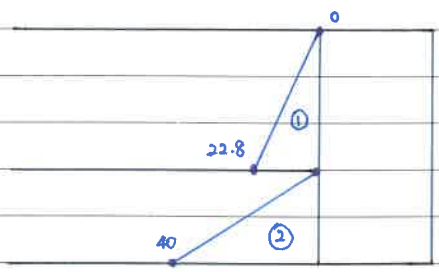
4(a)

Material	γ_k	c_{uk}	ϕ'_k		Material	γ_d	$c_{u,d}$	ϕ'_d
sand fill	20		32	DA1b	sand fill	20		26.56
clay fill	16	42		→	clay fill	16	30	
Dense sand	21		36	$\gamma_{\phi'} = 1.25$	Dense sand	21		30.17
Wall	25		21	$\gamma_\gamma = 1.0$	wall	25		17.07

$\gamma_{cu} = 1.4$

K_A (sand fill) $= \frac{1 - \sin 26.56}{1 + \sin 26.56} = 0.38$

4(a)(i)



* Not to scale

At 2.5m, $20(3)(0.38) = 22.8$

$20(3) - 2(30) = 0$

At 0m, $20(3) + 16(2.5) - 2(30) = 40$

$P_1 = \frac{1}{2}(22.8)(3) = 34.2$ (unfactored)

$P_2 = \frac{1}{2}(40)(2.5) = 50$ (unfactored)

4(a)(ii)

Weight of the wall $= (5.5)(B)(25)$

$= 137.5B$ (unfactored)

$F_{v,d} = 137.5(B)(1.0) = 137.5B$ (permanent, fav)

$R_{h,d} = \frac{137.5B(\tan 17.07)}{\gamma_{R;h}} = 42.22B$, $\gamma_{R;h} = 1.0$

$P_{ah,d} = 34.2(1.0) + 50(1.0) = 84.2$ (permanent, unfav)

$\frac{42.22B}{84.2} = 1.2 \Rightarrow B = 2.39$m

$F_{v,d}$ = Design vertical force

$R_{h,d}$ = Design horizontal resistance

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4(b)

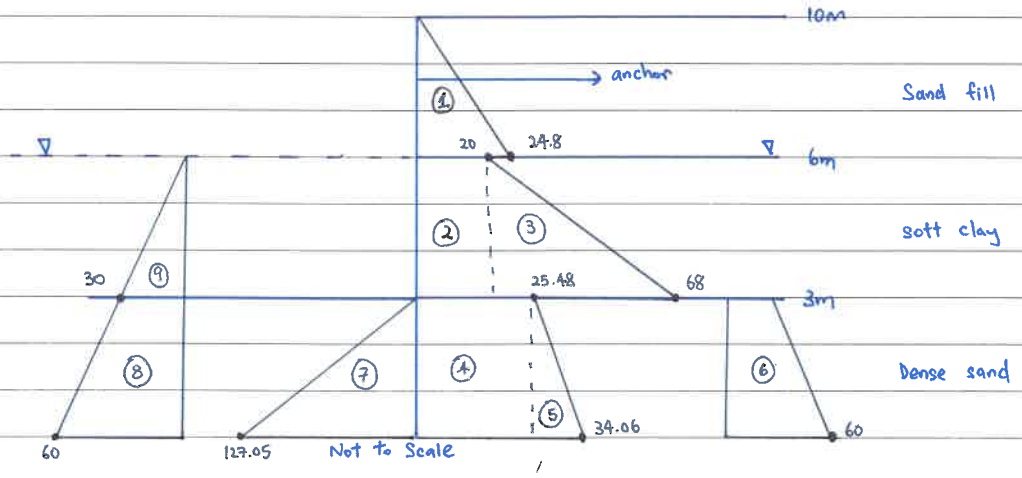
	γ_k	$C_{u,k}$	ϕ'_k		γ_d	$C_{u,d}$	ϕ'_d
Sand fill	20		32	$\gamma_\gamma = 1.0$, $\gamma_{\phi'} = 1.0$, $\gamma_{Cu} = 1.0$	20		32
Soft Clay	16	30		→ DA1a	16	30	
Dense sand	21		36		21		36

k_A (Sand fill) $= \frac{1-\sin 32}{1+\sin 32} = 0.31$

k_A (dense sand) $= \frac{1-\sin 36}{1+\sin 36} = 0.26$

k_p (dense sand) $= \frac{1+\sin 36}{1-\sin 36} = 3.85$

4(b)(i)



Active

(6m) $20(4)(0.31) = 24.8$

(6m) $20(4) - 20(3) = 20$

(3m) $20(4) + 16(3) - 2(30) = 68$

(3m) $[20(4) + (16-10)(3)](0.26) = 25.48$

(0m) $[20(4) + (16-10)(3) + (21-10)(3)](0.26) = 34.06$

(0m) $6(10) = 60$

Passive

(0m) $(21-10)(3)(3.85) = 127.05$

(0m) $6(10) = 60$

4(b)(ii) Taking moment about anchor, (Area 6 & 8 cancel out)

Area	P_a, active force	z (m)	Partial factor	$P_{a,d}$	M_a	$M_{a,d}$	Z calculations
1	$\frac{1}{2}(24.8)(4) = 49.6$	1.67	$\gamma_{G;dst} = 1.35$	66.96	82.83	111.82	$4 - (4/3) - 1 = 1.67$
2	$20(3) = 60$	4.5	$\gamma_{G;dst} = 1.35$	81	270	364.5	$3/2 + 3 = 4.5$
3	$\frac{1}{2}(68-20)(3) = 72$	5	$\gamma_{G;dst} = 1.35$	97.2	360	486	$3 - (3/3) + 3 = 5$
4	$25.48(3) = 76.44$	7.5	$\gamma_{G;dst} = 1.35$	103.19	573.3	773.96	$3/2 + 3 + 3 = 7.5$
5	$\frac{1}{2}(34.06-25.48)(3) = 12.87$	8	$\gamma_{G;dst} = 1.35$	17.37	102.96	139	$3 - (3/2) + 3 + 3 = 8$
			Σ	365.72	1389.1	1875.28	

Single Source principle *

Area	P_p, passive force	z (m)	Partial factor	$P_{p,d}$	M_p	$M_{p,d}$	
7	$\frac{1}{2}(127.05)(3) = 190.58$	8	$\gamma_{G;dst} = 1.35^*$	257.28	1524.64	2058.26	$3 - (3/3) + 3 + 3 = 8$
9	$\frac{1}{2}(30)(3) = 45$	5	$\gamma_{G;dst} = 1.35^*$	60.75	225	303.75	$3 - (3/3) + 3 = 5$
			Σ	318.03	1749.64	2362.01	

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$$ODF = \frac{\text{Total resisting moment}}{\text{Total overturning moment}} = \frac{M_{r,d}}{M_{o,d}}$$

$$M_{r,d} = \frac{2362.01}{\gamma_{R;e}} = 2362.01 \quad , \quad \gamma_{R;e} = 1.0$$

$$M_{o,d} = 1875.28$$

$$ODF = \frac{2362.01}{1875.28} = 1.26$$

$$\Sigma F_H = 0, \quad F_{anchor} + P_{p,d} = P_{a,d}$$

$$F_{anchor} = 363.72 - 318.03 = 47.69 \text{ kN/m} \times 2.5\text{m}$$

$$= 119.2 \text{ kN}$$