NO: DATE:

CV3013 - Foundation Engineering 2017/18

1. a) - Project Assessment & Office/Desk Study
- Field Reconnaissance or Site Visits
- Detailed Planning of SI Tasks
- Subsurface Exploration or Drilling, Sampling & In-Situ Testings
- Laboratory Testing and Soil Classifications
- Groundwater Exploration and Monitoring
- Synthesis of Data and Interpretation

b) $C_A = \frac{51^2 - 36^2}{36^2}$

$= 100.7\% > 10\%$

As area ratio is more than 10%, it is impossible to use this soil sampler to obtain undisturbed clay samples.

c) $\sigma_{vo}' = 2.2 \times 15.2 + 13.2 \times (16.1 - 9.81)$

$= 116.5 \text{ kPa}$

$C_N = \frac{200}{100 + 116.5}$

$= 0.92$

$(N_1)_{60} = 0.92 \times 20$

$= 18.5$

$18.5 / I_D^2 = 60$

$I_D = 55\%$

d) $I_D = -1.21 + 0.584 \log\left(\frac{11.2 \times 10^3}{116.5^{0.5}}\right)$

$= 55\%$

$\phi'_{max} = 6.6 + 11 \log\left(\frac{11.2 \times 10^3}{116.5^{0.5}}\right)$

$= 39.8^\circ$

NO:..... DATE:.....

2. a) The purpose of foundation is to transmit building loads to the soil safely, a process known as soil-structure interaction. To perform in a satisfactory way, the foundation must meet two principal performance requirements, namely:

1. such that its capacity or resistance is sufficient to support the loads applied
2. to avoid excessive deformation under these loads, which might damage the supported structure or lead to a loss of function

Other performance requirement: cost and constructibility

b) i) For combination 1,

$\gamma_{cu} = 1.0$, $\gamma_\gamma = 1.0$

$c_{u,d} = \frac{32}{1.0} = 32\ kPa$

$\gamma_d = \frac{18}{1.0} = 18\ kN/m^3$

$s_c = 1 + 0.2 \times 1 = 1.2$

$q_{fb} = s_c N_c c_u + b_q$

$= 1.2 \times (2+\pi) \times 32 + 0.6 \times 18$

$= 208.2\ kPa$

For combination 2,

$\gamma_{cu} = 1.40$, $\gamma_r = 1.0$

$c_{u,d} = \frac{32}{1.4} = 22.9\ kPa$, $\gamma_d = 18\ kN/m^3$

$q_{fb} = 1.2 \times (2+\pi) \times 22.9 + 0.6 \times 18$

$= 151.8\ kPa$

ii) $d/B = 0.6$

$M_0 = 0.94$

$H/B = \infty$

$L/B = 1$

$M_1 = 0.65$

immediate settlement, $s_i = 0.94 \times 0.65 \times \frac{85 \times 1}{200 \times 32}$

$= 8.1\ mm$

$\Delta\sigma' = \frac{85 \times 1\ m^2}{(1+z)^2}$, $\sigma_0' = 0.6 \times 18 + (19 - 9.81)z = 10.8 + 9.19z$

Divide into infinite sub-layers of thickness, $H = 1\ m$

For first layer,

$s_{oed} = \frac{H}{1+e_0}\left(C_c \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right)$ for NC day

$= 50.5\ mm$

Adding subsequent layers,

$\Sigma s_{oed} \simeq 87.2\ mm$

consolidation settlement $= 1 \times 87.2$

$= 87.2\ mm$

NO:..... DATE:.....

3. a) Total stress method or α method will be used to determine the side resistance of a pile for undrained soil. $\tau_{int} = \alpha c_u$ where α is a coefficient depending on the type of clay, the method of installation and the pile material.
Effective stress method or β method will be used to determine the side resistance of a pile for drained soil. $\tau_{int} = \beta \sigma_z'$ where $\beta = K \tan\delta'$ and $K = \frac{\sigma_h'}{\sigma_z'}$

b) i) see on next page

ii) $R_k = \frac{454.5}{1.55}$

$= 293.3\ kN$

iii) $c_{u,k} = \left(\frac{120-50}{15-0}\right) z + 50$

$= 4.67z + 50$

$c_{u,d} = \left(\frac{c_{u,k}}{\gamma_{cm}}\right) = \frac{4.67z+50}{1.0} = 4.67z + 50$

$\gamma_d = \frac{\gamma}{\gamma_\gamma} = \frac{18.5}{1.0} = 18.5\ kN/m^3$

$N_c = 9.0$

$Q_{bu,d} = \frac{(9 \times (4.67 \times 12 + 50) + 12 \times 18.5) \times 0.3^2}{1.4 \times 1.7}$

$= 19.8\ kN$

Precast concrete pile is driven pile.

From depth 0 to 12 m, $\frac{c_u}{\sigma'_{vo}} \geq 1$, $\alpha = 0.5 F_p \left(\frac{c_u}{\sigma'_{vo}}\right)^{-0.25}$

$\frac{L_p}{D_o} = 60$, $F_p = 1 + \frac{60-50}{120-50}(0.7-1.0)$

$= 0.96$

$\tau_{int} = 0.48 \left(\frac{50 + 4.67z}{0.5(18.5-9.81)z}\right)^{-0.25} (50 + 4.67z)$

$Q_{su,d} = \frac{4 \times 0.2 \times \int_0^{12} \tau_{int}\, dz}{1.4 \times 1.5}$

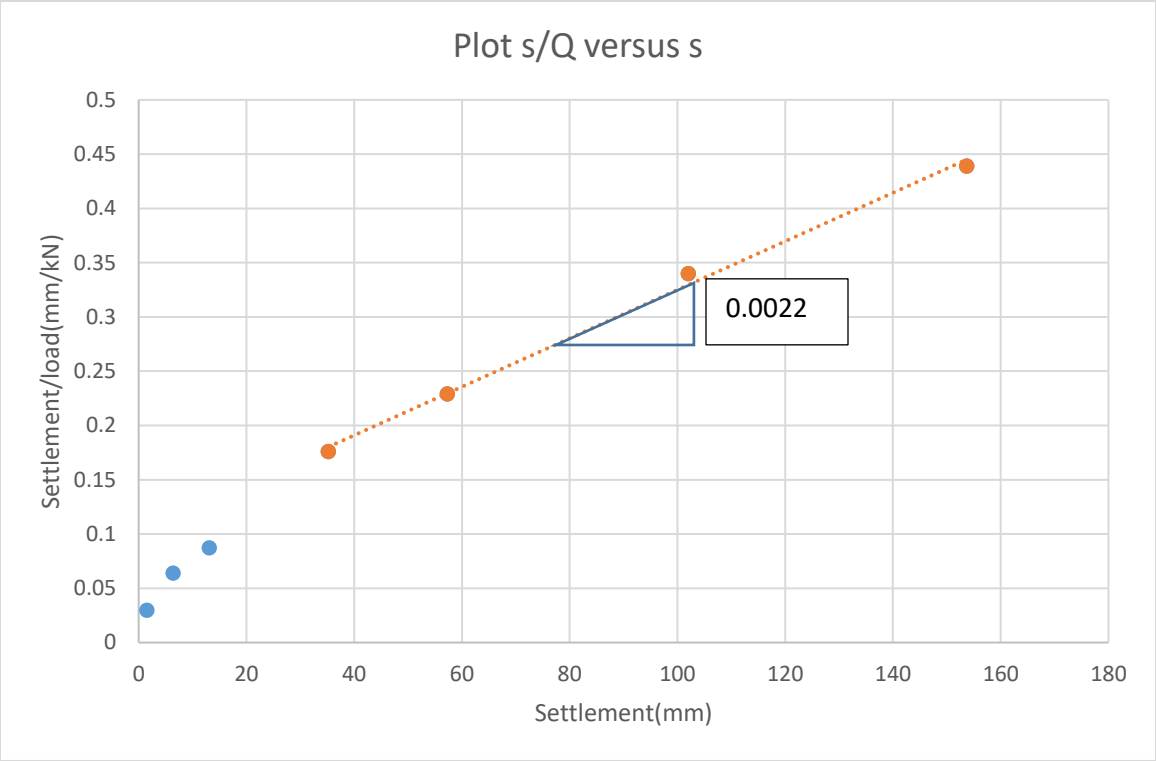
$= 126.7\ kN$

$R_d = Q_{bu,d} + Q_{su,d}$

$= 146.5\ kN$

iv) The pile may break as driving pile into sand layer would be difficult. During hard driving, it may cause delays and replacement changes, or worse still may suffer major unseen damage in hard driving conditions.

3 b)i)



Gradient = $\frac{1}{P_{ult}} = 0.0022$

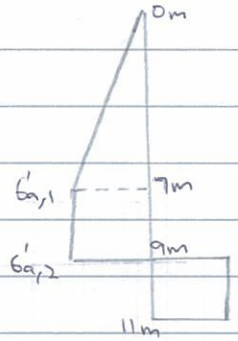
$P_{ult} = 454.5\ kN$

NO: DATE:

4. a) i) - Depth of embedment below excavation level is insufficient to produce fixity at the lower end of the wall.
- Wall is free to move/rotate at its lower end.
- Bending moment diagram as shown in diagram.

ii) Low tide level is more critical. Passive pressure is lower and active pressure is higher at low tide level.

iii)



$\tan\phi'_d = \frac{\tan 30}{1.25}$, $\gamma_d = \frac{18}{1.0} = 18\ kN/m^3$

$\phi'_d = 24.8°$, $K_a = \frac{1-\sin 24.8}{1+\sin 24.8} = 0.41$

$\sigma'_{a,1} = 0.41 \times 7 \times 18$

$= 51.6 kPa$

$\sigma'_{a,2} = 0.41 \times (7\times 18 + 2\times 8)$

$= 58.1\ kPa$

$\frac{4C_u}{1.4} = (18\times 9 - 2\times 10)$

$= 98 kPa$

iv) Destabilizing moment:

$M_{Ed} = \frac{1}{2} \times 51.6 \times 7 \times (\frac{2}{3}\times 7 - 2) + 51.6 \times 2 \times 6 + \frac{1}{2} \times 6.5 \times 2 \times (5 + \frac{4}{3})$

$= 1142\ kN.m/m$

Stabilizing moment:

$M_{Rd} = 98 \times 2 \times 8$

$= 1568\ kN.m/m$

$\therefore M_{Ed} < M_{Rd}$, hence overturning ULS is okay.

Over-design factor: $I = \frac{1568}{1142}$

$= 1.37$

$\frac{1}{2} \times 51.6 \times 7 + \frac{1}{2} \times (51.6 + 58.1) \times 2 = T + 98 \times 2$

$T = 94.3 \times 2$

$= 188.6\ kN$

b) net passive pressure $= \frac{4 \times 84}{1.4} - (18\times 9 + 1.3\times 20 - 2\times 10)$

$= 72 kPa$

$M_{Ed} = 1142 + 1.3\times 20 \times 0.41 \times 9 \times (4.5 - 2)$

$= 1381.8\ kN.m/m$

$M_{Rd} = 72 \times 2 \times 8$

$= 1152\ kN.m/m$

$I = \frac{1152}{1381.8} = 0.83$

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