CV3013 2016/17 PYP

1) a) characteristic values are values that are obtained from the results or derived values of lab / field tests and are chosen as cautious estimates. It is usually dermarcated with a subscript 'k' along with the parameter such as $C_{u,k}$.

On the other hand, Design values are values used in the calculation for designing structures or loadings. Design values are usually characteristic values of the geotechnical parameter that is multiply or divided by partial factors according to the type of values (loading, resistance, material properties) to account for any uncertanties or variability for a safe design.

b) i) DA1b A2 + M2 + R1

Bearing capacity (drained)

$q_f = s_c N_c c' + s_q N_q \sigma_q' + 0.5\gamma B s_\gamma N_\gamma$

$\gamma_{\phi'} = 1.25$ $\phi'_d = \tan^{-1}[\tan(35)/1.25] = 29.26°$

$\gamma_{c'} = 1.25$

$\gamma_{qu} = 1.4$

$\gamma_\gamma = 1.00$ $\gamma_d = \frac{\gamma_k}{\gamma_\gamma} = \frac{17.5}{1.0} = 17.5\ kN/m^3$ (sand)

$\gamma_d = \frac{\gamma_k}{\gamma_\gamma} = \frac{19}{1.0} = 19\ kN/m^3$ (clay)

$\gamma_{cu} = 1.4$ $C_{u,d} = \frac{C_{u,k}}{\gamma_{cu}} = \frac{90}{1.4} = 64.29$ kPa

$N_q = \frac{1+\sin\phi'}{1-\sin\phi'} e^{\pi \tan\phi'} = \frac{1+\sin 29.26}{1-\sin 29.26} e^{\pi \tan 29.26} = 16.93$

$N_c = \frac{N_q - 1}{\tan\phi'}$ (no need calc, $c' \to 0$)

$N_\gamma = 2(N_q - 1)\tan\phi' = 2(16.93-1)\tan(29.26) = 17.85$

$s_q = 1 + \frac{B}{L}\sin\phi' = 1$ (strip footing)

$s_c = \frac{s_q N_q - 1}{N_q - 1}$ (no need calc, $c' \to 0$)

$s_\gamma = 1 - 0.3\frac{B}{L} = 1$ (strip footing).

$q_f = s_c N_c c'$ (→ 0) $+ s_q N_q \sigma_q' + 0.5\gamma B s_\gamma N_\gamma$

$= (1)(16.93)[(17.5-9.81)\times 1] + 0.5(17.5-9.81)(2)(1)(17.85)$

$= 130.1917 + 137.2665$

$= 267.46$ kPa ✓ > 100 kPa.

ii) Schmertmann method

For strip footing, $L/B \geq 10$

→ $Z_{fp} = B$, $Z_{fo} = 4B$ } below fdn level

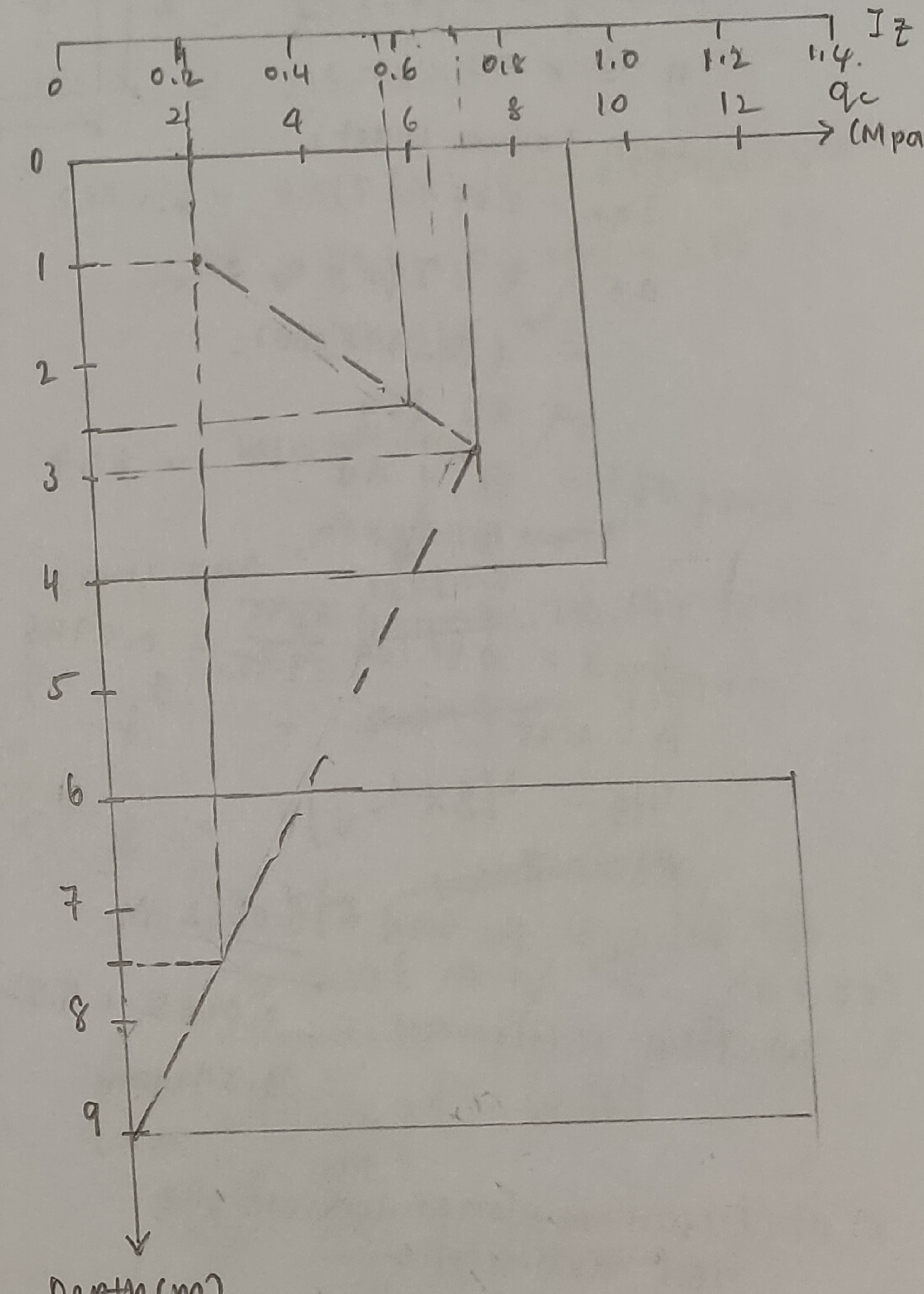
depth of foundation = 1m

$Z_{fp} = 1 + B = 1 + 2 = 3$ m

$Z_{fo} = 1 + 4B = 1 + 4(2) = 9$ m

$I_{zp} = 0.5 + 0.1\left(\frac{q_n}{\sigma'_p}\right)^{0.5}$

$= 0.5 + 0.1\left(\frac{100}{(17.5-9.81)\times 3}\right)^{0.5} = 0.708$ ✓



$S = C_1 C_2 q_n \sum_0^{Z_{fo}} \frac{I_z}{E}\Delta Z$

$E_s = 3.5 q_c$

Layer	z(m)	q_c(MPa)	E(MPa)	I_z	$I_z\Delta Z/E$
1	3	9	31.5	0.58	0.055
2	3	12	42	0.2	0.014

$\Sigma I_z \Delta/E = 0.069$ ✓

$C_1 = 1 - 0.5\frac{\sigma_q'}{q_n} = 1 - 0.5\frac{[(17.5-9.81)\times 1]}{100}$

$= 0.96155$ ✓

$C_2 = 1 + 0.2\log\left(\frac{t}{0.1}\right) = 1 + 0.2\log\left(\frac{15}{0.1}\right)$

$= 1.4352$ ✓

$S_i = (0.96155)(1.4352)(0.069)(100)$

$= 9.52$ mm ✓

1) b) iii) For NC clay,

$S_{oed} = \frac{H}{1+e_0} C_c \log \frac{\sigma_f'}{\sigma_0'}$, $S_c = \mu_c S_{oed}$

$= \frac{2}{1+0.95} (0.4) \log \frac{\sigma_f'}{\sigma_0'}$

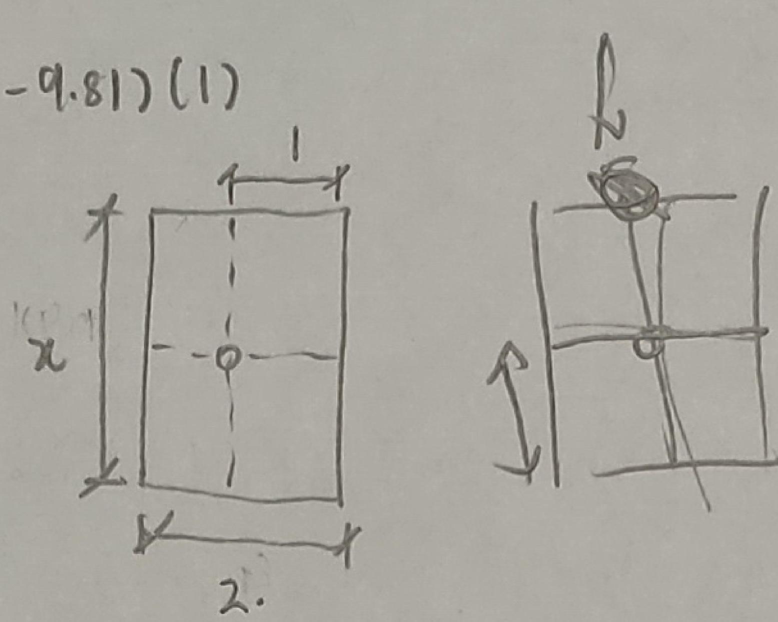
$= 0.41 \log \frac{\sigma_f'}{\sigma_0'}$

$\sigma_0' = (17.5 - 9.81)(4) + (19 - 9.81)(1)$

$= 39.95$ kPa

$m = \frac{1}{4} = 0.25$

$n = x$



From Fadum chart,

$I_{qr} = 0.07$

$\Delta\sigma' = 4 \times I_{qr} \times q$

$= 4(0.07)(100)$

$= 28$ kPa

$\sigma_f' = \sigma_0' + \Delta\sigma'$

$= 67.95$ kPa

$S_{oed} = 0.41 \log \frac{67.95}{39.95} = 0.0946$

$A = 0.45$

$H/B = 2/2 = 1$

$\mu_c = 0.7$

$S_c = \mu_c S_{oed} = 0.0662$ m.

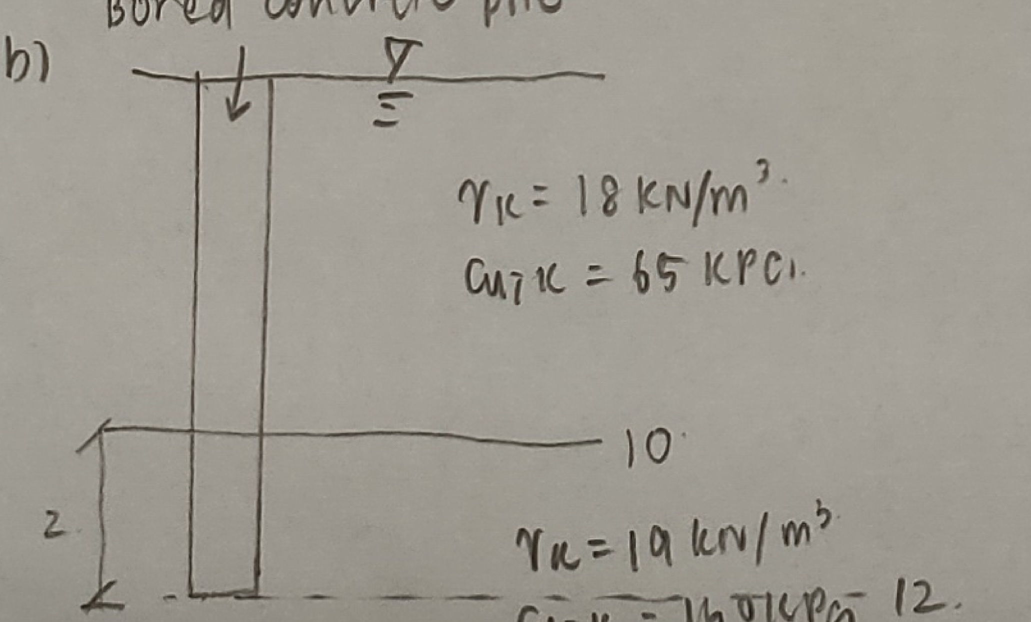
iv) Total settlement $= 0.0662 + 9.52$

$= 9.59$ mm

2) a). Precast reinforced concrete pile
Steel tubular pile
Steel H pile

Bored concrete pile

b)



DA1b A2 + M2 + R4

$\gamma_{\phi'} = 1.00$

$\gamma_{cu} = 1.00$ $C_{u1d} = \frac{65}{1.0} = 65$ kPa, $C_{u2d} = \frac{160}{1.0} = 160$ kPa.

$\gamma_\gamma = 1.00$. $\gamma_{d1}' = \frac{18}{1.0} = 18$ kN/m³, $\gamma_{d2}' = \frac{19}{1.0} = 19$ kN/m³

$Q_{bu} = A_p (N_c C_u + \sigma_q)$

$N_c = (2+\pi)(1 + 0.27\sqrt{\frac{d}{B}}) \leq 9.0$

$= (2+\pi)(1 + 0.27\sqrt{\frac{2}{0.4}}) = 8.25$

$Q_{bu,k} = \frac{A_p (N_c C_u + \sigma_q)}{\xi_1} = \frac{\frac{\pi (0.4)^2}{4} [8.25 C_{u2d} + (18 \times 10 + 2 \times 19)]}{1.4}$

$= 138$ kN ✓

For non-displacement pile,

$\alpha = 1.16 - (\frac{C_u}{185})$ for $30 < C_u < 150$ kPa

$\alpha = 0.35$ for $C_u \geq 150$ kPa

Layer 1, $\alpha = 1.16 - (\frac{65}{185}) = 0.81$ ✓

Layer 2, $\alpha = 0.35$ ✓

$Q_{su,k} = \frac{\pi D_0 \tau_{int} L_p}{\xi_1}$ ($\tau_{int} = \alpha C_u$)

$= \frac{\pi D_0 [10(0.81)(65) + (2)(0.35)(160)]}{1.4}$

$= 573.12$ kPa ✓

$R_d = \frac{Q_{bu,k} + Q_{su,k}}{2}$

$= \frac{138 + 573.12}{2} = 355.6$ kN

— or —

$R_d = \frac{Q_{bu,k}}{2} + \frac{Q_{su,k}}{1.6} = 427.2$ kN

c). The purpose of pile load test are :-

- The uncertainty associated with using empirical properties in calculations is reduced.
- It can be verified that the proposed construction technique is acceptable and allows the integrity of the cast-in-place piles formed using the proposed method to be checked.
- It can be verified that ULS & SLS will be met by the proposed design.

The difference between trial piles & working piles is that trial piles are constructed solely for the purpose of load testing, before main piling work commences. However, working piles will be a part of the foundation and are not tested to failure.
Trial piles allow ULS to be verified while working piles allow SLS to be verified.

d) $R_{avg} = \frac{1300 + 1250 + 1460 + 1320 + 1410}{5}$

$= 1348$ kN

$R_{min} = 1250$ kN

$R_k = \min [\frac{R_{avg}}{\xi_1}, \frac{R_{min}}{\xi_2}]$

For $n = 5$ (≥ 5), $\xi_1 = 1.35$, $\xi_2 = 1.08$

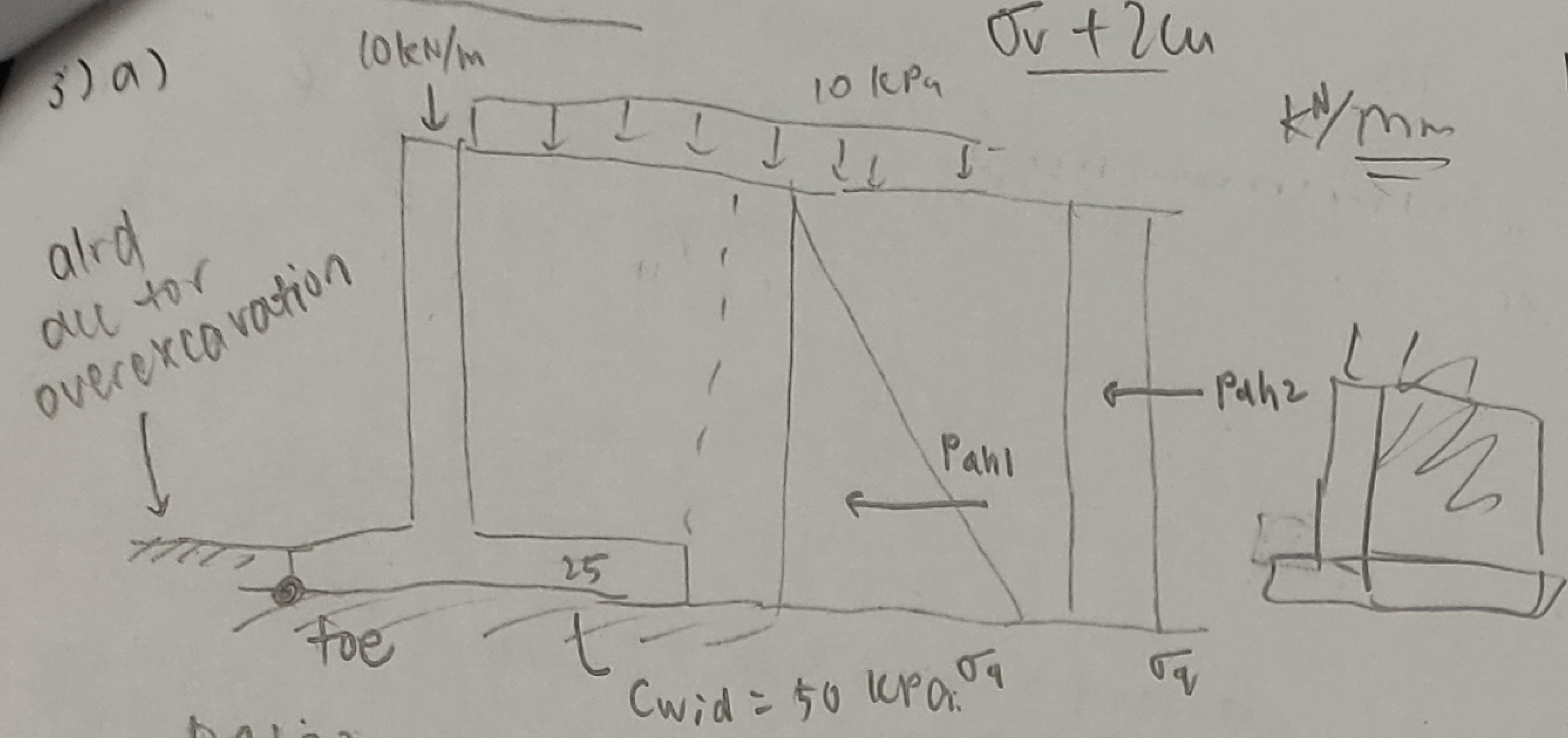
$R_k = \min [\frac{1348}{1.35}, \frac{1250}{1.08}]$

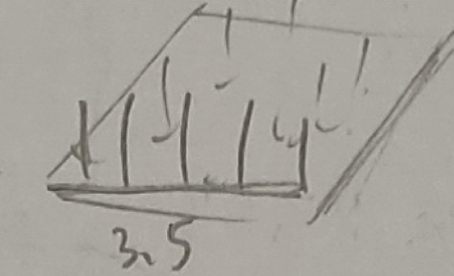
$= \min (998.52, 1157.41)$

$\therefore R_k = 998.52$ kPa ✓

PYP 2016/17

3) a)





DA1C2

$\gamma_{\phi'} = 1.25$

$\phi_d' = \tan^{-1}[\tan(38°)/1.25]$ ✓

$= 32°$ ✓

Assume Rankine,

$k_a = k_{ah} = \frac{1 - \sin 32}{1 + \sin 32}$

$= 0.307$ ✓

$\sigma_q = K_a \gamma H = 0.307 \times 5.5 \times 18$

$= 30.42$ kPa

$\sigma_q = K_a q = 0.307 \times 10 = 3.07$ kPa

* overexcavation of 10%

$5(0.1) = 0.5 \Rightarrow$ passive action omit

Fvid

‖

ΣV

Active Earth Pressure

$P_{ah1} = 0.5 \times 5.5 \times 30.42 \times \gamma_{G,dst}$ (1.0) $= 83.655$ kN/m ✓

$P_{ah2} = 5.5 \times 3.07 \times \gamma_{Q,dst}$ (1.3) $= 21.951$ kN/m ✓

$P_{ahd} = 105.606$ kN/m ✓

$P_{av1;d} = P_{av2;d} = 0$ (Rankine) ← (!)

weight of wall

$= [0.5(5) + 0.5(1.5 + 3.5)] \times 25 \times \gamma_{G,stb}$ ($\gamma_{c,k}$, 1.0)

$= 125$ kN/m ✓

weight of soil$_d$

$= 3.5 \times 5 \times 18 \times \gamma_{G,stb}$ (1.0) $= 315$ kN/m ✓

$P_{va} = 0$ ($\gamma_{Q,stb} = 0$)

$P_{vac} = 0$ ($\gamma_{Q,stb} = 0$) 440

$R_{vid} = 440$ kN/m ✓

$R_{hid} = R_{vid}\tan(\delta_{bid})/(\gamma_{Rih}) + C_{wid}B$ (= 0)

$= 0 + 50(5)$

$= 250$ kN/m ✓

Sliding ULS ⇒ ODF $= \frac{250}{105.606} = 2.37$ ✓

b i) $G_{wall;d} = [0.5(5) + 0.5(5)](25)(1.0) \gamma_{G,dst} = 125$ kN/m.

$G_{soil;d} = 3.5 \times 5 \times 18 \times \gamma_{G,dst}$ (1.0) $= 315$ kN/m.

$Q_{k;d} = 10 \times \gamma_{Q,dst} = 10 \times 1.3 = 13$ kN/m

$q_k = 10 \times 3.5 \times 1.3 = 45.5$ → F_{vid} = ~~453~~ kN/m. 498.5

ii) $\Sigma M_{oid} = P_{ah1;d}(\frac{5.5}{3}) + P_{ah2;d}(\frac{5.5}{2})$

$= 153.3675 + 60.36525$

$= 213.73$ kN m. ✓

$\Sigma M_{rid} = 0.5(5)(25)(1.25) + 0.5(5)(25)(2.5)$

$+ (3.5 \times 5 \times 18) \times 3.25$

$= 1258.125$ ✓

$F_{vid} = 440$ kN/m. ✓

Lever arm = Net moment / F_{vid}

$= (1258.125 - 213.73)/440$

$= 2.374$ m.

$\frac{\Sigma \text{Net M}}{\Sigma F_v} \; x^*$

$e = B/2 - x^*$

$= 5/2 - 2.374$

$= 0.126$ m ✓ < $B/6 = \frac{5}{6} = 0.833$ ✓

iii) $q_{max} = (R_v/B)(1 + 6e/B)$

$= \frac{498.5}{5}(1 + 6(0.126)/5)$

$=$ ~~101.3056 kPa~~

$= 114.77$ kPa < $q_{u;d} = 200$ kPa

∴ ULS satisfied

$q_{max} = (R_v/B)(1 + 6e/B)$ (440)

$= \frac{498.5}{5}(1 + \frac{6(0.126)}{5})$

$= 114.77 < q_{uid} = 200$ kPa ← design bearing resistance ✓

— or —

$B' = B - 2e$

$q_{uid} = 200$ kPa

$R_{vid} = q_{uid}(B')$ (440 kN)

$= 200(4.84) = 968$ kN/m.

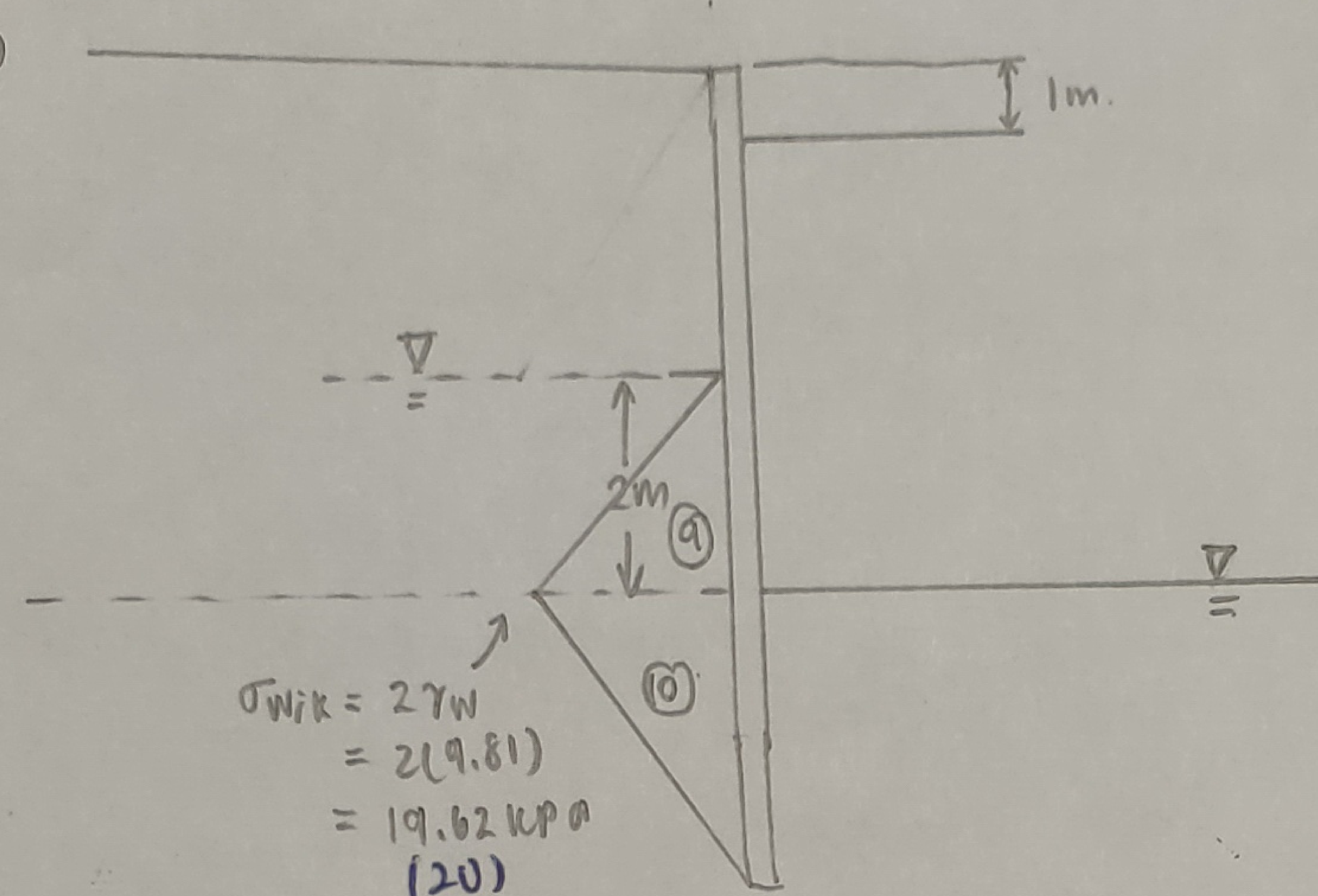
$\Sigma F_{vid} < R_{vid}$ → satisfactory.

DAICI (DA1a) - Ignore overexcavation

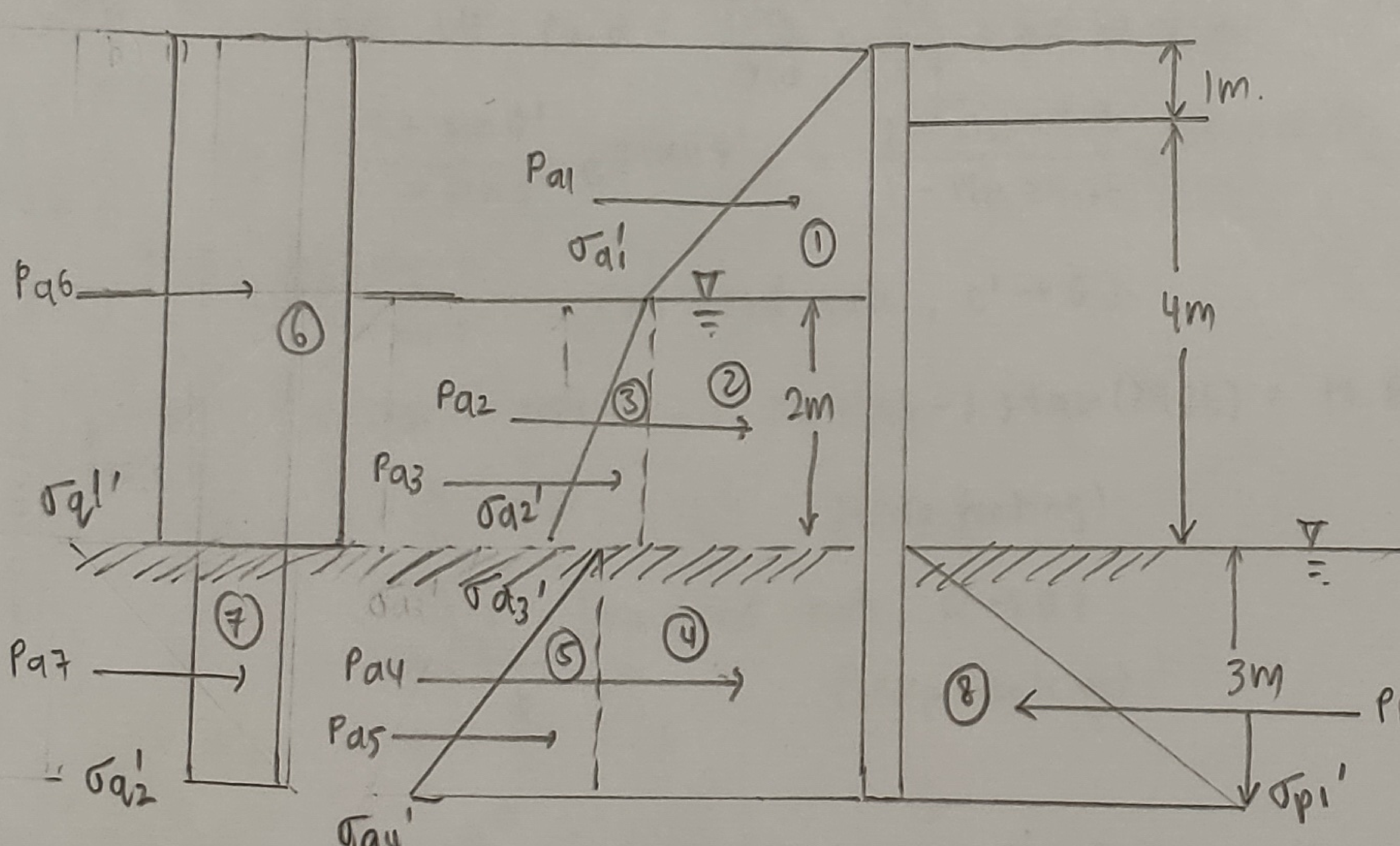
i) $\Delta H = 2m$

Flow path length, $L = 2 + 3 \times 2 = 8m$

ii)



b) ii), ii)



DAICI

Backfill ⇒ $\phi'_{d1} = \tan^{-1}(\tan(30°)/1.0) = 30°$

$\gamma_{\phi'} = 1.0$ < sand ⇒ $\phi'_{d2} = \tan^{-1}(\tan(35°)/1.0) = 35°$

$\gamma_{\gamma} = 1.0$

* From graph

$i_{ave} = h_w / (2d + h)$ (Backfill) $\delta = 2/3\phi'd = 20°$, $K_{ah} = 0.28$ (0.29)

$= 2/(2 \times 3 + 2)$ (Sand) $\delta = 2/3\phi'd = 23.3°$, $K_{ah} = 0.23$ (0.24)

$= 0.25$ ✓ $K_{ph} = 7.0$ (7.2)

Backfill

$\gamma_{a1;k} = (17 - 9.81) + i_{ave}\gamma_w$

$= (17 - 9.81) + 0.25(9.81)$

$= 9.6425$ kN/m³ ✓ (9.5)

sand $\gamma_{a2;k} = (20 - 9.81) + i_{ave}\gamma_w$

$= (20 - 9.81) + 0.25(9.81)$

$= 12.6425$ kN/m³ ✓ (12.5)

$\gamma_{p1;k} = (20 - 9.81) - i_{ave}\gamma_w$

$= (20 - 9.81) - 0.25(9.81)$

$= 7.7375$ kN/m³ ✓ (7.5)

Depth	characteristic effective
0	0
3	$3 \times 17 = 51$ kPa. $\gamma_{d1;k}$
5	$51 + 2 \times (9.5) = 70$ kPa.
8	$70 + 3 \times (12.5) = 107.5$ kPa $\gamma_{a2;k}$

$\sigma_{a1;k} = (17 \times 3)(0.28) = 14.28$ kPa (14.79)

$\sigma_{a2;k} = [(17 \times 3) + (9.6425 \times 2)](0.28) = 19.66$ kPa (20.3)

$\sigma_{a3;k} = [(17 \times 3) + (9.6425 \times 2)](0.23) = 16.15$ kPa (16.8)

$\sigma_{a4;k} = [(17 \times 3) + (9.6425 \times 2) + (12.6425 \times 3)](0.23) = 24.87$ kPa (25.8)

$\sigma_{q1}' = 0.28(15) = 4.2$ kPa ✓

$\sigma_{q2}' = 0.23(15) = 3.45$ kPa ✓

$\sigma_{p1}' = (7.7375 \times 3)(7.0) = 162.5$ kPa (162)

$\gamma_{a,dst} = 1.5$

c) DAICI ⇒ $\gamma_{G,dst} = 1.35$

single source principle

Active pressure (kPa)	Lever arm (m) abt anchor/strut	Moment (kNm)
① $\frac{1}{2}(3)(14.28)\gamma_{G,dst} = 28.917$	$2/3(3) - 1 = 1$ ✓	28.917
② $(14.28)(2)\gamma_{G,dst} = 38.556$	$2/2 + 2 = 3$ ✓	115.668
③ $\frac{1}{2}(19.66 - 14.28)(2)\gamma_{G,dst} = 7.263$	$2/3(2) + 2 = 10/3$ ✓	24.21
④ $(16.15)(3)\gamma_{G,dst} = 65.41$	$3/2 + 4 = 5.5$ ✓	359.74
⑤ $\frac{1}{2}(24.87 - 16.15)(3)\gamma_{G,dst} = 17.658$	$2/3(3) + 4 = 6$ ✓	105.948
⑥ $4.2(5)\gamma_{Q,dst} = 31.5$	$2.5 - 1 = 1.5$ ✓	47.25
⑦ $3.45(3)\gamma_{Q,dst} = 15.525$	$3/2 + 4 = 5.5$ ✓	85.3875
⑨ $\frac{1}{2}(19.62)(2)\gamma_{G,dst} = 26.487$	$2/3(2) + 2 = 10/3$ ✓	88.29
⑩ $\frac{1}{2}(19.62)(3)\gamma_{G,dst} = 39.731$	$\frac{1}{3}(3) + 4 = 5$ ✓	198.655
$\Sigma P_{a;d} = 271.0417$	$\Sigma M_{O;d} =$	1054.0655
Passive action		
$\frac{1}{2}(3)(162.5)\gamma_{G,dst} = 329.04$	$2/3(3) + 4 = 6$ ✓	1974.24

Rotational ULS

c) $ODF = \frac{1974.24}{1054.0655} = 1.873$ ✓

⇒ ULS is satisfactory!

d) Since Pp is larger than Pa

⇒ no need additional force for strut