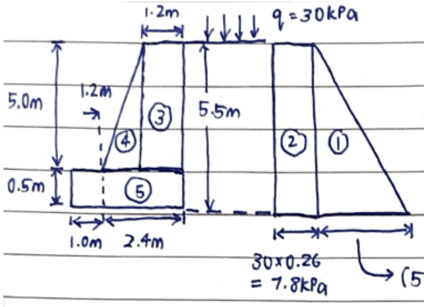
Q1

Date: No:



→ $(5+0.5)(19)(0.26) = 27.17\text{kPa}$

(a) $K_a = \frac{1-\sin 36^\circ}{1+\sin 36^\circ} = 0.26$

$\Sigma F_v = 147 + 73.5 + 41.65 = 262.15 \text{ kN/m}$

$FS_{sliding} = (262.15 \times \tan 34^\circ)/(74.72 + 42.9)$

$= 1.503 > 1.5 \Rightarrow$ acceptable

Force Component	Force (kN/m)	Lever arm to toe (m)	Moment (kNm/m)
①	$\frac{1}{2} \times 27.17 \times 5.5 = 74.72$	$\frac{1}{3}(5.5) = 1.833$	136.96
②	$7.8 \times 5.5 = 42.9$	$\frac{1}{2}(5.5) = 2.75$	117.98
③	$(5.0 \times 1.2)(24.5) = 147$	$1 + 1.2 + 0.6 = 2.8$	411.60
④	$(0.5 \times 5.0 \times 1.2)(24.5) = 73.5$	$1.0 + \frac{2}{3}(1.2) = 1.8$	132.3
⑤	$(3.4 \times 0.5)(24.5) = 41.65$	$\frac{1+2.4}{2} = 1.7$	70.81

(b) • Increase the cross-sectional size of the wall and hence increasing its total weight which increases the sliding resistance.

• Consider changing the concrete wall to a cantilever wall that allows the weight of the soil to be considered within the weight of the wall due to the concept of virtual wall back, hence increasing the total resistance against sliding

• On the front of the wall, consider to backfill up to a certain depth or to create a toe key such that passive earth pressure can be considered.

(c) $FS_o = [(136.96 + 117.98)/(411.6 + 132.3 + 70.81)]^{-1} = 2.41 > 2.0 \Rightarrow$ OK!

(d) $e = \frac{B}{2} - \frac{\Sigma M_R - \Sigma M_O}{\Sigma F_v} = \frac{3.4}{2} - \frac{411.6 + 132.3 + 70.81 - 136.96 - 117.98}{262.15}$

$= 0.3276 \text{ m} < B/6 = 3.4/6 = 0.567 \text{ m}$

$\Rightarrow$ OK!

(e) Meyerhoff Method

$q_{allowable} = 160 \text{kPa}$

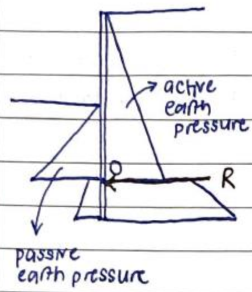
$q_{average} = \frac{262.15}{3.4 - 2(0.3276)} = 95.5 \text{kPa}$

$FS_{bearing} = 160/95.5 = 1.675 \leq 2.0 \Rightarrow$ not OK!

Q2

Q2. Fixed Earth Support Method :

(a) • Assumes that the embedded wall is fixed about a point O and ~~soil at the~~ above point O, the wall moves such that soil at the retained side ~~experiences~~ experience active earth pressure and soil at the restraining side experience passive earth pressure. This condition is reversed below point O.



• Assumes that the wall moves as a rigid body

• Since the ~~deform~~ movement of the wall required to achieve passive state is significantly larger than to reach active state, it is unlikely that the earth pressures are at the limiting states at the same time but it is assumed so.

• For simplified fixed earth support method, the pressures below point O are ignored and replaced with a single force component, R. This simplifies the calculation as we take moments about point O and R is ignored since it passes through point O (no lever arm). Thus, we can solve for the depth of embedment required to prevent rotation failure.

(b) Assumptions of free earth support method:

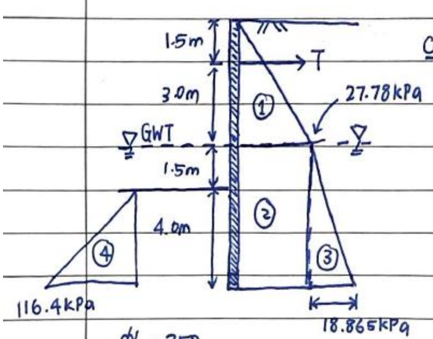
→ Wall moves as a rigid body as compared to the soil.

→ At the bottom of the wall, the ~~s~~ wall is able to move freely and is not restrained by passive earth pressures.

→ For an anchored wall, at the point where the anchor joins to the wall, it is assumed that the wall moves sufficiently forward to allow the active earth pressure condition to be attained.

(c) DA1C2 : Unfavourable Variable Actions → ×1.30
Material Partial Factors

• GW pressure cancelled out as it is level on both sides and due to single source principle



Component	Force (kN/m)	Lever Arm to T (m)	Moment (kNm/m)
①	$\frac{1}{2}(4.5)^2(18)(0.343) = 62.5$	$4.5(\frac{2}{3})-1.5 = 1.5$	93.75
②	$(4.5)(18)(0.343)(5.5) = 152.8$	$\frac{5.5}{2}+3 = 5.75$	878.6
③	$\frac{1}{2}(5.5)^2(10)(0.343) = 51.9$	$3+5.5(\frac{2}{3}) = 6.67$	346.173
④	$\frac{1}{2}(4.0)^2(10)(2.91) = 232.8$	$3+1.5+4(\frac{2}{3}) = 7.167$	1668.48

(i) ODF wrt kick-out failure $= 1668.48 / (93.75 + 878.6 + 346.173)$
$= 1.27 > 1 \Rightarrow$ OK!

(ii) Force in each anchor $= 3.0 \times (62.5 + 152.8 + 51.9 - 232.8)$
$= 3.0(34.4) = 103.2$ kN

$\phi'_k = 35°$

$\phi'_d = \tan^{-1}(\tan 35° / 1.25)$
$= 29.256°$

$K_a = \frac{1-\sin(29.256°)}{1+\sin(29.256°)} = 0.343$, $K_p = 1/K_a = 2.91$

Q2(c)(iii)

Anchor Force (per m run) = 34.4kN

Distance from top of the sheet-pile wall where lateral active thrust is equivalent to anchor force = $\sqrt{\frac{34.4}{0.5\times18\times0.343}} = 3.34m$

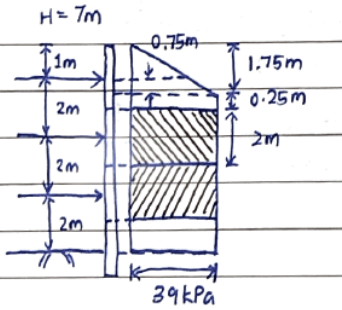
Max Bending Moment = $34.4\times(3.34-1.5)-34.4\left(\frac{1}{3}\times3.34\right)=25.0kNm/m$

Q3

(a) This is because the strut does not instantaneously take the load from the lateral earth pressures ~~and~~ as it requires some time for the load to be passed and for deformation to take place. Furthermore, as the excavation becomes deeper, the load transferred to the struts will be greater due to greater lateral earth pressures. Lastly, as other levels of struts are installed, the load will now be carried by more level of struts and ~~will no longer be the same~~ the measured load will no longer be the same.

(b) Using Peck's Empirical APD : ($m = 1.0$)

Check stability no. : $\frac{\gamma H + q}{C_{ub}} = \frac{(17\times7)}{28} = 4.25 > 4$



Load for Strut Lvl A $= 0.5(39)(0.25 + 2.0)\times 4.0 = 175.5\text{ kN}$

Load for Strut Lvl B $= (39)(2)\times 4.0 = 312\text{ kN}$

Load for Strut Lvl C $= (39)(2)\times 4.0 = 312\text{ kN}$

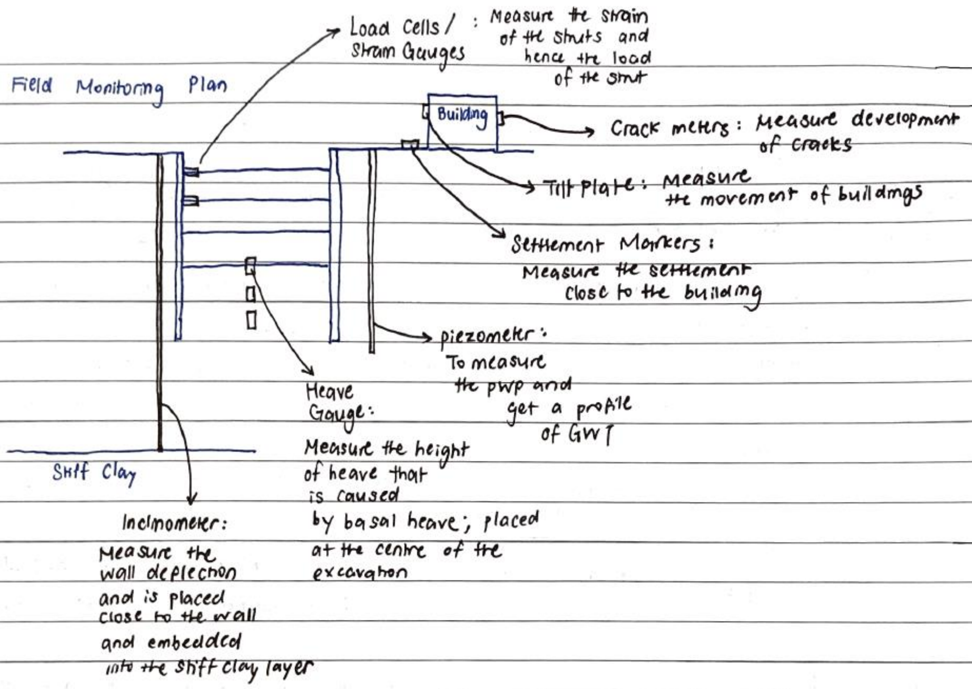
- Peck's method gives estimates of the same order of magnitude and is slightly more than the actual values.

$$p = \left(1 - 4\frac{C_{uh}\, m}{\gamma H}\right)\times \gamma H$$
$$= 1 - 4\times\frac{20}{17\times7} \times 17\times7$$
$$= 39\text{ kPa}$$

Estimated Max B.M

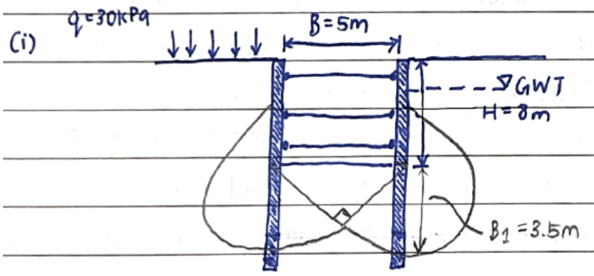
$$= \frac{P(d_{max})^2}{10} = \frac{(39)(2)^2}{10} = 15.6\text{ kN m/m}$$

Q3. (c) Field Monitoring Plan



Q4

(i)



$H > B = 5m \Rightarrow$ Deep Excavation

$B_1 = 0.7B = 0.7(5) = 3.5m < T = 10m$

Bjerrum & Eide Method

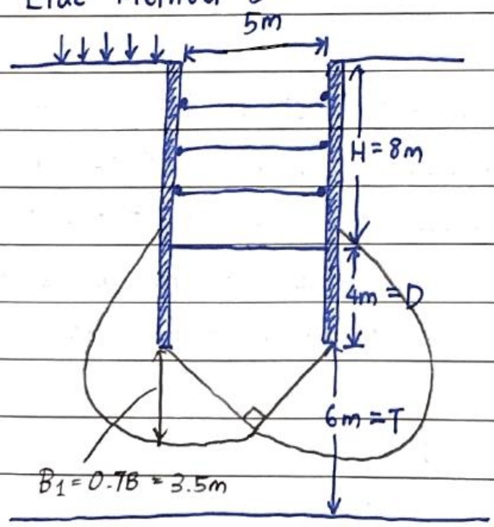
$$F_S = \frac{C_{ub} N_c \beta}{\gamma H + q} = \frac{(50)(6.93)}{(15)(8)+30} = 2.31$$

$H/B = 8/5 = 1.6 < 2.5$

$T/B = 10/5 = 2 \geq 0.7 \Rightarrow \beta = 1$

$$N_c = 5\left(1 + 0.2 \times \frac{5}{20}\right)(1 + 0.2 \times 1.6) = 6.93$$

(ii) Eide Method



$$F_S = \frac{C_{ub} N_c \beta + 2 C_A D (1 + B/L) \times 1/B}{\gamma H + q}$$

$$= \frac{(60)(7.77) + 2(40)(4)\left(1 + \frac{5}{20}\right) \times \frac{1}{5}}{(15)(8) + 30}$$

$$= 3.64$$

$(H+D)/B = 12/5 = 2.4$

$$N_c = 5\left(1 + 0.2 \times \frac{5}{20}\right)(1 + 0.2 \times 2.4) = 7.77$$

$T/B = 6/5 = 1.2 > 0.7 \Rightarrow \beta = 1.0$

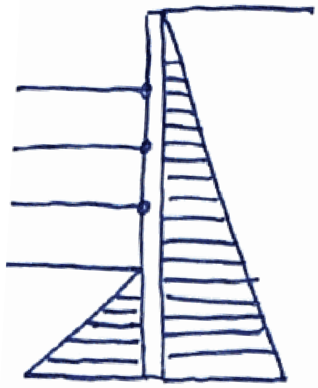
Q4(b)

$$FS\ (\text{uplift}) = \frac{\text{Resistance}}{\text{Uplift Force}}$$

$$= \frac{(4 \times 5)(17) + (6 \times 5)(18) + 2(40)(4) + 2(60)(6)}{(8+4+6+3)(10)(5)}$$

$$= 1.83$$

Q4(c)



FS against toe-kick out failure

- Greater depth of embedment gives greater passive resistance

- END -