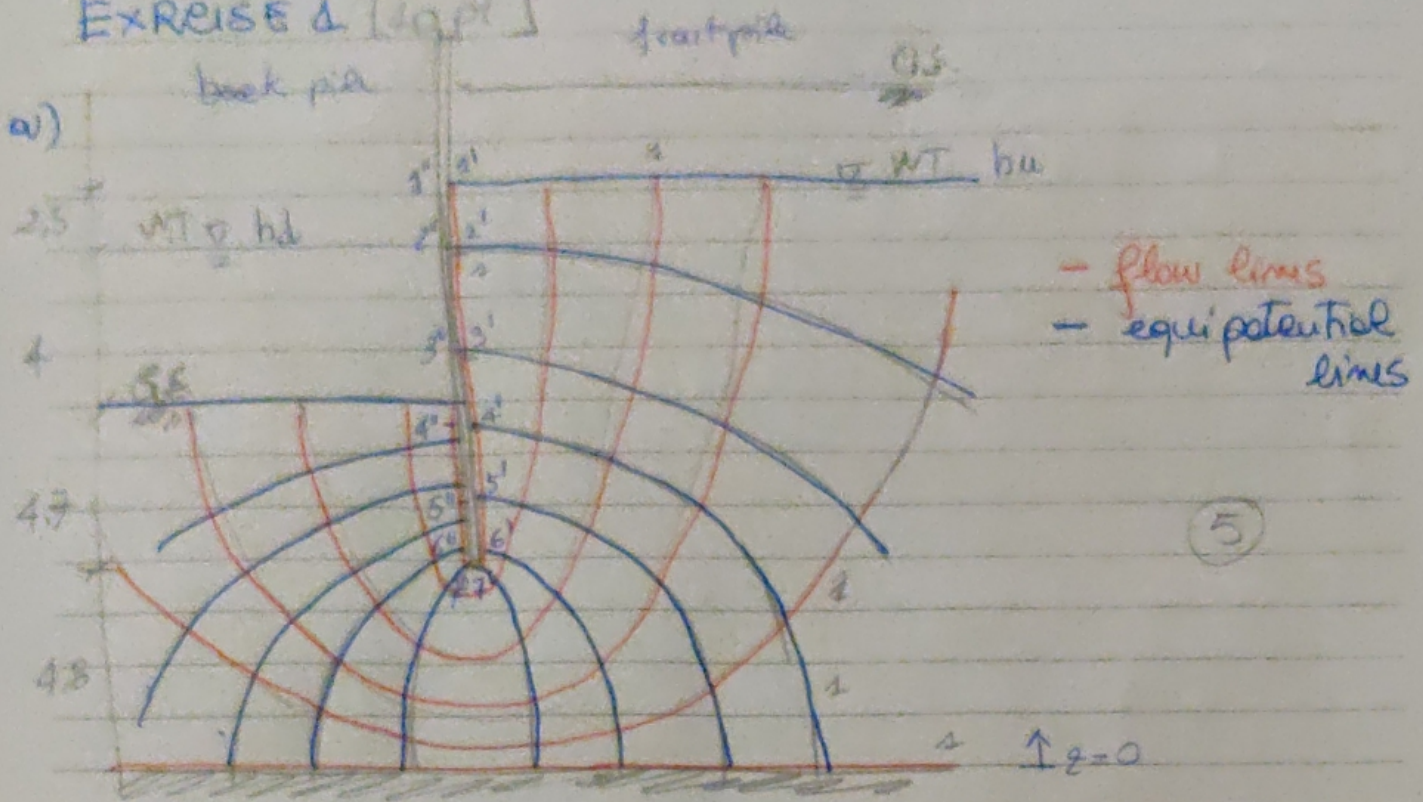


EXERCISE 1 [10pt]



- b) $N_d = 12$ 2 equipotential drops
 $N_f = 5$ flow channels

$h_u = h_d = 2.5 \text{ m}$ total head loss upstream-downstream

$\Delta h = \frac{h_u - h_d}{N_d} = \frac{2.5}{12} = 0.21 \text{ m}$ 2

↳ head loss per equipotential drop

$h_u = z_u + \frac{u_u}{\gamma_w} = 2.5(4.8 + 4.7 + 4 + 2.5) + 0 = 16 \text{ m}$ 2

$h_d = z_d + \frac{u_d}{\gamma_w} = (4.8 + 4.7) + 4 \frac{\gamma_w}{\gamma_w} = 13.5 \text{ m}$ 2

2 sides of pile = 2

I have selected some points on the front pile -
 For each of those I can calculate the corresponding head on the front of the pile h_f (right side) and on the back of the piling h_b (left side) and then the water pressure u_f and u_b :

$h_{p'} = h_u - m_{d,p'} \Delta h$ 2

$u_{p'} = \gamma_w (h_{p'} - z_{p'})$ 2

p' = front of the pile

$h_{p''} = h_d - m_{d,p''} \Delta h$

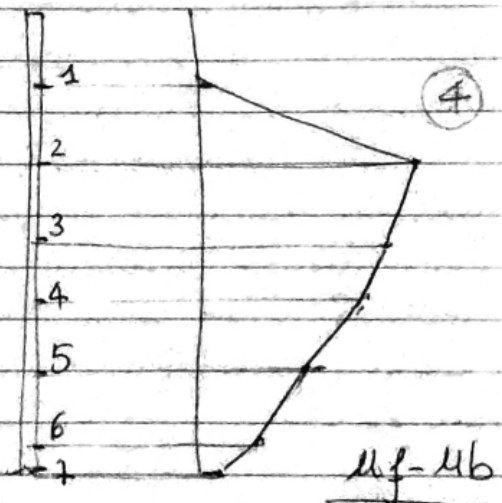
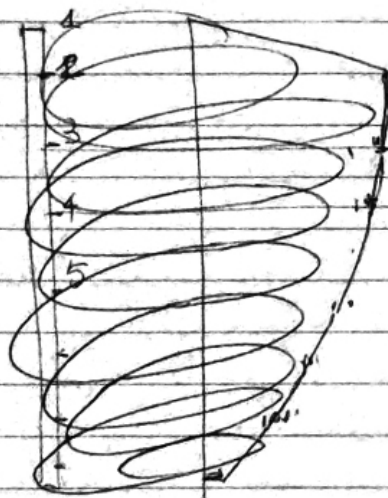
$u_{p''} = \gamma_w (h_{p''} - z_{p''})$

p'' = back of the pile

φ	z [m]	h_f [m]	h_b [m]	u_f [kN/m ²]	u_b [kN/m ²]	$u_f - u_b$ [kN/m ²]
1	16	16	0	0	0	0
2	13,5	15,79	13,5	22,9	0	22,9
3	10,5	15,58	13,5	50,8	30	20,8
4	9	15,37	13,55	63,7	45,5	18,2
5	7	15,16	13,81	81,6	68	13,6
6	5,5	14,95	14,32	94,5	88,2	6,3
7	4,8	14,74	14,53	99,4	99,3	2,1

In points 3" and 2" The head is the same as h_d as the water is at rest, not streaming.

In 1" The head and water pressure are $\emptyset$ as there is no water.



e) When the hole rises the downstream head increases and the total head loss $h_u - h_d$ decreases, it can even reach $\emptyset$

⑤ If the head loss decreases, the difference of u with respect to the hydrostatic pressure (static only due to $h_u - h_d$) decreases.
So for $h_u - h_d \rightarrow 0$ $u_f - u_b \rightarrow 0$

~~XXXXXXXXXX~~

$$\Delta\sigma = \gamma_e \cdot 1.5 = 22 \text{ kPa}$$

(40)

$$\sigma_{0A} = 15 \frac{\text{kN}}{\text{m}^2} \cdot 3 \text{ m} = 45 \text{ kPa}$$

$$A \quad u_{0A} = 0$$

$$\sigma'_{0A} = \sigma_{0A} - u_{0A} = 45 \text{ kPa} \quad \sigma'_{FA} = \sigma'_{0A} + \Delta\sigma = (45 + 22) \text{ kPa} = 67 \text{ kPa}$$

$$\sigma_{0B} = \gamma_e H_c + \sigma_{0A} = 20 \frac{\text{kN}}{\text{m}^2} \cdot 5 \text{ m} + 45 \text{ kPa} = 145 \text{ kPa}$$

$$B \quad u_{0B} = \gamma_w \cdot H_c = 10 \frac{\text{kN}}{\text{m}^3} \cdot 5 \text{ m} = 50 \frac{\text{kN}}{\text{m}^2}$$

$$\sigma'_{0B} = \sigma_{0B} - u_{0B} = 95 \text{ kPa} \quad \sigma'_{FB} = \sigma'_{0B} + \Delta\sigma = 122 \text{ kPa}$$

$$b \quad NC \Rightarrow \alpha_{cr} = \Delta \rightarrow \sigma'_h = K_0 \cdot \sigma'_v \Rightarrow K_0 = (1 - \sin \phi') / \tan \alpha_{cr}$$

$$K_{0e} = 1 - \sin(32) \sqrt{2} = 0.47$$

$$K_{0s} = 1 - \sin(30) \sqrt{2} = 0.5$$

$$K_{0c} = 1 - \sin(25) \sqrt{2} = 0.58$$

$$\sigma'_{H0A} = 0$$

$$\sigma'_{H0B} = (0.5) \cdot 45 \text{ kPa} = 22.5 \text{ kPa} \quad \sigma'_{H0c} = (0.58) \cdot 45 \text{ kPa} = 26.1 \text{ kPa}$$

$$\sigma'_{H0B} = (0.58) \cdot 95 \text{ kPa} = 55.2 \text{ kPa}$$

$$\sigma'_{H0c} = (0.47) \cdot 22 \text{ kPa} = 10.34 \text{ kPa}$$

$$\sigma'_{HFA} = (0.5) \cdot 67 \text{ kPa} = 33.5 \text{ kPa} \quad \sigma'_{HFB} = (0.57) \cdot 67 \text{ kPa} = 38.19 \text{ kPa}$$

$$\sigma'_{HFB} = (0.58) \cdot 122 \text{ kPa} = 70.76 \text{ kPa}$$

c. Total Settlement

$$\text{Sand Settlement: } S_s = \epsilon_s \cdot H_s; \quad \epsilon_s = \frac{-\Delta e}{1 + e_s}; \quad \Delta e = -C_c \log \left(\frac{\sigma'_{FB}}{\sigma'_{0B}} \right)$$

$$\Delta e = -0.03 \log \left(\frac{122}{95} \right) = -0.06$$

$$\epsilon_s = \frac{-(-0.06)}{1 + 0.5} = 0.04$$

$$\rightarrow S_s = 0.04 \cdot 3 \text{ m} = 0.12 \text{ m}$$

$$\text{Clay Settlement: } S_c = \epsilon_c \cdot H_c; \quad \epsilon_c = \frac{-\Delta e}{1 + e_c}; \quad \Delta e = -C_c \log \left(\frac{\sigma'_{FB}}{\sigma'_{0B}} \right)$$

$$\Delta e = -0.091 \log \left(\frac{122}{95} \right) = -0.0099$$

$$\epsilon_c = \frac{-(-0.0099)}{1 + 0.8} = 0.0055$$

$$\rightarrow S_c = 0.0055 \cdot 5 \text{ m} = 0.028 \text{ m}$$

$$S_{\text{TOT}} = S_s + S_c = 0.12 + 0.028 = 0.148 \text{ m} \approx 15 \text{ cm}$$

1. $OCR = 2 \rightarrow OCR = \frac{\sigma'_{1cr}}{\sigma'_0} \rightarrow \sigma'_{1cr} = 2 \cdot \sigma'_0 = 120 \text{ kPa}$ 1

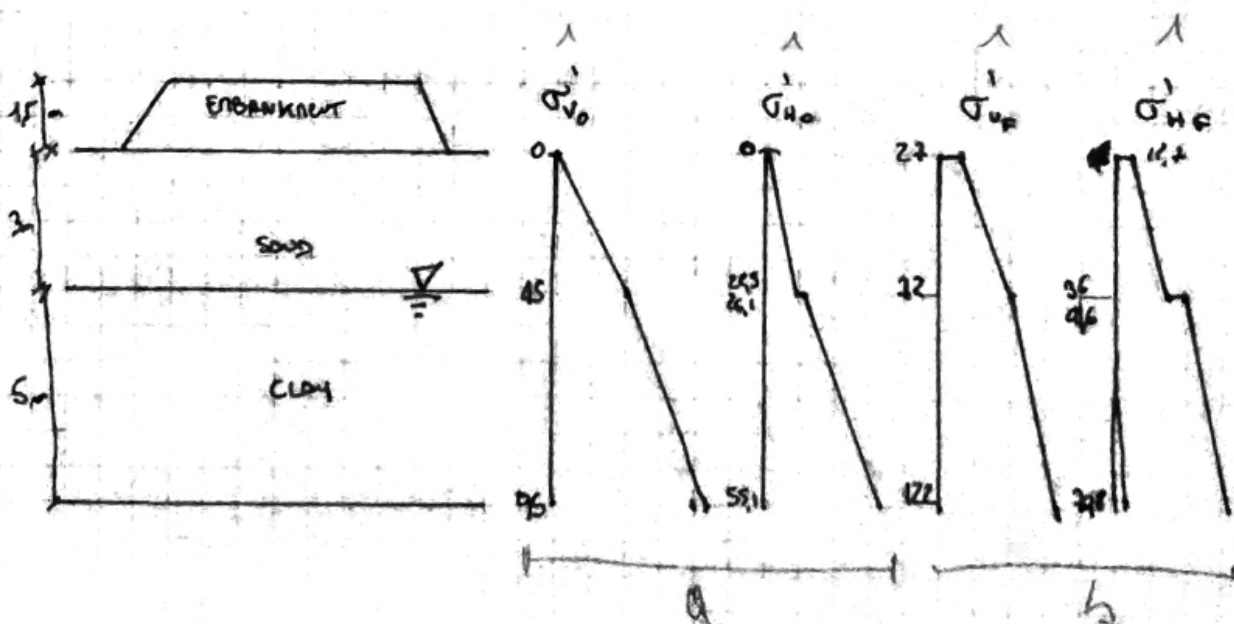
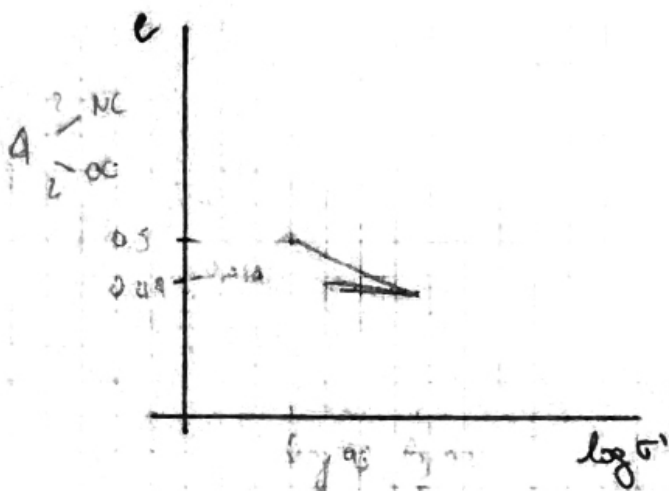
$OCR > 2; \sigma'_{1cr} > \sigma'_0 \rightarrow \Delta e = -C_e \log\left(\frac{\sigma'_{1cr}}{\sigma'_0}\right)$

2. $\Delta e = -0.006 \log\left(\frac{120}{95}\right) = -0.00065$

$\epsilon_2 = \frac{-(-0.00065)}{1+0.98} = 0.00033 \rightarrow S_c = 0.00033 \cdot 5m = 0.00165m$ 1

$S_{tot} = 1.2cm + 0.165cm = 1.365cm$ 1

Due to the stress history of the soil layer the settlement of an overconsolidated clay is smaller than the settlement of a normal consolidated clay (i.e. a clay that has never ^{being subjected to} ~~been~~ load before).



Exercise #3

confining pressure $\sigma_2 = 100 \text{ kN/m}^2$ 1

deviatoric stress $\Delta\sigma_{df} = 89,4 \text{ kN/m}^2$ 2

pore pressure $\Delta u_{df} = 58,1 \text{ kN/m}^2$ 1

Normal Consolidated clay $\Rightarrow \text{OCR} = 1$

$$\sigma_1 = \sigma_2 + \Delta\sigma_{df} = (100 + 89,4) \frac{\text{kN}}{\text{m}^2} = 189,4 \text{ kN/m}^2 \quad 2$$

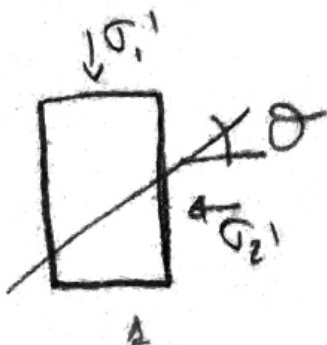
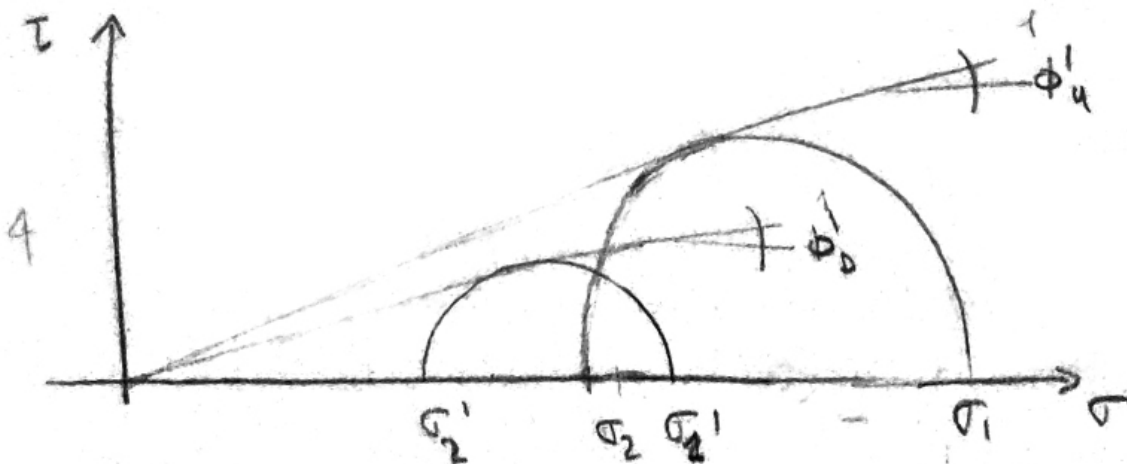
UNDRAINED FRICTION ANGLE

$$\phi' = \sin^{-1} \left(\frac{\sigma_1 - \sigma_2}{\sigma_1 + \sigma_2 - 2(\Delta u_{df})} \right) =$$

$$= \sin^{-1} \left(\frac{(189,4 - 100) \frac{\text{kN}}{\text{m}^2}}{(189,4 + 100 - 2 \cdot 58,1) \frac{\text{kN}}{\text{m}^2}} \right) = 31,1^\circ$$

DRAINED FRICTION

$$\phi' = \sin^{-1} \left(\frac{\sigma'_1 - \sigma'_2}{\sigma'_1 + \sigma'_2} \right) = \sin^{-1} \left(\frac{(189,4 - 100) \frac{\text{kN}}{\text{m}^2}}{(189,4 + 100) \frac{\text{kN}}{\text{m}^2}} \right) = 17,97^\circ$$



$$\theta = 45^\circ + \frac{\phi'}{2} = 45^\circ + \frac{18^\circ}{2} = 54^\circ \quad 2$$