Exam 2008-2009

(i) #200 (0.075 mm) % Passing > 50% → fine grained soil

LL = 19%
PL = 14%

$I_p = 19 - 14 = 5\%$ falls between (4-7%)
so dual classification

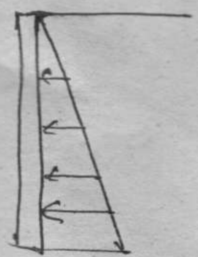
So the soil is (CL-ML)

(c) $\omega_s = 12\%$

As it has initial water content < shrinkage limit

the soil sample won't go any volumetric change

so, $\% \Delta V = 0$



dry sand so use γ_d

$$\frac{P_{initial}}{P_{final}} = \frac{\frac{1}{2} k_{p_1} \gamma_1 H^2}{\frac{1}{2} k_{p_2} \gamma_2 H^2} = \frac{\left(\frac{1+\sin\phi_1}{1-\sin\phi_1}\right) \times \gamma_1}{\left(\frac{1+\sin\phi_2}{1-\sin\phi_2}\right) \times \gamma_2}$$

Now, ~~γ_{d_1} = ...~~

$$= \frac{\left(\frac{1+\sin 30^\circ}{1-\sin 30^\circ}\right) \times 17.8}{\left(\frac{1+\sin 35^\circ}{1-\sin 35^\circ}\right) \times 18.8}$$

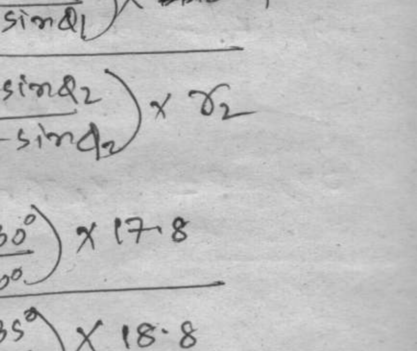
$$= 0.769$$

(2) Saturated clay

Cell pressure $= 100\ kN/m^2 = \sigma_3$

$\sigma_1 = \sigma_3 + \Delta\sigma = 100 + 200 = 300\ kN/m^2$

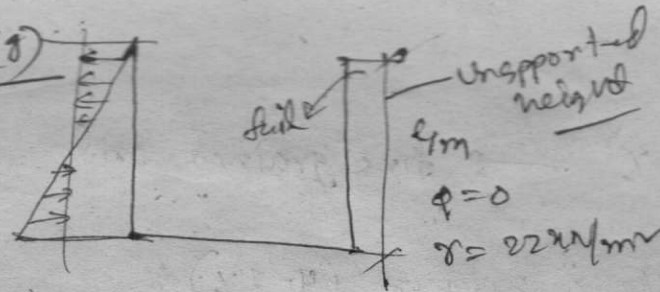
undrained → $\phi =$



$c = \frac{\Delta\sigma}{2} = \frac{200}{2} = 100$

undrained cohesion $= \frac{1}{2} \times$ deviator stress

1.(g)



As the soil caved after 4m it means that it has failed to take the self lateral pressure, which means 4m is the unsupp[orted] height of the soil.

$$H_u = \frac{4c}{\gamma} \Rightarrow c = \frac{\gamma H_u}{4}$$

$$= \frac{22 \times 4}{4} = 22 kN/m^2$$

1(h)

LL = 40%

PL = 25%

PI = 40 - 25 = 15

OCR = 2.5

$K_0 = 0.19 + 0.233 \log 15 = 0.464$

~~$P = \frac{1}{2} K_0$ $K_0' = K_0 \times \sqrt{OCR} = 0.464 \times \sqrt{2.5} = 0.733$~~

But, $K_0 = 1 - \sin\phi$ so, $1 - \sin\phi = 0.464$

$\phi = 32.41°$

so, $K_0' = 0.464 \times OCR^{\sin\phi}$

$= 0.464 \times 2.5^{\sin 32.41°} = 0.758$

so, $P = \frac{1}{2} K_0' \gamma h^2 = 0.5 \times 0.758 \times \gamma h^2$

$= 13.644\, \gamma$

6

2.(b)

#200 (0.075) = 8%   LL = 27%

#100 (0.15) = 10%   PL = 15%

#40 (0.425) = 30%

#10 (2mm) = 60% ← D_{60}

#4 (4.75 mm) > 60%

① % passing #200 < 50% → Coarse grained

② % passing #4 > 60% → sand

③ % fine = 8%. 5 < % fine < 12 → sand with fines

Dual classification

So, $D_{60} = 2$ mm

$D_{10} = 0.15$ mm

$D_{30} = 0.425$ mm

$C_u = \frac{D_{60}}{D_{10}} = \frac{2}{0.15} = 13.33 > 6$ ✓

$C_c = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{0.425^2}{2 \times 0.15} = 0.6$ (×)

So poorly graded,

S-P

For fines

LL = 27%

PL = 15%

PI = 27 − 15 = 12%

PI. A-line = 0.73 (LL − 20)

= 5.11

So above A-line and LL < 50%

Clay   low

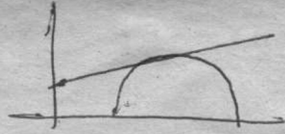
So it is CL

So SP-CL

3(b)

Silty clay sample

C-U test



Samp 1

$\sigma_3 = 170\ kN/m^2,\ \Delta\sigma = 125\ kN/m^2$

$\sigma_1 = 170 + 125 = 295\ kN/m^2$

Pore water pressure, $u = 110\ kN/m^2$

So, $\sigma_3' = 170 - 110 = 60\ kN/m^2$

$\sigma_1' = 295 - 110 = 185\ kN/m^2$ } effective

Sample 2

Cell pressure, $\sigma_3 = 430\ kN/m^2,\ \Delta\sigma = 310\ kN/m^2$

$\sigma_1 = 430 + 310 = 740\ kN/m^2$

Pore water pressure, $u = 270\ kN/m^2$

So, $\sigma_3' = 430 - 270 = 160\ kN/m^2$

$\sigma_1' = 740 - 270 = 470\ kN/m^2$

From graph (using effective stress)

$\phi = \tan^{-1}\frac{250}{450} = 29.05$

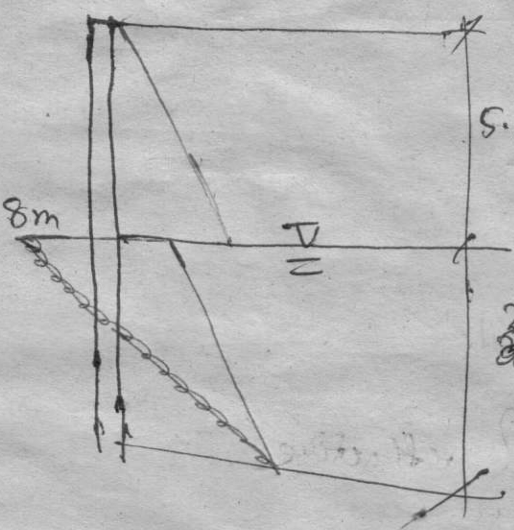
$c = 0$

Now, $\Delta u = B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)]$ — change in $\Delta\sigma$

$270 - 110 = 1 \times [(430 - 125) + A \times (310 - 125)]$

$A = -0.788.$

4(a)



$\gamma_d = 18.5$
$\varphi = 34^\circ$
$c = 0$

$\gamma_{sat} = 20.3$
$\varphi = 28^\circ$
$c = 17\,kPa$

For layer 1, $K_a = \frac{1 - \sin\varphi}{1 + \sin\varphi} = \frac{1 - \sin 34^\circ}{1 + \sin 34^\circ} = 0.283$

$P_a(h) = K_a \gamma h = 0.283 \times 18.5 \times h = 5.2355\, h$

$P_a(0) = 0$, $P_a(5.5) = 28.7953$

For layer 2

$h_e = \frac{5.5 \times 18.5}{20.3} = 5\, m$

~~So, K_a = $P_a(h) = K_a \gamma h - 2c\sqrt{K_a} = 0.283 \times (20.3 - 9.81) \times (5 + h)$~~
$- 2 \times 17 \times \sqrt{0.283}$

$=$ ~~$14.84 + 2.97h - 18.09$~~

$=$ ~~$-3.25 + 2.97h$~~

~~$P_a(0) = -3.25$~~

~~$P_a(2.5) = 4.175$~~ + ~~Pore water~~ =

~~latur thrust~~

so, $P_a(h) = \underset{O.B.P}{\underbrace{0.283 * \ldots}}$

$= 28.7245 + 0.283 * (20.3 - 9.81) * h - 2 * 17 * \sqrt{0.283}$

$= 28.7245 + 2.8838h - 18.1$

$= 10.6 + 2.8838h$

$P_a(0) = 10.6$

$P_a(2.5) = 17.81$

Pore water, $P_u(0) = 0$

$P_u(2.5) = 2.5 \times 9.81 = 24.525$

active lateral thrust $= \frac{1}{2} * 28.8 * 5.5 + \frac{1}{2} * (10.6 + 17.81) * 2.5 + \frac{1}{2} \times 24.525 \times 2.5$

$= 145.36$ kN.

4(b)

$\phi = 32^\circ$
$\gamma = 19.8$ kN/m³ | Direct shear.

σ_N = O.B.P (over burden pressure) $= \gamma H = 19.8 \times 4.5 = 89.1$ kN/m²

(5+h)

so, $\tau = \sigma_N \tan\phi = 89.1 \tan 32^\circ = 55.68$ kN/m²

After superimposing the surcharge,

$\sigma_N = 89.1 + 65 = 154.1$

$\tau = 55.68 + 50 = 105.68$

$\phi = \tan^{-1}\frac{\tau}{\sigma_N} = \tan^{-1}\frac{105.68}{154.1} = 34.44^\circ > 32^\circ$ ← failure angle

So the structure will not be stable failure will occur.

section B

5(c)

Borrow

$w = 10\%$

$\gamma = 1.8$ ton/m^3

$\gamma_d = \frac{\gamma}{1+w} = \frac{1.8}{1.10}$

$= 1.64$ ton/m^3

Now, $\gamma_d = \frac{\gamma_w G_s}{1+e}$

So, $1+e = \frac{\gamma_w G_s}{\gamma_d}$

So, $\frac{V_b}{V_f} = \frac{\gamma_{df}}{\gamma_{db}} = \frac{1.85}{1.64}$

$V_b = 1.128 V_f = 1.128$ m^3

Fill

compacted

$\%w = 18\%$

$\gamma_d = 1.85$ ton/m^3

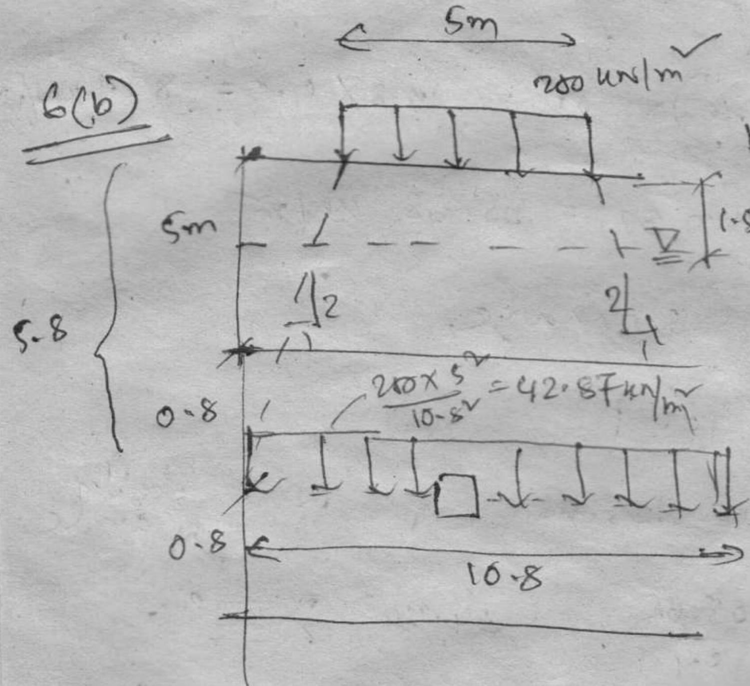
Extra water needed

$= 1.64 * \frac{(18-10)}{100} * 1.128$

$= 0.147$ ton

$= 0.147$ m^3

6(b)



$p_0 = 1.5 \times 18.34 + 3.5 * (20.4 - 9.81) + 0.8 * (19.5 - 9.81)$

$= 72.327$

$p = p_0 + \Delta p = 42.87 + 72.327$

$= 115.197$

$p_0 \rightarrow e_0 = 0.7077$

$p \rightarrow e = 0.6716$

$\Delta e =$

$S = \frac{\Delta e}{1+e_0} H = \frac{(0.7077 - 0.6716)}{1 + 0.7077} \times 1.6 = 0.0338$ m

$= 33.8$ mm

(b) Now

$$\frac{t_{90\,field}}{t_{90\,sample}} = \frac{H_{dr\,field}^2}{H_{dr\,sample}^2}$$

$H_{dr\,field} = 1.6m = 1600$

$H_{dr\,sample} = \frac{20}{2} = 10mm$

double drain

$$\frac{t_{90\,f}}{t_{90\,sample}} = \frac{(1600)^2}{(10)^2}$$

1h 46 min

= 1.77 hour

= 6372 sec

$$t_{90f} = \left(\frac{1600}{10}\right)^2 \times 1.77$$

= 45312 hour

= 5.17 year

= 5 year 63 day

= 5 year 2 month 3 day.

(c) $m_v = \frac{\frac{\Delta e}{\Delta p}}{1+e_0} = \frac{\frac{0.0361}{42.87}}{1+0.7077} = 4.931 \times 10^{-4}\ m^2/kN$

$t_{90} = 1.77$

- 9.81)

But, $C_v = \frac{0.848 \times H_{dr}^2}{t_{90}} = \frac{0.848 * ~~0.10~~\ 0.01^2}{6372} = 1.331 \times 10^{-8}\ m^2/sec$

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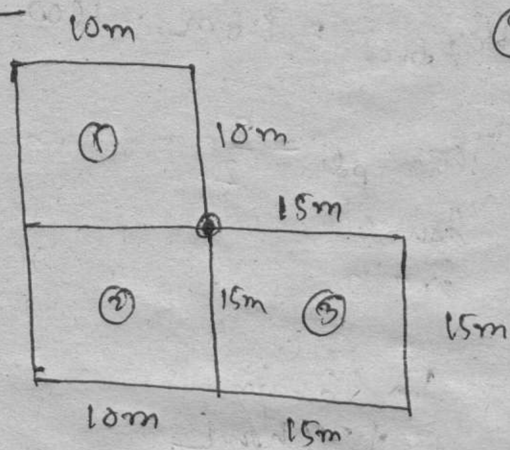
So, $k = C_v \times m_v \times \gamma_w$

$= 1.331 \times 10^{-8}\ m^2/sec * 4.931 \times 10^{-4}\ m^2/kN * 9.81\ kN/m^3$

$= 6.438 \times 10^{-11}\ ms^{-1}$

=

7(b)



$q = 75 kN/m^2$, $z = 10m$

(i) $m = \frac{L}{z} = \frac{10}{10} = 1$

$n = \frac{B}{z} = \frac{10}{10} = 1$

$m^2 + n^2 + 1 = 3$ ✓ Formula 1

$m^2 n^2 = 1$

$\sigma_z = \frac{q}{4\pi}\left(A \times B + \sin^{-1} A\right)$

$A = \frac{2mn\sqrt{m^2+n^2+1}}{m^2+n^2+1+m^2n^2}$

$= 0.866$

$= \frac{75}{4 \times \pi} * (0.866 * 1.333 + 1.047)$

$= 13.13 \ kN/m^2$

$B = \frac{m^2+n^2+2}{m^2+n^2+1} = 1.333$

$\sin^{-1} A = 1.047$

(ii) $m = \frac{10}{10} = 1$

$m^2 + n^2 + 1 = 4.25$ ✓ F 1

$n = \frac{15}{10} = 1.5$

$m^2 n^2 = 2.25$

$A = 0.952$

$B = 1.235$

$\sigma_z = \frac{75}{4 \times \pi} * (0.952 * 1.235 + 1.26)$

$\sin^{-1} A = 1.26$

$= 14.54$

(iii) $m = \frac{15}{10} = 1.5$

$m^2 + n^2 + 1 = 5.5$ ✓ F 1

$n = \frac{15}{10} = 1.5$

$m^2 n^2 = 5.06$

$A = 1$

$\sigma_z = \frac{75}{4 \times \pi} * (1 * 1.182 + 1.571)$

$B = 1.182$

$= 16.43 \ kN/m^2$

$\sin^{-1} A = 1.571$

total = 13.13 + 14.54 + ~~…~~ 16.43

= ~~…~~ kN/m²

44.1

8(c) Constant head permeameter

$q = KiA = \frac{K h A}{L} \Rightarrow K = \frac{qL}{hA}$, $q = 500 ml = 500 cm^3$

$L = 15 cm$

$h = 40 cm$

$q = \frac{500}{15 min}$

$= \frac{500 \times 15}{40 \times 19.635 \times 15}$

$A = 0.7854 \times 5^2$

$= 19.635 cm^2$

$= 0.637$ cm/min

$= 10.61 \times 10^{-3}$ cm/sec

Discharge velocity, ~~$v = qA = \frac{q}{t} A$~~

$q = VA.$

~~$= \frac{500}{15} \times 19.635 = 654.5$~~

$\Rightarrow V = \frac{q}{A} = \frac{Q}{At} = \frac{500 cm^3}{19.635 cm^2 \times 15} = 1.697$ cm/min

$= 0.0282$ cm/sec

seepage velocity

$V_s = \frac{V}{n}$

$= \frac{0.0282}{0.377}$

$= 0.0747$ mms⁻¹

$\gamma_d = \frac{W}{V} = \frac{486}{H A}$ ← sample height

$= \frac{486}{15 \times 19.635}$

$= 1.65$

$e = \frac{\gamma_w G_s}{\gamma_d} - 1 = \frac{2.65}{1.65} - 1 = 0.61$

$n = \frac{e}{1+e} = 0.377$