Exam : 2010 - 2011

<u>Consistency</u>

~~Liquid limit, $LL = \left(\frac{W}{25}\right)^{0.1} \times \left(\frac{45}{25}\right)^{0.1}$~~

Liquid limit, $LL = \omega \times \left(\frac{N}{25}\right)^{0.1} = 45 \times \left(\frac{28}{25}\right)^{0.1} = 45.513$ (ω_L)

Plastic limit, $PL = 18.2\%$ (ω_P)

natural water content, $\omega_N = 40\%$

Plasticity Index, $I_P = LL - PL = 45.5 - 18.2 = 27.3\%$

flow Index, $I_F = \frac{\omega_1 - \omega_2}{\log \frac{N}{N_2}} = \frac{45.5 - 45}{\log\left(\frac{28}{25}\right)} = 10.16$

Toughness Index, $I_T = \frac{I_P}{I_F} = \frac{27.3}{10.16} = 2.69$

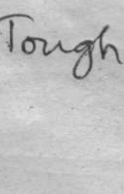
Consistency Index, $I_C = \frac{\omega_L - \omega_n}{I_P} = \frac{45.5 - 40}{27.3} = 0.2014$

<u>shrinkage limit</u>

~~void ratio at liquid limit, = (100% saturated)~~

$S_R = \frac{wG}{e}$

Given, void ratio at shrinkage limit, $e = 0.40$



So porosity $= \frac{e}{1+e} = \frac{0.40}{1+0.40} = 0.2857$

For 100% saturation at shrinkage will give the shrinkage limit, $S_R = 1$

So, $\omega = \frac{e}{G_s} = \frac{0.40}{2.70} = 0.148 = 14.8\%$

2(a) $\boxed{C-U}$ Saturated

cell pressure, $\sigma_3 = 50$ kpa
$\sigma_1 = 86.2$ kpa

unconfined, consolidated under 50 kpa

$q_u = 86.2 - 50$ (the deviator stress)
$= 36.2$ kpa

2(b) USCS

① $\frac{3.1\%}{96.9\%}$ #200 → fine grained

② LL = 20
PI = 6

A line, PI = 0.73 (LL−20)
= 0.73 × (20−20) = 0

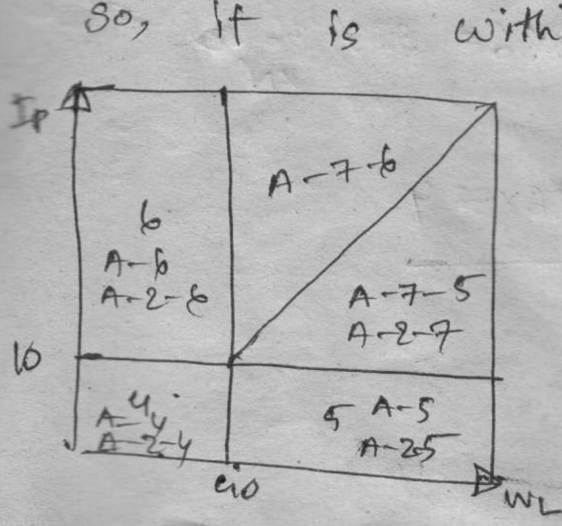
so border line

It is between 4 and 7 → dual fine classification

so it is CL−ML

AASHTO

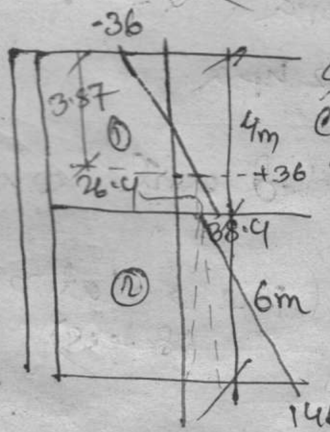
PL and LL exist so it can't be A−1, −2, 3
on the other hand %fines > 35%.
so, it is within A4, 5, 6, 7



so, $\boxed{A-4}$ Ans

(no mention of water table)

3. (a)



$\phi = 0$ (as it's undrained)
$C_u = 18$ kpa
$\gamma = 18.6$ kN/m^3

$C_u = 24$ kpa
$\gamma = 20$ kN/m^3
$\phi = 0$

$\phi = 0$, $K_a = 1$
(active)

Saturated bcz of capillary rise

For layer 1, $P_a(h) = K_a \gamma h - 2c\sqrt{K_a}$

$= 18.6h - 2 \times 18 \times 1 = 18.6h - 36$

Depth of the tension crack, $h_c = \frac{36}{18.6} = 1.935$ m

$P_a(0) = -36$ kpa

$P_a(4) = 38.4$ kpa

For layer 2, $h_e = \frac{4 \times 18.6}{20} = 3.72$ m

$P_a(h) = K_a \gamma (3.72 + h) - 2c\sqrt{K_a} = 20(3.72 + h) - 2 \times 24$

$= 74.4 + 20h - 48 = 20h + 26.4$

$P_a(0) = 26.4$

$P_a(6) = 146.4$

Total Active thrust $= \frac{1}{2} \times (36 + 38.4) \times 0.13$

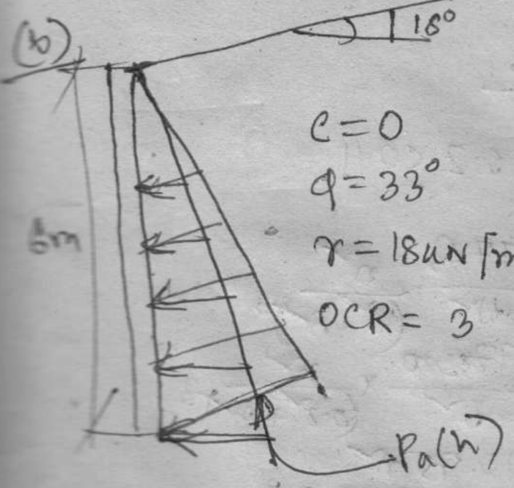
$+ \frac{1}{2} \times (26.4 + 146.4) \times 6 = 523.236$ kN.

Location

$$\bar{y} = \frac{\frac{6}{3} \times \frac{1}{2} \times 6 \times 146.4 + \frac{2}{3} \times 6 \times \frac{1}{2} \times 6 \times 38.4}{523.236}$$

$= 2.56$ m (?)

(b)



$c = 0$

$\phi = 33^\circ$

$\gamma = 18\,kN/m^3$

$OCR = 3$

Thrust = Area

(i) wall is Restricted to any movement (Earth pressure at rest)

~~K_a =~~

$K_0 = 1 - \sin\phi = 1 - \sin 33^\circ$

$= 0.455 \cdot OCR^{\sin\phi}$

So, $P_a(h) = K_a \gamma h (1 + 0.5\tan\beta)^2 \cdot OCR^{\sin\phi}$

$= 0.455 \times 18 \times (1 + 0.5\tan 18^\circ)^2$
$3^{0.544} \times h$

$= \underline{20.12h}$

lateral pressure $= 20.12h \times \cos\beta$

$= 19.135h$

~~horizontal~~ Inclined thrust

$= \frac{1}{2} \times 20.12h \times \cos\beta \times h$

$= 9.57h^2$

So horizontal ~~horiz~~ thrust $= 9.57 \times 6^2 \times \cos\beta = 327.65$

inclined $\frac{1}{2} \times h \times 20.12h \cos\beta$

horz (cos component

(ii) yield sufficiently = Active Earth pressure

$$K_a = \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}} = \frac{\cos 18^\circ - \sqrt{(\cos^2 18 - \cos^2 33^\circ)}}{\cos 18^\circ + \sqrt{(\cos^2 18 - \cos^2 33^\circ)}}$$

(বইয়ের সাথে সমাধান মেলে

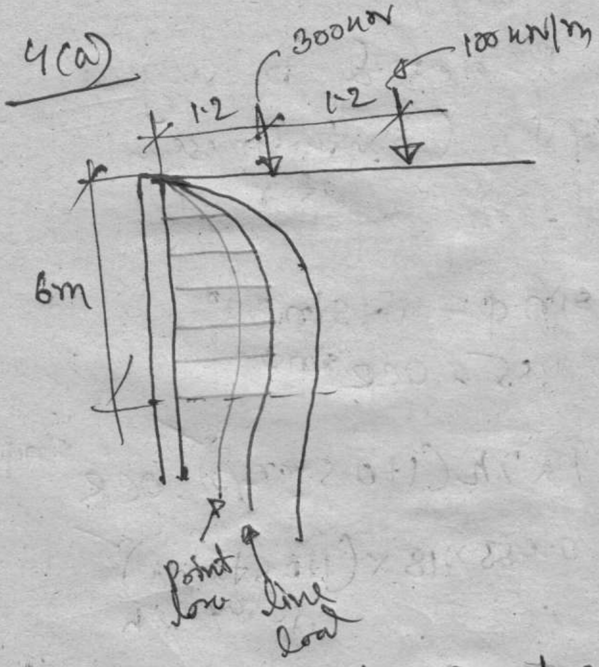
$\beta = 0^\circ \rightarrow \frac{1 - \sin\phi}{1 + \sin\phi}$ সমাধান হয় $= \underline{0.359}$

Inclined Pressure $= K_a \gamma h = 0.359 \times 18 \times h = 6.462h$

Inclined thrust $= \frac{1}{2} \times h \times 6.462h \times \cos\beta^{18^\circ} = 3.07h^2$

Horz Thrust $= 3.07 \times 6^2 \times \cos\beta = 105.21\,kN$

4(a)



For Point load

$m = \frac{x}{z} = \frac{1.2}{6} = 0.2 \leq 0.4$

So, use $P_h = \frac{1.77Q}{H^2} \cdot \frac{n^2}{(m^2+n^2)^3}$

$= \frac{1.77 \times 300}{6^2} \times \frac{n^2}{(0.2^2+n^2)^3}$

$= \frac{14.75\, n^2}{(0.04+n^2)^3}$

For line load

$m = \frac{x}{z} = \frac{2.4}{6} = 0.4$

$P_h = \frac{4 \times q}{\pi H} \cdot \frac{m^2 n}{(m^2+n^2)^2}$

$= \frac{4 \times 100}{\pi \times 6} \times \frac{0.4^2 \times n}{(0.4^2+n^2)^2}$

$= \frac{3.395 \times n}{(0.16+n^2)^2}$

y	$n = \frac{y}{z}$	$P_P(h)$	$P_L(h)$
1	0.167	1315.9	16.047
2	0.33	474.96	15.396
3	0.5	151.19	10.096
4	0.67	57.66	6.1949
5	0.833	25.855	3.88
6	1	13.112	2.523

total Press

1 —— 1332
2 —— 490.4
3 —— 161
4 —— 63.9
5 —— 30
6 —— 15.6

total thrust $= \frac{1}{2} \times \left(1332 + 2(490.4 + 161 + 63.9 + 30) + 15.6\right)$

$= 1419.1$ kN

5(c)

Section B

$G_s = 2.65$

Area A

$e_a = 0.80$

$w = 20\%$

So

$$\frac{V_A}{V_F} = \frac{1+e_a}{1+e_f}$$

$$V_A = \frac{1+0.80}{1+0.62} \times 10000$$

$$= 11{,}111\ m^3$$

Cost

$$\frac{11111}{100} \times 2000$$

$$= 2{,}22{,}220\ \text{Tk}$$

water

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

$$= \frac{1 \times 2.65}{1+0.80}$$

$$= 1.472$$

water

$$= \underset{\gamma_d}{1.472} \times \overset{\text{water diff}}{\frac{(22-20)}{100}} \times \overset{\text{Vol}^m}{11111}\ \text{ton}$$

$= \cancel{322800}$ 327 ton water

$= 327\ m^3$ water (additional)

Fill

$V_F = 10000\ m^3$

$\gamma = 2\ \text{ton}/m^3$

$w = 22\%$

Fill void ratio

$$e_f = \frac{\gamma_w G_s}{\gamma_d} - 1$$

$$= \frac{1 \times G_s}{\gamma_d} - 1$$

$$= \frac{G_s \times (1+w)}{\gamma} - 1$$

$$= \frac{2.65 \times (1+0.22)}{2} - 1$$

$= 0.62$

([illegible])

Area B

$e_B = 0.70$

$w = 15\%$

So

$$\frac{V_B}{V_F} = \frac{1+e_B}{1+e_f}$$

$$= \frac{1+0.70}{1+0.62}$$

$$V_B = 1.0494 \times 10000$$

$$= 10493\ m^3$$

Cost

$$\frac{10493}{100} \times 2200$$

$$= 2{,}30{,}846$$

water

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

$$= \frac{1 \times 2.65}{1+0.70}$$

$$= 1.559$$

water required

$$= \gamma_d \times \frac{\Delta w}{100} \times V$$

$$= 1.559 \times \frac{(22-15)}{100} \times 10493$$

$= 1145$ ton

$= 1145\ m^3$ of water (additional)

6(b)

we know that, sattlement, $S \propto U$ (% sattlement)

~~pore water pressure~~ But, $U^2 \propto T_v$

and $T_v \propto t$

~~so, $S^2 \propto U^2 \propto T_v \propto t$~~

so, $S^2 \propto t$

6(c)

$H = 4m$ (clay) (double drainage)

$\Delta p = 55\ kN/m^2$

$U = 5\%$

$K = 0.020\ m/yr$

$H_{dr} = \frac{4}{2} = 2m$

determine sattlement in 1 year.

5% consolidation in 1 year

$U = 5 < 60\%$

so, $T_v = \frac{\pi}{4}\left(\frac{5}{100}\right)^2$ আগের মত ওভার হবে
$= 1.963 \times 10^{-3}$

so, $T_v = \frac{C_v \times t}{H_{dr}^2}$, $C_v = 7.882 \times 10^{-3}\ m^2/yr$

1.963×10^{-3}, $t = 1$ year, $H_{dr} = 2m$

Now, $K = C_v m_v \gamma_w$

$0.02 = 7.852 \times 10^{-3} \times m_v \times 9.81$

$m_v = 0.259\ m^2/kN$

For 50% consolidation

$$\frac{U_1}{U_2} = \sqrt{\frac{t_1}{t_2}}$$

$$\Rightarrow \frac{5}{50} = \sqrt{\frac{1}{t_2}}$$

$$\Rightarrow t_{50} = 2500\ year$$

so, $C_v = \frac{0.197 \times 2^2}{2500} = 3.152 \times 10^{-4}\ m^2/yr$

Now, $K = C_v m_v \gamma_w$

$0.02 = 3.152 \times 10^{-4} \times m_v \times 9.81$
$m^2/year$ kN/m^3

$m_v = 6.468\ m^2/kN$

$S = H m_v \Delta p$

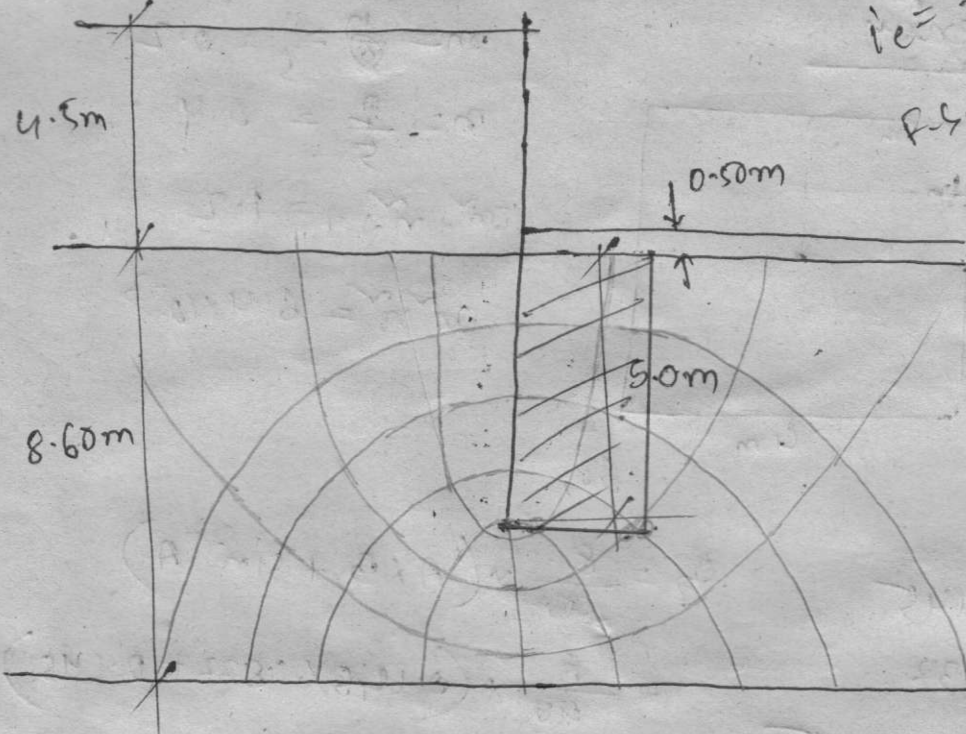
$= 4 \times 6.5 \times 55 = 1430$

7(d)

32cm = 5m
32mm = 5m
1mm = 0.142

$i_c = \frac{\gamma'}{\gamma_w}$

$F.S. = \frac{\sigma_c}{\sigma_{ext}}$



$1\ kg/m^2 = 9.81\ kN$

$N_d = 10$

$N_f = 3.1$

$i_{av} = \frac{h_{avt}}{D} = \frac{1.5}{5} = 0.3$

$F.S. = \frac{\gamma'}{i_{av} \times \gamma_w} = \frac{21.5 - 9.8}{0.3 \times 9.8} = 3.94 \approx 4$

safe!

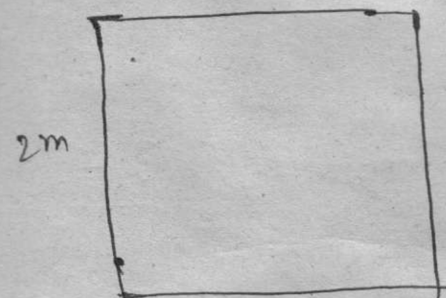
$q = k \frac{H}{N_d} \times N_f = 2.5 \times 10^{-5} \times \frac{4}{10} \times 3.1$

$= 3.1 \times 10^{-5}\ m^3/sec$

$Q = qt = 3.1 \times 10^{-5} \times 6 \times 30 \times 24 \times 60 \times 60$

$= 482\ m^3$ (Ans Bcz of flow net)

8(b)



$m = \frac{2}{5} = 0.4 \quad m^2 + n^2 + 1 = 1.8$

$n = \frac{4}{5} = 0.8 \quad m^2 n^2 = 0.1024$

$m^2 + n^2 + 1 > m^2 n^2$

so, $\sigma_z = \frac{8}{4\pi} \times \left(A \times B + \sin^{-1} A \right)$

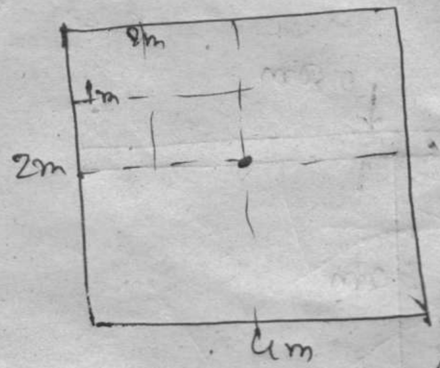
$A = \frac{2mn\sqrt{m^2 + n^2 + 1}}{m^2 + n^2 + 1 + m^2 n^2} = 0.457$

$B = \frac{m^2 + n^2 + 2}{m^2 + n^2 + 1} = 1.56$

$= \frac{8}{4\pi} \times \left(0.457 \times 1.56 + \sin^{-1} 0.457 \right)$

$= 0.745\ ton/m^2$

For centre



$m = \frac{1}{5} = 0.2$

$n = \frac{2}{5} = 0.4$

$m^2 + n^2 + 1 = 1.2$

$m^2 n^2 = 6.4 \times 10^{-3}$

So,

$A = 0.145$

$B = 1.833$

$\sin^{-1} A = 0.145$

$\sigma_z = \frac{8}{4\pi} \times (A \times B + \sin^{-1} A)$

$= \frac{8}{4\pi} \times (0.145 \times 1.833 + 0.145)$

$= 0.2615 \text{ ton/m}^3$

i(b) $\sigma_3 = 100 \text{ kN/m}^2$

$\sigma_1 = 100 + 250 = 350 \text{ kN/m}^2$

sand, $c = 0$

$\phi = 33.69°$ from Mohr's circle