$V = \frac{\gamma_s - \gamma_w}{18\,\eta} D^2$

$D = \sqrt{\frac{18\,\eta}{\gamma_s - \gamma_w}}\sqrt{V}$, $V = \frac{L}{t}$

uniformity coefficient $(C_u) = \frac{D_{60}}{D_{10}}$

concavity coeff. / coeff. of grad. $C_c = \frac{D_{30}^2}{D_{60}\,D_{10}}$

air content $= \frac{V_a}{V} \times 100$

$G.s = \frac{\gamma_s}{\gamma_w} = \frac{\rho_s}{\rho_w}$

$G_m = \frac{\gamma}{\gamma_w}$

$\rightarrow \gamma_s = \frac{W_s}{V_s}$, $\gamma_w = \frac{W_w}{V_w}$

$\gamma = \frac{W}{V}$ unit weight

Void ratio $(e) = \frac{V_v}{V_s}$

porosity $(n) = \frac{V_v}{V}$

$e = \frac{n}{1-n}$, $n = \frac{e}{1+e}$

w% [water content] moisture content $= \frac{W_w}{W_s} \times 100$

degree of saturation $S_r, S = \frac{V_w}{V_v} \times 100$

unit weight ($\gamma_{bulk}, \gamma_{total}, \gamma_{moist}$)

$\gamma = \frac{W}{V} \rightarrow \rho = \frac{M}{V}$

$\gamma = \rho g$

γ_d (dry unit) $= \frac{W_s}{V}$

$\gamma = \gamma_{dry}[1 + w\%]$

$\gamma_{dry} = \frac{G.s\,\gamma_w}{1+e}$

$(S_r)(e) = (w)(G.s)$

$\gamma = \frac{G.s\,\gamma_w[1 + w]}{1+e}$

if soil saturated:

$\gamma_d = \frac{G.s\,\gamma_w}{1+e}$

$\gamma_{sat} = \frac{\gamma_w[G.s + e]}{1+e}$

$w\% = \frac{e}{G.s}$

relative density $D_r = \frac{e_{max} - e^*}{e_{max} - e_{min}}$

$= \left[\frac{\gamma_d - \gamma_{d\,min}}{\gamma_{d\,max} - \gamma_{d\,min}}\right]\left(\frac{\gamma_{d\,max}}{\gamma_d}\right)$

$\rightarrow \gamma_{d\,min} = \frac{W_s}{V_{max}}$

$P.I = L.L - P.L$

liquidity index (L.I) $= \frac{W_n - P.L}{P.I}$

consistency index (C.I) $= \frac{L.L - W_n}{L.L - P.I}$

$L.L = w\left(\frac{N}{25}\right)^{0.121}$

1 year = 365 day

1 yd³ = 27 ft³

1 ft = 30.48 cm

$w_i = \frac{m_1 - m_2}{m_2} \times 100\%$

$\Delta w_i = \frac{\Delta V\,\rho_w}{m_2}$

$(\Delta V) = V_i - V_f$

$= \Delta V \rho_w$

shrinkage ratio $(S_R) = \frac{m_2}{V_f\,\rho_w} = \frac{\rho_d}{\rho_w}$

volumetric shrinkage $= \frac{V_i - V_d}{V_d} \times 100$

$G.s = \frac{1}{\frac{1}{S.R} - \frac{S.L}{100}}$

A-Line = 0.73 (L.L − 20)

U-Line = 0.9 (L.L − 8)

other coarse fraction ≥ 15%

max dry density (Theoretical dry unit weight)

$\gamma_z = \frac{\gamma_w}{w + \frac{1}{G.s}}$

$\gamma_d = \frac{G.s\,\gamma_w}{1 + \frac{w\,G.s}{S.r}}$

degree of compaction $= \frac{\gamma_{d\,field}}{\gamma_{d\,max}} \times 100$

$1 < C_c < 3$ { S $C_u > 6$, G $C_u > 4$ }

$A \le 0.7$, $0.7 \le A \le 1.25$, $A > 1.25$

$S_N = 1.7\sqrt{\frac{3}{D_{50}^2} + \frac{1}{D_{20}^2} + \frac{1}{D_{10}^2}}$

$D = \frac{1}{2}\sqrt{\omega \cdot h}$ (ton)

1 ft = 30.48 cm

$O.C = \frac{W_1 - W_2}{W_1} \times 100$

$E = \frac{(\text{no. of layers})(\text{blows})(\text{weight})(\text{height})}{\text{volume of mold}}$

hydraulic gradient (i)

$h_t = \frac{P}{\gamma_w} + \frac{V^2}{2g} + Z$; h_p, h_v, datum

$\Delta h = h_A - h_B$

$i = \frac{\Delta h}{L}$

$V = K\,i$ discharge velocity

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

$= V\left(\frac{e+1}{e}\right)$

$Q = V\,A\,t$

$= K\,i\,A\,t$

$= k\,\frac{\Delta h}{L}\,A\,t$

head T_c … $\Delta h\, t\, A$

$\rightarrow K_{20} = \frac{\eta_{T_c}}{\eta_{20}} K_{T_c}$

falling head $\rightarrow$

$K_{T_c} = 2.303 \frac{aL}{At} \log \frac{h_1}{h_2}$

empirical relationship

for Sand

$K_{cm/sec} = C_K\, D_{10\,mm}^2$ (1-1.5)

$K = 1.4\, e^2\, K_{0.85}$

void ratio

for normally cons. clay

$K = \frac{C_3\, e^n}{1+e}$

$K_{H_{eq}} = \frac{1}{H}\left[K_{H_1} H_1 + K_{H_2} H_2 + \dots K_{H_n} H_n\right]$

$K_{V_{eq}} = \frac{H}{\left[\frac{H_1}{K_{V_1}} + \frac{H_2}{K_{V_2}} + \dots + \frac{H_n}{K_{V_n}}\right]}$

$\frac{K_H}{K_V} > 1$

horizontal

$i_1 = i_2 = i_3 = \dots = i$

$k_{H_1} \ne k_{H_2} \ne k_{H_3}$

$V_{H_1} \ne V_{H_2} \ne V_{H_3} \ne \dots \ne V_{H_n}$

$q_{H_1} \ne q_{H_2} \ne \dots \ne q_{H_n}$

$Q = K_{H_{eq}}\, i\, A = q_1 + q_2 + \dots$

* $A = H\, w\, 1$

* $q_1 = K_{H_1} (i_1)\, A_1$ $\searrow_{H_1 * 1}$

(5)

$i_1 \ne i_2 \ne i_3 \ne \dots \ne i_n$

$K_{V_1} \ne K_{V_2} \ne \dots$

$V_{V_1} = V_{V_2} = \dots V_{V_n}$

$q_1 = q_2 = \dots = q_n$

$Q_{eq} = K_{eq_V}\, i_{eq}\, A$

$q_1 = K_1\, i_1\, A$

K in the field:

permeable layer -- imp. layer

$K = \frac{2.303\, q \log\left(\frac{r_1}{r_2}\right)}{\pi \left(h_1^2 - h_2^2\right)}$

confined permeable layer

$K = \frac{q \log\left(\frac{r_1}{r_2}\right)}{2.727\, H\, (h_1 - h_2)}$

slug test

$K = \frac{(40)\,(r)(Dy)}{\left(20 + \frac{L}{r}\right)\left(2 - \frac{y}{L}\right)(y)(\delta t)}$

isotropic $\rightarrow K_H = K_V$

* $K_{eq} = \sqrt{K_H K_V} = K_H = K_V$

potential drop $= \frac{\Delta h}{N_d}$

$\Delta q = K \frac{\Delta H}{N_d} \times N_f$

$K_H = K_x$ $\quad K_V = K_z$

anisotropic $K_{eq} = \sqrt{K_x K_z}$

horizontal scale $= \sqrt{\frac{K_z}{K_x}} \times$ vertical scale

(6)

force $= V$ (…)

المساحة للشكل

[illegible]

seepage through ……

$q = K_{eq} \tan\alpha \sin\alpha\, L$

$L = \frac{d}{\cos\alpha} - \sqrt{\frac{d^2}{\cos^2\alpha} - \frac{H^2}{\sin^2\alpha}}$

$\sigma' = \sigma - u$

γ': (submerged unit weight) (effective unit weight)

$= (\gamma_{sat} - \gamma_w)$

no seepage $\sigma' = \gamma' z$

$= (\gamma_{sat} - \gamma_w)(H_A - H)$

upward seepage

$\sigma' = z\gamma' - i z \gamma_w$

* seepage pressure $= i z \gamma_w$

إتجاه عكس إتجاه الـ flow

$i_{cr} = \frac{\gamma'}{\gamma_w}$ $\left[\begin{array}{c} 0.9 \rightarrow 1.1 \\ \text{with avg} \\ \boxed{1} \end{array}\right]$

حالة σ' = صفر يعني السويل لا تحمل أشيا

boiling - quick condition

* $i_{cr} = \frac{G_s - 1}{1 + e}$

downward seepage

$\sigma' = \gamma' z + i z \gamma_w$

* $\frac{\Delta H}{N_d} = N_d$ value

potential drop

$i = \frac{\Delta h}{L}$

(7) $1\,m^3 = 1000\,L$

seepage pressure $= i z \gamma_w$

Seepage force $= i z \gamma_w A$

seepage per unit volume $= \frac{i z \gamma_w A}{z A}$

$= i\gamma_w$

$F.S_{heave} = \frac{\gamma'}{i_{avg}\gamma_w} \ge 4$

$= \frac{i_{cr}}{i_{avg}}$

ثابتة من الطاولة

$i_{avg} = \frac{\text{avg. driving head}}{D}$

$i_{exit} = \frac{\text{exit head}}{\text{exit distance}}$

$F.S_{piping / boiling} = \frac{i_{cr}}{i_{exit}} > 1$

Filter (Terzaghi)

$4 = \frac{\gamma' + \left(\frac{D_1}{D}\right)\gamma_f}{i_{avg}\gamma_w}$ (1)

$D_{15}(F) < 4\, D_{85}(B)$ (2)

$D_{15}(F) > 4\, D_{15}(B)$

cappillary

$\frac{\pi}{4} d^2 h_c \gamma_w = T\cos\alpha\, \pi d$

$h_c = \frac{4\, T \cos\alpha}{d\, \gamma_w}$

cappillary $u = (-h_c)(\gamma_w)(S_r)$

$F.S$ against uplift $= \frac{\text{structure weight}}{\text{uplift force}} \ge 1.5$

(8)

$$\Delta\sigma = \frac{P}{z^2} I_1$$

$I_1 \to$ table 10.1 $f\left(\frac{r}{z}\right)$

$$\Delta\sigma = \frac{P}{z^2}\left[\frac{3}{2\pi} \times \frac{1}{\left[\left(\frac{r}{z}\right)^2+1\right]^{5/2}}\right]$$

* vertical line flow: kN/m

$$\Delta\sigma = \frac{2q z^3}{\pi (x^2+z^2)^2}$$

or $\frac{\Delta\sigma}{q/z} = f\left(\frac{x}{z}\right)$ table 10.2

* horizontal line load

$$\Delta\sigma = \frac{2q (x)(z)^2}{\pi (x^2+z^2)^2}$$

$\frac{\Delta\sigma}{q/z} = f\left(\frac{x}{z}\right)$ table 10.3

* $\Delta\sigma$ due to a strip load finite width and infinite length

$q = \gamma h = kN/m^2$

$\frac{\Delta\sigma}{q} = f\left(\frac{2z}{B}, \frac{2x}{B}\right)$

table 10.4

$\Delta\sigma$ due to linearly increasing load

$\frac{\Delta\sigma}{q} = f\left(\frac{2x}{B}, \frac{2z}{B}\right)$

table 10.5

$\Delta\sigma$ under any shape of uniformly loaded area

$\boxed{\Delta\sigma = V q M}$ kN/m²

distance (r) from the center of circular loaded area with radius (R)

$\Delta\sigma = q(A' + B')$

$A', B' \Rightarrow f\left(\frac{z}{R}, \frac{r}{R}\right)$

$A' \to 10.7$

$B' \to 10.8$

$\Delta\sigma = q f\left(\frac{z}{R}\right)$ Table 10.6 اذا كان [illegible]

$\Delta\sigma$ @ corner of uniform rect. loaded area.

$q = \frac{P}{area}$ kN/m²

$\Delta\sigma = q I_3$

$I_3 \Rightarrow f(m, n)$, $m = \frac{B}{z}$, $n = \frac{L}{z}$

table 10.9

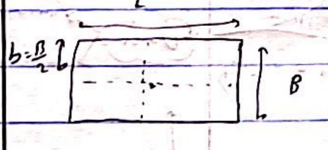
B البعد الأصغر , L البعد الأكبر

center of rec load area

$\Delta\sigma = q I_4$

$I_4 \Rightarrow f(m_1, n_1)$, $m_1 = \frac{L}{B}$, $n_1 = \frac{z}{b}$

table 10.10



Newmark's method influence chart method

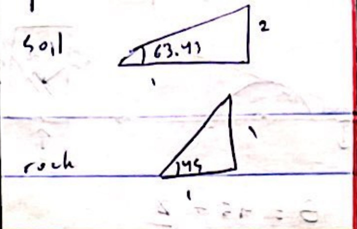
influence value $V = \frac{1}{N}$

N: # of element

M: # of element (اللي تغطيه الشكل)

z : ab

5m : 5



$$S_t = \underbrace{S_i}_{\text{immediate / elastic}} + \underbrace{S_c + S_s}_{\text{consolidation}}$$

primary consolidation S_c

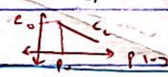
$S_c = \frac{H \Delta e}{1 + e_0}$ general

For normally consolid.

$$C_c = \frac{-\Delta e}{\log\left[\frac{\bar{P}_0 + \Delta P}{\bar{P}_0}\right]}$$

$$S_c = \frac{C_c H}{1+e_0} \log\left[\frac{\bar{P}_0 + \Delta P}{\bar{P}_0}\right]$$

$$S_c = \frac{C_c}{1+e_0} \sum H_i \log\left[\frac{\bar{P}_{0i} + \Delta P_i}{\bar{P}_{0i}}\right]$$



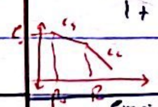
for over consol. clay

① $\bar{P}_0 + \Delta P \le \bar{P}_c$

$$S_c = \frac{C_s H}{1+e_0} \log\left[\frac{\bar{P}_0 + \Delta P}{\bar{P}_0}\right]$$

② $\bar{P}_0 + \Delta P > \bar{P}_c$

$$S_c = \frac{C_s H}{1+e_0} \log\left(\frac{\bar{P}_c}{\bar{P}_0}\right) + \frac{C_c H}{1+e_0} \log\left[\frac{\bar{P}_0 + \Delta P}{\bar{P}_c}\right]$$



empirical relationship

1. $C_c = 0.009(LL - 10)$
2. $C_c = \frac{PI}{74}$
3. $C_s = (0.1 \to 0.2)\, C_c$
4. $C_s = \frac{PI}{370}$

(S_s) Secondary conso.

$$S_s = C'_\alpha H \log\left(\frac{t_2}{t_1}\right)$$

$$C'_\alpha = \frac{C_\alpha}{1 + e_p}$$

$$C_\alpha = \frac{\Delta e}{\log\left(\frac{t_2}{t_1}\right)}$$

secondary compression index

coeff. of volume compress. change (m_v)

$m_v = \frac{\Delta V}{V} \cdot \frac{1}{\Delta\sigma'}$

$m_v = \frac{\Delta H}{H} \cdot \frac{1}{\Delta\sigma'}$

$m_v = \frac{1}{E}$

$m_v = \frac{\Delta e}{1+e_{avg}} \cdot \frac{1}{\Delta\sigma'}$

$m_v = \frac{a_v}{1 + e_{avg}}$

a_v = coef. of compressibility $= \frac{\Delta e}{\Delta P}$ $\left(\frac{m^2}{kN}\right)$

$e_{avg} = \frac{e_0 + e_1}{2}$

$S_c = m_v \Delta\sigma' H$

coeff of consol. (C_v) (cm²/sec)

$$C_v = \frac{k}{\gamma_w m_v}$$

k: coeff. of permeability

kPa = kN/m²

C'_α: normally → 0.005 → 0.03

over < 0.001

org > 0.04

....

Time-factor (T_v) :

$$T_v = \frac{c_v\, t}{(H_{dr})^2}$$

degree of cons. $U \rightarrow (0 - 60)\%$

$$\rightarrow T_v = \frac{\pi}{4}\left(\frac{U\%}{100}\right)^2$$

degree of cons. $U \rightarrow (> 60\%)$

$$\rightarrow T_v = 1.781 - 0.933 \log(100 - U\%)$$

excess pore water pressure at time t

$$U = 1 - \frac{u_z}{u_0}$$

initial excess pore water pressure $= \Delta\sigma$

$$U = \frac{S_{c\,t}}{S_{c\,\infty}}$$

consolidation

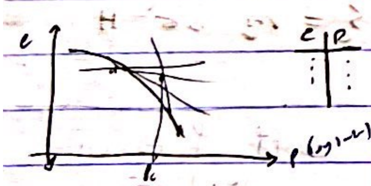
calculate e at end of each loading stage

$$\bullet\ H_s = \frac{W_s}{(\frac{\pi}{4} d^2)(G_s)\, \gamma_w}$$

$$\bullet\ e_0 = \frac{V_v}{V_s} = \frac{H_v}{H_s} = \frac{H - H_s}{H_s}$$

$$\bullet\ e_1 = e_0 - \Delta e_1 \leftarrow \frac{\Delta h_1}{h_s}$$

$$e_2 = e_1 - \Delta e_2$$



$\alpha = 1 \rightarrow$ nor. cons. clay

$\alpha > 1 \Rightarrow$ over cons. clay

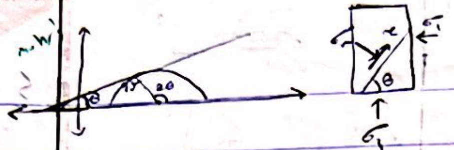
nor. $\rightarrow \bar{P}_0 \geq \bar{P}_c$

over $\rightarrow \bar{P}_c > \bar{P}_0$

$$O.C.R = \frac{\bar{P}_c}{\bar{P}_0}$$

$\Delta\sigma$: diviator stress, axial stress

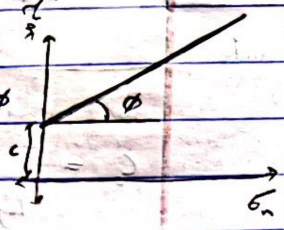
shear strength parameter (c, ϕ)



$$\theta = 45 + \frac{\phi}{2}$$

$$\sigma_n = \frac{\sigma_1 + \sigma_3}{2} + \frac{\sigma_1 - \sigma_3}{2}\cos 2\theta$$

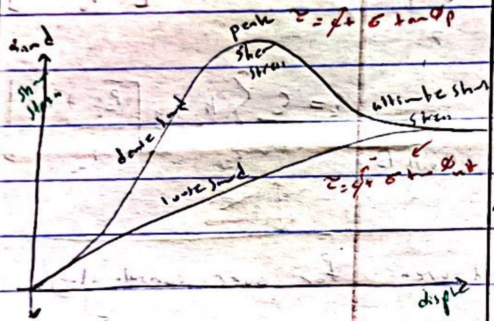
$$\tau = \frac{\sigma_1 - \sigma_3}{2}\sin 2\theta$$



$\tau_f = c + \sigma \tan\phi$

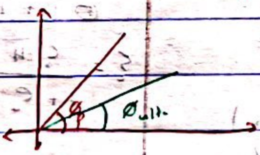
failure

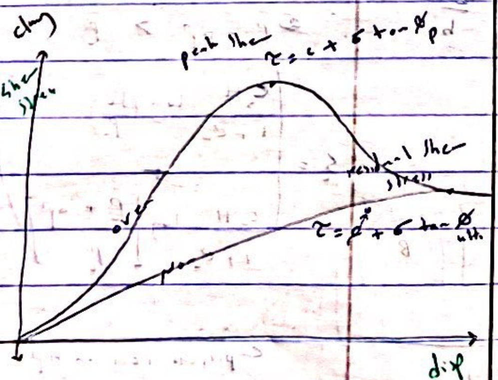
$$\sigma_1 = \sigma_3 \tan^2\left(45 + \frac{\phi}{2}\right) + 2c\tan\left(45 + \frac{\phi}{2}\right)$$



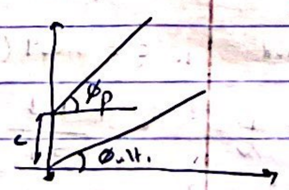
sand: peak $\tau_f = \not{c} + \sigma\tan\phi_p$; ultimate shear stress $\tau_f = \not{c} + \sigma\tan\phi_{ult}$; dense sand; loose sand; disp.

$\phi_p > \phi_{ult}$





clay: peak shear $\tau_f = c + \sigma\tan\phi_p$; residual shear stress $\tau = \not{c} + \sigma\tan\phi_{ult}$; disp.



σ_3: minor, containing, cell chamber

u_c: minor pressure ... pore water pressure

skempton: $\beta = \frac{u_c}{\sigma_3} = 1$

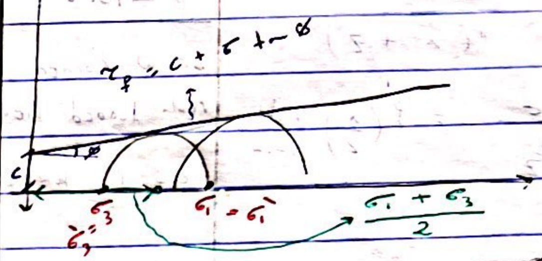
stage ① $u_c = \sigma_3 \rightarrow$ stage ② $\Delta u_d = 0$

$$\sigma_1 = \sigma_3 + \Delta\sigma_{df} \quad \} \sigma_1: \text{major}$$

$$\sigma_1 = \sigma_1' \qquad \sigma_3 = \sigma_3'$$

c_d, ϕ_d } drained shear strength parameter } effective shear strength parameter

$$\sigma_1 = \sigma_3\tan^2\left(45 + \frac{\phi}{2}\right) + 2c\tan\left(45 + \frac{\phi}{2}\right)$$



$\tau_f = c + \sigma\tan\phi$

σ_3, $\sigma_1 = \sigma_1'$, $\frac{\sigma_1 + \sigma_3}{2}$

C-U skempton: $A_f = \frac{\Delta u_{df}}{\Delta\sigma_{df}}$ } Sensivity, Thixotropy

normally $\rightarrow A_f\ (0.5 \rightarrow 1)$

over clay $\rightarrow A_f\ (-0.5 - 0)$

$$*\ \sigma_3 \Rightarrow \sigma_3' = \sigma_3 - \Delta u_{df}$$

$$*\ \sigma_1 \Rightarrow \sigma_1 = \sigma_3 + \Delta\sigma_{df}$$

$$\sigma_1' = \sigma_1 - \Delta u_{df}$$

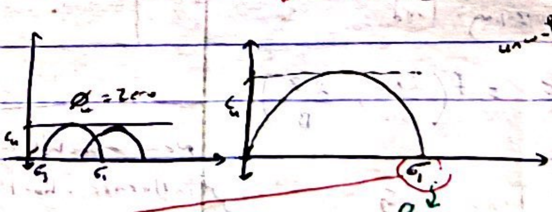
Total stress analysis : $\tau_f = \sigma\tan\phi_{cu}$

ϕ_{cu}: consolidated undrained shear stress

Effective stress analysis : $\tau_f = \sigma'\tan\phi$

ϕ: drained angle

U-U: unconsol. $\rightarrow u_c = \beta\sigma_3$; undrained $\rightarrow u_d = A\,\Delta\sigma_d$ ثابت



$\phi_u = \text{zero}$; unconfined

$$q_{un} = 2C$$

$\sigma_1 = \frac{\text{force fail}}{A_f}$ } $A_f = \frac{A_0}{1 - \varepsilon}$

empirical

Norm. cons. clay: $\frac{C_u}{\sigma'} = 0.11 + 0.0037\, P.I$

$C_u = \lambda\, c\, \sigma$ } $\lambda = 1.7 - 0.54\log P.I$

over cons. clay: $\frac{(\frac{C_u}{\sigma'})_{over}}{(\frac{C_u}{\sigma'})_{norm}} = (O.C.R)^{0.8}$