8-22-11
ENCE

Sieve Analysis

- Hydrometer analy. → for parts < No. 200 sieve
- USCS, AASHTO

Weight - Volume Relationships

Tbl. 1.3

Void ratio = e
Porosity = n
degree of sat. = S
w% = water content
total unit weight = γ_T
dry unit weight = γ_D

Plasticity characteristics

Atterburg limits
Plasticity Index = LL - PL

USCS

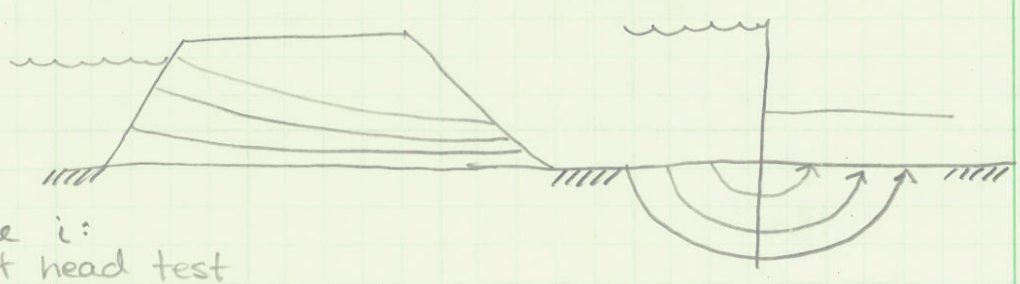
- % passing No. 200
- LL
- % gravel vs. % sand
- group name & group symbol   ex. Fat Clay → CH

Darcy's Law

$v = Ki$

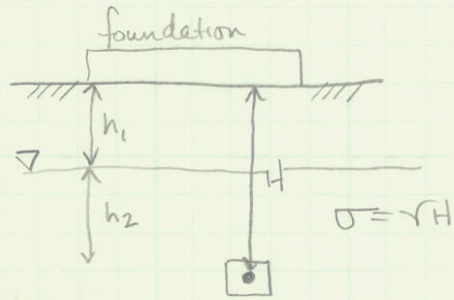
v = Darcy velocity
K = hydraulic conductivity of soil
i = hydraulic gradient = $\frac{h}{L} = \frac{\text{head diff}}{\text{distance}}$

hyd. cond. important in levee design & sheet pile wall



To determine i:
- constant head test
- falling head permeability test

i_{cr} = critical hydralic gradient = $\frac{G_s - 1}{1 + e}$



Stresses in Soil

$\sigma = \sigma' + u$

total stress (σ); eff stress (σ'); pore water (u)

C_c = compression index = $\frac{e_1 - e_2}{\log \sigma_2' - \log \sigma_1}$

$\sigma = (\gamma_T h_1) + [(\gamma_T - 62.4) \times h_2]$

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

c = cohesion; ϕ = angle of internal friction

Settlement

1. Primary settlement
2. consolidation settlement
3. secondary settlement

Time Rate of Settlement

$$T_v = \frac{C_v \cdot t}{H^2}$$

T_v = time factor
C_v = coeff. of consolidation
t = time
H = Drainage layer thickness

$$\text{Total Settlement} = S_c = \frac{C_c \cdot H}{1 + e_o} \log \frac{\sigma_o + \Delta\sigma'}{\sigma_o'}$$

Ch. 2
Natural Soil Deposits & Subsoil Exploration

Origin of soils
Soil is mechanically or chemically weathered rocks.

Mechanical - does not change physical properties.
Chemical - can " " "

Residual Soils -
Transported Soils -
- Gravity
- Locustrrane (Lake)
- Alluvial (Water) Mississippi River
- Glacial (Glacial) can be stratified or unstratified
- Aeolian (Wind)

Determination of Boring min depth, spacing, placement

ASCE Criteria
1) $\Delta\sigma'$ = net increase in eff depth
2) variation of vertical eff. stress, σ_o' w/depth
3) $D=D_1$ at which $\Delta\sigma' = \frac{1}{10} V$
4) $D=D_2$ @ which

Different regions have own "rule of thumb"
Ex. Jefferson Parish
1) 1 boring for 10000 SF footprint
2) add one boring for every 15000 SF additional footprint

Types of Boring
→ hand Auger 
Disturbed Soil - soil is "drilled" out, used mostly for soil classification.
Undisturbed Soil - used for str. tests
Split-Spoon sampler - Sand
Shelby tube - Clay

SPT = Stand. Penetration Test used to test bearing str. of sand.

Area Ratio, $A_R (\%) = \frac{D_o^2 - D_i^2}{D_i^2}(100)$

SPT = standard penetration test

$A_R < 10\%$ or less ⟶ undisturbed sample
for SPT, $A_R = 111.5\%$

Standard Hammer Efficiency

$$E_r = \frac{\text{Actual hammer energy to the sampler}}{\text{input energy} = wh\ \text{(weight of hammer)(height of drop)}} (100\%)$$

Average energy efficiency of 60%

$$N_{60} = \frac{N \eta_H \eta_B \eta_S \eta_R}{60}$$

This is the corrected number due to hammer mech. inconsistency

η_H = hammer efficiency
η_B = correction for bore hole diam
η_S = sampler correction
η_R = correction for rod length

For thin welded shelby tube

$$A_R = \frac{(50.8)^2 - (47.63)^2}{(47.63)^2}(100) = 13.75\%$$

$$\text{Consistency Index (CI)} = \frac{LL - w}{LL - PL}$$

(w = moisture content)

For cohesionless soils, use split spoon sampler. (gravel, sand)
blow count for 6" increments
140 lb hammer, 30" drop

__6"
__6"
__6"
} Σ count = N

Cohesive Soils

① Hara, et al. (1971)

$$\frac{c_u}{p_a} = 0.29 N_{60}^{0.72}$$

② Meyer & Kemper, (1988)

$$OCR = 0.193 \left(\frac{N_{60}}{\sigma_o'}\right)^{0.689}$$

Granular Soils

① $(N_1)_{60} = C_N N_{60}$
pg. 85-86

② Relative density of sand

$$N_{60} = \left[17 + 24\left(\frac{\sigma_o'}{p_a}\right)\right] D_r^2$$

In Situ test

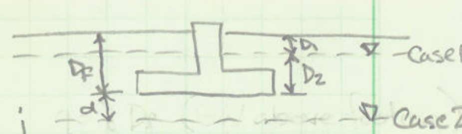
Field Vane Shear Test - typ done on soft clay

undrained shear strength ⟶ $c_u = \frac{T}{K}$

T = Torque in N·m, applied to Vane
K = constant depending on shape of Vane

Mayne & Mitchell

$$\sigma_c' = 7.04\,(c_{u(field)})^{0.83} \qquad OCR = \beta \frac{c_{u,field}}{\sigma_o'}$$



Case 1: $0 \le D_1 \le D_f$

$q = D_1\gamma + D_2(\gamma_{sat} - \gamma_w)$

Case 2: $0 \le d \le B$

$q = \gamma D_f$

$\bar{\gamma} = \gamma' + \frac{d}{B}(\gamma - \gamma')$

Case 3: $d \ge B$

No affect from water.

General Shear Failure

Continuous / Strip Footing $q_u = c'N_c + qN_q + \frac{1}{2}\gamma B N_\gamma$;

Square Footing $q_u = 1.3c'N_c + qN_q + 0.4\gamma B N_\gamma$

Circular Footing $q_u = 1.3c'N_c + qN_q + 0.3\gamma B N_\gamma$

Local Shear Failure

Continuous / Strip Footing $q_u = \frac{2}{3}c'N_c' + qN_q' + \frac{1}{2}\gamma B N_\gamma'$

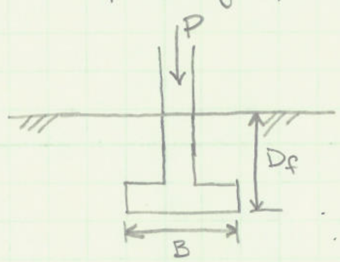
Square Footing $q_u = 0.867c'N_c' + qN_q' + 0.4\gamma B N_\gamma'$

Circular Footing $q_u = 0.867c'N_c' + qN_q' + 0.3\gamma B N_\gamma'$

$\phi' = \tan^{-1}\left(\frac{2}{3}\tan\phi'\right)$

Shallow Foundations

Strip footing, spread footings, matt foundations, grade beams, slab on grade



q_u = ult. bearing capacity

If $D_f/B < 3$ or 4, and soil below is strong then it is a shallow foundation

General Bearing Capacity Eqn

Ultimate bearing capacity

$q_u = (c'N_c F_{cs} F_{cd} F_{ci}) + (qN_q F_{qs} F_{qd} F_{qi}) + \frac{1}{2}(\gamma N_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma i})$

↑ shape factors ↑ depth factors ↑ load inclination factor

Allowable bearing Capacity

$q_{all} = \frac{q_u}{FS} = \frac{q_u}{\text{Factor of safety}}$; FS is generally = 3 for shallow found.

Gross: $q_{all} = \frac{q_u}{FS}$

Net: $q_{all\,net} = \frac{q_u - q}{FS}$

Soil Compressibility

$F_{cc}, F_{qc}, F_{\gamma c}$

(Vesic 1973) $q_u = c'N_c N_{cs} N_{cd} F_{cc} + qN_q F_{qs} F_{qd} F_{qc} + \frac{1}{2}\gamma B N_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma c}$

Steps: 1. $I_r = \frac{G_s}{c' + q'\tan\phi'}$

2. $I_{r(cr)} = \frac{1}{2}\left\{\exp\left[3.30 - 0.45\frac{B}{L}\right]\left[\cot\left(45 - \frac{\phi'}{2}\right)\right]\right\}$

Eccentric loading

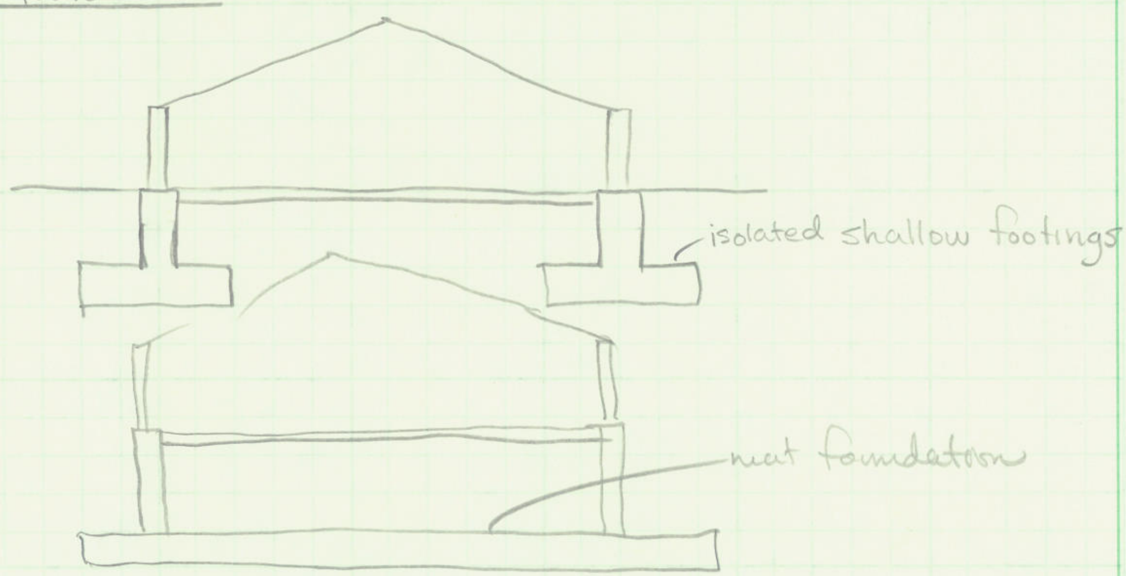
$$FS = \frac{Q_u}{Q}$$ ← load on foundation

1 Effective area method: a) B' = eff. width = $B - 2e$
L' = eff. length = L
b) q_u = gen bearing cap eqn.
c) $F_{cd}, F_{qd}, F_{\gamma d} \rightarrow L'$ and B'
d) B' stays as B

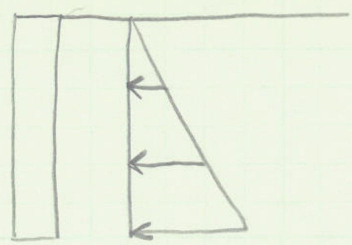
$$Q_{ult} = \frac{A'}{q'_u (B')(L')}$$

$$FS = \frac{Q_{ult}}{Q}$$

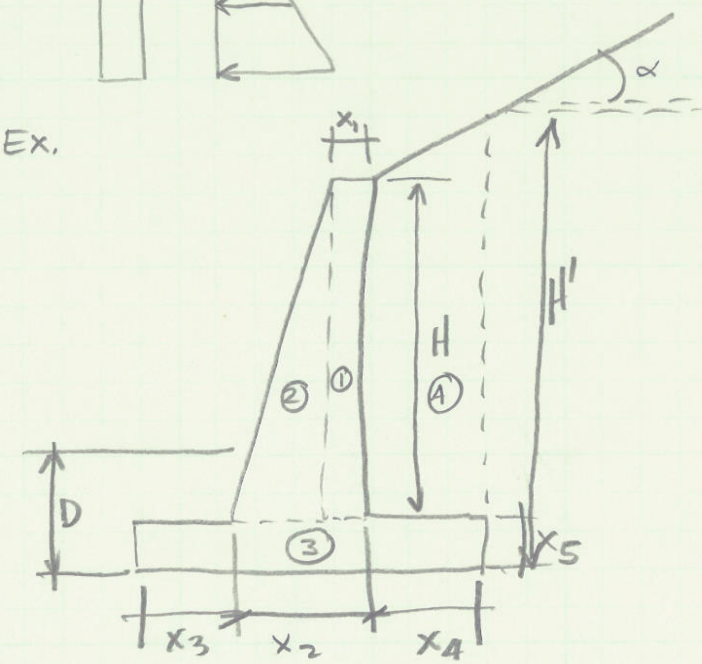
Chile Mat Foundation



Lat. Earth pressure



Ex.



Given: $H = 8m$
$x_1 = .4m$
$x_2 = .6m$
$x_3 = 1.5m$
$x_4 = 3.5m$
$x_5 = .96m$
$D = 1.75m$
$\alpha = 10°$
$\gamma_1 = 16.8\ kN/m^3$, $\phi_1' = 32°$
$\gamma_2 = 17.6$ $\quad \phi_2' = 28°$
$c_2' = 30\ kN/m^2$

Find: Calc the F.S. WRT overturning, sliding,

Solution:

$H' = H + x_5 + \tan(10)(x_4) = 9.58\ m$

$P_a = \frac{1}{2}(H')^2 \gamma_1 \times K_a = \frac{1}{2}(9.58)^2(16.8)(0.3210) = 246.9\ kN/m$

$P_v = P_a \sin\alpha = 246.9 \times \sin 10 = 42.9\ kN/m$

$P_h = P_a \cos\alpha = 246.9 \times \cos 10 = 243.1\ kN/m$

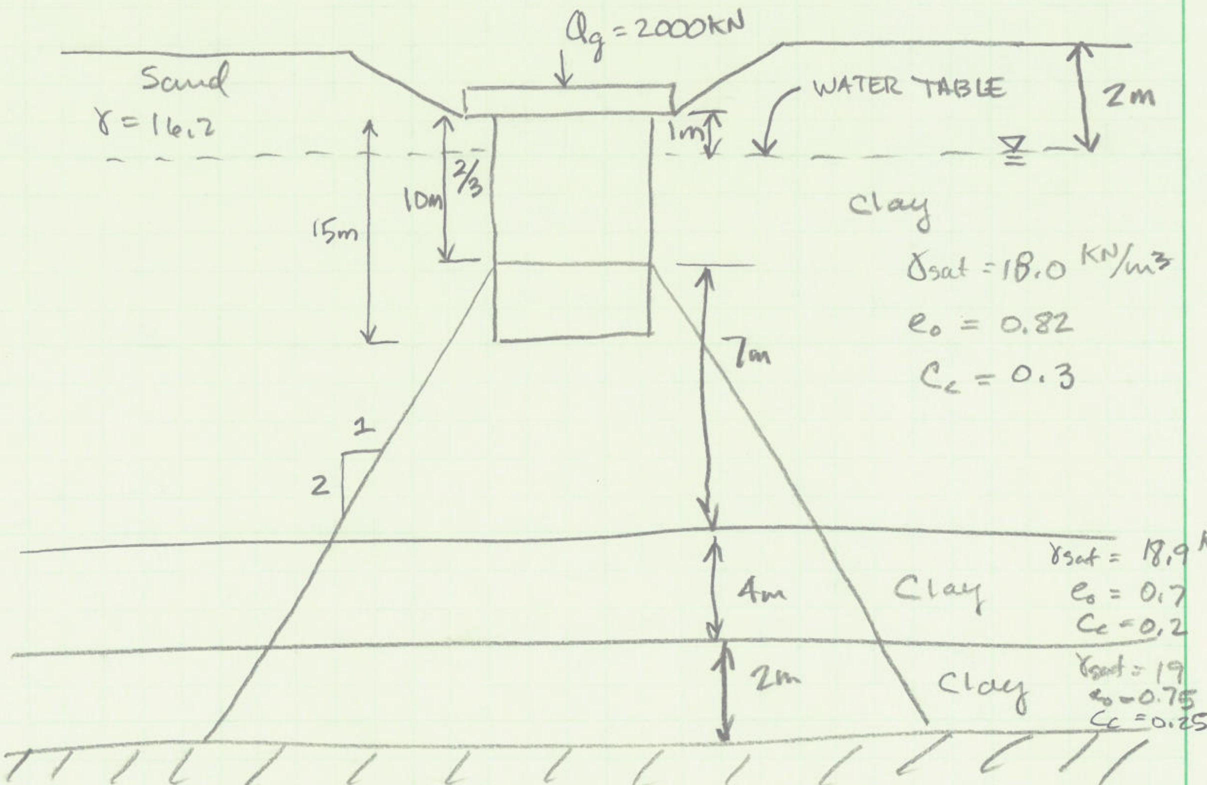
$M_o = P_h\left(\frac{H'}{3}\right) = 243.1\left(\frac{9.58}{3}\right) = 776.3\ kN\text{-}m$

Area	Weight	Arm	Moment
① = .4(8) = 3.2 (23.58) =	75.5	1.9	143.4
② = .5(.2)(8)(23.58) =	18.9	1.63	30.8
③ 0.96(5.6)(23.58) =	126.8	2.8	355
④ 3.5(8)16.8 = 470.4 ⟶		3.85	1811.04

Σ 2340.24 $M_{resisting}$

$F.S. = \frac{2340.24}{776.3} = 3.02$

Group of piles in clay is shown in the following figure, Determine the consolidation settlement of piles, All clays are normaley consolidated.



$$S_c = \frac{C_c H}{1+e_0} \log\left[\frac{\sigma_0' + \Delta\sigma_0}{\sigma_0'}\right]$$

$S_{c1} + S_{c2} + S_{c3}$

Clay Layer 1:

$C_c = 0.3$

$H = 7$

$e_0 = 0.82$

$\gamma_{sat} = 18\ \mathrm{kN/m^2}$

$\sigma_{0(1)}'$ (overburden) $= 2(16.2) + 12.5(18-9.81) = 134.8\ \mathrm{kN/m^2}$

$$\Delta\sigma_0 = \frac{Q_g}{A} = \frac{2000}{(3.3+3.5)(2.2+3.5)} = 51.6\ \mathrm{kN/m^2}$$

$$S_{c1} = \frac{0.3(7)}{1+0.82} \log\left[\frac{134.8+51.6}{134.8}\right] = \underline{\underline{0.1624\ m}}$$

Clay layer 2:

$C_c = 0.2$

$H = 4$

$e_0 = 0.7$

$\gamma_{sat} = 18.9$

$$\sigma_{0(2)}' = 2(16.2) + 16(18-9.81) + 2(18.9-9.81) = 181.6\ \mathrm{kN/m^2}$$

$$\Delta\sigma_{0(2)} = \frac{2000}{(3.3+9)(2.2+9)} = 14.52\ \mathrm{kN/m^2}$$

$$S_{c2} = \frac{0.2(4)}{1+0.7} \log\left[\frac{181.6+14.52}{181.6}\right] = \underline{0.0157\ m}$$

Clay Layer 3 :

$C_c = 0.25$

$H = 2$

$e_0 = 0.75$

$\gamma_{sat} = 19$

$\sigma'_{o(3)} = 2(16.2) + 16(18 - 9.81) + 4(18.9 - 9.81) + 1(19 - 9.81)$

$= 208.99$

$\Delta\sigma_{o(3)} = \dfrac{2000}{(3.3 \times 12)(2.2 + 12)} = 9.205$

$S_{c(3)} = 0.0053\,m$

$S_{c\,TOTAL} = 0.1824\,m = 182\,mm$