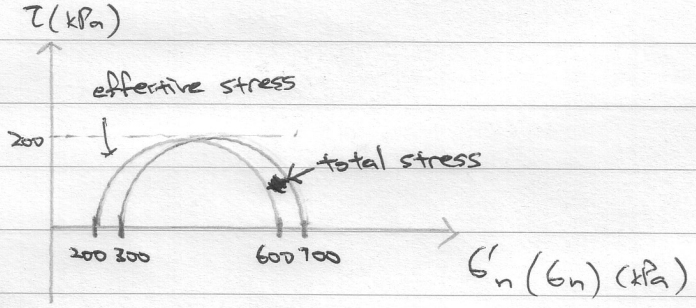
CV 2014 April/May 2016

1. a) i) As no back pressure, effective consolidation stress is σ_{3f} (total stress at failure).

$\sigma_{1f} = 700 kPa$, $\sigma_{3f}' = 200 kPa$, $\sigma_f' = 600 kPa$



ii) $\sin\phi' = \frac{\sigma_1' - \sigma_3'}{\sigma_1' + \sigma_3'}$

$= \frac{600-200}{600+200} = \frac{1}{3}$

$\phi' = 30°$

iii) $c_u = \frac{\sigma_1 - \sigma_3}{2}$

$= \frac{400}{2} = 200 kPa$

b) For CD test, $\sigma_{3f}' = \sigma_{3f} = 300 kPa$

effective stress, friction angle remain the same from CU test. $\therefore \phi' = 30°$

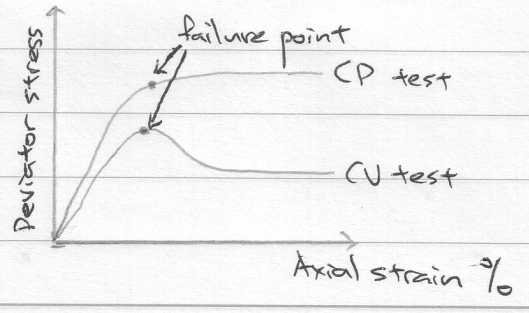
$\sin 30 = \frac{\sigma_1' - 300}{\sigma_1' + 300}$

$\sigma_1' = 900 kPa$

deviator stress $= \sigma_1' - \sigma_3'$

$= 600 kPa$, higher than deviator stress obtain from CU test.

c)



d) In CU test, there is no volume change. So, void ratio of the soil will remain the same after consolidation. In CD test, there will be decreased in volume. So, void ratio of the soil will decrease after consolidation.

e) $C_u = \frac{240}{2}$

$= 120\ kPa$

As the result of a UU test depends on $-u_r$ and $-u_r$ is affected by sample disturbance, the C_u value determined by UU is very sensitive to sample disturbance.

2. i) $K_a = \frac{1-\sin\phi'}{1+\sin\phi'}$

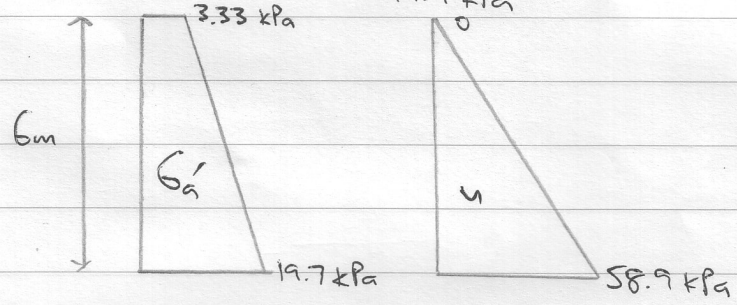
$= \frac{1-\sin 30}{1+\sin 30}$

$= \frac{1}{3}$

σ_a' at top $= \frac{1}{3} \times 10 = 3.33\ kPa$

σ_a' at bottom $= \frac{1}{3} \times [10 + 6 \times (18 - 9.81)]$

$= 19.7\ kPa$



Total thrust $= \frac{1}{2} \times (19.7 + 3.33) \times 6 + \frac{1}{2} \times 58.9 \times 6$

$= 245.7\ kN$

ii) inclination $= 45 + \phi'/2$

$= 60°$

iii) Total thrust will be the same answer in (i), that is 245.7 kN

iv) σ_A at top $= 10 - 2\times20$

$= -30$ kPa

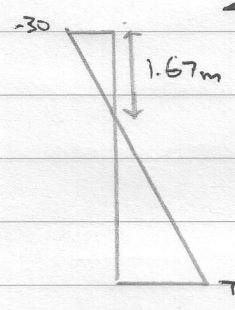
σ_A at bottom $= (10 + 6\times18) - 2\times20$

$= 78$ kPa

$\gamma z_c + q - 2c_u = 0$

$z_c \times 18 + 10 - 2\times20 = 0$

$z_c = 1.67$ m



Total thrust $= \frac{1}{2} \times 4.33 \times 78$

$= 169$ kN

vi) $m = 60/6$

$= 10$

$n = 12/6$

$= 2$

From Fadum's Chart, $I_r = 0.24$

$\Delta\sigma_z = q I_r$

$= 10 \times 0.24$

$= 2.4$ kPa

3. a) Information required :

- unit weight of soil
- groundwater table level
- geometry of the slope
- friction angle of the soil

Site investigation works and laboratory tests :

- Triaxial tests
- Sand Cone test
- Proctor Compaction test
- Groundwater monitoring : install piezometers

b) i) $W = \{(z-mz)\gamma + mz\gamma_{sat}\}1$ $\quad \sigma = \frac{W\cos\beta}{1/\cos\beta} = \frac{\{(1-m)\gamma + m\gamma_{sat}\}z\cos\beta}{1/\cos\beta}$

$= \{(1-m)\gamma + m\gamma_{sat}\}z\cos^2\beta$

~~$\{(z-mz)\gamma$~~

$= \{(1+m)\gamma + m\gamma_{sat}\}z$

ii) $\tau_{mob} = \frac{W\sin\beta}{1/\cos\beta} = \frac{\{(1-m)\gamma + m\gamma_{sat}\}z\sin\beta}{1/\cos\beta}$

$= \{(1-m)\gamma + m\gamma_{sat}\}z\sin\beta\cos\beta$

$u = mz\cos^2\beta \times \gamma_w$

$= m\gamma_w z\cos^2\beta$

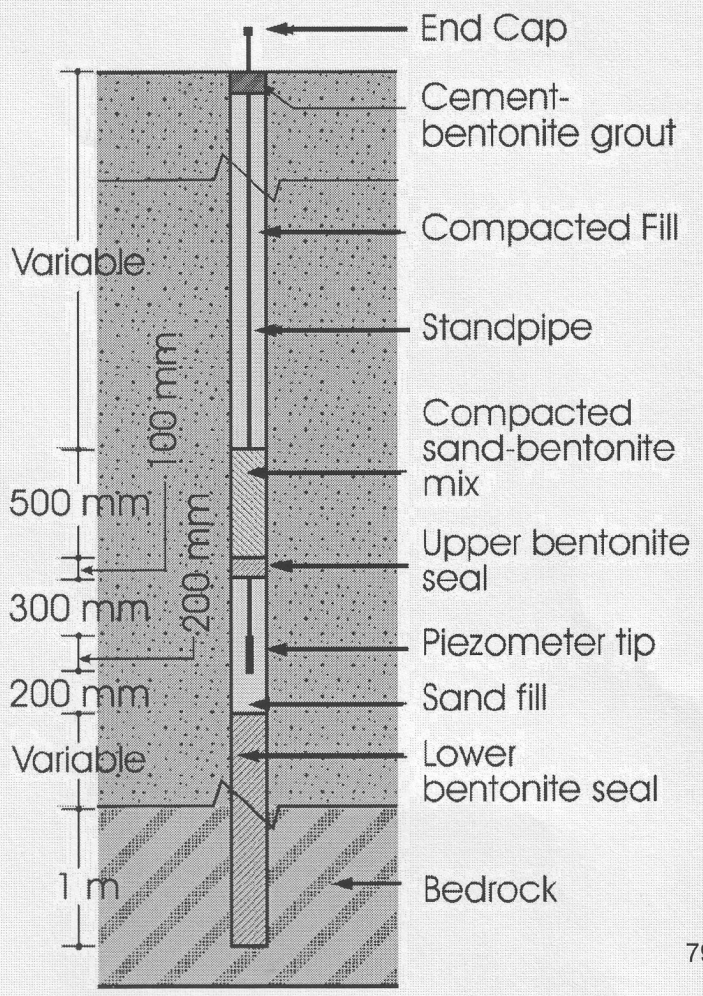
iii) $F = \frac{\tau_f}{\tau_{mob}} = \frac{(\sigma-u)\tan\phi'}{\tau_{mob}}$

$= \frac{[\{(1-m)\gamma + m\gamma_{sat}\}z\cos^2\beta - mz\gamma_w\cos^2\beta]\tan\phi'}{\{(1-m)\gamma + m\gamma_{sat}\}z\sin\beta\cos\beta}$

$= \frac{[(1-m)\gamma + m(\gamma_{sat} - \gamma_w)]\tan\phi'}{\{(1-m)\gamma + m\gamma_{sat}\}\tan\beta}$

3. c)

Instruments for measuring positive pressures



Piezometer

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When the piezometer is installed, water will rise to certain level in the tube, and the water level in the soil will be determined. After that, we can measure other area of the slope and the position of water table can be determined.

4. a) For 0.5m thick loose sand, removal and replacement will be appropriate. As the soil is contaminated, it need to be hauled away and replace with compacted fill. For 10 m thick soft clay, precompression and vertical drains will be appropriate. Precompression is useful in soft clayey soils as the static weight of the fill causes them to consolidate, thus improving both their settlement and strength properties. As the consolidation process is slow, installing vertical drains can accelerate the process. The excess pore water within the compressible soil now drains horizontally to the nearest vertical drain, a much shorter distance than before. This further increases the rate of consolidation.

b) For 1 m thick silty clay, placed a permanent fill will be sufficient to consolidate to improve their settlement and density. Another method will be excavate the soil and replace them with compacted fill. Vibro-compaction will be appropriate method to improve 14 m thick loose sand. This method compact the soils in-situ using vibration and treatment depths is range from 3 to 15 m.

c) As soil is strong in compression but weak in tension, placement of tensile reinforcement members such as steel strips, special plastic grids or geotextiles can significantly improve its stability and load-carrying capacity.

d) i) $\frac{\gamma_d}{(\gamma_d)_{max}} \times 100\% = 0.95$

$\gamma_d = 18.05 \text{ kN/m}^3$

$\frac{\gamma}{1+0.125} = 18.05$

$\gamma = 20.3 \text{ kN/m}^3$

~~$W_{borrow\ pit} = W_{fill}$~~

$W_{fill} / 1 = 20.3$

$W_{fill} = 20.3$ ~~$= W_{borrow\ pit}$~~

$W_s + W_{w,new} = 20.3$

$\frac{W_{w,new}}{W_s} = 0.125$

$W_s = 18.05$ kN

$W_{w,new} = 2.26$ kN

$\frac{W_{w,old}}{W_s} = 0.09$

$W_{w,old} = 1.62$ kN

$W_{w,added} = 2.26 - 1.62$

$= 0.63$ kN

$V_{w,added} = 0.63 / 9.81$

$= 0.064 m^3$

ii) $\gamma_s = 9.81 \times 2.7$

$= 26.5$ kN/m^3

$V_s = 18.05 / 26.5$

$= 0.681 m^3$

$V_w = 2.26 / 9.81$

$= 0.23 m^3$

$V_{air} = 1 - 0.681 - 0.23$

$= 0.09 m^3$

$w = S\left(\frac{\gamma_w}{\gamma_d} - \frac{1}{G_s}\right)$

$0.125 = S\left(\frac{9.81}{18.05} - \frac{1}{2.7}\right)$

$S = 72.2\%$

iii) Sand cone test can be carried out in the field to obtain γ, γ_d and w and compare ~~the~~ with Standard Proctor compaction test result.

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