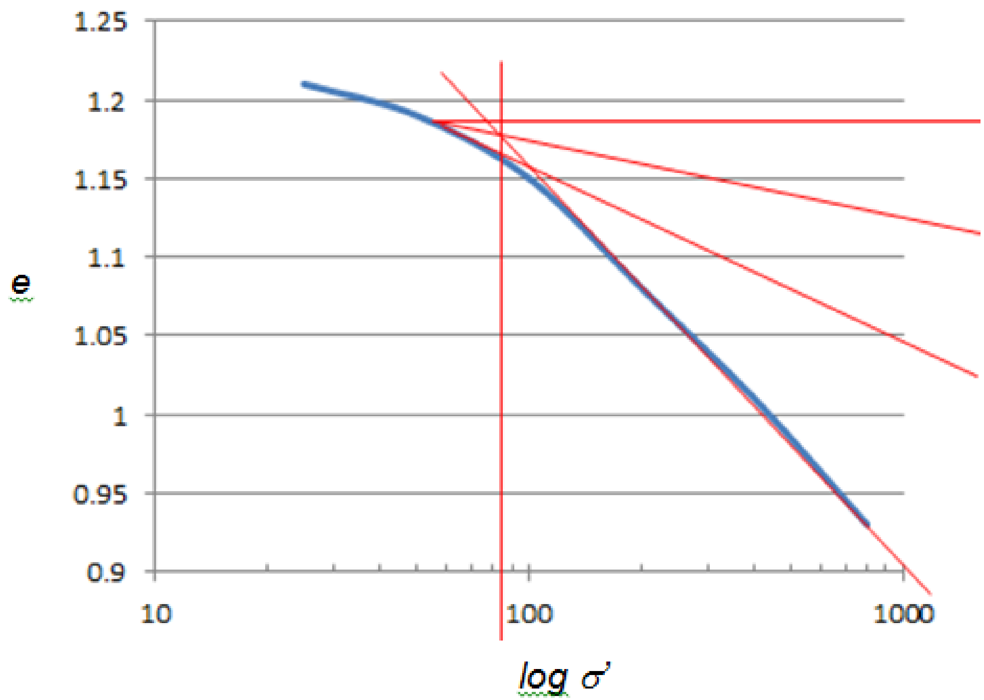
CVG 3109: SOIL MECHANICS 1 – ASSIGNMENT # 4 (Fall 2017)

CONSOLIDATION

Solution:

Q1.

a. Plot the *e – log σ'* curve



b. Using Casagrande's method, the preconsolidation pressure $\sigma_c' = 84 kN/m^2$

c. the compression index C_c

$$C_c = \frac{e_0 - e_1}{\log(\sigma_1'/\sigma_0')} = \frac{1.08 - 0.93}{\log(800/200)} = 0.249$$

Q2.

$$s_c = \frac{C_c \log(\sigma_1'/\sigma_0')}{1 + e_0} H$$

The average initial effective pressure in the clay:

$$\sigma_0' = \gamma_{dry(sand)} H_1 + \left(\gamma_{sat(sand)} - \gamma_w\right) H_2 + \left(\gamma_{sat(clay)} - \gamma_w\right) H_3 / 2$$
$$= 15.6 \times 1.5 + \left(18.3 - 9.81\right) \times 1.5 + \left(20.3 - 9.81\right) \times 2 / 2 = 46.625 kN / m^2$$

$$C_c = 0.009(LL - 10) = 0.009(38 - 10) = 0.252$$

$$s_c = 2 \times \frac{0.252}{1 + 0.75} \log \frac{46.625 + 150}{46.625} = 0.18 m = 180 mm$$

Q3.

a. The coefficient of volume compressibility

The average void ratio $e_{av} = \frac{e_1 + e_2}{2} = \frac{0.8 + 0.5}{2} = 0.65$

$$m_v = \frac{1}{1 + e_{av}} \frac{e_1 - e_2}{\sigma_2' - \sigma_1'} = \frac{1}{1 + 0.65} \frac{0.8 - 0.5}{400 - 150} = 0.000727 m^2 / kN$$

b.

$$c_v = \frac{k}{m_v \gamma_w} = 0.003 cm^2 / \sec = 3 \times 10^{-7} m^2 / \sec$$

$$k = c_v m_v \gamma_w = 3 \times 10^{-7} \left(\frac{m^2}{\sec}\right) \times 0.000727 \left(\frac{m^2}{kN}\right) \times 9.81 \left(\frac{kN}{m^3}\right)$$
$$= 3 \times 10^{-7} \times 0.000727 \times 9.81$$
$$= 2.14 \times 10^{-9} m / \sec$$
$$= 2.14 \times 10^{-7} cm / \sec$$

c. The effective pressure *σ' corresponding to e = 0.7:*

$$C_c = \frac{e_0 - e_1}{\log\left(\sigma_1' / \sigma_0'\right)} = \frac{0.8 - 0.5}{\log\left(400 / 150\right)} = 0.704$$

$$\log\left(\sigma'/\sigma_0'\right) = \frac{e_0 - e}{C_c} = \frac{0.8-0.7}{0.704} = 0.142$$

$$\sigma' = 10^{0.142}\sigma_0' = 1.387 \times 150 = 208 kN/m^2$$

Q4.

a.

$$T_v = \frac{c_v t}{d^2}$$

$$\frac{t_{lab}}{d_{lab}^{\ 2}} = \frac{t_{field}}{(H_{field}/2)^2}$$

$$\frac{26\min}{(0.04m)^2} = \frac{t_{field}}{(4m/2)^2}$$

$$t_{field} = 26\min \times \left(\frac{2}{0.04}\right)^2 = 65000\min = 45.14\text{days}$$

b.

$T_v = \frac{c_v t}{d^2}$ implies $c_v = \frac{T_v d^2}{t}$

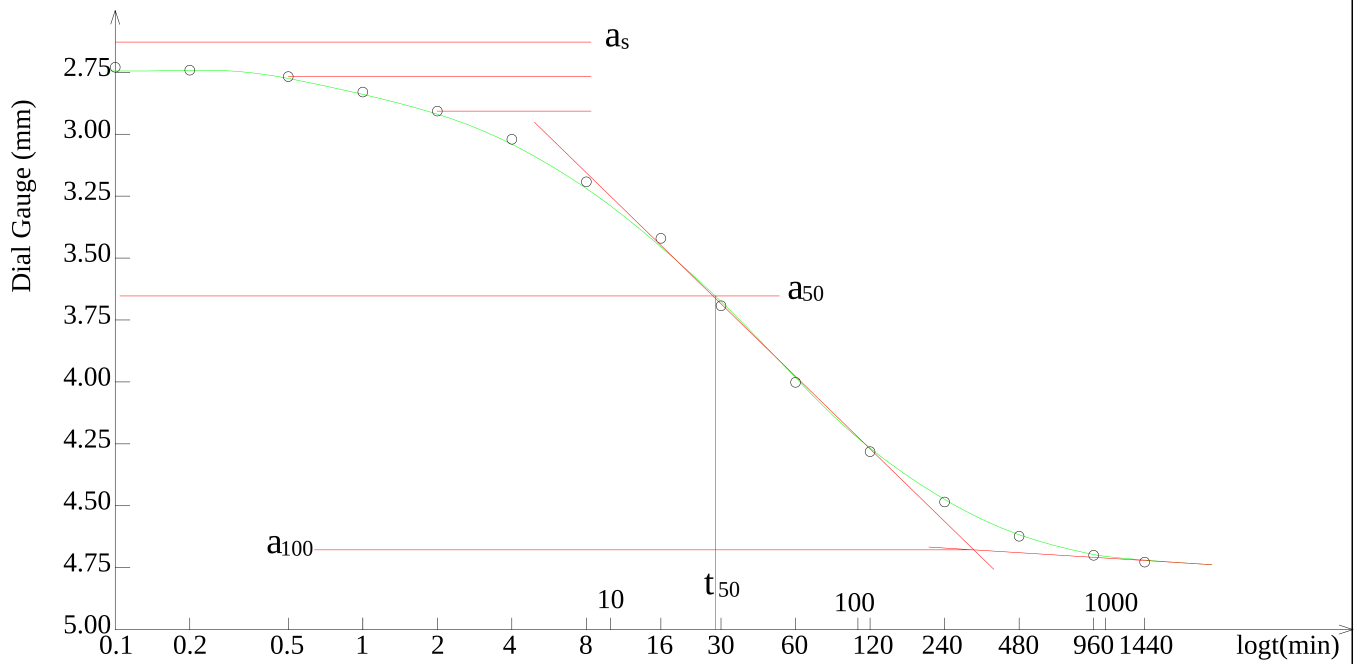
$$T_v = \frac{\pi}{4}U^2 = \frac{3.14}{4} \times 0.5^2 = 0.196$$

$$c_v = \frac{0.196 \times 0.04^2}{26} = 1.206 \times 10^{-5} m^2/\min$$

For U=80%, $T_v = -0.933\log(1-U) - 0.085 = -0.933\log(1-0.8) - 0.085 = 0.567$

$$t = \frac{T_v d^2}{c_v} = \frac{0.567 \times 2^2}{1.206 \times 10^{-5}} = 188059.7\min = 130.6\,\text{days}$$

Q5.



$$a_s = 2.63mm$$

$$a_{100} = 4.68mm$$

$$a_{50} = \frac{a_s + a_{100}}{2} = \frac{2.63 + 4.68}{2} = 3.655mm$$

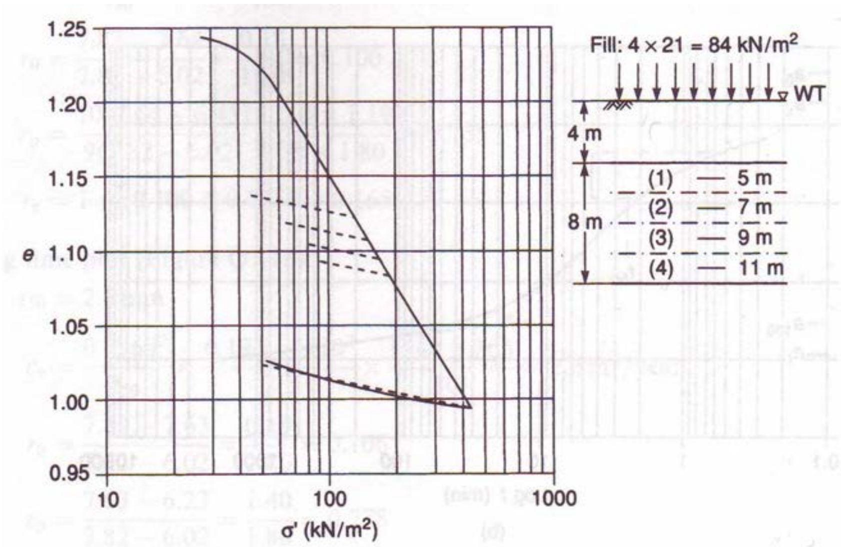
$$t_{50} = 26.5\,\text{min}$$

Q6.

a.

Use Equation $s_c = \frac{e_0 - e_1}{1 + e_0} H$.

According to test results, we can plot the *e – log σ'* curve as below.



The clay will be divided into four sublayers, hence H = 2000 mm. Appropriate values of e are obtained from *e – log σ'* curve.

Settlement

Layer	σ'_0 (kN/m²)	σ'_1 (kN/m²)	e_0	e_1	$e_0 - e_1$	s_c (mm)
1	45.95	129.95	1.236	1.123	0.113	101.1
2	64.33	148.33	1.200	1.108	0.092	83.6
3	82.71	166.71	1.172	1.095	0.077	70.9
4	101.09	185.09	1.150	1.083	0.067	62.3

Sample:

Layer 3

$$\sigma'_0 = (4+5)(19-9.81) = 82.71 kN/m^2$$

$$\sigma'_1 = \sigma'_0 + H_{fill}\gamma_{fill} = 82.71 + (4)(21) = 166.71 kN/m^2$$

$$s_c = \frac{e_0 - e_1}{1+e_0} H = \frac{0.077}{1+1.172} \times 2000 = 70.9$$

Settlement: $\sum s_c = 317.9$ mm

b.

Heave

Layer	σ'_0 (kN/m^2)	σ'_1 (kN/m^2)	e_0	e_1	$e_0 - e_1$	s_c (mm)
1	129.95	45.95	1.123	1.136	-0.013	-12.2
2	148.33	64.33	1.108	1.119	-0.011	-10.4
3	166.71	82.71	1.095	1.104	-0.009	-8.6
4	185.09	101.09	1.083	1.091	-0.008	-7.7

Settlement: $\sum s_c = 39.0$ mm

Q7. (NOT FOR FINAL EXAM)

a.

The layer is open,

$$\therefore d = \frac{8}{2} = 4 \text{ m}$$

$$T_v = \frac{c_v t}{d^2} = \frac{2.4 \times 3}{4^2} = 0.45$$

$$u_i = \Delta\sigma = 84kN/m^2$$

The excess pore water pressure is given by:

$$u_e = \sum_{m=0}^{m=\infty} \frac{2u_i}{M}\left(\sin\frac{Mz}{d}\right)\exp\left(-M^2T_v\right)$$

In this case, z = d:

$$\therefore \sin\left(\frac{Mz}{d}\right) = \sin M$$

Where

$$M = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \cdots$$

M	sin M	M^2T_v	exp ($-M^2T_v$)
$\frac{\pi}{2}$	+1	1.110	0.329
$\frac{3\pi}{2}$	- 1	9.993	4.57×10^{-5}

$$\therefore u_e = 2 \times 84 \times \frac{2}{\pi} \times 1 \times 0.329$$ (other terms are negligible)

$$= 35.2kN/m^2$$

Q8.

a.

Since the degree of consolidation is U = 50%, we know that Tv = 0.197.

The layer is open,

$$\therefore d = \frac{1000}{2} = 500 \text{ cm}$$

$$t = \frac{T_v d^2}{c_v} = \frac{0.197 \times 500^2}{0.03} = 1.642 \times 10^6 \text{ min} = 1140\text{days}$$

b.

1 year is: t = 365 days = 525600 min, so,

$$T_v = \frac{c_v t}{d^2} = \frac{0.03 \times 525600}{500^2} = 0.063$$

From *Tv* = 0.063, it is known that *U* = 28%,

Then, the settlement at this time is,

$$S_t = S_{final} \times U = 60 \times 0.28 = 16.8\text{cm}$$

c.

Only the sand layer above the clay layer is pervious, then *d* = 1000 cm,

Then,

$$t = \frac{T_v d^2}{c_v} = \frac{0.197 \times 1000^2}{0.03} = 6.567 \times 10^6 \text{ min} = 4560\text{days}$$