Tanta University | Structural Engineering Department | Faculty of Engineering

Course Title: Soil Mechanics (1)	Course Code: CSE2208	Year: 2nd Civil Eng.
Date: **1June 2016** (Second term)	Allowed time: 1 hrs	No. of Pages: (6)

- **SOLVE the following Four questions**
- **Assume any missing data**

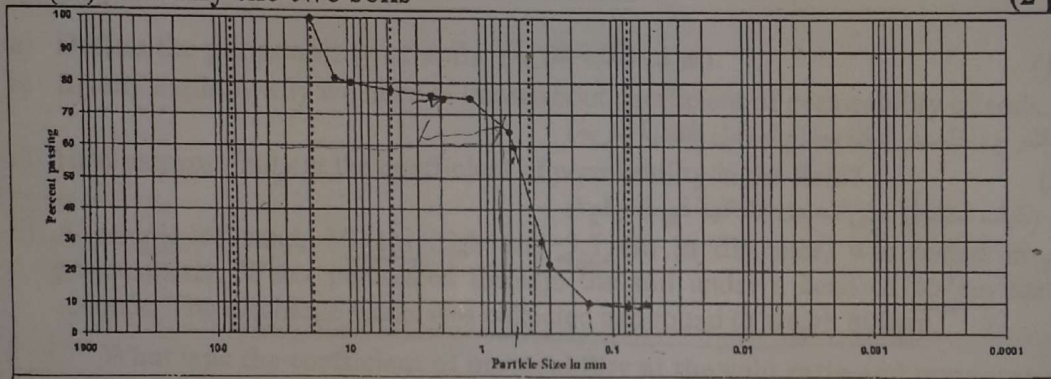
Question Number (1) *(13Points)*

a) The grain size distribution curves of two different soils are shown in Figure (1). It is required to:

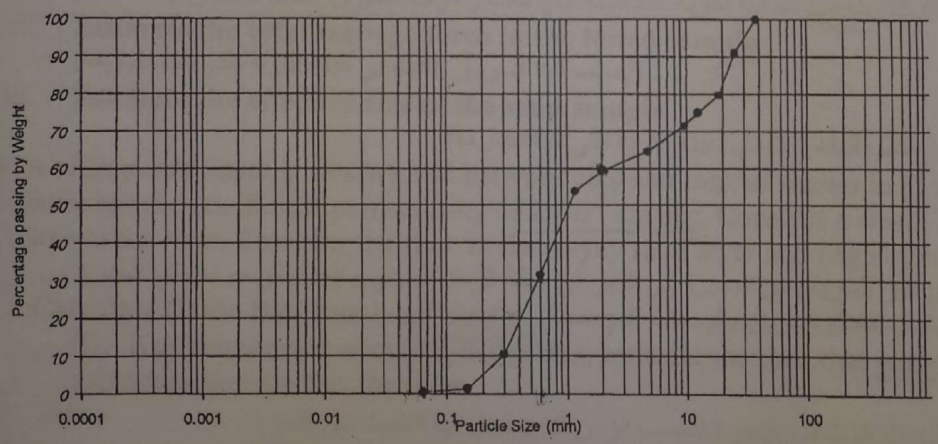
(i) **Estimate** the effective diameter, the uniformity coefficient, and the coefficient of gradation of both soils. **(2 Point)**

(ii) **Determine** the percentages of the different components of each soil. Assuming Unified Soil Classification System **(2 Point)**

(iii) **Classify the two soils** **(2 points)**



Zafarana Soil Sample



Assiut Soil Sample

Figure (1)

b) The Atterberg Limits results of soil sample from the Casagrande Cup and Plasticity tests are given in Figure (2). Two determinations for the plastic limit gave water contents of 20.3% and 20.8%.

Determine the following

(I) the liquid limit of the sample **(1 point)**

(II) the Plastic limit of the sample **(1 point)**

(III) The activity of the sample if Clay Fraction is 35% **(1 point)**

(IV) The Liquidity Index of the sample if the natural water content is 25 % **(1 point)**

(V) The classification of the soil according to the Unified Soil Classification System **(1 point)**

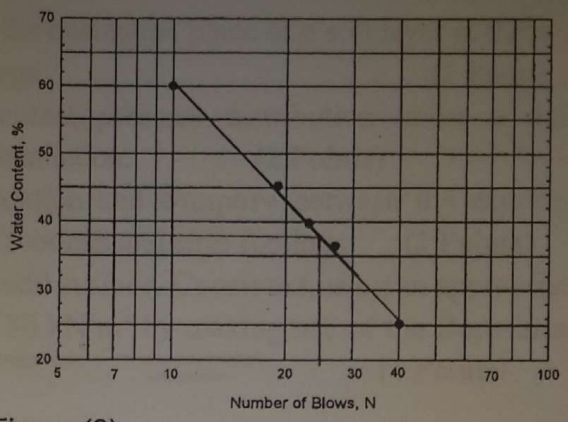


Figure (2)

(VI) The void ratio corresponding to liquid limit if specific gravity is 2.70. **(2 points)**

Question Number (2) (15 Points)

a) **Define** the permeability of soils. (عرف نفاذية التربة) **(1 Points)**

b) **Briefly explain** why we need to know about coefficient of permeability of soils. **(2 Points)**
(إشرح بإختصار لماذا نحتاج لمعامل النفاذية للتربة)

c) How can you find out the coefficient of permeability in the field? **(2 Points)**
(كيف نحصل على معامل النفاذية في الموقع؟)

d) A sample of sand, 15 cm high and 5.5 cm in diameter, was tested in a constant-head permeameter. Water percolated through the soil under a head of 45 cm for a period of 10 seconds. The discharge water was collected and found to weigh 800gm.

i. **What was the coefficient of permeability at the void ratio and temperature of the test?**
(ماذا كان معامل النفاذية للتربة عند نسبة الفراغات و درجة الحرارة أثناء الاختبار؟) **(2 Points)**

ii. **Estimate the total seepage force in the tested sample** **(2 Points)**
(إحسب قوة السريان الكلية في عينة التربة التي تم اختبارها)

iii. **Estimate the effective size of the sand sample.** **(1 Points)**
(إحسب المقاس الفعال لعينة التربة التي تم اختبارها)

e) A clayey sand layer is sandwiched between clay and rock as shown in Figure 3. The clayey sand layer has the coefficient permeability of 2×10^{-5} cm/sec. Consider a steady state flow from the lake to the river. Consider the flow in the clayey sand layer and neglect the flow in the clay.
(إعتبر السريان من البحيرة إلى النهر في طبقة الرمل الطيني و إهمل أي سريان في الطين)

Calculate (I) the flow rate in m^3/day/m. (إحسب معدل السريان بالوحدات الموضحة) **(2 Points)**

(II) If contamination occurred in the lake, estimate the time that will pass before the contamination reaches the river.
(إذا حدث تلوث في البحيرة فاحسب الزمن الذي يصل فيه التلوث الى النهر) **(3 Points)**

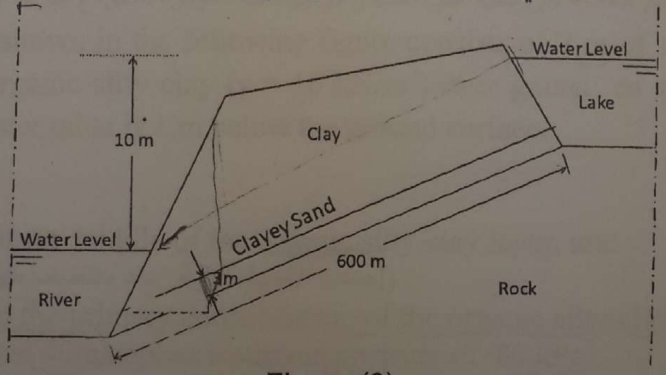


Figure (3)

QuestionNumber (3) ***(14Points)***

a) **Draw** the variation of vertical stress in the horizontal plane of a soil layer at three different depths below a surface surcharge. **(1 Point)**

b) **Draw** the shape of the expected contact pressure distribution under a rigid foundation as well as under a flexible foundation. **(2 Points)**

c) **Define**the pressure bulb under a foundation and **compare** between the expected sizes of the pressure bulb below square footings and strip footings. **(2 Points)**

d) A point load of 1000 kN acts at the ground surface. **Construct**,using an appropriate scale, the isobar for a value of $\Delta\sigma v = 30$ kN/m^2 by making use of the Boussinesq equation. **(4 Points)**

e) A rectangular foundation 6x3m carries uniform pressure of 300 kPa near the surface of a soil mass Figure (4). Determine the vertical stress at a depth of 3m below a point (A) on the center line 1.5 m outside a long edge of the foundation. **(5 Points)**

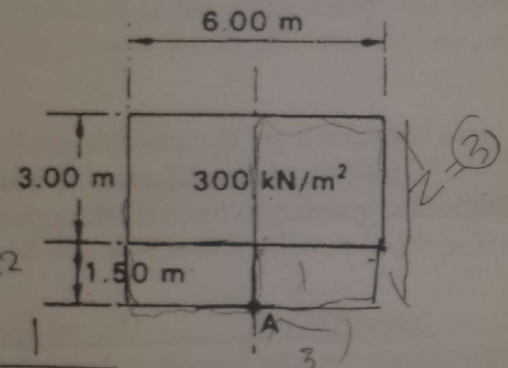
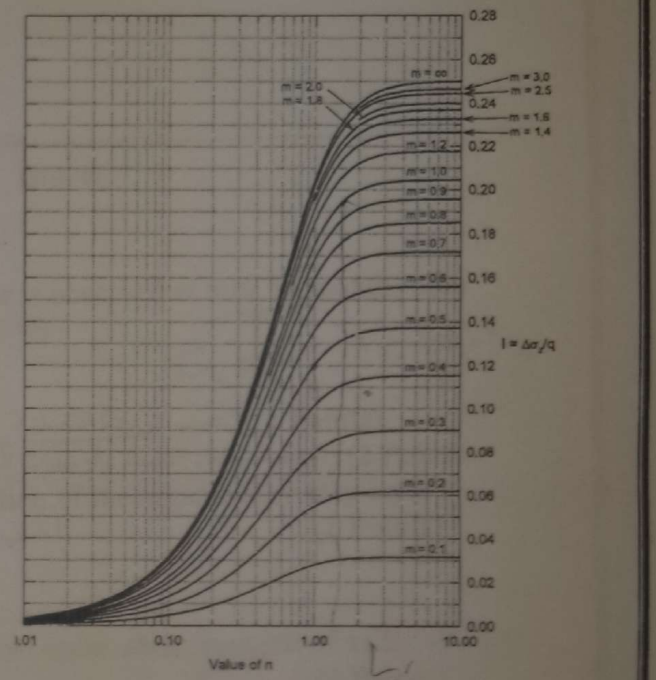


Figure (4)



Question Number (4) ***(15Points)***

a) **Briefly explain** the fundamental factors influence compressibility of soils. (إشرح بإختصار ماهي العوامل التي تؤثر في إنضغاطية للتربة) **(2 Points)**

b) **Sketch and label** the void ratio versus effective stress relationship for (I) Normally consolidated clay and (II) Overconsolidated clay, **(2 Points)**
(إرسم مع التعليم على الرسم العلاقة بين نسبة الفراغات و الإجهادات المؤثرة للأنواع التربة المذكورة)

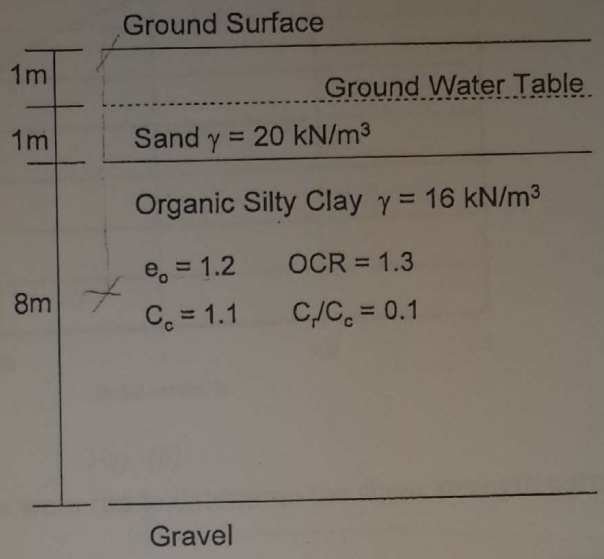
c) A soil profile shown in the following figure consists of 2 m of sand ($\gamma = 20$ kN/m^3) over 6 m of organic silty clay ($\gamma = 16$ kN/m^3) over gravel as shown in Figure (5). The ground water table is 1 m below the ground surface.

Calculate

i. effective stress at the middle of the organic silty clay layer, and **(2 Points)**
(إحسب الإجهاد المؤثر عند منتصف طبقة الطين)

ii. settlement due to the primary consolidation of the organic silty clay layer if a surface tank with diameter 40m applies a surface pressure of 80 kPa. **(3 Points)**

(إحسب الهبوط نتيجة إنضغاط طبقة الطين إذا تم وضع خزان بقطر 40متر يسبب قيمة إجهاد على سطح الأرض بالقيمة المذكورة بالسؤال)



Given the U-T relationship

U(t) %	T	U(t) %	T
0	0	60	0.286
10	0.008	70	0.403
20	0.031	80	0.567
30	0.071	90	0.848
40	0.126	95	1.129
50	0.197		

Figure (5)

if 50 cm of settlement of the organic silty clay layer is observed at time 16 months after loading. (إذا تم رصد قيمة هبوط حوالي 50 سم بعد حوالي 16 شهر)

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

Calculate

iii. degree of consolidation at the mentioned time, (إحسب درجة التصلد) **(2 Points)**
iv. coefficient of consolidation in m^2/year, (إحسب معامل التصلد بالوحدات المذكورة) **(2 Points)**
v. the time required for end of primary consolidation of the organic silty clay layer (أحسب الزمن الازم لحدوث الهبوط نتيجة تصلد طبقة الطين) **(2 Points)**

Question Number (5) ***(18Points)***

a) Using clear sketches discuss why we need to know about shear strength of soils. **(2 Points)**

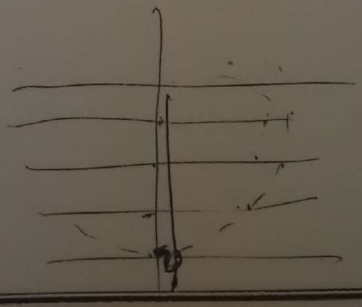
b) Briefly explain the fundamental factors influence shear strength of soils. **(2 Points)**

c) **Draw** the expected relations between shear stress and shear displacement strain and, also, the expected relation between volumetric change and shear displacement for loose and dense sand samples when tested in a direct shear box apparatus. **(2 Points)**

d) The results of unconfined compression test on blue clay sample are shown in Fig. (6). It is required to:

(i) **Determine** the unconfined compressive strength of the clay. **(1 Point)**
(ii) What are the shear strength parameters of the clay sample? **(1 Point)**
(iii) Are these parameters, drained or undrained parameters? & Why? **(2 Points)**

$\frac{3C_u}{4H^2}\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2}$



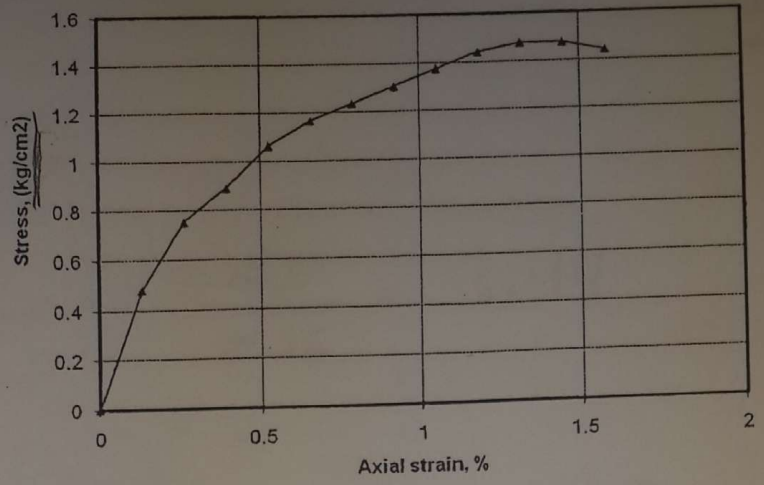


Fig. (6)

e) A series of **Direct Shear Box** tests were run to determine the shear strength parameters of a soil. The tests results are:

Test No.	Normal Stress σ' (kN/m^2)	Shear Stress at Failure τ (kN/m^2)
1	50	33
2	100	51
3	200	88

i) **Draw** the Mohr Shear strength envelope for the given data. **(1 Point)**

ii) Based on a best-fitted straight line Mohr envelope, **evaluate** the value of c'and ϕ'. **(2 Points)**

iii) Considering that the same soil was tested in the **triaxial apparatus** and that the same shear strength envelope was developed, if the confining stress (σ_3) = 40 kN/m^2, **determine** the maximum axial stress (σ_1). **(3 Points)**

f) A natural slope consists of the same stiff silty clay in (e) above (it has the same c' and ϕ'). For stability analysis of the slope, consider one segment of the failure surface with effective normal stress σ'_n of 40 kN/m^2. **Calculate** the shear strength of the soil on the segment. **(2 Points)**

End of questions ..... Best Wishes

Prof. Dr. Marawan M. Shahien & the committee

السؤال الأول:-

Soil (A)

(i)

$\rightarrow D_{10\%} = 0.16$

$\rightarrow C_u = \frac{D_{60\%}}{D_{10\%}} = \frac{0.55}{0.16} = 3.44$

$\rightarrow C_g = \frac{(D_{30\%})^2}{D_{60\%} * D_{10\%}} = \frac{(0.35)^2}{0.16 * 0.55} = 1.4$

Soil (B)

$\rightarrow D_{10\%} = 0.3$

$\rightarrow C_u = \frac{D_{60\%}}{D_{10\%}} = \frac{2}{0.3} = 6.67$

$\rightarrow C_g = \frac{(D_{30\%})^2}{D_{60\%} * D_{10\%}} = \frac{(0.6)^2}{2 * 0.3} = 0.6$

(ii)

Soil (A)

% gravel = 100 - 78 = 22 %

% Sand = 78 - 9 = 69 %

% Fines = 9 %

Soil (B)

% gravel = 100 - 65 = 35 %

% Sand = 65 %

% Fines = 0 %

(iii)

Soil (A) → Poorly graded Sand

Soil (B) → " " "

(b):-

→ L.L. = 38 %.

→ P.L. = $\frac{20.3 + 20.8}{2}$ = 20.55 %.

→ $A = \frac{P.I}{\%\text{ Age of Clay}}$

P.I. = L.L − P.L = 38 − 20.55 = 17.45 %.

$A = \frac{17.45}{35} = 0.49 \simeq 0.5$

→ $L.I. = \frac{w_c - P.L.}{L.L. - P.L.} = \frac{25 - 20.55}{38 - 20.55}$

$= 0.255$

→ **CL**

→ $w_c * G_s = S * e$

$0.38 * 2.7 = 1 * e$

$\therefore e = 1.03$

(3) السؤال الثانى :-

(d) $k = \frac{q L}{h \cdot A \cdot t}$

$k = \frac{800 * 15}{45 * \frac{\pi}{4} * (5.5)^2 * 10} = 1.12 \text{ cm/sec}$

→ SeePage Force $= i \gamma_w = \frac{h}{L} * \gamma_w$

$= \frac{45}{15} * 1 = 3 \text{ tan}/m^3$

$k = 1.12 = C * D_{10\%} = 1 * D_{10\%}^2$

$\therefore D_{10\%} = 1.058 mm$

(e) $q = k i A = 2 * 10^{-5} * 10^{-2} * \frac{10}{600} * 3 * 1 * 60 * 60 * 24$

$= 3.6 * 10^{-5} * 24 \; m^3/day/m$

$8.64 * 10^{-4}$

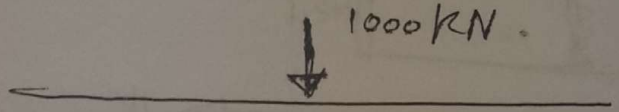
$$V = ki = 2*10^{-5} * 10^{-2} * \frac{10}{600} = 3.33*10^{-9} \text{ m/sec}$$

$$V = \frac{L}{t} = 3.33*10^{-9} = \frac{600}{t}$$

$$t = 1.8*10^{11} \text{ sec}$$

السؤال الثالث :-

(d)



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

$$3\sigma = \frac{3*1000}{2\pi * z^2} \left[\frac{1}{1+0}\right]^{\frac{5}{2}}$$

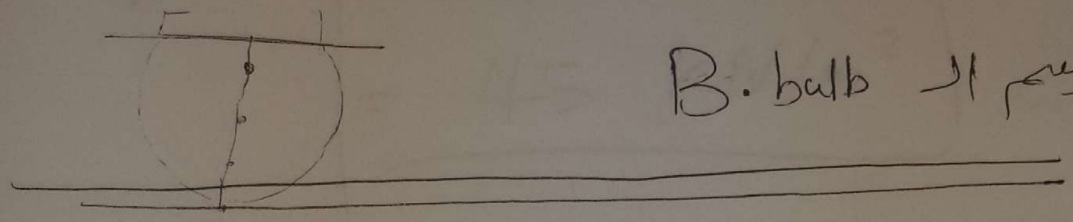
$z^2 = 15.9$ m ⟶ نهاية Pressure Bulb

$\therefore z = 3.99$ m

at ~~Z~~ = 1m → r = 1.42

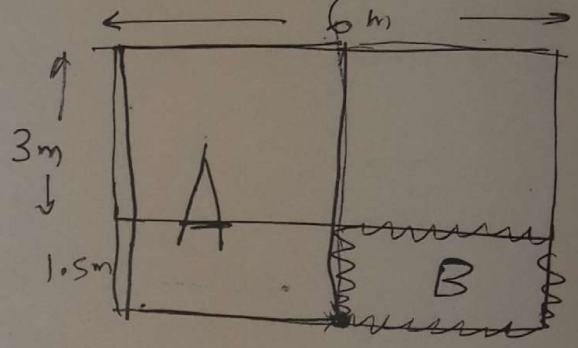
at Z = 2m → r = 1.72

Z = 3m → r = 1.52



← نرسم الـ B. bulb

(e)



← الإجهادات الناتجة من المساحة (A)

$(4.5 * 3)\ m$

$$m = \frac{x}{z} = \frac{3}{3} = 1$$

$$n = \frac{y}{z} = \frac{4.5}{3} = 1.5$$

} → I = 0.195

← الإجهادات الناتجة من المساحة B ← $(3 * 1.5)$

$$m = \frac{1.5}{3} = 0.5$$

$$n = \frac{3}{3} = 1$$

} → I = 0.12

$$\therefore \Delta\sigma_{v(A)} = 2\left[0.195 * 300 - 0.12 * s\right.$$

$I * q$

$$= 45 \text{ kN/m}^2$$

Q4 (1)

(c)

(i) $\sigma_o' = 1 + 20 + 1 + 10 + 4 + 6 = 54$ kN/m²

(ii) $\Delta\sigma_v = \dfrac{q\,\pi/4\,(D)^2}{\pi/4\,(D+Z)^2}$

$= \dfrac{80 \cdot \pi/4 \cdot (40)^2}{\pi/4\,(40+6)^2} = 60.5$ kN/m²

OCR $= \dfrac{\sigma_p}{\sigma_{vo}}$ $\quad \sigma_p = 1.3 + 54 = 70.2$ kN

$\sigma_f = 54 + 60.5 = 114.5$ kN/m²

$S = \dfrac{C_r \cdot L}{1+e_o} \log\left(\dfrac{\sigma_p}{\sigma_{vo}}\right) + \dfrac{C_c \cdot L}{1+e_o} \log\left(\dfrac{\sigma_f}{\sigma_{vo}}\right)$

$= \dfrac{0.11 \times 8}{1+1.2} \log\left(\dfrac{70.2}{60.5}\right) + \dfrac{1.1 \times 8}{1+1.2} \log\left(\dfrac{114.5}{70.2}\right)$

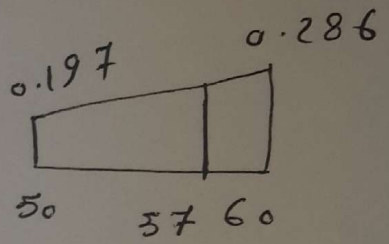
$= 0.876$ m $= 87.6$ cm

(iii) $t = 16$ months $\Rightarrow S = 50$ cm

$$U = \frac{St}{Sf} = \frac{50}{87.6} * 100 = 57\ \%$$

(iv)

$$T_v = 0.197 + (0.286 - 0.197) * \frac{7}{10}$$



$$\simeq 0.26$$

$$T_v = \frac{C_v * t}{d^2} \qquad d = 4\ m$$

$$0.26 = \frac{C_v * (\frac{16}{12})}{(4)^2} \qquad C_v = 3.12 \quad m^2/year$$

(iv)

Put $\rightarrow U = 95\%$ $\Rightarrow T_v = 1.129$

$$T_v = \frac{C_v . t}{d^2} \qquad 1.129 = \frac{3.12 * t}{4^2}$$

$$t = 5.79 \quad year.$$

Q5

(d) (i) $q_{un} = 1.44$ kg/cm²

(ii) $C_{un} = \frac{q_{un}}{2} = \frac{1.44}{2} = 0.72$ kg/cm²

(iii) undrained

(e)

(i) في الورقة المرفقة

(ii) $c = 5$ kN/m² $\phi = 24^\circ.52'$

(iii) $\sigma_3 = 40$ kN/m²

$\sigma_1 = 93$ kN/m²

(f) $\sigma = 40$ kN/m² $c = 5$ kN/m²

$\phi = 24^\circ.52'$

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

$= 5 + 40 \tan(24.52) = 23.6$ kN/m²

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