

**THE HONG KONG POLYTECHNIC UNIVERSITY  
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING  
2015/16 SEMESTER II EXAMINATION**

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Programme: Higher Diploma in Civil Engineering (31363)

Subject: Soil Mechanics

Subject Code: CSE10256

Session: 2015/16

Date: 28 April 2016

Time: 8:45am - 11:45am

Time Allowed: **Three** Hours

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This question paper has **ELEVEN** pages.

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**Instructions to Candidates:**

1. This question paper contains two parts.
  2. Part I is **compulsory**. Answer **TWO** out of three questions in Part II.
  3. All questions carry equal marks.
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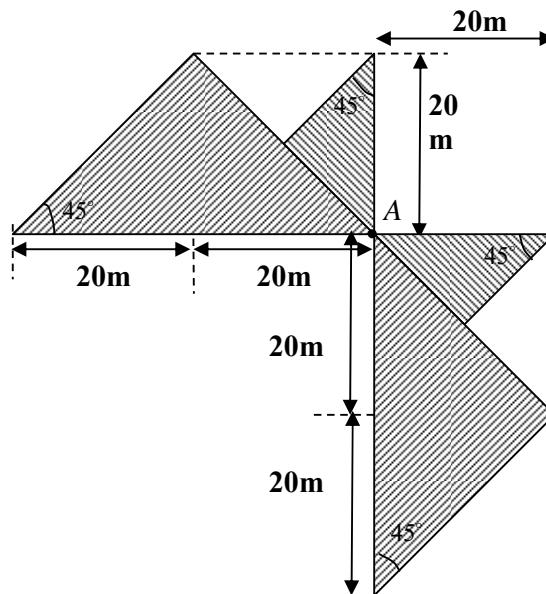
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**DO NOT TURN OVER THE PAGE UNTIL YOU ARE TOLD TO DO SO.**

**Part I: Compulsory section and answer all questions (Total of 50 marks)****Question 1:**

- (a) A soil mass of volume  $0.025\text{m}^3$  weighed 54 kg and after being dried it weighed 52 kg. The specific gravity of the solid particles is 2.71. Determine the water content, void ratio, degree of saturation, porosity, and air content of the soil. (5 marks)
- (b) An architect proposed a strange building layout as shown in Figure 1 for office building. The surface loading induced by building blocks shown by the hatched-line areas is  $120\text{ kPa}$ . These buildings are built on flexible shallow foundations.
- (i) Use Fadum chart to find the vertical stress increment at a depth of 20m below point A. (4 marks)
- (ii) Use Newmark chart to find the vertical stress increment at a depth of 20m below point A. (3 marks)

**Figure 1**

Hints:

- (i) Both Fadum chart and Newmark chart are attached
- (ii) Please detach the Newmark Chart from this examination paper and attach with your answer book
- (c) A 7 m thick sand overlies a 4 m thick clay, with initial water table 6 m below the ground. An impermeable layer of rock further locates underneath the clay. The unit weights of the clay, the dry sand and saturated sand are  $20\text{ kN/m}^3$ ,  $17\text{ kN/m}^3$  and  $19\text{ kN/m}^3$  respectively. Over a short period of time, surface load of  $100\text{ kN/m}^2$  is applied on the ground surface with a 4 m rise in the water table. What are the water pressures and effective stresses at 6 m and 9 m below the ground immediately and many years after these changes?

*(Hints: 8 answers are needed)*

(8 marks)

(d) Following Question 1(c) above, if the compression index of the clay is 0.3 and the coefficient of consolidation is  $1.1 \text{ m}^2/\text{year}$ . It is given that the initial water content of the clay is 0.25 and the specific gravity of the solid particles is 2.70.

- (i) Find the long term settlement due to consolidation of the clay layer. (3 marks)
- (ii) Find the settlement 2 years after the changes. (2 marks)

Hints:

|   |               |
|---|---------------|
| Useful results: $T_v \approx (\pi/4)U^2$    | for $U < 0.6$ |
| $T_v \approx -0.933 \log_{10}(1-U) - 0.085$ | for $U > 0.6$ |

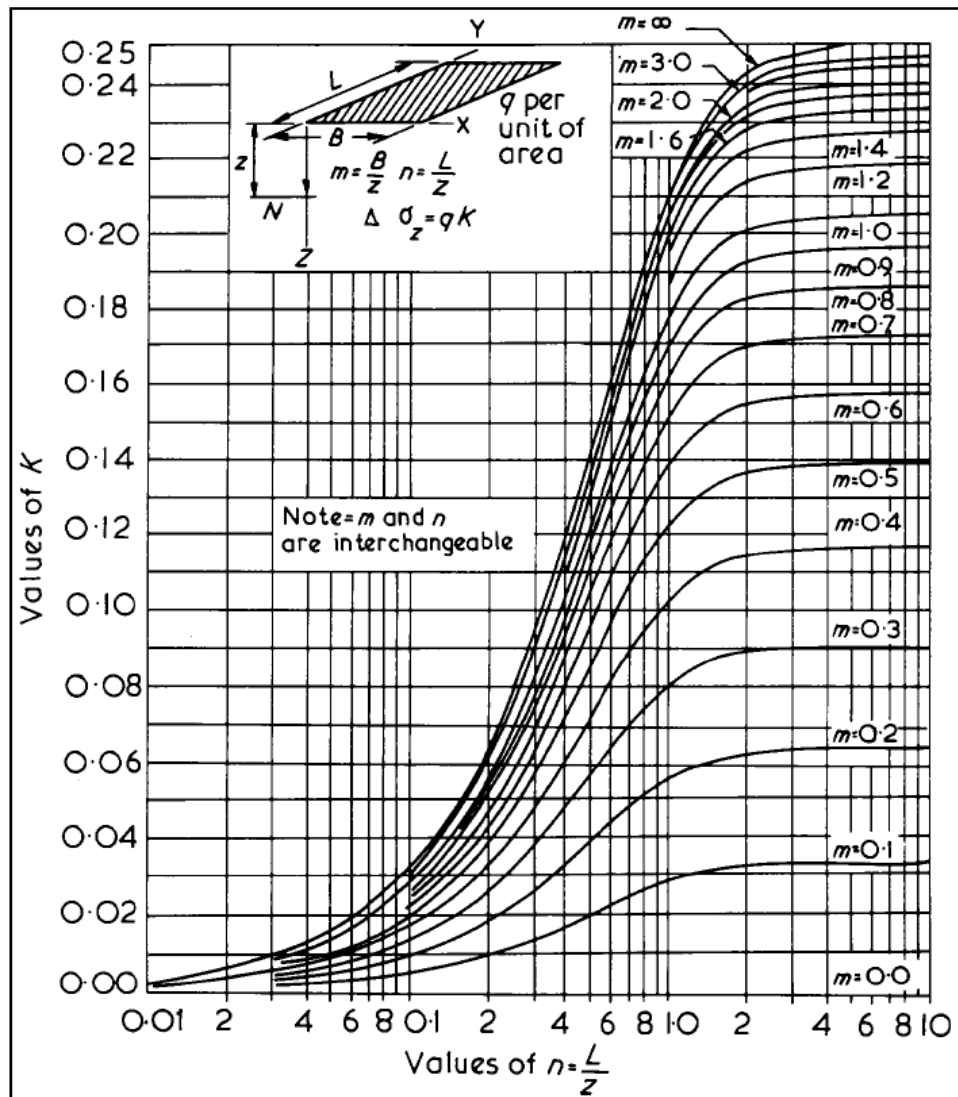


Figure 5. Vertical stress under corner of a rectangular area carrying a uniform pressure (e.g. Fadum, 1948).

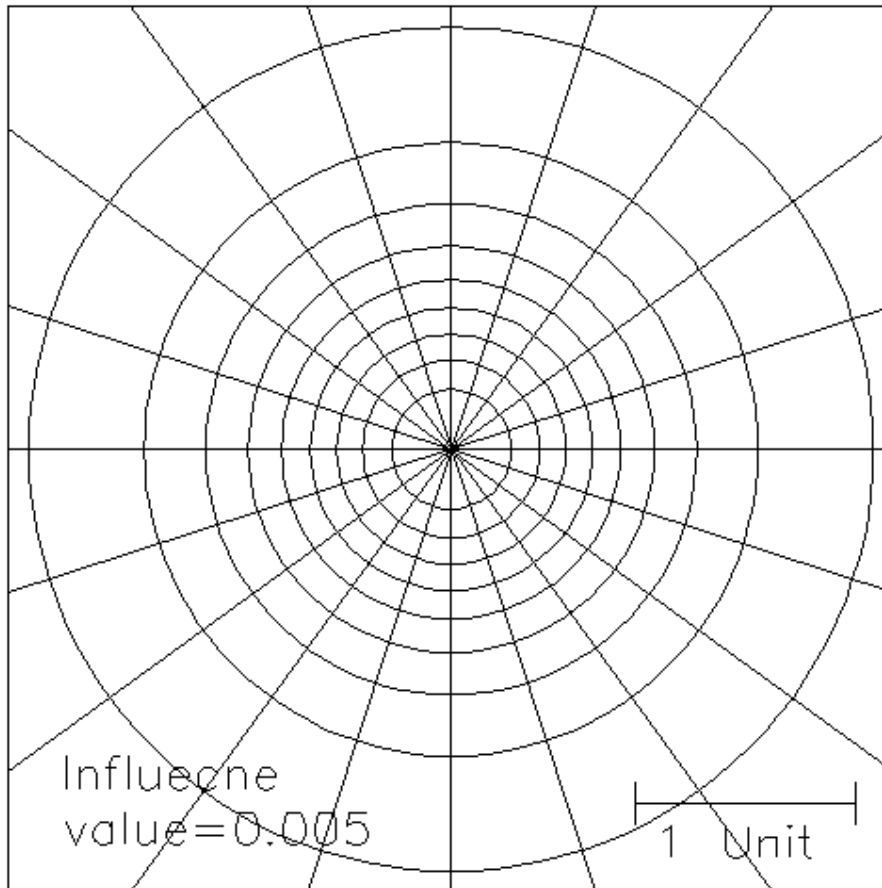
**Newmark chart for Question 1**

Answer sheet for Question 1.

*Detach this paper and submit it with your examination answer book*

Student Name: \_\_\_\_\_ Student Number: \_\_\_\_\_

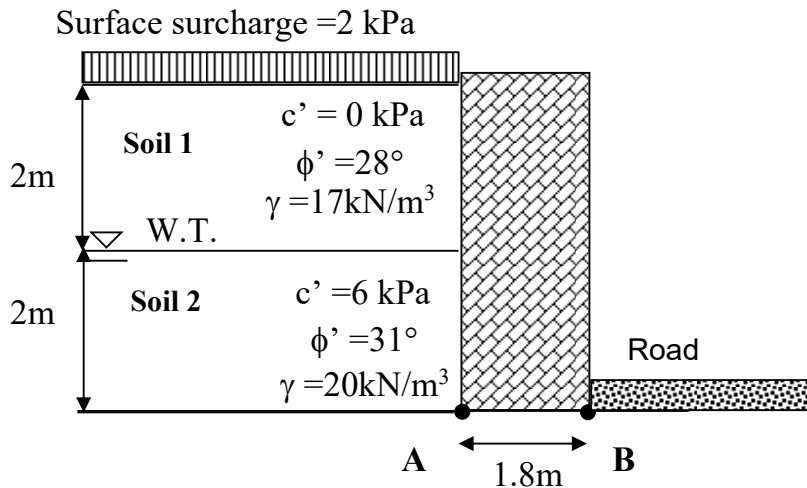
Please also show the counting of the number of mesh covered by your buildings.



Step of counting:

**Question 2:**

- (a) A 4 m high masonry retaining wall of width 1.8 is built to retain a 2-layered soil profile shown in Figure 2 on Bonham Road on Hong Kong Island with a surface surcharge of 20 kPa. The soil parameters are given in the figure. During raining season, ground water rises to interface between Soil 1 and Soil 2. Assume that there is no friction between the vertical wall and the soils. The sliding friction angle between the base and the soil is  $25^\circ$ . The unit weight of stone is  $23.5 \text{ kN/m}^3$ .
- Plot the effective earth pressure and water pressure the retaining wall at active failure. (8 marks)
  - Taking moment at Point A, find the total thrust acting on the wall. (3 marks)
  - Find the maximum and the minimum base pressures on the wall. (2 marks)
  - Find the factor of safety against sliding. (2 marks)

**Figure 2A**

- (b) On July 22, 2015, a Chinese Banyan tree of over 16 m fell down from a masonry wall on Bonham Road, injured a 54 year old lady. On August 7, Highways Department removed four healthy Banyan trees on the same masonry wall, and caused some protests from environmental group. In this part, you are asked to check the stability of the wall in Part (a) again if the Banyan tree on Bonham Road were now on this wall.

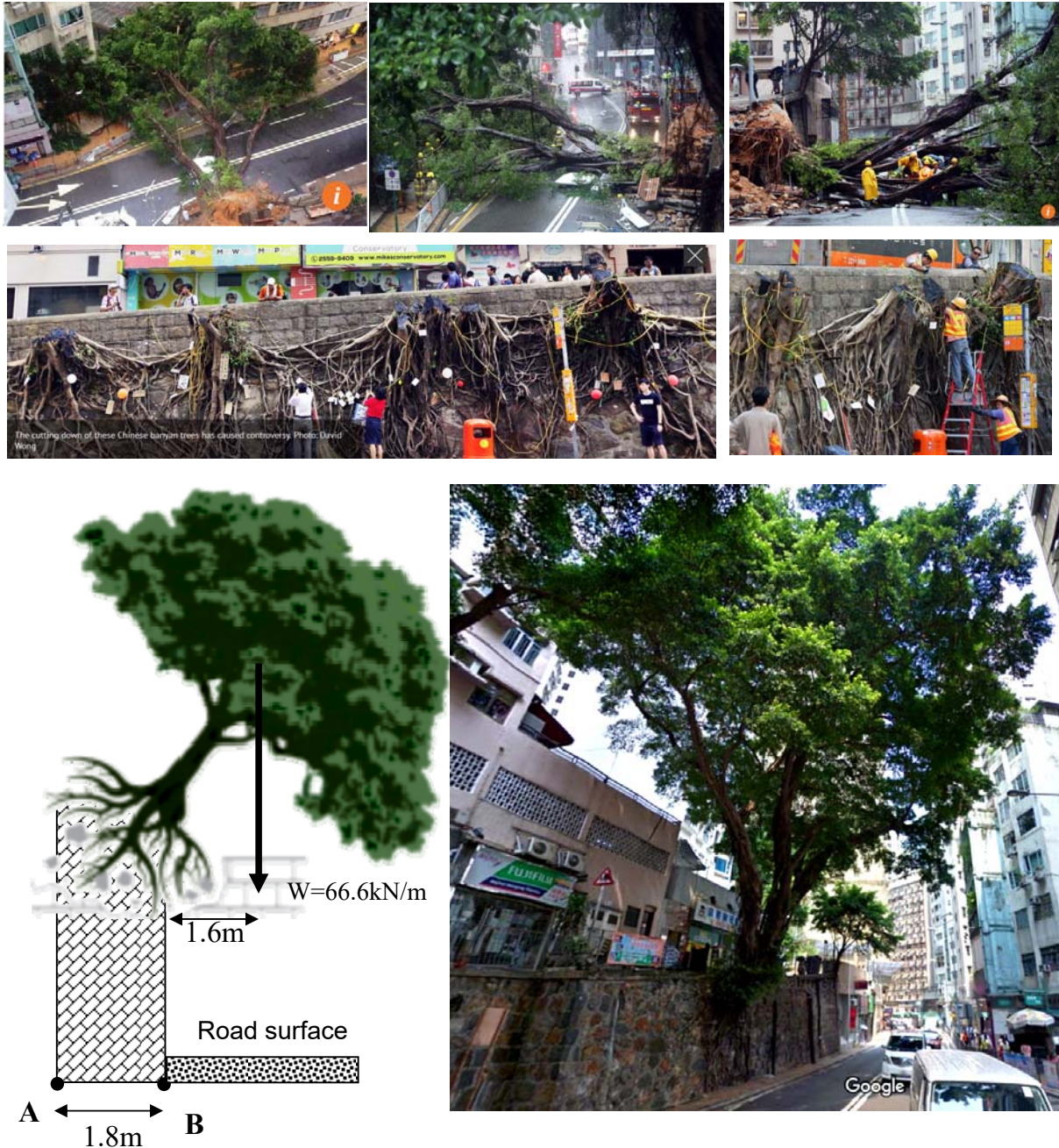


Figure 2B

- (i) Referring Figure 2B for the weight of tree per length and position of center of mass of the tree. Find the factor of safety against sliding including the effect of the tree. (3 marks)
- (ii) With the tree, find the maximum and minimum base pressures on the wall. (3 marks)
- (iii) Discuss whether the tree will make the retaining wall more unstable. If yes, why? If not, why not? (2 marks)
- (iv) Briefly discuss what factors have been left out in our analysis for the effect of the trees on the retaining wall. (2 marks)

**Part II: Answer any 2 out of 3 questions (each question carries 25 marks)****Question 3:**

- (a) Derive the following formula starting from the definitions of all the parameters involved (*hints: you have to prove any formula that you use them*):

$$\gamma_d = \frac{G_s(1 - A)}{1 + wG_s} \gamma_w \quad (2 \text{ marks})$$

$$\gamma' = \frac{G_s - 1}{1 + e} \gamma_w \quad (3 \text{ marks})$$

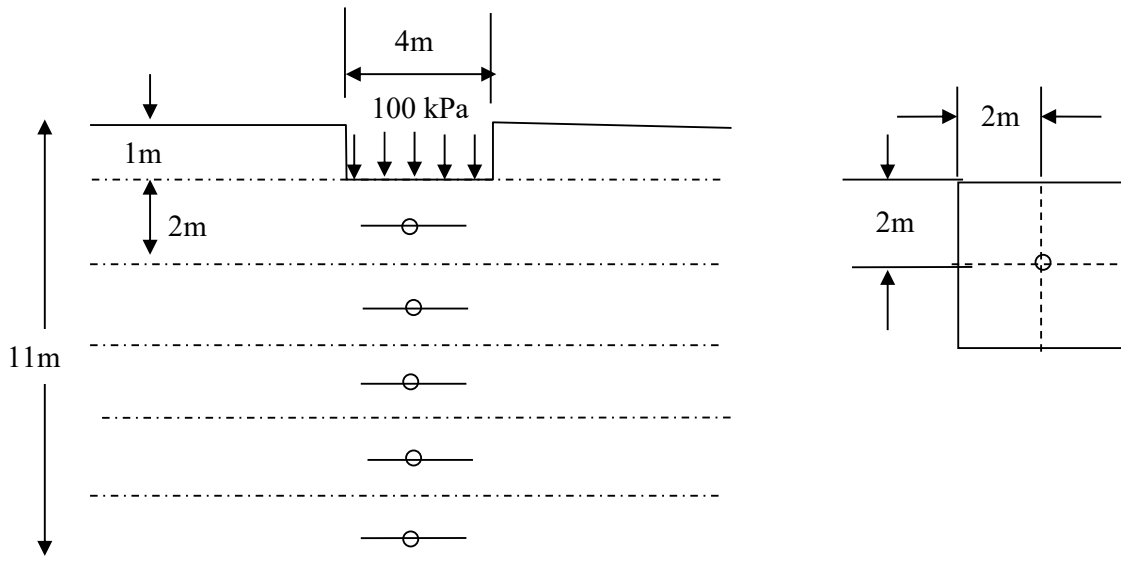
where  $e$ ,  $G_s$ ,  $\gamma_w$ ,  $w$ ,  $\gamma'$  and  $\gamma_d$  are the void ratio, specific gravity of solid particles, unit weight of water, water content, submerged unit weight, and dry unit weight of a soil.

- (b) Figure 3 shows a cofferdam of width 5.5m which is formed by driving two lines of sheet piling to 6m deep in a layer of sandy river bed. The depth of the river is 2.5m. An excavation of a depth of 2m is carried out into the river bed. The coefficient of permeability is  $2 \times 10^{-5}$  m/s. Continuous pumping is needed to withdraw the water from the bottom of the excavation. The unit weight of the sand is 20 kN/m<sup>3</sup>.
- (i) Find the total head of Points D and E; (4 marks)
  - (ii) Use the flow net technique to estimate the flow rate of the water. Please use graph paper in your plotting of the flow net. (5 marks)
  - (iii) Find the pressure head at Point A; (2 marks)
  - (iv) Find the water pressure at Point B; (2 marks)
  - (v) Find the effective stress at Point C; (3 marks)
  - (vi) Find the factor of safety against boiling instability; (2 marks)
  - (vii) Find the factor of safety against heaving instability. (2 marks)

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**Question 4:**

- (a) As shown in Figure Q4, a square footing of 4m in size carrying a net pressure of 100 kPa is located at a depth of 2m in a layer of stiff clay of 11m thick. A firm impermeable stratum is beneath the stiff clay. From oedometer test, the  $m_v$  and  $c_v$  of the clay is  $0.8 \text{ m}^2/\text{MN}$  and  $1.1 \text{ m}^2/\text{year}$ . The pore water pressure coefficient  $A$  is 0.4. The undrained Young's modulus of the clay is  $30 \text{ MN/m}^2$ .
- (i) Find the initial settlement of the clay subject to 100 kPa; (5 marks)
- (ii) Find the one-dimensional consolidation of the clay by considering 5 sub-layers as shown in Figure Q4; (10 marks)
- (iii) Find the long term three-dimensional consolidation of the clay using Skempton-Bjerrum method; (5 marks)
- (iv) Find the settlement 2 years after the application of the loading; (5 marks)

**Figure 4**

*Hints:* Fadum Chart has been given in Question 1

|   |
|---|
| Useful results: $T_v \approx (\pi/4)U^2$ for $U < 0.6$<br>$T_v \approx -0.933 \log_{10}(1-U) - 0.085$ for $U > 0.6$ |
|---|

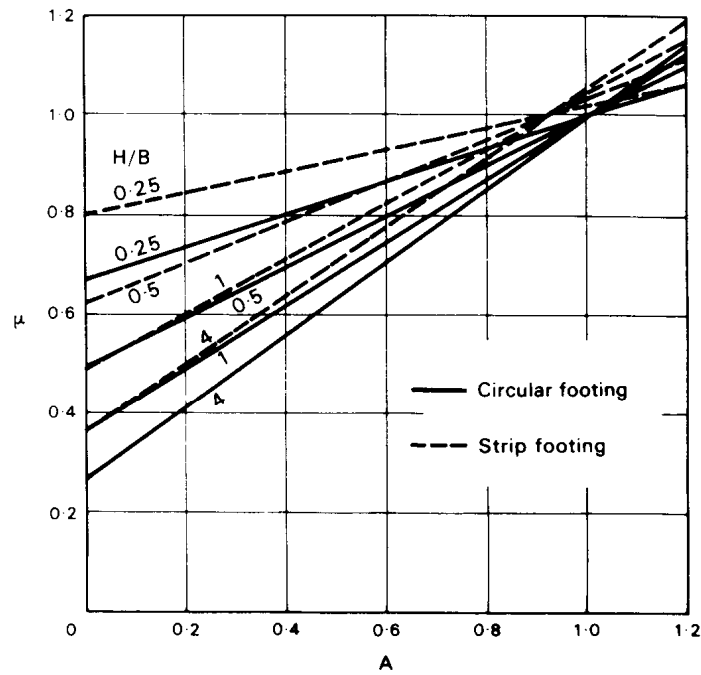


Fig. 7.12 Settlement coefficient. (Reproduced from R.F. Scott (1963) *Principles of Soil Mechanics*, by permission of Addison-Wesley Publishing Company, Inc., Reading Mass.)

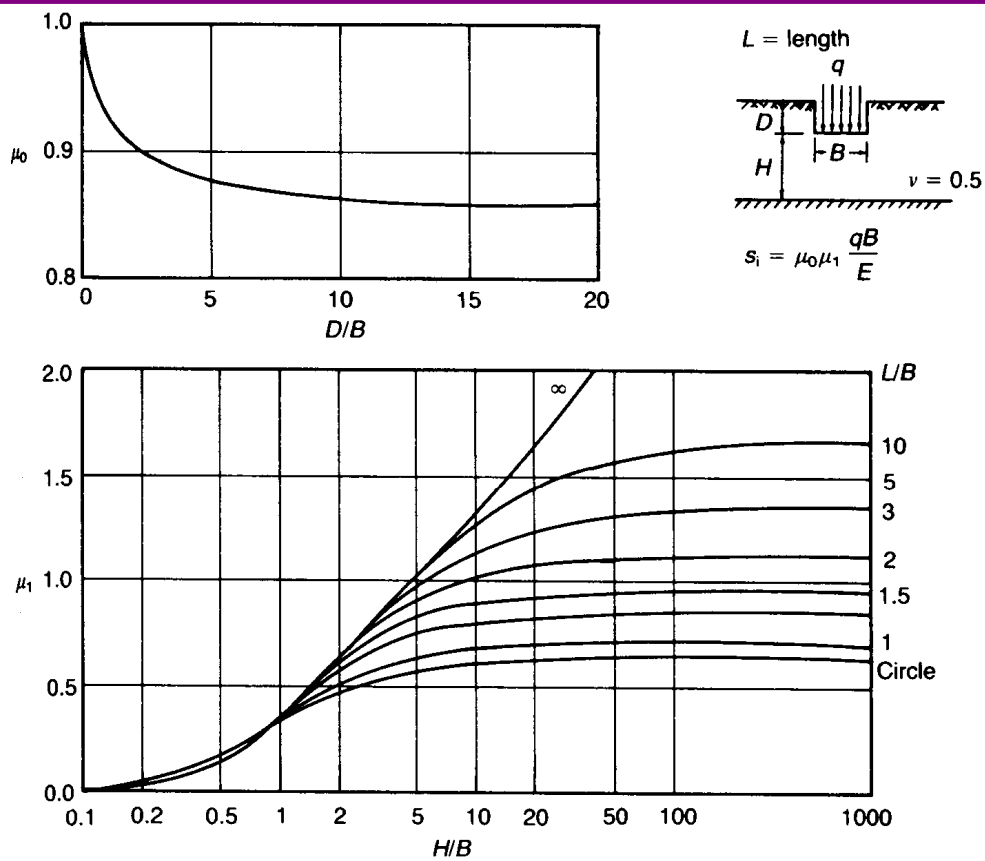


Fig. 5.15 Coefficients for vertical displacement.

**Question 5:**

- (a) A CD triaxial test was conducted on a marine sand under an all round pressure of 100 kPa. The initial length, area and volume are 100mm, 19.6cm<sup>2</sup>, and 196cm<sup>3</sup>.
- (i) During the consolidation phase, the volume change is 2 ml, find the updated length, area and volume; (3 marks)
- (ii) In the compression phase, the axial deformation is 8 mm, volume change is 4 ml, and axial force is 0.7 kN at failure. What is the principal stress difference at failure? (5 marks)
- (iii) Find the  $c'$  and  $\phi'$  of the soil. (2 marks)
- (b) Derive the ratio of AB:AC in Figure Q5a at 90% of consolidation for Taylor's root time method. (3 marks)

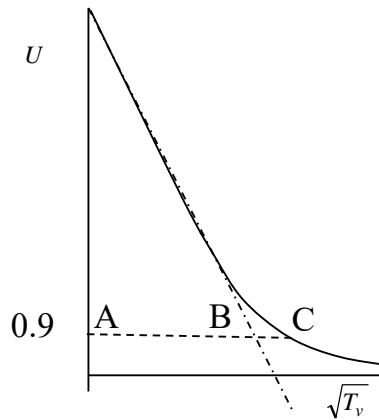


Figure Q5

- (c) Taylor's root time method is applied to find consolidation parameters of a clay given by the technician in the soil laboratory. The following dial gauge readings with various time are obtained under a vertical stress of 120 kPa. The initial thickness is 19mm and the final thickness is 16.1 mm at 24 hours. The unit weight of the clay is 19 kN/ m<sup>3</sup>.

| Time (min) | Dial gauge reading (division) |
|------------|-------------------------------|
| 0          | 0                             |
| 0.25       | 406                           |
| 0.5        | 460                           |
| 1          | 564                           |
| 2          | 694                           |
| 4          | 871                           |
| 9          | 1169                          |
| 16         | 1426                          |
| 25         | 1565                          |
| 36         | 1613                          |

- (i) Use the root time method to find the coefficient of consolidation of the clay (in the unit of m<sup>2</sup>/year); (8 marks)
- (ii) Find the coefficient of volume compressibility (in the unit of m<sup>2</sup>/MN); (2 marks)
- (iii) Find the coefficient of permeability of the clay (in the unit of m/s). (2 marks)

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