00153

THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (CIVIL) – LEVEL 04
Final Examination 2014/2015
CEX4230 – SOIL MECHANICS AND INTRODUCTION TO ROCK MECHANICS

Time allowed: Three Hours. Index No. _____

Date: Friday, 11th September, 2015 Time: 0930-1230

PART A:

Answer all questions. All questions carry equal marks. Attach Part A of this paper to your answer script. You are advised to spend approximately One (1) hour for Part A. Circle the correct response.
(3x12 = 36 points)

1. The saturated unit weight of a sandy soil estimated to be 19.2kN/m^3. The theoretical value of its Critical Hydraulic Gradient is:

   a. 0.96 b. 0.98 c. 1.0 d. 1.02 e. 1.04 a b c d e

2. Which of the following statements are true?

   A. During a Hydrometer Test, solid particles are considered to fall at constant velocities.

   B. Hydrometer reading represents the specific gravity of solids in suspension.

   C. It is assumed that solid particles in the soil solution are not attracted to each other.

   D. Hydrometer test measures the size distribution for particle sizes smaller than 0.002mm.

   a. A and B only b. B and C only c. C and D only d. A and C only
   e. A and D only a b c d e

3. A soil has 8% of soil fraction passing 0.063mm sieve size. The soil type could be:

   a. SW b. SW-SM c. SM d. SW-GM e. GW-SM a b c d e

4. Kaolinite is a clay mineral with the chemical composition $Al_2Si_2O_5(OH)_4$. Which of the following statements are true?

   A. It is a crystalline form of a silica tetrahedral sheet and an aluminium octahedral sheet.

   B. It displays medium to low plasticity.

   C. It displays a medium reaction to dilatancy.

   D. Kaoline slurry is used as 'drilling mud' when constructing bored cast-in-situ piles.

   a. A and B only b. B and C only c. C and D only d. A and C only
   e. A and D only a b c d e

5. Which of the following statements are true, regarding Liquid Limit and Plastic Limit?

   A. Liquid Limit is the water content of the soil slurry, when it changes from a liquid state to a semi-liquid state.

   B. The volume of the soil slurry remains constant at water contents lower than its Plastic Limit.

   C. Liquid Limit is a measure of soils ability to adsorb water.

   D. The natural water content of an over-consolidated clay is near its Plastic Limit.

   a. A, B and C only b. B, C and D only. c. A, B and D only. d. A, C and D only.
   e. A, B, C and D. a b c d e

6. Which of the following statements are true, regarding classification of engineering soils?

   A. Liquid Limit differentiates organic clays from inorganic clays.

   B. Liquid and plastic limit tests are determined when GP soils are classified.

   C. Silty sands have its fine fraction between 12 – 50%.

D. A-line differentiates clays from silts.

a. A and B only. b. B and C only. c. C and D only. d. A and C only.
e. A and D only.

a b c d e

7. Which of the following statements are true, regarding rise of capillary water, Z_c, in a soil?

A. Z_c increases with decreasing average particle size.

B. Z_c increases with increasing dry density.

C. Z_c depends on surface tension of fluid/solid particle surface.

D. Z_c depends on atmospheric pressure.

a. A, B and C only b. B, C and D only. c. A, B and D only. d. A, C and D only.
e. A, B, C and D.

a b c d e

8. Which of the following statements are true, regarding the Standard Proctor Compaction Test?

A. Compaction below optimum moisture content causes mass of solids to increase with water content.

B. For given moisture content, distance between the Compaction Curve and the Zero Air Voids Curve represents the amount of air voids.

C. At higher moisture contents sandy soils plot closer to the zero air voids curve.

D. In-situ compaction is carried out at optimum moisture content.

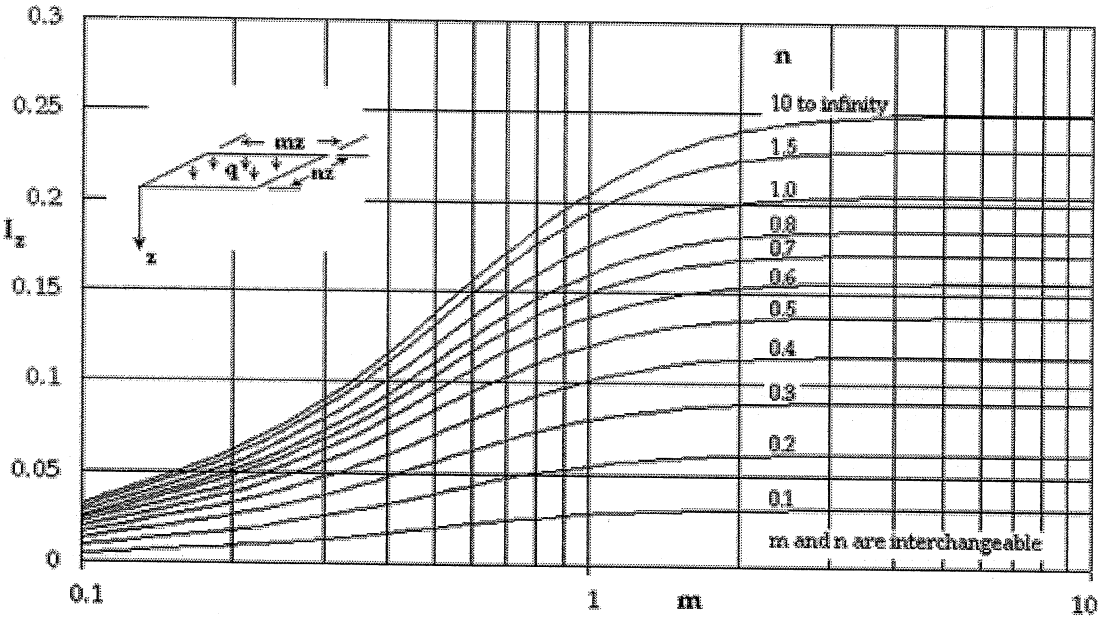
a. A, B and C only b. B, C and D only. c. A, B and D only. d. A, C and D only.
e. A, B, C and D.

a b c d e

9. Figure below shows Influence factor, I_z below a corner of a rectangular area. A 2m×4m footing bears 50kPa. The bearing stress along the centreline of the footing, at 1m depth is:

a. 10 kPa b. 20 kPa c. 25 kPa d. 30 kPa e. 40 kPa

a b c d e



10. Which of the following statements are true, regarding 1-D consolidation test?

A. The vertical dial measures settlement up to 0.002mm.

B. The specimen is subjected to both vertical and horizontal effective stresses.

C. The specimen is subjected to a vertical strain only.

D. Primary Consolidation is expected to occur within 24 hours.

a. A, B and C only b. B, C and D only c. A, B and D only d. A, C and D only
e. A, B, C and D

a b c d e

11. Figure below shows the variation of stresses with depth for a saturated clay soil element dx, dy, dz, subject to vertical compression. Which of the following statements are true?

A. Excess pore pressure dissipates at top and bottom ends.

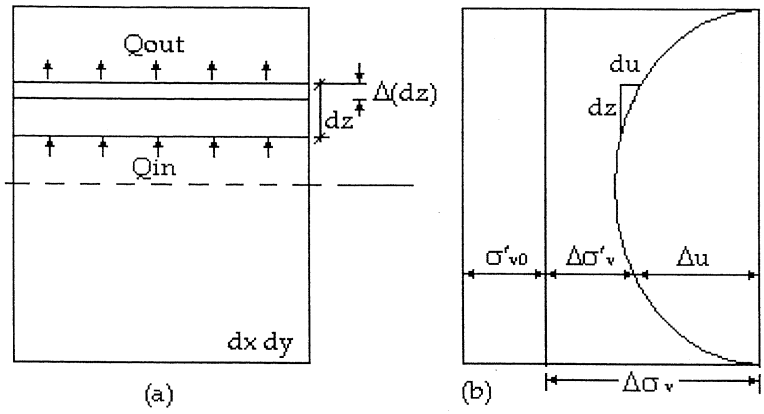
B. The initial excess pore water pressure distribution is considered parabolic.

C. Water movement at the centre is greater than the movement near the top surface.

D. At end of Primary Consolidation, the effective vertical consolidation stress increases by $\Delta\sigma_v$.

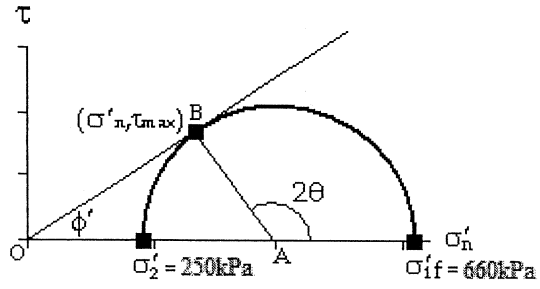
a. A and B only b. A and C only c. A and D only d. B and C only

e. C and D only a b c d e



12. Figure below shows a Mohr's Circle plot in terms of effective stress. The effective friction angle ϕ' is equal to:

a. 25.2° b. 26.8° c. 27.6° d. 29° e. 31.2° a b c d e



PART B:

Answer four questions. All questions carry equal marks. You are advised to spend approximately 28 minutes per question. (16x4 = 64 points)

1. The bulk unit weight, γ of a soil can be expressed as $\rho = \left[\frac{G_s + Se}{1+e}\right]\rho_w$.

A. Define all terms used in this equation, in terms of volume and mass parameters representing the 3-phase soil model. (5 points)

B. Describe how you would determine G_s of an undisturbed soil specimen obtained during sampling. (4 points)

C. If the specimen is partially saturated, explain how you could determine parameter S. (4 points)

D. A clayey soil specimen has the following parameters w = 18% and G_s = 2.7. Compute its saturated unit weight in kN/m^3. (3 points)

2. Figure B2 shows a Constant Head Permeameter. The elevations of points A, B, C, D, E, and F are 51.25, 106.25, 11.25, 21.5, 0.0, and 60.5cm, respectively.

A. Compute the total head drop across Specimen EF. (2 points)

B. Compute the pressure head at Point D. (4 points)

C. Compute the average hydraulic gradient across soil column EF. (2 points)

D. A uniform flow rate of 10ml per minute occurs across the permeameter, at room temperature of 30°C. The average diameter of the soil sample is 50mm. Determine k_{20}. η_{20} = 1.002 mPa.s; η_{30} = 0.798 mPa.s; $\rho_{30}/\rho_{20} \approx 1.0$. (4 points)

E. Discuss the possibility of sand boiling in this apparatus at Critical Hydraulic Gradient; state your reasons. Assume ρ_{sat} = 2.05 g/cc. (4 points)

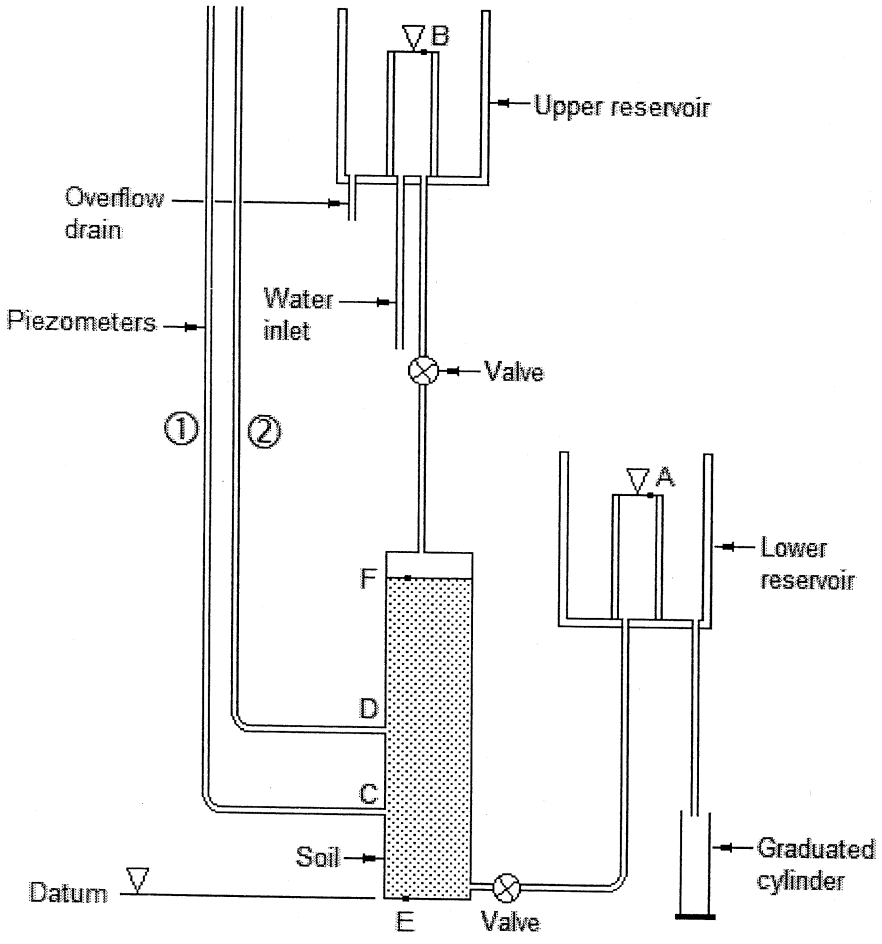


Figure B2

3. Figure B3 shows the variation of total volume with water content. When water content is reduced from a higher value to a lower value, the soil changes its consistency.

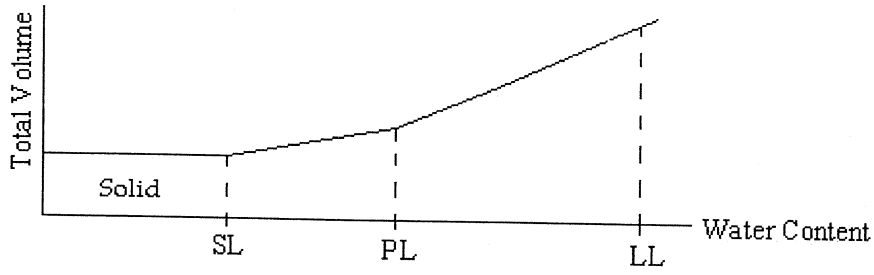


Figure B3

A. Define Liquid Limit (LL) and Plastic Limit (PL). (2 points)

B. Two clayey soils, A and B are compared. Soil A has a greater Plasticity Index (PI) than Soil B. Describe engineering properties of the two soil types. (4 points)

C. Define Specific Surface Area (SSA); explain the relationship between SSA and LL. (3 points)

D. During visual classification of a fine-grained soil, explain how you would identify a high plasticity soil from a low plasticity soil. (3 points)

E. In expansive soils, soil uplift pressure, P, in pounds per square foot (psf) is expressed as: P = 100×PI – 1000. Discuss why P increases with increasing PI. (4 points)

4.

A. Using mass and volume parameters defining the three phase soil model derive an algebraic expression for dry density, ρ_d in terms of degree of saturation, S, specific gravity, G_s and water content, w. (4 points)

B. Standard Proctor Compaction Test results give us the Compaction Curve and the Zero Air Voids Curve. Based on the above two curves, sketch the variation of degree of saturation with water content you would observe for a well-graded sandy soil. (4 points)

C. A clayey soil when compacted wet of optimum moisture content forms a dispersive structure. Discuss the validity of this statement; state your reasons. (4 points)

D. Figure B4 shows how Dry Density varied with depth when a 240cm lift height was compacted using a 5670kg roller operating at 27.5Hz (after D'Appolonia, et al., 1969). If specifications expect you to maintain a relative density (i.e. Relative Compaction) of 80%, compute the lift height (as compacted) for 5 and 15 roller passes, respectively. State the number of roller passes you would select for the said compaction; state your reasons. (4 points)

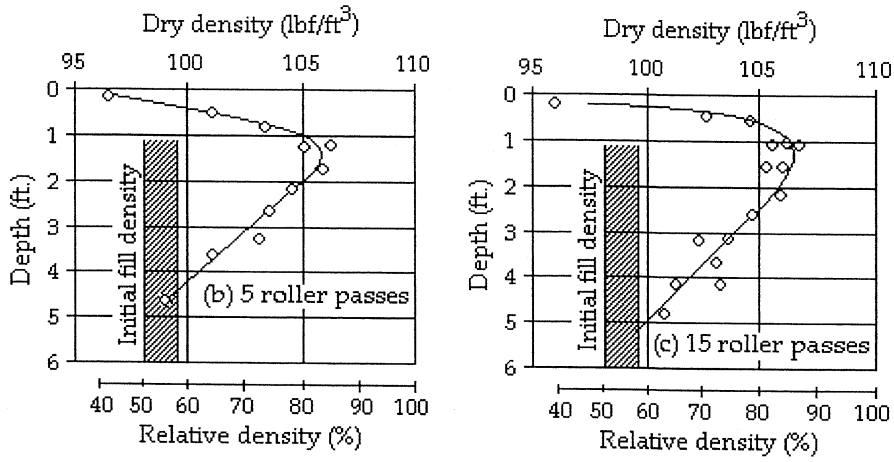


Figure B4

5. Figure B5 shows stress-strain and volume change behaviour of a dense sandy soil observed during a conventional triaxial loading test.

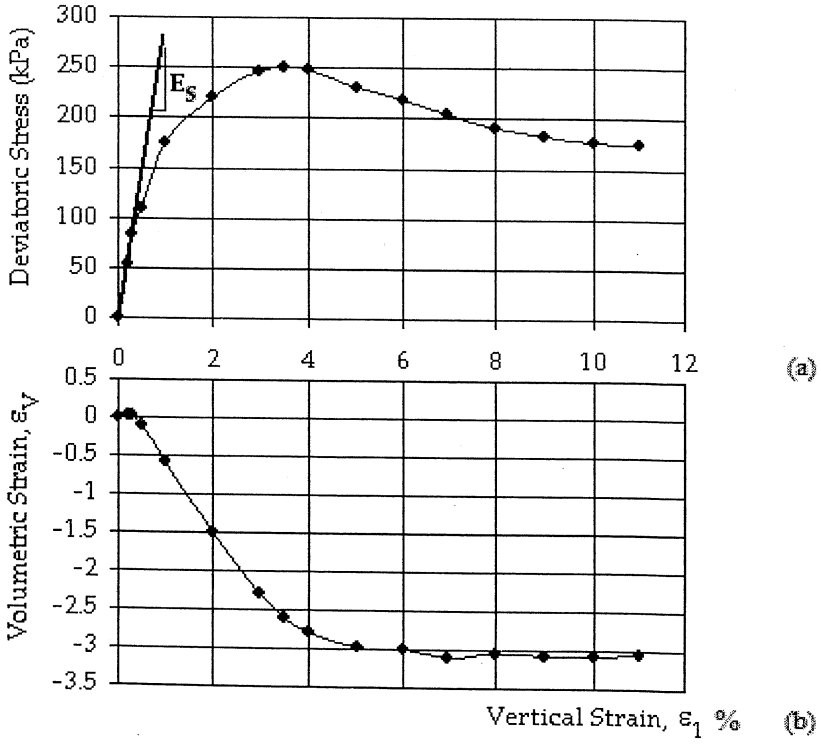


Figure B5

A. State the type of conventional triaxial loading test that yields above results; justify your response. (4 points)

B. Compare stress-strain behaviour shown in Figure B5(a) with the stress-strain behaviour of steel. (4 points)

C. Compute Modulus of Elasticity (refer Figure 5B) in Mega Pascals. Describe a field application where Modulus of Elasticity of soil is used. (4 points)

D. Explain how the specimen (refer Figure 5B) changes its volume when the Deviatoric Stress is increased from zero to its residual value. (4 points)

6.

A. Figure B6A below shows General Shear Failure condition as described in Vesic (1973). The ultimate bearing capacity for a square or rectangular footing is expressed as

$$q_u = \left[1 + 0.3\frac{B}{L}\right] cN_c + \gamma D N_q + 0.5\gamma B N_\gamma \left[1 - 0.2\frac{B}{L}\right].$$

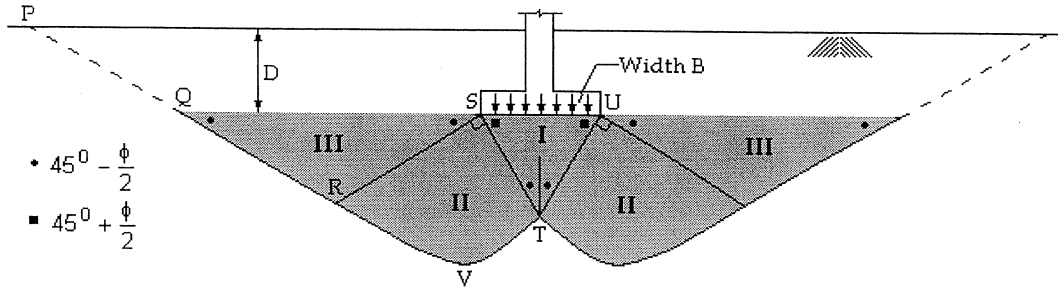


Figure B6A

i. Describe the states of stress and possible deformations in zones I, II and III when the footing load is increased to a maximum value, causing bearing capacity failure (4 points)

ii. Discuss the ultimate resistance represented by the term $\gamma D N_q$ in the above equation. (2 points)

iii. Explain Net Ultimate Bearing Capacity. (2 points)

B. Figure B6B shows a slope to be excavated on a saturated clayey soil.

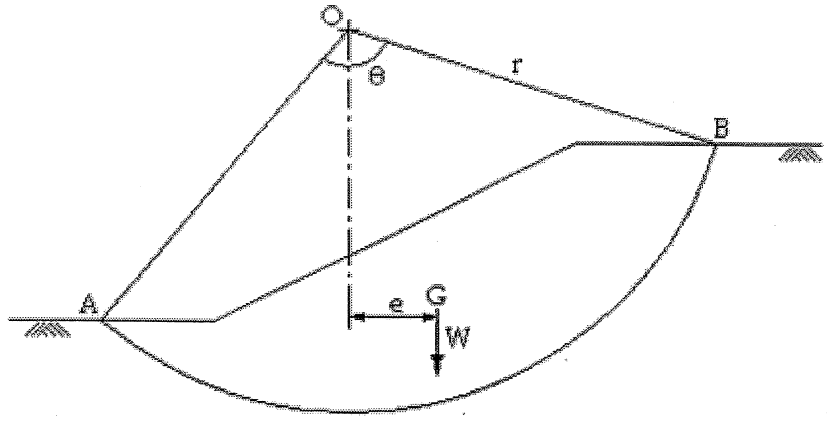


Figure B6B

i. Suppose that you are requested to perform an undrained analysis in order to determine its safety at end of excavation, explain how you would compute the overturning and restoring moments. (4 points)

ii. State how you would experimentally determine strength parameters to be used in this analysis. (4 points)