00198

THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (CIVIL) – LEVEL 04
Final Examination 2015/2016
CEX4230 – SOIL MECHANICS AND INTRODUCTION TO ROCK MECHANICS

Time allowed: Three Hours. Index No. _____

Date: Saturday, 10th December, 2016 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)

Questions 1 – 2

An undisturbed clay specimen has following properties: e = 0.75; w = 15%; G_s = 2.72.

1. The dry unit weight in kN/m^3 is:

   a. 15.25 b. 15.93 c. 16.23 d. 16.53 e. 17.37 a b c d e

2. The degree of saturation (%) is:

   a. 49.3 b. 51.3 c. 54.4 d. 57.1 e. 59.5 a b c d e

3. The equation $S = \frac{wG_s}{e}$ represents the phase relationship in an engineering soil. Which of the following statements are true?

   A. G_s is a dimensionless parameter.
   B. Parameter e always represents values between 0 and 1.
   C. S quantifies the fraction of water present in voids.
   D. Parameter w always represents values between 0 and 1.

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

4. Which of the following statements are true?

   A. At Liquid Limit, soil consistency changes from liquid to semi-liquid state.
   B. At Plastic Limit, soil consistency changes from semi-liquid to Solid state.
   C. If 13mm groove closure occurs at 30 blows, water content of the sample is more than its Liquid Limit.
   D. Liquid Limit of a soil varies with its natural moisture content.

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

5. Which of the following statements are true?

   A. A soil that shows a rapid dilatancy reaction has a high clay content.
   B. Plasticity Test measures soil's ability to adsorb water to clay minerals.
   C. A high plastic soil has a high thread toughness.
   D. A high plastic soil has a low Dry Strength.

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

6. Which of the following statements are true?

   A. 50g of mineral Kaolinite adsorbs less water than 50g of mineral Montmorrilonite.
   B. Plasticity Index is the water content range representing the semi-liquid state.
   C. A `SM' soil is a silty sand.
   D. A `CH' soil has a Plasticity Index greater than 50.

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

7. Which of the following statements are true regarding the Unconfined Compression Test?

   A. The test is performed on cohesive soils only.
   B. The test yields the shear strength parameter c'.
   C. The test gives a zero friction angle.
   D. The test is performed on fully saturated specimens only.

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

8. The Coefficient of Permeability was determined for a sandy soil. The specimen is 150cm long; the mould diameter is 15cm. A volume flow of 390cm^3 occurred within 80s, under a total head difference of 40cm. The Coefficient of Permeability measured in cm/s is:

   a. $1x10^{-4}$ b. $4x10^{-4}$ c. $1x10^{-3}$ d. $6x10^{-3}$ e. $1x10^{-2}$ a b c d e

9. In-situ bulk density of a field compaction was found to be 18.5 kN/m^3. Its natural moisture content was 14%. The maximum Proctor dry density was found to be 17.1 kN/m^3; at an optimum moisture content of 16.5%. Relative compaction achieved is:

   a. 85% b. 87% c. 91% d. 95% e. 97% a b c d e

10. Stresses acting on a soil element in two perpendicular directions x and y are: $\sigma_x = 360kPa$; $\sigma_y = 190kPa$; $\tau_{xy} = +75kPa$. The Minor Principal Stress is:

    a. 161.6 kPa b. 175.3 kPa c. 203.8 kPa d. 275 kPa e. 388.4 kPa
    a b c d e

11. Which of the following statements are true regarding the Hydrometer Test?

    A. Meniscus correction is sensitive to temperature changes.
    B. Percentage passing is computed based on the mass of solids settled at the bottom.
    C. Settling velocity depends on the viscosity of water in the soil solution.
    D. The test enables us to determine the percentage clay fraction.

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

12. Which of the following statements are true regarding the 1-D Consolidation Test?

    A. Mass of water at end of test is required to determine the initial void ratio.
    B. It is assumed that the initial degree of saturation is equal to 1.
    C. The initial void ratio is computed based on an assumed G_s value.
    D. The smallest division of the settlement dial gauge is 0.002mm.

    a. A and B only b. B and C only c. C and D only d. A and D only e. A and C only
    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. Table 1 gives the particle size distribution for a fine-grained soil.

Table 1

Particle Size (mm)	Percentage passing
20	100
6.3	97
2.0	92
0.6	80
0.425	78
0.212	74
0.1	65
0.063	55
0.040*	31
0.020*	19
0.010*	13
0.005*	10
0.002*	7
0.001*	2

Natural water content = 18%
Liquid Limit = 35
Plastic Limit = 28

*Hydrometer test results

A. Plot the above data on the semi-log graph sheet provided. (4 points)

B. Determine the percentage fractions of gravel, sand, silt and clay based on the total weight of specimen. (2 points)

C. Determine the group symbol based on MIT Soil Classification System. .....(4 points)

D. State the Soil Description. (2 points)

E. Discuss the results you would expect for Dry Strength, Dilatancy Reaction, Toughness of soil thread near Plastic Limit, and Plasticity. (2 points)

F. Describe its compressibility characteristics. (2 points)

2.

A. Table 2A below states properties of three important clay mineral types. Discuss Liquid Limit and Plasticity Index values you would expect for the three clay mineral types. State your reasons. (4 points)

Table 2A

Type	SSA (m^2/g)	Thickness (μ)	Lateral dimensions (μ)
Kaolinite	15	0.1-1	1-20
Illite	80	0.05-0.5	1-5
Montmorillonite	800	0.01-0.05	1-5

B. Define Rock Quality Designation. A particular rock stratum gave a RQD range between 50-75%. Discuss the nature of the said stratum. (4 points)

C. Discuss the reasons for a capillary fringe being formed in a granular soil, above its ground water table level. (4 points)

D. Fig. 2D compares the influence of stress distribution when a shallow footing is placed at depth D from the surface. Discuss reasons for the observed change. (4 points)

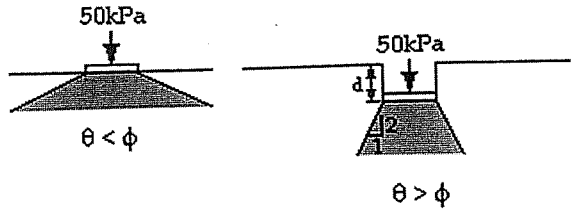


Fig. 2D

3.

A. Fig. 3A shows piston-spring analogy used to explain the One-dimensional Consolidation Process. Explain the drained and the undrained loading situation of a clay stratum using the said analogy. (4 points)

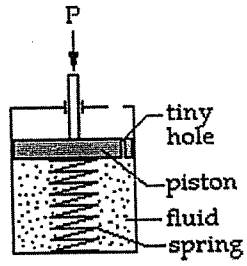


Fig. 3A

B. Show how the initial degree of saturation is computed based on measurements made during the One-dimensional Consolidation Test. (4 points)

C. Explain how hydrometer reading taken at a given time is used to compute i) particle size and ii) the percentage finer corresponding to the said particle size. (4 points)

D. An Unconfined Compression Test is performed on a saturated clay specimen. Compute the normal stress and shear stress acting on a 30^0 plane, measured from the horizontal plane, in the clockwise direction. The corresponding deviatoric stress is 40kPa. (4 points)

4.

A. Angle of repose is the steepest angle of dip measured from a horizontal planer surface. Discuss the influence of physical properties on the angle of repose of a i) dry sandy soil and a ii) moist sandy soil. (4 points)

B. The factor of safety of a circular slip circle is expressed as $F_s = \frac{c + \sigma' \tan\phi}{c_d + \sigma' \tan\phi_d}$. Define the terms given in this equation. (3 points)

The slope shown in Fig. 4 needs to be checked for stability. AC represents a trial failure plane. The soil properties of wedge ABC are $\gamma = 18kN/m^3$, $\phi = 20^0$, and $c = 20kN/m^2$.

C. Compute the force that causes instability along plane AC. (4 points)

D. Compute the force that resists sliding along plane AC. (3 points)

E. Compute the factor of safety against sliding. (2 points)

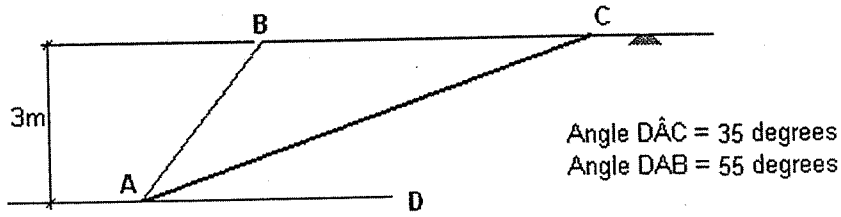


Fig. 4

5. Fig. 5 shows a saturated clay soil element located at a depth of 5m from the soil surface.

   A. If this soil element is at `at rest' state, determine its horizontal effective principal stresses. (2 points)

   B. Sketch the Mohr's circle of stress representing the soil element, on a τ vs. σ'_n plot. Show principal values. (2 points)

   C. Sketch the line representing Mohr-Coulomb failure criterion on the same figure. (1 point)

   D. Compute the normal and shear stresses acting on a plane that has a clockwise inclination of 35^0 with respect to the horizontal plane. (3 points)

   E. Explain whether the shear stress acting on any such plane of the soil element is considered `safe'. (2 points)

   F. Suppose that the wall moves to the left causing the soil mass to attain an active Rankin state of plastic equilibrium. Sketch the Mohr's circle of stress corresponding to this state on the same figure. (1 points)

   G. Determine the active earth pressure acting on the soil element. (3 points)

   H. Determine the angle, which the failure plane makes with the horizontal plane. (2 points)

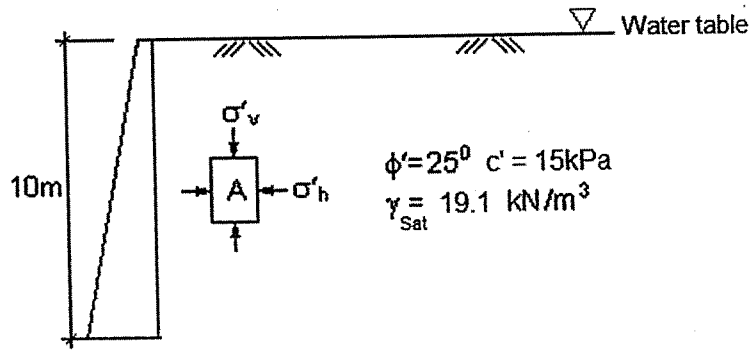


Fig. 5

6. A strip footing is to be designed for a two-story house that is founded on a sandy soil (refer Fig. 6). The Standard Penetration Test N at the base level is estimated at 12; the average SPT N over its excavated depth is 8.

   A. Compute the net ultimate bearing pressure available to carry the super-structure load. (4 points)

   B. Compute the factor of safety against ultimate failure if the super-structure load gives rise to a bearing stress of 55 kPa. (4 points)

   C. Check whether the footing width satisfies a maximum settlement of 25mm. (4 points)

   D. State all assumptions you have made when responding to above sections. (4 points)

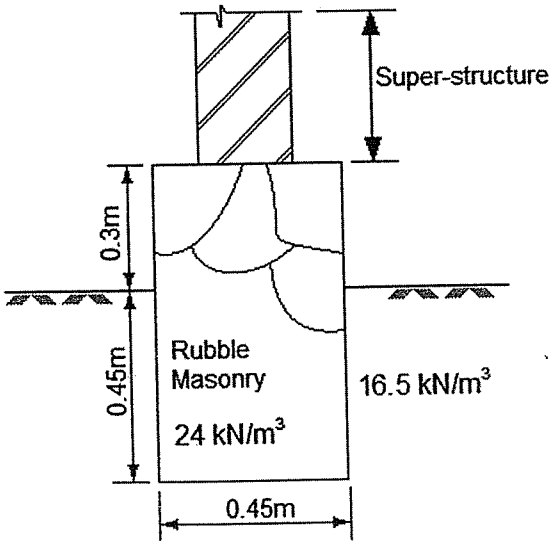
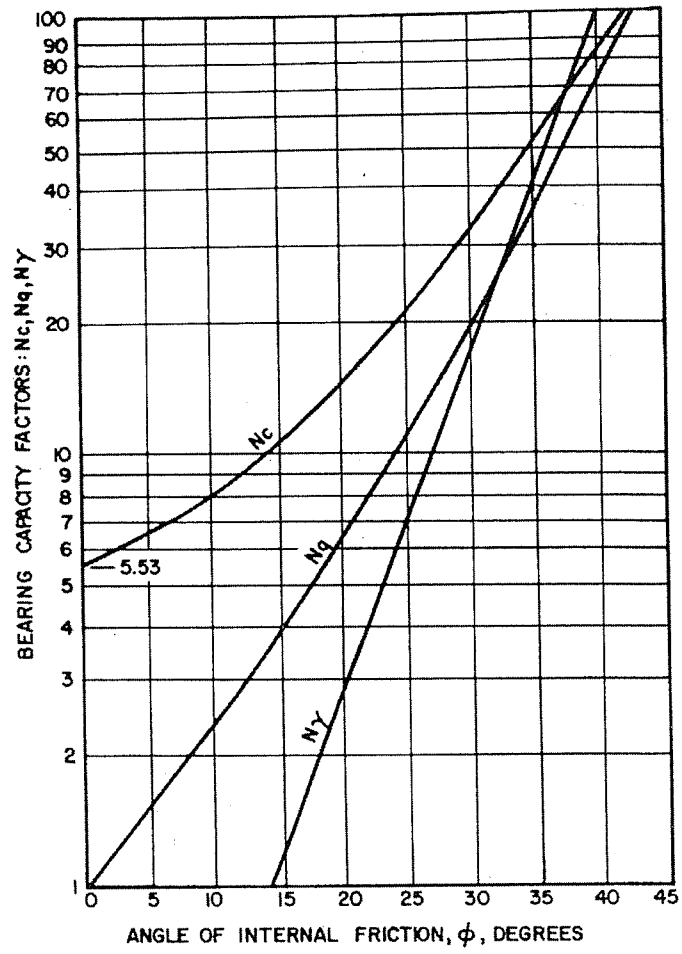
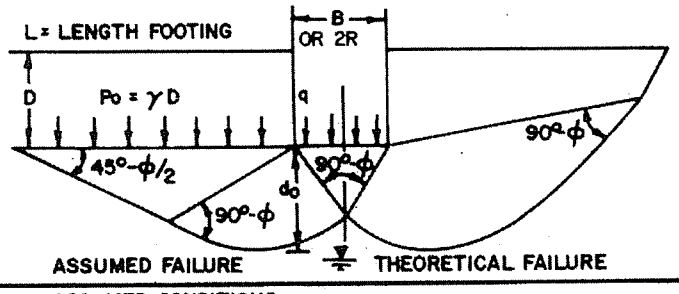


Fig. 6





ULTIMATE BEARING CAPACITY = q_{ult}

CONTINUOUS FOOTING; GENERAL CASE

$q_{ult} = q' + q''$

q' = PORTION OF BEARING CAPACITY ASSUMING WEIGHTLESS FOUNDATION SOIL

q'' = PORTION OF BEARING CAPACITY FROM WEIGHT OF FOUNDATION SOILS

$q' = cN_c + \gamma DN_q$

$q'' = \gamma \frac{B}{2} N\gamma$

$q_{ult} = cN_c + \gamma DN_q + \frac{\gamma B}{2} N\gamma$

SQUARE OR RECTANGULAR FOOTING

$q_{ult} = cN_c\,(1+.3\frac{B}{L}) + \gamma DN_q + 0.4\gamma BN_\gamma$

CIRCULAR FOOTING: R = B/2

$q_{ult} = 1.3\,cN_c + \gamma DN_q + 0.6\gamma RN_\gamma$

FOR COHESIONLESS FOUNDATION SOILS (c = 0)

CONTINUOUS FOOTING:

$q_{ult} = \gamma DN_q + \frac{\gamma B}{2} N\gamma$

SQUARE OR RECTANGULAR FOOTING:

$q_{ult} = \gamma DN_q + 0.4\gamma BN_\gamma$

CIRCULAR FOOTING:

$q_{ult} = \gamma DN_q + 0.6\gamma RN_\gamma$

FOR COHESIVE FOUNDATION SOILS ($\phi = 0$)

CONTINUOUS FOOTING:

$q_{ult} = cN_c + \gamma D$

SQUARE OR RECTANGULAR FOOTING:

$q_{ult} = cN_c(1+.3\frac{B}{L}) + \gamma D$

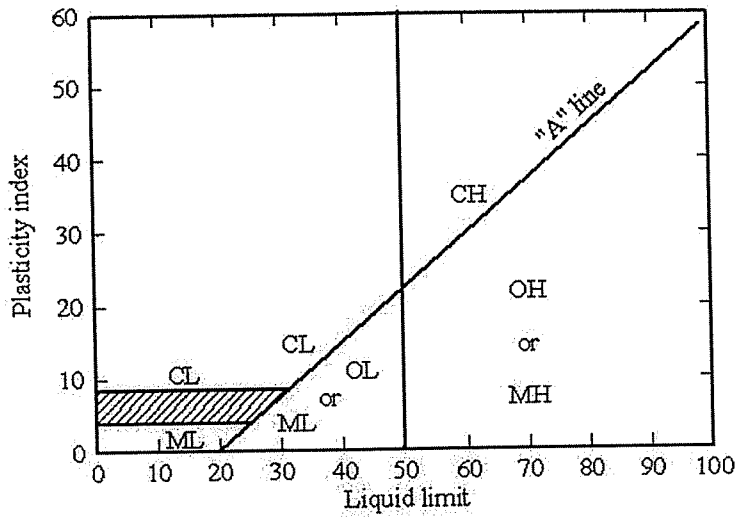
CIRCULAR FOOTING:

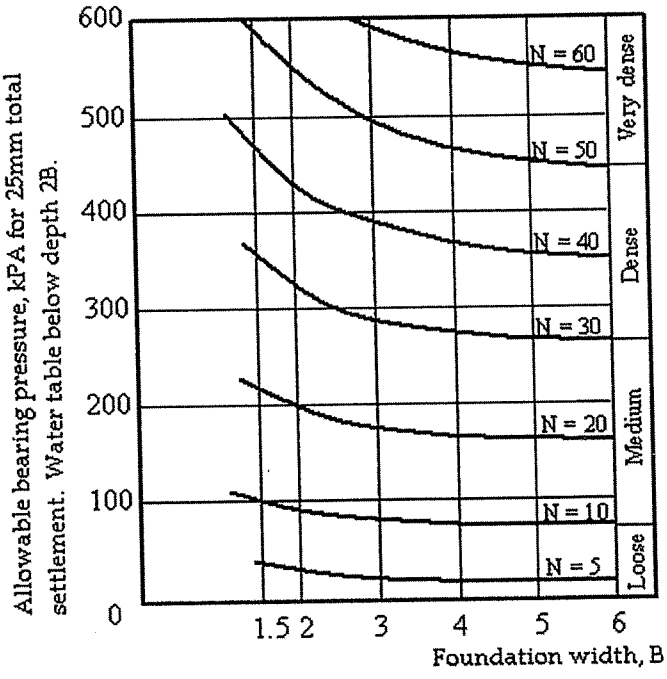
$q_{ult} = 1.3\,cN_c + \gamma D$

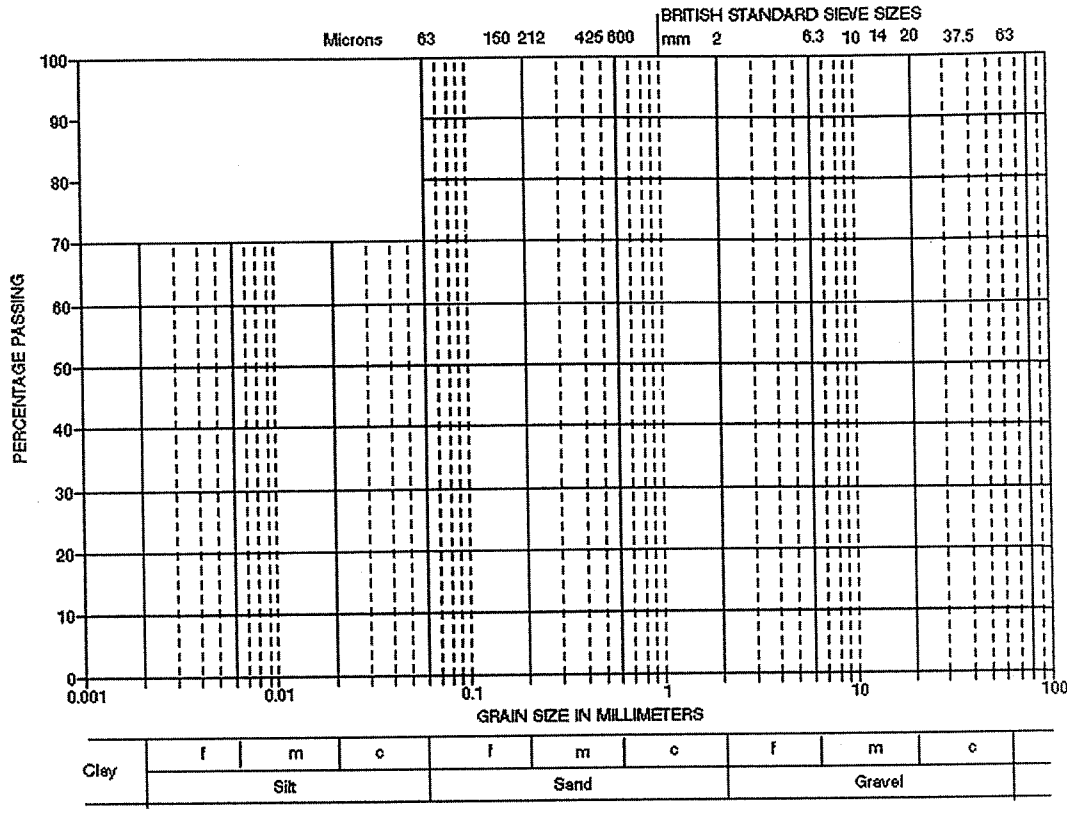
ASSUMED CONDITIONS:

1. $D \leq B$
2. SOIL IS UNIFORM TO DEPTH $d_o > B$.
3. WATER LEVEL LOWER THAN d_o BELOW BASE OF FOOTING.
4. VERTICAL LOAD CONCENTRIC.
5. FRACTION AND ADHESION ON VERTICAL SIDES OF FOOTING ARE NEGLECTED.
6. FOUNDATION SOIL WITH PROPERTIES c, ϕ, γ

FIGURE 1
Ultimate Bearing Capacity of Shallow Footings With Concentric Loads


Plasticity index
Liquid limit
"A" line
CH
OH
or
MH
CL
CL
OL
or
ML
ML
0
10
20
30
40
50
60
70
80
90
100


Allowable bearing pressure, kPA for 25mm total settlement. Water table below depth 2B.
Foundation width, B
N = 60
N = 50
N = 40
N = 30
N = 20
N = 10
N = 5
Very dense
Dense
Medium
Loose
600
500
400
300
200
100
0
1.5
2
3
4
5
6


BRITISH STANDARD SIEVE SIZES
Microns 63 150 212 425 600
mm 2 6.3 10 14 20 37.5 63
PERCENTAGE PASSING
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
100
GRAIN SIZE IN MILLIMETERS
Clay
f
m
c
f
m
c
f
m
c
Silt
Sand
Gravel