Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	ADVANCED GEOTECHNIC
COURSE CODE	:	BFG 40203
PROGRAMME	:	4 BFF
EXAMINATION DATE	:	DECEMBER 2014 / JANUARY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1(a) Differentiating clearly between plane strain and plane stress conditions, explain with appropriate examples the statement "Most geotechnical problems can be simplified into a two dimensional form using the concepts of plane strain and plane stress loading".

(5 marks)

(b) Show that, the Mohr-Coulomb concept defines the triaxial principal stresses on an axisymmetric soil sample at failure by the equation given below, where C and $\emptyset$ are the classical Coulomb shear strength parameters of the soil.

$$\sigma_1 = \sigma_3 N_\emptyset + 2C\sqrt{N_\emptyset}$$

$$where\ N_\emptyset = tan^2\left(45 + \frac{\emptyset}{2}\right)$$

(8 marks)

(c) The table below gives observations recorded at failure in two consolidated undrained triaxial tests carried out on two undisturbed specimens of the same saturated clay (Specific Gravity, $G_s = 2.65$):

Specimen	Consolidation Stage		After shearing to failure		
	Cell Pressure (kPa)	Back Pressure (kPa)	Axial Stress (kPa)	Pore Water Pressure (kPa)	Water Content (%)
1	100	0	179.2	38.3	26.7
2	200	45	343.0	88.5	23.3

Indicating your assumption/s, determine the critical state and classical geotechnical parameters M, Γ, λ, C and Φ for the above clay soil and comment on its geological history.

(12 marks)

Q2 (a) With the aid of a clearly labelled illustration, define the terms

(i) Initial Stiffness,

(ii) Tangent Modulus, and

(iii) Secant Modulus

Briefly explain the significance of the knowledge of these in geotechnical engineering.

(4 marks)

(b) Indicating your assumptions and using the expressions involving Elasticity parameters for the linear strains in the x, y and z directions of a stressed three dimensional soil element;

(i) Derive an expression for the "bulk modulus" of a soil in terms of the elasticity parameters.

(4 marks)

(ii) Show that for the case of a saturated soil, the undrained Poisson's ratio, ν_u is equal to 0.5.

(4 marks)

(iii) Write down the soil structure constitutive equation for uniaxial loading of an unsaturated soil in terms of matric suction

(3 marks)

(c) When a (38 mm diameter, 76 mm long) saturated cylindrical soil specimen is uniaxially compressed by 5 mm, the specimen radius increased by 0.3 mm. Calculate the axial, radial and volumetric strain and the Poisson's ratio.

(4 marks)

(d) The table shows observations made during the shearing stage of a consolidated undrained triaxial test of a specimen of silty clay that was initially consolidated isotropically to a cell pressure of 100 kN/m^2

Axial Strain (%)	Deviator Stress (kN/m^2)	Pore Water Pressure (kN/m^2)
0	0	0
0.05	5.5	4.0
0.12	11.0	8.6
0.29	24.5	19.1
0.38	28.5	29.3
0.56	35.0	34.8
1.08	50.5	41.0
2.43	85.0	49.7
4.02	105.0	55.8
9.15	120.8	59.0

Determine: (i) the stress and strain at failure

(ii) tangent modulus at 50% failure strain,

(iii) secant modulus at failure

(6 marks)

Q3 (a) With the aid of suitable sketches, describe the following and their relevance to geotechnical engineering in unsaturated soils.

(i) Volume – mass properties of unsaturated soils

(3 marks)

(ii) Soil water characteristic curve (SWCC)

(3 marks)

(b) Explain with sketches how the SWCC and soil suction is sensitive to the grading / type of soil.

(3 marks)

(c) Describe briefly with appropriate illustrations how the concepts of unsaturated soil mechanics can help explain certain phenomena peculiar to the following geotechnical situations.

(i) Design and construction of earth dams.

(ii) Compaction of soils and highway engineering

(iii) Slope failures in residual soils subjected to environmental changes

(iv) Coefficient of earth pressure at rest with varying matric suction

(8 marks)

(d) A lateritic soil (specific gravity = 2.70) , becomes saturated after a heavy continuous rainfall and has an equilibrium water content of 50%. After a couple of days of heat wave, shrinkage cracks appear in the soil. The average water content and degree of saturation of the near surface (<100 mm) of the ground was observed to have fallen to 20% and 10% respectively. Making suitable assumptions calculate the volumetric shrinkage in the soil due to the drying shrinkage. What are the engineering implications of such shrinkage cracking in geotechnical engineering and what field instruments would you suggest be used to monitor such effects?

(8 marks)

Q4(a) With suitable illustrations, explain briefly the geotechnical differences between any **THREE (3)** of the following pairs of terms;

(i) Dilatancy and swelling of soils

(ii) Elastic and Elasto plastic behaviour

(iii) Strain hardening and strain softening

(iv) Yield function and plastic potential function

(v) Stress path and Strain path testing

(3 x 4 = 12 marks)

(b) Outline the procedure of carrying out a consolidated drained direct shear test on an unsaturated soil specimen. A labelled diagram must be given indicating particularly the features that are unique to the modified direct shear box.

(6 marks)

(c) Table below are the observations from a modified direct shear test on a 60mm x 60mm x 20mm unsaturated soil specimen.

Matric suction (kN/m^2)	Net normal stress (kN/m^2)	Shear stress (kN/m^2)
0	0	9
83.7	45	39.6
143.1	90	61.2
202.5	135	82.8
259.2	180	103.5
318.6	225	125.1
378	270	146.7

(i) Evaluate the shear strength of the soil if a matric suction and a net normal stress of 450 kN/m^2 and 495 kN/m^2 respectively is applied on the test specimen.

(3 marks)

(ii) If on the other hand, what will be the shear strength if the soil is fully saturated

(3 marks)

Q5 (a) Giving examples and making reference to common physical modelling principles, critically discuss the statement that "Though physical modelling has been successfully adopted within reason in the fields of hydraulic and structural engineering, it cannot be readily adopted in geotechnical engineering ". Give reasons why this is the case and describe some of the principles of innovative geotechnical modelling and field testing.

(9 marks)

(b) "Classical soil mechanic theories provided only a working platform of hypothesis and are bound by all the assumptions upon which the theories were based to minimize the contradictions between theory and practice."
Critically discuss the assumptions in Terzaghi's one dimensional consoilidation theory, giving examples where such assumptions are controversial and a closer review must be made.

(8 marks)

(c) Discuss the pros and cons of the impact of advances in Sensor technology and Software development that are relevant to geotechnical engineering. Use examples from the experience gained in your study of the geotechnical software models.

(8 marks)

-END OF QUESTIONS-