FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF MINING ENGINEERING

ROCK MECHANICS

EMI 3201

Final Examination Paper

June 2020

This examination paper consists of 6 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Mr D. Chawira

INSTRUCTIONS

1. This paper contains One section with Five questions
2. Answer Question **One** (28 marks) and any other **Three** questions (24 marks each)
3. Where a question contains subdivisions, the mark value of each subdivision is shown in brackets.
4. Start each question on a new page

NB: DO NOT TURN OVER THE QUESTION PAPER OR COMMENCE WRITING UNTIL INSTRUCTED TO DO SO

Additional Requirements

Non-Programmable Calculator, Graph Papers, Mathematical set

MARK ALLOCATION

Question 1	**28Marks**
Question 2 to 5	**24Marks**
Total Attainable Marks	**100**

Question 1 (28 marks)

a. Briefly describe how the triaxial compression test on core samples is performed in a laboratory and state three useful information that can be obtained from the test. **[10 marks]**

b. A series of triaxial compressive tests on specimens of slate gave the following results

σ_3 MPa	σ_1 MPa	α^o (cleavage plane inclination)
2.0	62.0	40
5.0	62.5	32
10.0	80.0	37
15.0	95.0	39
20.0	104.0	27

In each of the tests carried out failure occurred along the cleavage plane and failure was in shear. Determine the shear strength criterion for the slate **[5 marks]**

c. Triaxial compression tests of a porous sandstone rock yields cohesion *c* equal to 1.17 MPa and angle of internal friction $\emptyset = 40^0$. Calculate:

i. Unconfined compressive strength and estimate the tensile strength for this rock. **[4marks]**

ii. The value of pore water pressure P_w that will cause fracture of the sandstone in-situ (assume fracture occurs at peak stress) if P_w will be raised by the construction of a reservoir. The initial state of stress at a point in this rock mass is σ_3 = 8.96 MPa and σ_1 = 34.48 MPa. **[6marks]**

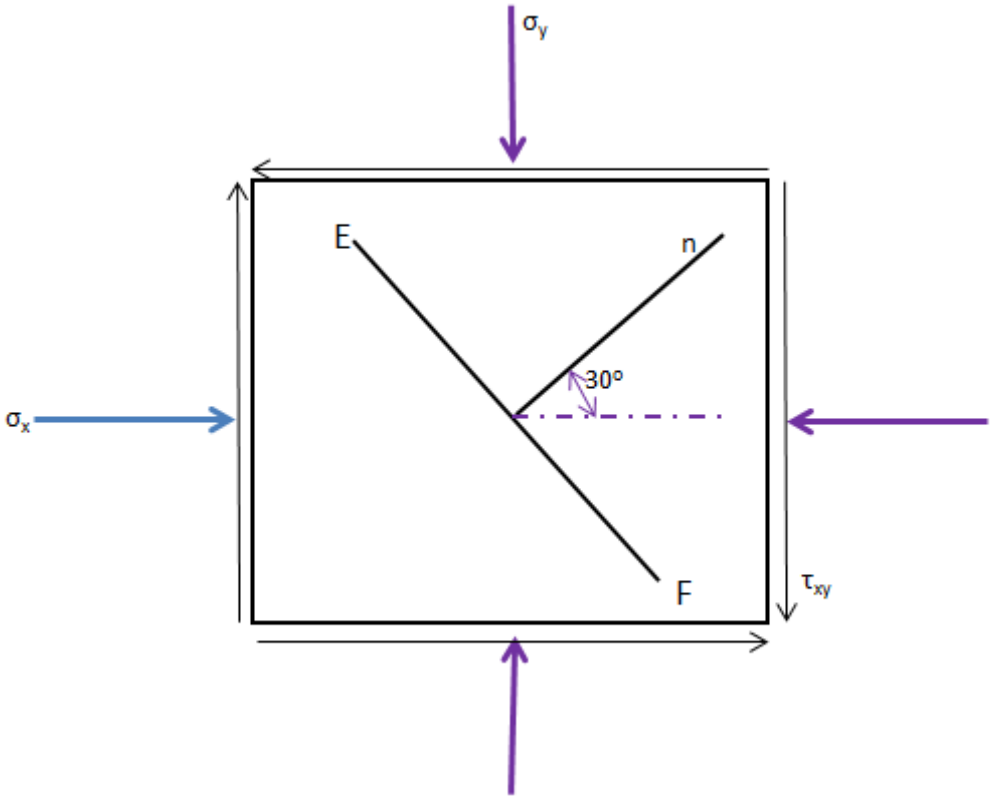
iii. What is the value of principal stress ratio σ_3/σ_1 above which "failure" cannot occur? **[3marks]**

Question 2 (24marks)

Give a brief description of the four factors that affect the in-situ state of stress. **[24 marks]**

Question 3 (24marks)

a. The element shown in the figure below is subject to triaxial loading with stress components given by σ_x = 12MPa, σ_y=20MPa, τ_{xy}=8MPa



i. Construct the Mohr's circle diagram representing this state of stress. **[6 marks]**

ii. Determine, **from the diagram**, the magnitude of the principal stresses, and the inclination of the principal axis relative to the x reference direction. **[4 marks]**

iii. Determine, **from the diagram**, the normal and shear stress components σ_n and τ_{nm} on the EF plane oriented as shown. **[4 marks]**

b. The following strain components were measured at a point in a rock

$\varepsilon_x = 0.003$ $\varepsilon_y = 0.00012$ $\gamma_{xy} = 0.0005$

Determine the principal stresses in the x-y plane given that the modulus of elasticity is 72 GPa and the Poisson's ratio is 0.2. **[10 marks]**

Question 4 (24 marks)

a. Give three (4) conditions of rock masses that the Hoek-Brown criterion can be used. **[4marks]**

b. The generalized Hoek-Brown failure criterion given below was used in Phase**2D** numerical software program for stress and displacement evaluations in a tunnel construction project.

$$\sigma'_1=\sigma'_3+\sigma_{ci}\left[m_b\frac{\sigma'_3}{\sigma_{ci}}+s\right]^a$$

i. Identify each parameter in the failure criterion **[5marks]**

ii. As the Geotechnical Engineer working on the project, briefly describe how you would determine the following parameters for you to be able to satisfactorily run your model in the software:

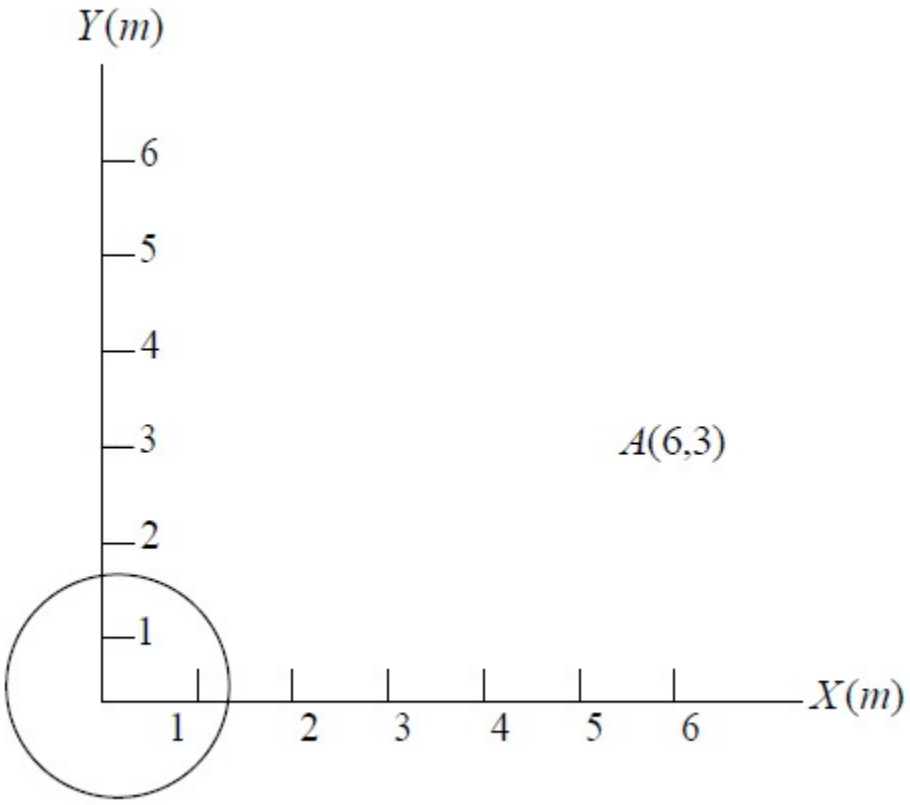
- σ_{ci}, **[5marks]**
- m_b, s and a. **[10marks]**

Question 5 (24 marks)

A Horizontal tunnel 3m in diameter is bored into competent rock as shown in the diagram below. The depth of the tunnel is 200m and the horizontal to vertical stress ratio, **k** is 0.3

(i) If the density of the rock is 2650kg/m^3, determine the virgin vertical stress, **q** and the virgin horizontal stress, **kq** at the site of the tunnel. **[4 marks]**

(ii) Assuming that the stresses are elastically distributed, where will the maximum compressive and tensile stresses occur and how large are, they? **[6 marks]**



$$\sigma_r = \frac{1}{2}q(1+k)\left(1-\frac{R^2}{r^2}\right)-\frac{1}{2}q(1-k)\left(1-\frac{4R^2}{r^2}+\frac{3R^4}{r^4}\right)\cos 2\theta$$

$$\sigma_\theta = \frac{1}{2}q(1+k)\left(1+\frac{R^2}{r^2}\right)+\frac{1}{2}q(1-k)\left(1+\frac{3R^4}{r^4}\right)\cos 2\theta$$

$$\tau_{r\theta} = \frac{1}{2}q(1-k)\left(1+\frac{2R^2}{r^2}-\frac{3R^4}{r^4}\right)\sin 2\theta$$

(iii) Determine the state of stress acting in the rock at a point **A** in an r,θ coordinate system.

[6 marks]

(iv) Draw the Mohr circle representation of the stresses acting at a point A and from the Mohr circle determine the magnitudes and the directions of the principal stresses and sketch their orientation at point **A**. **[8 marks]**