MUZAFFARPUR INSTITUTE OF TECHNOLOGY, MUZAFFARPUR
B.Tech 6th Semester Mid-Term Examination, 2019
Soil mechanics and Rock Mechanics (011X15)

Time: 2 hours **Full Marks: 20**

Instructions: (i) Attempt any four questions. Attempt at least one question from group A and B.
(ii) Question No. 1 is compulsory.
(iii) All questions carry equal marks.

1. Chose the correct option of the following

(a) For triaxial test which of the following statement is true

i. Stress act from only two direction
ii. $\sigma_1 = \sigma_3 \neq \sigma_2$
iii. $\sigma_1 \neq \sigma_3 = \sigma_2$
iv. $\sigma_1 = \sigma_3 = \sigma_2$

(b) In which of the following shear strength test volume change behavior cannot be measured

(i) Triaxial compression test
(ii) Direct shear test
(iii) Vane shear test
(iv) (i) and (ii) both

(c) According to the 'Mohs Scale' hardness of chalk is considered as

(i) 10
(ii) 9
(iii) 2
(iv) 1

(d) As per geological classification sandstone is considered as

(i) Hard Rock
(ii) Metamorphic rock
(iii) Igneous Rock
(iv) Sedimentary rock

(e) Unconfined shear strength can be written as

(i) Equal to cohesion
(ii) Equal to unconfined compressive strength
(iii) Twice of cohesion of soil
(iv) None of these

Group A

2. Explain the friction circle method used for stability analysis of slope.
3. A 3m high retaining wall is supporting a saturated sand (saturated due to capillary action) of bulk density 18 kN/m^3 and angle of shear resistance 30^o. What will the change in magnitude of active earth pressure at the base due to rise in ground water table from the base of the footing to the ground surface?
4. Write short notes on direct shear test. Also plot the stress strain behavior of the dense and loose soil. Also draw the variation of the tangent modulus with strain for both type of soil.

Group B

5. What do you mean by rock and minerals? Explain the classification of the rock on the basis of geological origin.
6. Explain the method to find out the uniaxial stress-strain behavior of rock. Fig. Q6 shows uniaxial stress-strain behavior of different rocks. Give your specific comments/observation on the stress-strain behavior shown.
7. Write short notes on the application of rock mechanics in civil engineering construction.

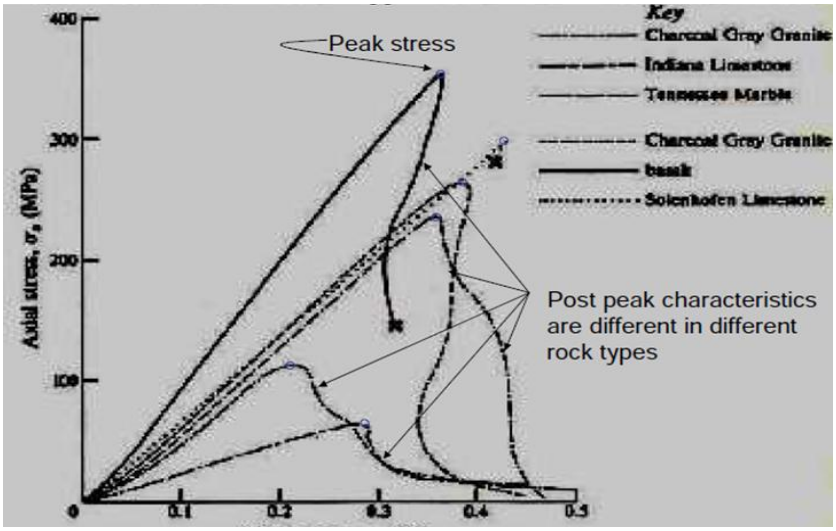


Figure Q6

Solution

Question 1.

a. iii

b. iv

c. iv

d. iv

e. i

Question 2.

11.11 FRICTION CIRCLE METHOD

This method is based on *total stress analysis*, but it enables the angle of shearing resistance to be taken into account. It should be noted that some soils, such as saturated silts and unsaturated clays, do exhibit a ϕ value under undrained conditions.

The friction circle method also assumes a circular slip surface. Fig. 11.12 shows a slope with a trial slip surface in the form of a circular arc of radius R with its centre at O. The three forces which are considered in the equilibrium of the sliding mass $ABCA$ are: the weight W of the sliding mass, the total frictional force P (or the resultant reaction P) on the slip surface and the cohesive resistance C along the slip surface.

Let the slip circle are AC ($= L$) be considered to be made up of a number of elementary arcs of length ΔL. The elementary cohesive force acting along this element of length ΔL opposing the probable movement of the soil mass is $c_m\ \Delta L$. c_m is the unit mobilised cohesion which is assumed to be constant along the slip surface. The total cohesive force is considered to be made up of elementary cohesive forces $c_m\ \Delta L$ representing a force polygon, the closing link of which must represent the magnitude and direction of the resultant cohesive force. If L_c is the length of the chord AC, the magnitude of the resultant cohesive resistance is $c_m\ L_c$. The

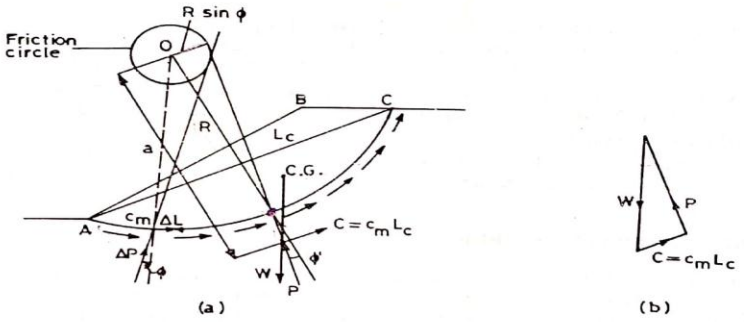


Fig. 11.12 Friction circle analysis and the force triangle

position of the resultant $c_m L_c$ is determined by equating the sum of the moments of all the elementary cohesive forces along the slip circle about the centre of rotation O, to the moment of the resultant about O.

$$\Sigma c_m\ \Delta L\ R = (c_m\ L_c)\ a$$

or

$$c_m\ L\ R = c_m\ L_c\ a$$

Thus,

$$a = \frac{L}{L_c} \cdot R \qquad (11.21)$$

where a is the moment arm of the cohesive force $c_m\ L_c$. $a > R$ since $L > L_c$. The cohesive forces $c_m\ \Delta L$ acting along the slip surface can, thus, be replaced by their resultant $c_m\ L_c$ acting parallel to the chord AC at a distance a from the centre of rotation.

2. [redacted]

Question 3.

21. (a) Angle of shearing resistance,

$$\phi = 30°$$

Active earth pressure coefficient,

$$K_a = \frac{1-\sin\phi}{1+\sin\phi}$$

$$= \frac{1-\sin 30°}{1+\sin 30°} = \frac{1}{3}$$

Active earth pressure at the base,

$$P_a = K_a\sigma_z$$

$$= K a\gamma z$$

$$= \frac{1}{3} \times 18 \times 3$$

$$= 18 \text{ kN/m}^2$$

Active earth pressure at the base when water table is at the ground surface

$$Pa_2 = K_a\gamma_{sub} z + 1 \times \gamma_w \times z$$

$$= \frac{1}{3}(18-10)\times 3 + 10 \times 3$$

$$= 38 \text{ kN/m}^2$$

Change in earth pressure

$$= 38 - 18$$

$$= 20 \text{ kN/m}^2 \text{ (increase)}$$

Question 4.

Direct Shear Test

This test, also called the shear box test, is the oldest shear test that is in use and is also quite simple to perform. The soil specimen that is to be tested, is confined in a metal box of square cross-section that is split into two halves horizontally, a small clearance being maintained between the two halves of the box. If the specimen is fully or partially saturated, perforated metal plates and porous stones are placed above and below the specimen to allow free drainage. Solid metal plates are used if the specimen is dry. A pressure pad is placed on top and the entire box is placed in the trolley. The set-up is shown in Fig. 10.10. One half of the box is fixed and the other half is pushed or pulled relative to the fixed one. A vertical load is applied to the specimen through a

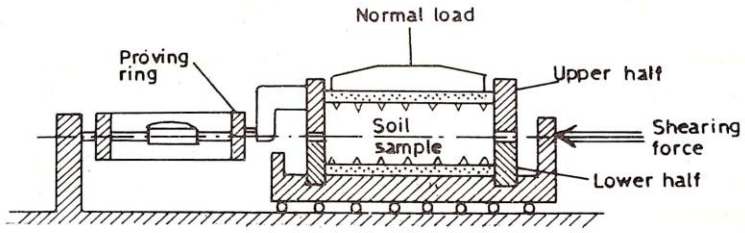


Fig. 10.10 Direct shear test

Question 5.

The term ‘Rock’ is broad term used for variety of the materials. In geology rock is defined as natural occurring material, which is essential part of earth crust, having distinct mineral properties. From engineering point of view rock is firm and coherent substance composed of crystalline and non-crystalline grains cemented together. Properties of the rock depend upon the different constituent minerals and on the formation process of the rocks.

Minerals are basically inorganic materials, which have specific structure and chemical composition. Calcite, Quartz, Chlorite, Hematite etc. are example of different minerals

Based upon the geology or origin rock can be classified in three major groups.

1. Igneous Rock
2. Sedimentary Rock
3. Metamorphic Rock

Based upon the formation process first category of rock is igneous rock, which forms by the solidification of the molten ‘magma or lava’ (Fluid having constituents silicates, water vapour and volatiles). It is also known as ‘Magmatic rock’. Granite, Basalt etc. are the examples of the Igneous rock.

Decomposition and disintegration of earth crust continuously occurs in nature continuously and formation of the sediments takes place. Sedimentary rocks are formed by the accumulation and cementation of the sediments.

Transformation of existing rock occurs continuously in nature due to the physical forces like high pressure, high temperature, high stresses etc. and it is known as ‘metamorphism’. Formation of metamorphic rocks takes place from igneous rock, sedimentary rock or other metamorphic rock through metamorphism.

Question 6.

Mechanical or Strength Properties of Rocks

Direct Method: It requires a preparation of sample as accordance to ISRM (International Society of RockMechanics).

Uniaxial compressive strength (UCS) of rock material and deformation behavior under loading is verified by applying compressive load until failure occurs in the core by a fracture in the middle using high capacity Compressive testing machines

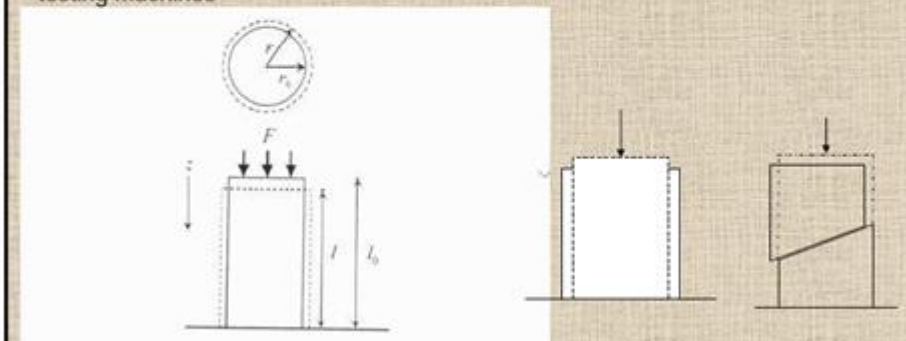


Figure 2-2. Deformation of a cylindrical specimen due to an external force (F) acting on the cylinder in a uniaxial direction. l_0 and r_0 are the initial length and radius of the cylinder, and l and r are the final length and radius of the cylinder.

Compressive Testing Machines

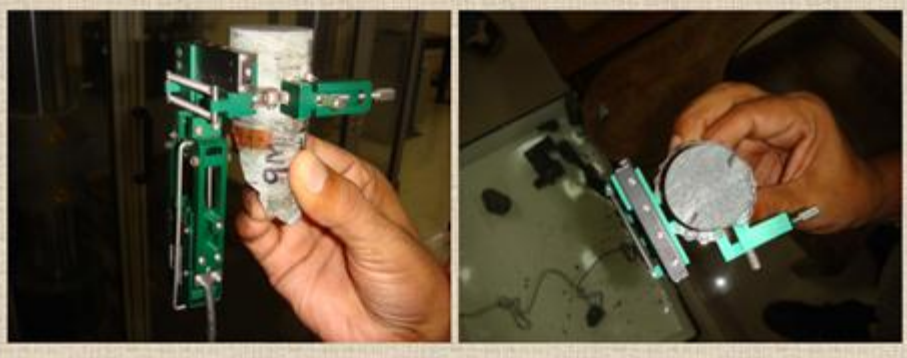
Universal Testing Machine Manual

INSTRAN Testing Machine

With UTM, the axial displacement w.r.t. load is to be recorded manually with the help of proving ring, while lateral deformation recorded using dial gauges or strain gauges coupled to LVDT,If provided.

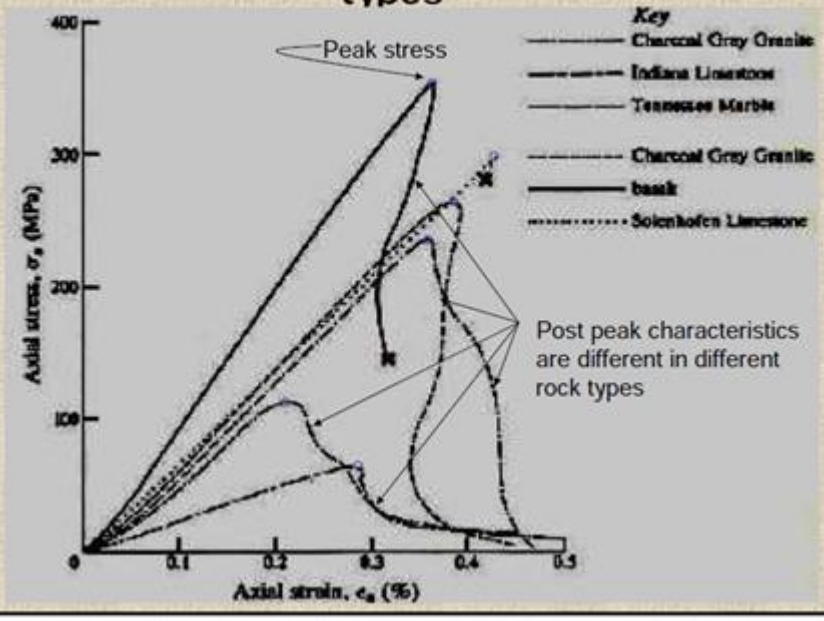
With Instran machine Displacement between Loading Platens will give axial displacement of the specimen under loading and directly get recorded in connected computer

Lateral displacement will be recorded in computer using the special attachment shown below or manually recorded using strain gauges coupled to LVDT



Lateral Displacement Measurement

Uniaxial stress-strain curves for different rock types



Question 7

Different application of rock mechanics can be summarized as follows.

- Construction of tunnel and underground space
- Selection of construction site as well as selection of layout of construction
- Selection of suitable construction materials
- Analysis of structures like embankment, foundation , slope etc. constructed over rock
- Selection and planning of of site investigation program
- Determination of rock properties through in-situ and laboratory testing
- Selection of excavation technique and design of blasting operation
- Designing and construction of support system
- For petroleum industry design of hydraulic fracturing and bore hole stability
- Study of excavation characteristics
- Study of rock deformation under high temperature and pressure
- For application of geothermal energy
- For management of nuclear wastes
- In construction of different structures like; Hydropower project, road construction, etc.
- Study of geological hazards, landslides, slope stability etc.