

LECTURE 4

2.3.2 MECHANICAL PROPERTIES

2.3.2.1 Uniaxial compression strength (UCS)

The uniaxial compressive strength is the value of compressive stress at which the specimen fails. The compressive strength is usually obtained by compression testing machine. This test is usually conducted in straight circular cylindrical having height to diameter ratio of 2.0- 3.0 and diameter preferably of not less than NX core size (approx. 54 mm). Figure 2.6 shows the laboratory testing for uniaxial compressive strength on cylindrical specimen. Load on the specimen shall be applied continuously at a constant stress rate such that the failure will occur within 5-10 minutes of loading. For practical consideration at least five numbers of tests are preferred. The unconfined compressive strength of the specimen shall be calculated by dividing the maximum load (peak failure load) carried by the specimen during the test, by the average original cross sectional area.



Figure 2.6: UCS test under progress with 200t capacity compression testing machine

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Modulus of elasticity and Poisson's ratio

From uniaxial compression test, young's modulus of elasticity and Poisson's ratio of rock specimen are determined if the stress strain behaviour till peak is captured. The slope of the stress-strain curve is basically gives the elastic modulus of the specimen.

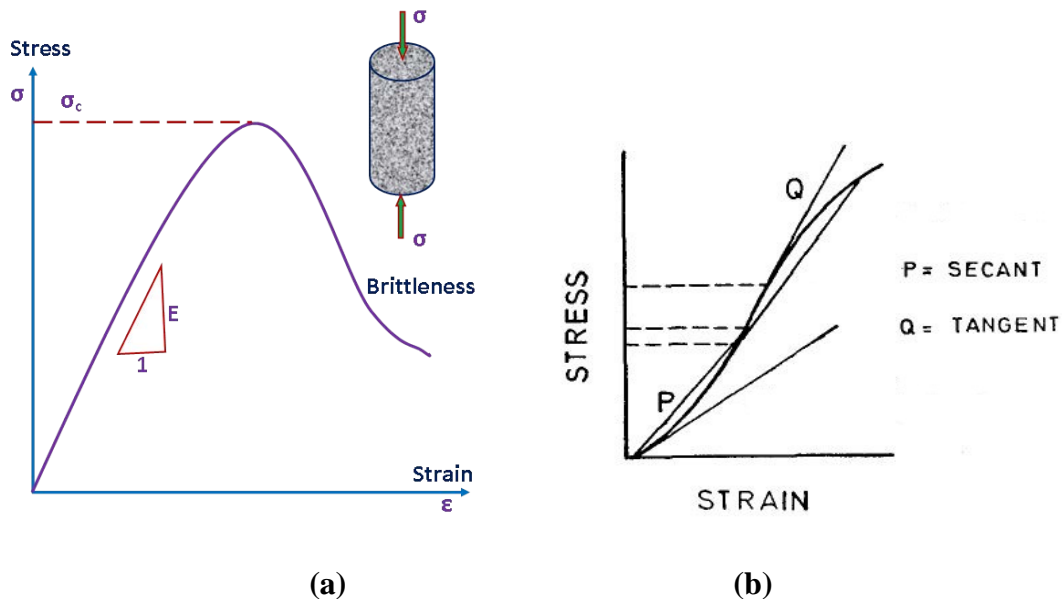


Figure 2.7: Tangent and Second modulus from Stress-Strain curve

Young's modulus defined as the ratio of the axial stress change to axial strain rate produced by the stress change may be calculated using any one of several methods plotted by stress - strain curve. Tangent young's modulus is measured at stress level which is fixed percentage of the ultimate strength (shown in Figure 2.7a). Secant young's modulus measured from zero stress to some fixed percentage of the ultimate strength taken generally at 50% (shown in Figure 2.7b). Poisson's ratio shall be calculated as the ratio of the total diametric strain to the total axial strain at any given stress level.

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Table 2.8: Modulus of Elasticity, Poisson's ratio, UCS, Tensile strength and Point load strength of some common rocks

Types of Rocks	Name of Rocks	Young's Modulus of Elasticity (E), GPa	Average Values of Poisson's Ratio (ν)	UCS MPa	Tensile strength MPa	Point Load Strength Index (I_{s50}) MPa
Igneous Rocks	Basalt	20-80	0.1-0.2	70-300	10-30	4-20
	Rhyolite	10-40	0.2-0.3	60-150	5-10	--
	Andesite	10-70	0.2	100-250	5-15	5-15
	Gabbro	40- 100	0.2-0.3	150-250	7-30	6-15
	Granite	30-70	0.17	100-300	7-25	5-15
	Dolerite	30-100	0.1-0.2	100-350	7-30	--
Sedimentary Rocks	Limestone	20 -70	0.3	30-250	6-25	3-7
	Sandstone	15-50	0.15	20-170	4-25	1-8
	Conglomerate	10-90	0.1-0.15	30-230	3-10	--
	Dolomite	20-70	0.15	20-120	6-15	0.5-6
	Mudstone	5-50	0.15	10-100	5-20	--
	Shale	5-30	0.1-0.4	5-100	2-10	--
Metamorphic Rocks	Marble	30-70	0.15 – 0.3	50-200	7-20	4-12
	Phyllite	10-85	0.25	5-150	6-20	--
	Slate	20-90	0.2-0.3	50-150	7-20	1-9
	Quartzite	50-90	0.17	150-300	5-20	5-15
	Schist	5-60	0.15-0.25	70-150	4-10	5-10
	Gneiss	30-80	0.24	100-250	7-20	5-15

2.3.2.2 Tensile Strength

The tensile strength generally defined as the maximum stress a specimen can withstand when it is subjected to pulling or stretching. This test influenced by loading along the plane of weakness or across it in specimen. There are several methods used for determination of tensile strength of rocks by indirect tests, out of that Brazilian test is generally adopted. Usually Brazilian test is conducted on NX size specimen with length equal to the diameter. The test specimen shall be wrapped around its periphery as shown in the below figure 6 such that curved platens load the specimen diametrically with axes of rotation for specimen coincident. Load on the specimen shall be applied continuously at a constant rate such that weakest rocks occur within 15-30seconds. Normally ten numbers of specimens are recommended for practical consideration. Tensile strength of rock shall be calculated load at failure divided by circumferential area. Figure 2.8 shows the schematic view of Brazilian tensile test apparatus (IS-10082-1981) which has to be kept between the platens of a compression testing machine during the test. Figure 2.9 shows the desirable mode of failure in Brazilian tensile strength test (IS-10082-1981)

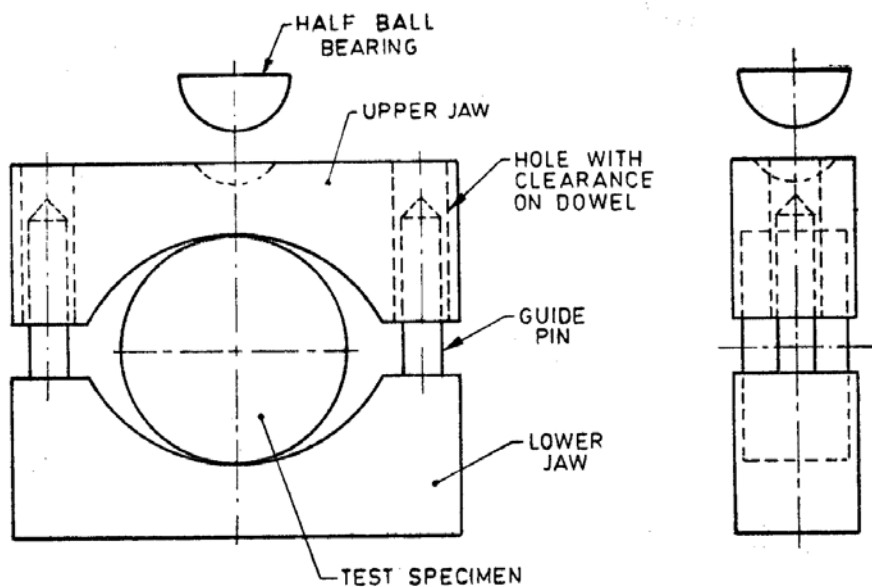


Figure 2.8: Brazilian tensile test apparatus (IS-10082-1981)

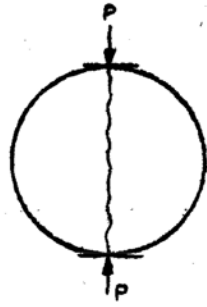


Figure 2.9: Desirable mode of failure during Brazilian tensile strength test (IS-10082-1981)

Tensile strength of the rock specimen is then calculated from the formula,

$$\sigma_t = \frac{2P}{\pi D t}$$

where,

σ_t = Brazilian tensile strength of the rock specimen

P = Peak failure load of the specimen

D = Diameter of the specimen

t = Thickness of the specimen

2.3.2.3 Point Load Index

This test is intended primarily as a simple and practical one for field classification of rock materials. Both irregular as well as regular samples including cylindrical cores can be tested using the method. Procedure helps to determine the diametrical and axial point load strength index of rock cores, cut blocks or irregular lumps, which may be tested without any treatment. In the test, load is applied to the specimen through conical indents fitted with hydraulic jacks. The below diagram (Figure 2.11) shows the set-up for the Point load index test as per IS 8764 (1998). Figure 2.10 shows the Loading direction of cylindrical specimen for point load index test. Minimum of 10 test specimens are required to find out the average value of point load strength index. Test can be conducted on the core specimens which are completely dry or after soaking it for 2 days. The total length (l) and diameter (d) of the core specimen is measured and specimen of $l/d=1.5$, are considered to be suitable for this test. The

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specimen placed horizontally between two platens in such a way that the distance between the contact point and the nearest free end (L) is at least 0.75 times the diameter of the core (d). The distance between two platen contact points (D) with the help of the scale attached with the loading frame is measured. In case of diametrical test, the diameter of the core (d) and the distance between two platens (D) will be same. Load to the core specimen is applied such that failure occur within 10-60 sec. record the failure load 'P'.

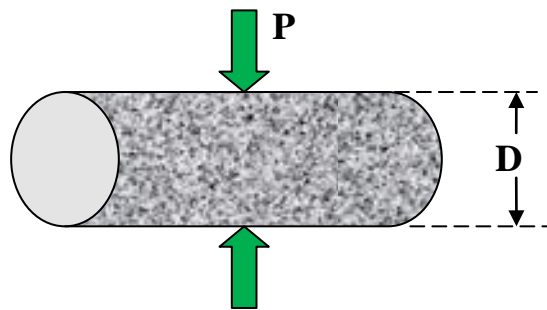


Figure 2.10: Loading direction of cylindrical specimen for point load index test

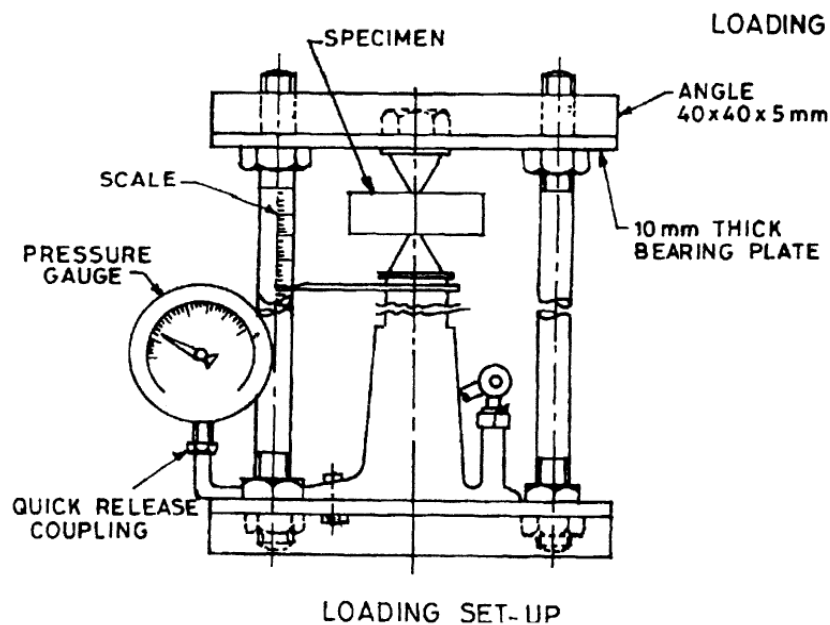


Figure 2.11: Setup for the point load index testing (IS-8764)

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Calculations

Uncorrected Point load strength index (I_s) = P/D^2 MPa

Where,

D= Core diameter/ Distance between the tips of two conical platens in mm

P = The breaking load in N

Corrected point load strength index for the standard core size of 50 mm (I_{s50}) diameter is given by the following equation

$$I_{s50} = (P)/(D^{1.5}\sqrt{50}) \text{ MPa}$$

Approximate uniaxial compressive strength of rock may be predicted from the following equation

$$q_c = 22 * I_{s50} \text{ MPa}$$

The failure mode of the specimen plays a role in the determination of strength and therefore IS 8764 given some guideline for the valid and invalid tests (Figure 2.12).

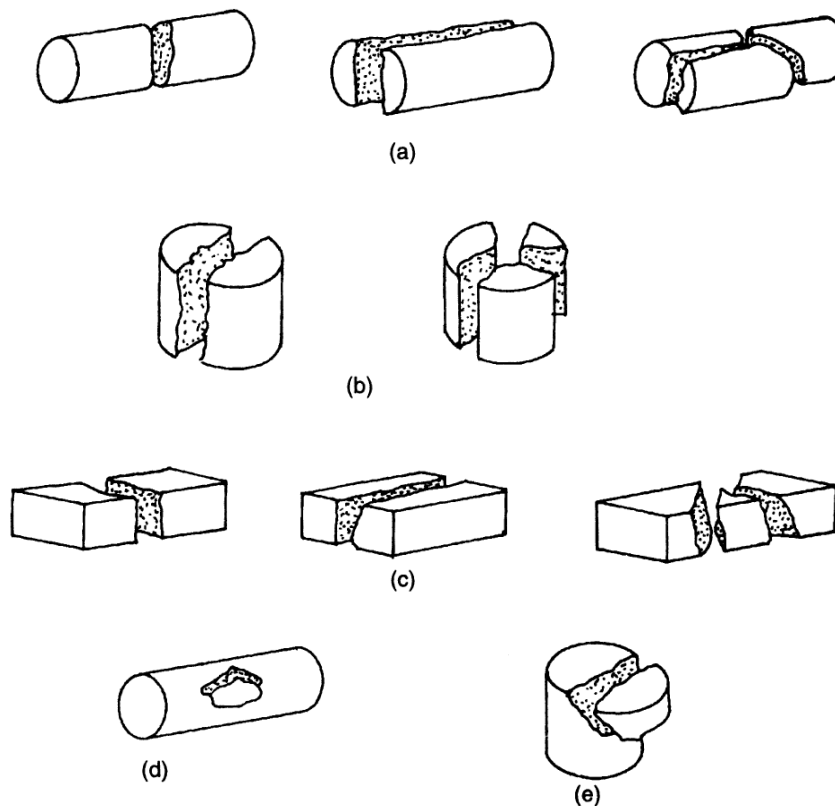


Figure 2.12: Typical modes of failure for valid and invalid test a) valid diametrical test b) valid axial test c) valid block test d) invalid core test e) invalid axial test (IS-8764)