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Indian Standard

METHOD FOR DETERMINATION OF MODULUS OF ELASTICITY AND POISSON'S RATIO OF ROCK MATERIALS IN UNIAXIAL COMPRESSION

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Soil Engineering and Rock Mechanics Sectional Committee, BDC 23

(*Continued on page* 2)

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Indian Standard
METHOD FOR DETERMINATION OF MODULUS OF ELASTICITY AND POISSON'S RATIO OF ROCK MATERIALS IN UNIAXIAL COMPRESSION

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 12 June 1979, after the draft finalized by the Soil Engineering and Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 A number of Indian Standards covering the method for tests of rock materials are being formulated. In this standard method for determination of modulus of elasticity and Poisson's ratio of rock materials in uniaxial compression is covered.

0.3 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

0.4 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

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1. SCOPE

1.1 This standard covers the method for determination of Young's modulus of elasticity and Poisson's ratio of cylindrical rock specimens in compression.

1.2 This standard does not cover (a) the procedure necessary to obtain stress strain curve beyond the ultimate strength, and (b) the method for determining rock moduli in tension.

2. APPARATUS

2.1 A suitable loading machine shall be used for applying and measuring the axial load to the specimen. The capacity of the testing machine should

*Rules for rounding off numerical values (*revised*).

be sufficient to assure reasonable longitudinal stiffness for size of the specimen tested. It shall provide adequate control on loading rate to suit the requirements as set in **4.3.** It shall be verified and calibrated at suitable time intervals depending on the work load.

2.2 Discs made of steel having a hardness of not less than *HRC* 30 (*see* IS : 1586-1968*) shall be placed at specimen ends. The diameter of the discs should be same as the diameter of the specimen. The thickness of the discs shall be atleast 15 mm. Surfaces of the discs shall be ground and their flatness shall be within ·025 mm.

NOTE — With abrasive rocks, these discs tend to roughen after a number of specimens have been tested and hence need to be resurfaced from time to time.

2.3 One of the two discs shall incorporate a spherical seat. The spherical seat shall be placed on the upper end of the specimen. It shall be lightly lubricated with mineral oil. The specimen, the discs and the spherical seat shall be accurately centred with respect to one another and loading frame. The curvature centre of the seat surface should coincide with the centre of the top surface of the specimen.

2.4 Circumferential and axial deformations or strains may be determined from data obtained by electrical resistance strain gauges, compressometers, optical devices or other suitable means. The design of the measuring device shall be such that the average of atleast two circumferential and two axial strain measurements can be determined for each increment of load. Measuring positions shall be equally spaced around the circumference of the specimens close to the mid height. They should not fall within $D/2$ of the specimen ends, where D is the diameter. The length over which the strains are measured shall be atleast five times the grain size diameter, in magnitude. Both axial and circumferential strains shall be determined with an accuracy of 2 percent of the reading and a precision of 0·2 percent of the full scale.

3. TEST SPECIMENS

3.1 Test specimen shall be a right circular cylinder with tolerances as specified in **3.2** although specimen of any shape with regular geometry could be used and should be prepared as per IS : 9179-1979†.

3.1.1 The specimen shall be tested at moisture contents as close to field conditions as possible.

3.2 Dimension of Specimen

3.2.1 The length to diameter ratio of the specimen should preferably be 2 to 3.

*Method for Rockwell hardness test (B and C scales) for steel.

†Method for preparation of rock specimen for laboratory testing.

3.2.2 The diameter of the specimen shall not be less than ten times the largest mineral grain in rock and preferably of 45 mm and in no case less than 30 mm. In the latter case the tolerances given in **3.2.3** and **3.2.5** be comparatively lowered.

3.2.3 Specimen ends shall be flat within 0·05 mm.

3.2.4 The ends shall be parallel to each other within 0·002*D* where *D* is the specimen diameter.

3.2.5 The ends shall be perpendicular to the axis of the specimen within 0·001 radians (3·5 minutes) or 0·05 mm in a 45 mm diameter specimen.

3.2.6 The cylindrical surface shall be smooth and free from abrupt irregularities and straight to within 0·3 mm over the full length of the specimen and the dimensions of the specimen shall not vary by more than 0·2 mm over the length of the specimen.

3.2.7 The diameter of the test specimen shall be measured to the nearest 0·1 mm by averaging two diameters measured at right angles to each other at about the upper height, the mid height and the lower height of the specimen. It shall not vary by more than 0·3 mm over the length of the specimen.

4. TEST PROCEDURE

4.1 The ability of spherical seat to rotate freely shall be checked before each test.

4.2 The surfaces of the two bearing discs and the test specimen shall be wiped clean. The specimen shall be kept on the lower disc. The axis of the specimen shall be carefully aligned with the centre of the thrust of the spherical seat. As the load is generally brought to bear on the specimen, the movable portion of the spherical seated disc shall be adjusted to ensure uniform seating.

4.3 Load on the specimen shall be applied continuously and without shock to produce an approximately constant rate of load or deformation such that failure will occur within 5 to 15 minutes of initiation of loading if carried to failure. Alternatively, the stress rate shall be within the limits of 0·5 Mega Pascal/s to 1 Mega Pascal/s. Load and the axial and diametral or circumferential strains shall be measured frequently at evenly spaced load intervals during the test. The maximum load on the specimen shall be recorded in kg within 1 percent. Atleast 10 readings should be taken over the load range to define the axial and diametric stress strain curves.

5. CALCULATION

5.1 The axial strain (ε_a) and the diametric strain (ε_d) may be recorded directly from strain indicating equipment or may be calculated from the measured deformation depending upon the type of apparatus or instrument used.

5.2 The axial (ε_a) and diametric (ε_d) strains shall be calculated as follows:

$$\varepsilon_a = \Delta l / l$$
$$\varepsilon_d = \Delta d / d$$

where

l = original axial length before deformation,

d = original diameter before the deformation,

Δl = change in measured axial length (positive for a decrease in length), and

Δd = change in diameter (positive for an increase in diameter).

NOTE — It may be noted that circumferentially applied electrical resistance strain gauges also reflect diametric strain, the value necessary for computing Poisson's ratio. Since,

$$C = \pi d$$
$$\text{and } \Delta c = \pi \Delta d$$

The circumferential and diametral strains are related as follows:

$$\begin{aligned} \varepsilon_c &= \Delta c / c \\ &= \pi \Delta d / \pi d \\ &= \Delta d / d \\ &= \varepsilon_d \end{aligned}$$

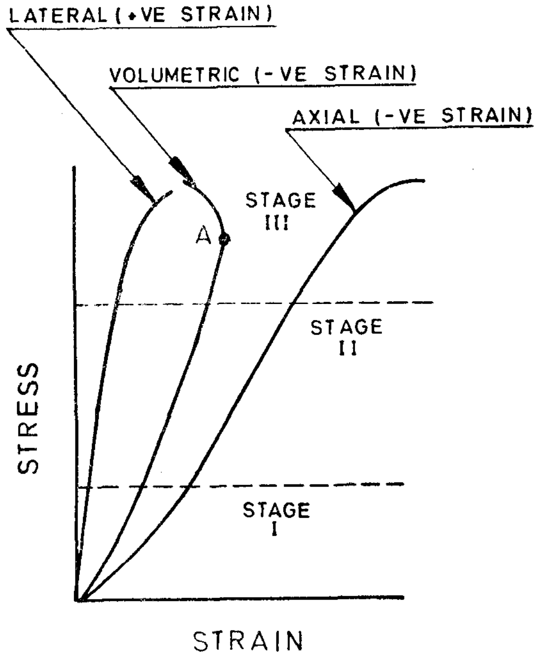
where C and d are circumference and diameter of the specimen respectively.

5.3 The compressive stress in the test specimen σ shall be calculated from compressive load P and the θ initially computed cross-sectional area A, as follows:

$$\sigma = \frac{P}{A}$$

5.4 The stress *versus* axial and lateral strain shall be plotted as a curve (*see* Fig. 1).

5.5 The Young's modulus of elasticity E may be calculated using one of the several methods employed in engineering practice depending on the type of problem. The commonly used moduli are given in **5.5.1** to **5.5.3** (*see* Fig. 2).



Stage I — Internal cracking commences, closure of cracks and pores takes place
Stage II — Linear compression
Stage III — Internal cracking commences

FIG. 1 TYPICAL LATERAL, VOLUMETRIC AND AXIAL STRAIN DIAGRAMS FOR ROCK, IN COMPRESSION

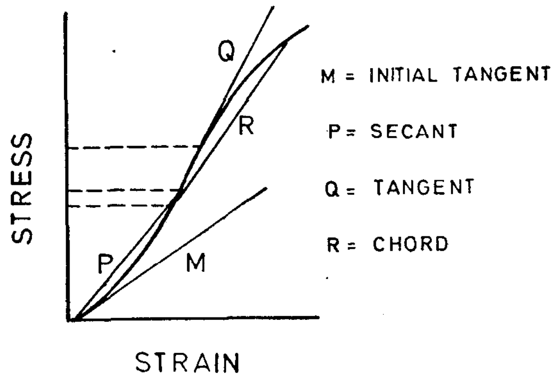


FIG. 2 DEFINITION OF MODULI FOR A NON-LINER STRESS-STRAIN DIAGRAM

5.5.1 *Tangent Modulus* — Slope of the tangent at a given stress level, which is some fixed percentage of the maximum strength.

5.5.2 *Chord Modulus* — The average slope between two specified points defined by the chord joining them.

5.5.3 *Secant Modulus* — Chord modulus between origin and some other points on the curve.

5.6 Poisson's Ratio (ν) — Poissons's ratio shall be calculated as the ratio of the total diametric strain ε_d to the total axial strain ε_a at any given stress level.

NOTE — When the terms 'Modulus' and 'Poisson's Ratio' are used without any qualification, they shall be taken to mean as the tangent modulus and the Poisson's ratio at 50 percent of the ultimate stress.

6. REPORT

6.1 The report shall give a plot of stress strain curve appropriate for the intended use, Young's modulus E and Poisson's ratio ν with their method of determination and the stress levels.

6.2 The report of test shall include the following information:

a) Number of specimens tested.

b) Mode of failure.

c) Lithological description of rock.

d) Orientation of loading axis with respect to anisotropy, for example, bedding planes, foliations, etc.

e) Source of sample, location, depth and orientation, date of sampling.

f) Storage history and environment.

g) Date of testing and type of machine used.

h) Specimen diameter and height.

j) Moisture content and room temperature.

k) Duration of the test and stress rate.

m) Other physical properties, such as specific gravity, absorption, permeability and porosity, citing their method of determination, if available.

n) Any other observation.

p) Should it be necessary to test specimens of size less than 45 mm or length to diameter ratio less than 2 to 3, suitable mention of these facts shall be made in the report.

INDIAN STANDARDS

ON

ROCK MECHANICS

IS:

7292-1974	Code of practice for *in-situ* determination of rock properties by flat jack
7317-1974	Code of practice for uniaxial jacking test for deformation modulus of rock
7746-1975	Code of practice for *in-situ* shear test on rock
8764-1978	Method for determination of point load strength index or rocks
9143-1979	Method for determination of unconfined compressive strength of rock materials
9179-1979	Method for preparation of rock specimen for laboratory testing

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