

Australian Standard®

Methods of testing rocks for engineering purposes

Method 4.3.1: Rock strength tests— Determination of deformability of rock materials in uniaxial compression—Strengths of 50 MPa and greater

1 SCOPE

This Standard sets out the method for determining the stress-strain characteristics and Young's modulus, and Poisson's ratio in uniaxial compression of a rock sample in the form of specimens of regular geometry.

CAUTION: SOME OF THE TESTS SPECIFIED IN THIS STANDARD INVOLVE THE USE OF PROCESSES THAT COULD LEAD TO A HAZARDOUS SITUATION.

2 REFERENCED DOCUMENT

The following document is referred to in this Standard:

AS

2193 Calibration and classification of force-measuring systems

3 APPARATUS

The following apparatus is required:

- (a) A suitable machine for applying and measuring axial load to the specimen. It shall be of sufficient capacity and capable of applying load at the rate specified in Clause 5. The machine shall include a force-measuring device meeting the accuracy and repeatability requirements of AS 2193, Class B testing machines for the range of forces used in the test.
- (b) Steel discs having a Rockwell hardness of not less than 30 HRC. The discs shall be placed at the specimen ends. The diameter of the discs shall be the same as the diameter of the specimen. The thickness of the discs shall be not less than the larger of 15 mm or $d/3$, where d is the specimen diameter. Surfaces of the discs shall be ground and their flatness shall be within 0.02 mm. 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 so that it locks after the dead-weight of the cross-head has been picked up. The specimen, the discs and spherical seat shall be accurately centred with respect to one another and to the axis of load application of the loading machine. The curvature centre of the spherical seat surface shall coincide with the centre of the specimen top face.

NOTE: A spherical seat that does not comply with this Clause should be removed or placed in a locked position with the two loading faces of the machine parallel to each other.

- (c) A measuring instrument such as vernier, digital or micrometer callipers capable of measuring specimen dimensions to within 0.1 mm.
- (d) Electrical resistance strain gauges, linear variable differential transformers (LVDTs), compressometers, optical devices or other suitable measuring devices. Their design shall be such that the average of two circumferential and two axial strain measurements, equally spaced, can be determined for each increment of load. The devices shall be robust and stable, with strain sensitivity of the order of 5×10^{-6} .

NOTES:

- 1 Whatever measuring devices are selected, it is recommended that they are calibrated against the known properties of specimen tested in the manner described in Clause 5. A suitable specimen should consist of a right cylinder of aluminium or steel. Such procedure is essential when using devices other than electrical resistance strain gauges.
- 2 Strain gauges should be bonded to the specimen by an epoxy resin as recommended by the manufacturer of the strain gauges.

Where electrical resistance strain gauges are used, the length of the gauges over which axial strain is determined shall be at least 10 grain diameters in magnitude and the gauges should not encroach within $d/2$ of the specimen ends, where d is the diameter of the specimen. Circumferential strain shall be determined over a gauge length between 5% and 10% of the circumference of the specimen.

NOTE: Electrical resistance strain gauges should only be used for non-friable, coherent rocks, which permit an effective bond between the gauges and the rock surface. Alternative techniques are generally necessary for rocks that fall outside this category, or for rocks whose testing moisture content precludes the necessary bond between the gauges and the rock surface.

Where dial micrometers or LVDTs are used for measuring axial or diametral deformation due to loading, they shall be graduated to read in 0.002 mm units and accurate within 0.002 mm in any 0.02 mm range and within 0.005 mm in any 0.25 mm range. The dial micrometer or LVDTs shall not encroach within $d/2$ of the specimen ends. The gauge shall be centrally positioned with a gauge length of not less than d .

- (e) An apparatus for continuously recording the loads and deformation (optional).

4 PREPARATION

- (a) Prepare a specimen having the following characteristics (see Notes to Item 3(d)):
 - (i) The specimen shall be a straight circular cylinder having a length to diameter ratio of 2.5 to 3.0, and a diameter preferably of not less than 50 mm. The diameter of the specimen shall be at least ten times the size of the largest grain in the rock.
 - (ii) The ends of the specimen shall be cut parallel to each other to within 0.05 mm in 50 mm.
 - (iii) The ends of the specimen shall be square to its longitudinal axis to within 1%.
 - (iv) The ends of the specimen shall be flat to 0.02 mm.
 - (v) The sides of the specimen shall be smooth and free of abrupt irregularities and straight to within 0.3 mm over the full length of the specimen.
 - (vi) The use of capping materials or end surface treatments other than machining is not permitted.

- (b) Determine and record the average diameter of the specimen as the mean of six measurements to a precision of 0.1 mm, taken across two diameters at right angles and at the centre and near the top and bottom. Measure and record the height of the specimen to a precision of 1 mm.
- (c) Prior to testing, the specimen should be conditioned in a uniform environment.

5 PROCEDURE

The procedure shall be as follows:

- (a) Attach the measuring devices to the specimen.
- (b) Load the specimen continuously at a constant stress rate such that failure will occur within 5 min to 15 min of loading.

NOTE: Where it is desired to perform a few cycles of loading and unloading, a suitable maximum load for the cycle may be taken as half the estimated failure load.

WARNING: MANY ROCKS FAIL IN A VIOLENT MANNER WHEN LOADED TO FAILURE. A PROTECTIVE SHIELD SHOULD BE PLACED AROUND THE TEST SPECIMEN TO PREVENT INJURY FROM FLYING ROCK FRAGMENTS.

If the load and deformations are not continuously recorded, load, axial and circumferential strains or deformations shall be recorded at evenly spaced load intervals during the test. At least 10 readings shall be taken over the load range to define the axial and diametral stress-strain curves. Both axial and circumferential strains shall be determined with a precision of 0.2% of full scale.

6 CALCULATIONS

The following calculations shall be carried out as required:

- (a) Axial strain (ε_a), which may be recorded directly from strain indicating equipment or calculated from deformation readings depending upon the type of instrumentation used, and then calculated from the following equation:

$$\varepsilon_a = \frac{\Delta l}{l_o} \quad \dots 6(1)$$

where

ε_a = axial strain

Δl = change in measured axial gauge length (defined to be positive for a decrease in length), in millimetres

l_o = original undeformed axial gauge length, in millimetres

- (b) Diametral strain (ε_d), which may be determined either by measuring the change in specimen diameter or by measuring the circumferential strain. Where the changes in diameter are measured, the diametral strain is calculated from the following equation:

$$\varepsilon_d = \frac{\Delta d}{d_o} \quad \dots 6(2)$$

where

ε_d = diametral strain

Δd = change in diameter (defined to be positive for a decrease in diameter), in millimetres

d_o = original diameter, in millimetres