RTH 324-80

SUGGESTED METHOD FOR DEFORMABILITY AND STRENGTH DETERMINATION USING AN IN SITU UNIAXIAL COMPRESSIVE TEST

1. Scope

1.1 This method of test is intended to measure the strength and deformability of large in situ specimens of weak rock such as coal. The test results take into account the effect of both intact material behavior and the behavior of discontinuities contained within the specimen block.

1.2 Since the strength of rock is dependent on the size of the test specimen, it is necessary to test specimens by increasing size until an asymptotically constant strength value is found (Note 1). This value is taken to represent the strength of the rock mass. It can, for example, be applied to the design of mine pillars provided that the constraining effect of the roof and floor is taken into consideration.

NOTE 1—Bieniawski, Z. T. and Van Heerden, W. L., "The Significance of Large-Scale In Situ Tests," Int. J. Rock Mech. Min. Sci., Vol 1, 1975.

2. Apparatus

2.1 Preparation equipment, including:

(a) Equipment for cutting rectangular specimen blocks from existing underground mine pillars or exposed faces, e.g., a coal cutting machine, pneumatic chisel, and other hand tools. No explosives are permitted.

2.2 A loading system consisting of:

(a) Hydraulic jacks or flat jacks to apply a uniformly distributed load to the complete upper face of the specimen. The loading system should be of sufficient capacity and travel to load the specimen to failure.

(b) A hydraulic pumping system to supply oil at the required pressure to the jacks, the pressure being controlled to give a constant rate of displacement or strain rather than a constant rate of stress increase (Note 2).

NOTE 2--Experience has shown that deformation-controlled loading is preferable to stress-controlled loading because it results in a more stable and thus safer test. One way to achieve uniform deformation of the specimen is to use a separate pump for each jack and to set the oil delivery rate of each pump to the same value. Standard diesel fuel injection pumps have been found suitable and are capable of supplying pressures up to 100 MPa. The delivery rate of these pumps can be set very accurately.

2.3 Equipment to measure applied load and strain in the specimen, including:

(a) Load measuring equipment, e.g., electric, hydraulic, or mechanical load cells, to permit the applied load to be measured with an accuracy better than ±5 percent of the maximum in the test.

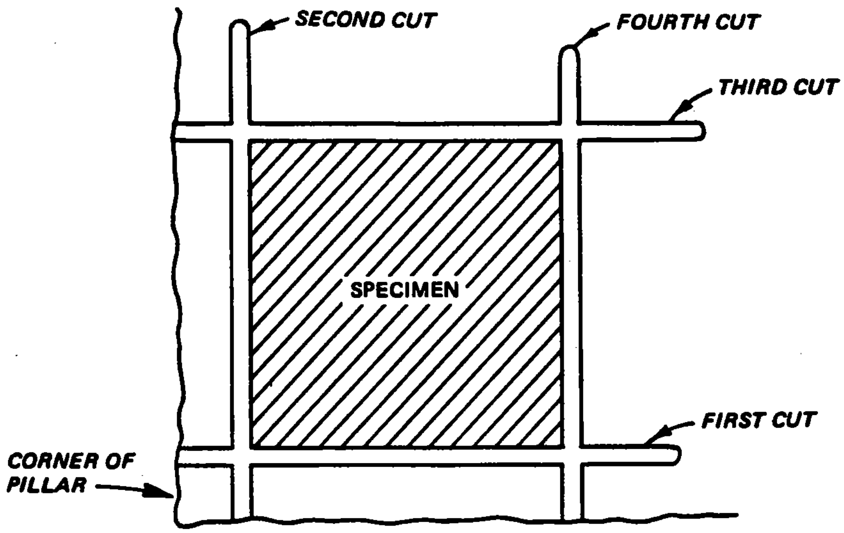
(b) Dial gage or similar displacement measuring devices with robust fittings to enable the instruments to be mounted so that the strain in the central third of each specimen face is measured with an accuracy better than $\pm 10^{-5}$. Strain is to be measured in the direction of applied load, also in a perpendicular direction if Poisson's ratio values are to be determined.

2.4 Equipment to calibrate the loading and displacement measuring systems, the accuracy of calibration to be better than the accuracies of test measurement specified above.

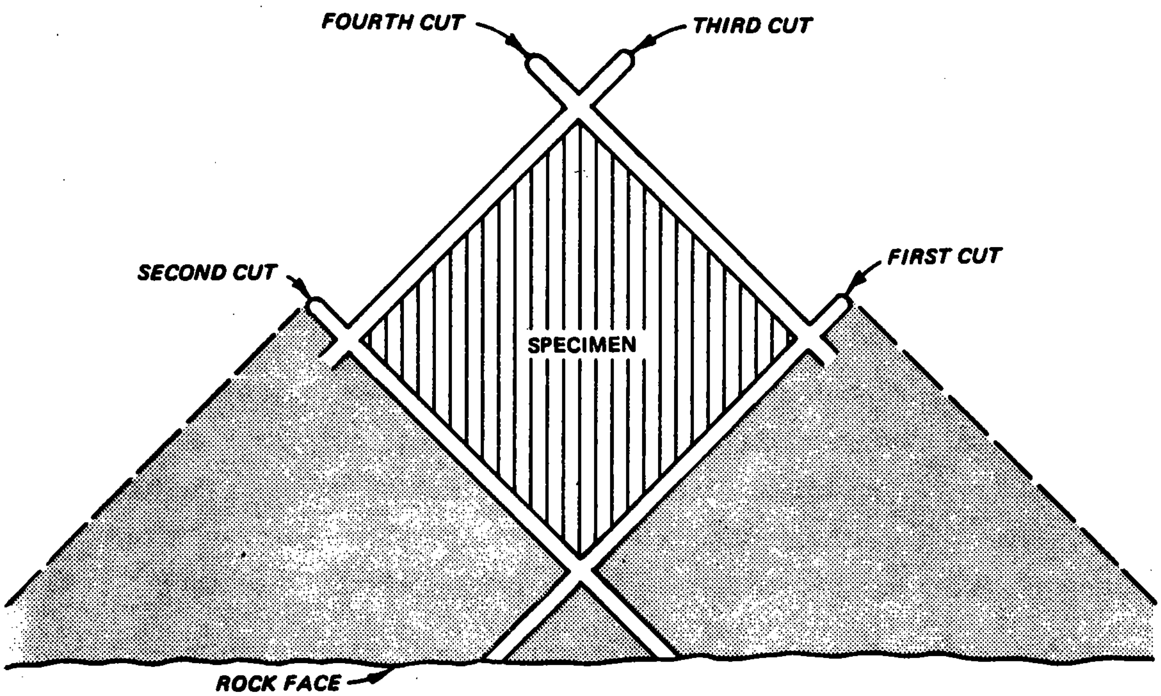
3. Procedure

3.1 Preparation:

(a) Specimens of the required dimensions (Note 3) are cut either from the corners of existing pillars or from exposed rock faces (Fig. 1). Loose and damaged rock is first removed. Vertical cuts are then made, e.g. as shown in Fig. 1, to form the vertical faces of



a. SEQUENCE OF VERTICAL CUTS TO SEPARATE A SPECIMEN FROM THE CORNER OF A PILLAR



NOTE: ROCK IN THE SHADED REGIONS TO BE REMOVED BEFORE MAKING THIRD AND FOURTH CUTS.

b. SEQUENCE OF VERTICAL CUTS TO SEPARATE A SPECIMEN FROM A ROCK FACE

Fig. 1. Vertical cuts to separate specimen from the corner of a pillar and from a rock face.

the specimen. A horizontal cut is made to form the top face of the specimen. Loose rock is removed and the specimen trimmed to final size using hand tools.

NOTE 3—Specimen dimensions cannot be specified because these depend very much on the rock properties, e.g., the thickness of strata and the ease with which specimens can be prepared. It is recommended that a number of tests should be done with a specimen size of about 0.5 m and that the size of subsequent specimens should be increased until an asymptotically constant strength value is reached.

(b) The specimen is cleaned and inspected, recording in detail the geological structure of the block and of the reaction faces above and below. Specimen geometry, including the geometry of defects in the block, should be measured and recorded with an accuracy better than 5 mm. Photographs and drawings should be prepared to illustrate both geological and geometric characteristics.

(c) A concrete block, suitably reinforced, is cast to cover the top face of the specimen (Fig. 2). The thickness of this block should be sufficient to give adequate strength under the full applied load. The top face of the block should be flat to within ±5 mm and parallel to within ±5 deg with the basal plane of the block.

(d) Rock is removed from above the specimen to make space for the loading jacks, the rock being cut back to a stratum of sufficient strength to provide safe reaction. Generally, a concrete reaction pad must be cast to distribute the load on the roof and to prevent undue deformation and movement of the jacks during the test (Note 4). The lower face of the reaction block should be flat to within ±5 mm and parallel to within ±5 deg with the upper face of the specimen block. All concrete should be left to harden for a period of not less than 7 days.

NOTE 4—If a suitably designed concrete cap to the specimen is not employed, the corners and sides of the specimen will often fail before the central portion. The corner jacks will then cease to operate, and the test results will be suspect. The concrete cap should if possible be designed to ensure that the stress distributions in the top and bottom thirds of the specimen are nearly identical.

(e) The loading jacks and pumps are installed and checked to ensure that they operate as intended. Load and displacement measuring equipment is installed and checked. All measuring instruments should be calibrated both before and after each test series.

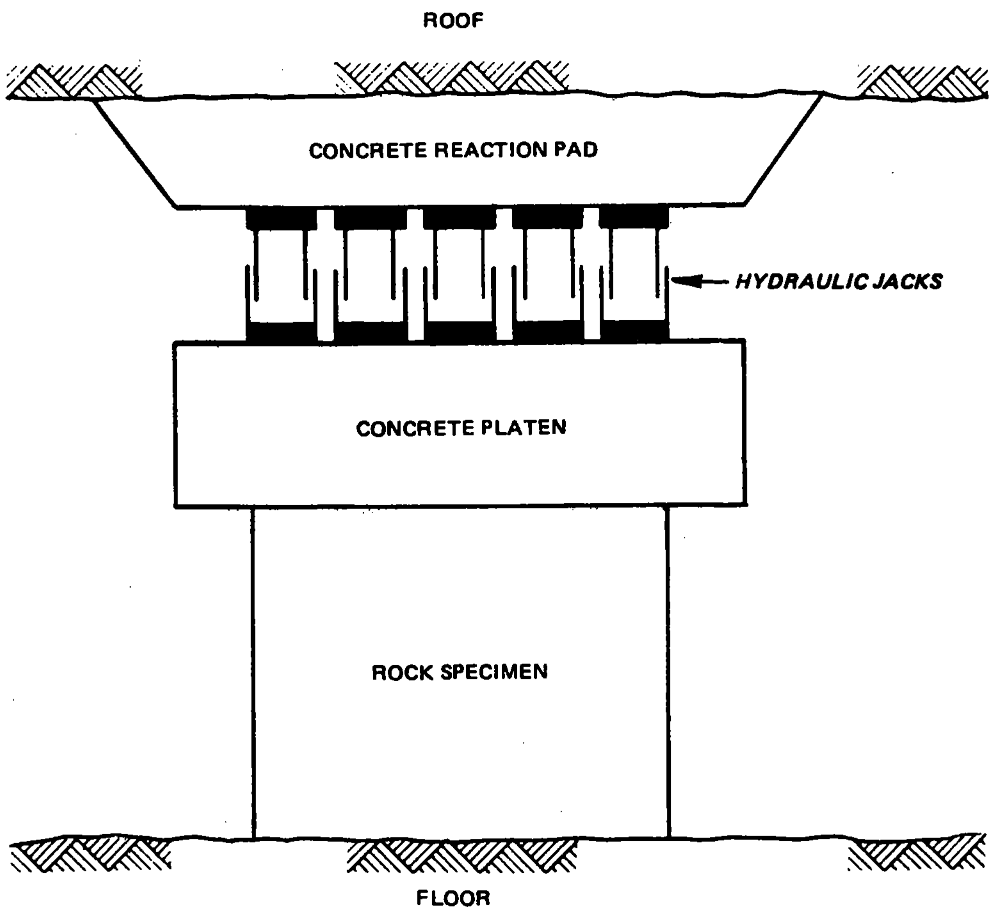


Fig. 2. Testing arrangement.

3.2 Testing:

(a) An initial load of approximately one-tenth of the estimated full test load is applied, and the jacks are checked to ensure that each is in firm contact with the specimen block. Displacement measuring equipment is again checked to ensure that it is rigidly mounted and is functioning correctly. Zero readings of load and displacement are taken.

(b) The specimen load is then increased by applying the same slow and constant oil delivery to each jack. The rate of specimen strain should be such that a displacement rate of between 5 and 15 mm per hour is recorded at each of the four faces of the specimen block.

(c) Readings of applied load and displacements are recorded at intervals such that the load-displacement or stress-strain curve can be adequately defined. There should be not less than ten points on this curve, evenly spaced from zero to the failure load.

(d) Unless otherwise specified, the test is to be terminated when the specimen fails. Specimen failure is indicated by a drop in hydraulic pressure to less than one-half the maximum applied, or by disintegration of the specimen to an extent that the loading system becomes inoperative or the test dangerous to continue. The mode of specimen failure is recorded, and a sketch is made of all failure cracks.

4. Calculations

4.1 The uniaxial compressive strength of the specimen shall be calculated by dividing the maximum load carried by the specimen during the test by the original cross-sectional area of the specimen.

4.2 Young's modulus for the specimen shall, unless otherwise specified, be calculated as the tangent modulus E_{t50} at one-half the uniaxial compressive strength. This modulus is found by drawing a tangent to the stress-strain curve at 50 percent maximum load, the gradient of this tangent being measured as E_{t50}. The construction and calculations used in deriving this and any other modulus values should be shown on the stress-strain curve.

4.3 If a number of specimens of different shape and/or size are tested, the trends in strength values due to shape and size effects should be plotted graphically, e.g., as shown in Fig. 3.

5. Reporting of Results

5.1 The report should include the following information:

(a) A diagram showing details of the locations of specimens tested, the specimen numbering system used, and the situation of each specimen with respect to the geology and geometry of the site.

(b) Photographs, drawings, and tabulations giving full details of the geological and geometrical characteristics of each specimen, preferably including index test data to characterize the rock. Particular attention should be given to a detailed description of the pattern of joints, bedding planes, and other discontinuities in the specimen block.

(c) A description, with diagrams, of the test equipment and method used. Reference may be made to this "suggested method," noting only the departures from recommended procedures.

(d) Tabulated test results, including recorded values of load and displacements together with all derived data, calibration results, and details of all corrections applied.

(e) Graphs showing load versus displacement or stress versus strain, including points representing all recorded data and a curve fitted to these points. The uniaxial compressive strength value should be shown, together with all constructions used in determining Young's modulus and other elastic parameters. The mode of specimen failure should be shown diagrammatically and described.

(f) Summary tables and graphs giving the values of uniaxial compressive strength and Young's modulus, and showing how these values vary as a function of specimen shape and size and the character of the rock tested.

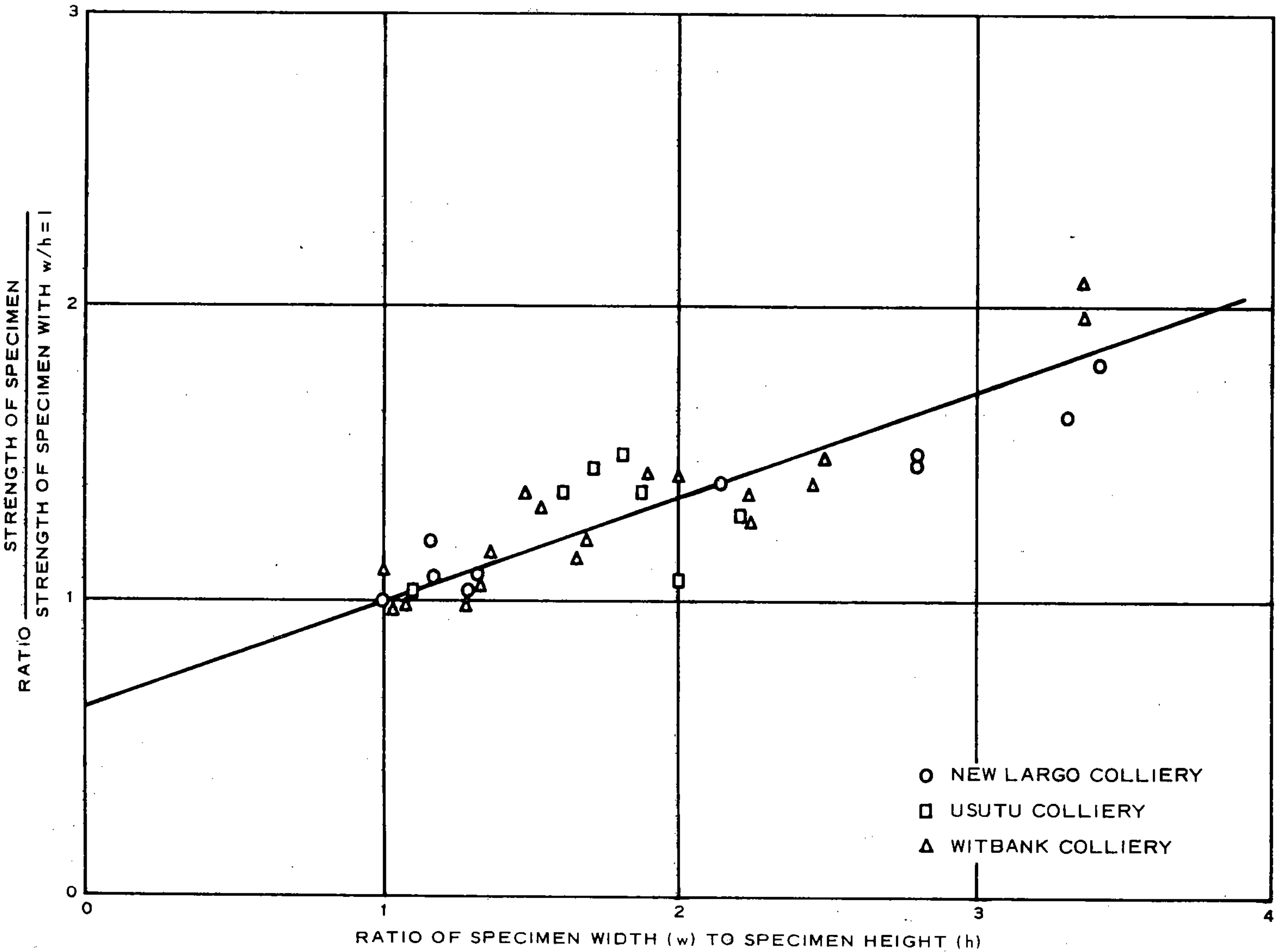


Fig. 3. Example showing the representation of strength data in dimensionless form.