Paper Number: 670

Prediction of the shear strength of discontinuities by a single shear test

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Proper determination of the shear strength of a rock mass is critically important for engineering structures built on or in a rock mass. Laboratory tests conducted for this purpose usually require several samples collected from the project site, as the character of such tests necessitates the use of identical samples. Sampling of a rock mass in situ to include a discontinuity surface is a difficult task. In addition, the surface roughness of the collected samples would not be identical. Bilinear failure criterion is the most commonly employed technique to determine the shear strength of a discontinuity surface. It involves shear testing of a discontinuity at both low- and high-normal stress conditions. Several pairs of normal stress and shear stress are required to construct a bilinear failure envelope. The scope of this investigation is to illustrate whether a bilinear failure envelope for a discontinuity plane could be established using only a single shear test on a discontinuity surface.

The materials used for this investigation consist of five igneous rocks of varying uniaxial compressive strength. Cubic blocks with dimensions of 10x10x10 cm were prepared through saw cuts. The blocks were then carefully split into two blocks using a compression machine fitted with a pair of specially designed jaws. In this way, a sufficient number of "artificially prepared" discontinuity surfaces were obtained. Although the artificially constructed discontinuities are not exactly the same in regard to the surface asperities, they could be considered "identical" for practical purposes.

Cubic rock blocks with the artificial discontinuity surfaces were first subjected to a direct shear test conducted under normal stresses of 0.25, 0.5, 1.0, 2.0, 4.0, and 8.0 MPa. The first three normal stresses were intended to obtain the first and steeper part of the bilinear failure curve, whereas the last three were intended to simulate the high-normal stress conditions. The shear stresses at failure were determined and the failure envelopes were obtained for each rock type. No infilling material was applied to the discontinuity planes.

Saw-cut surfaces of cubic blocks were subjected to tilt tests to determine the basic friction angle for each rock. The artificial discontinuity planes were scanned through a high-precision profilometer to obtain the asperity angle of the plane.

For the second part of the direct shear test, only one discontinuity plane was sheared under a normal stress of 4 MPa. The resulting shear stress was plotted on a new diagram along with the applied normal stress. A straight line was drawn through the plotted point at the angle of basic friction to represent the second and less steep part of the failure envelope. The first part of the failure envelope was constructed such that it has an inclination angle of the basic friction angle plus the asperity angle. Eventually, a failure envelope consisting of two parts was constructed for each rock.

The failure envelopes obtained from the multi-point direct shear tests and the single-point direct shear tests were compared for each rock. The degree of similarity between the two envelopes was

significantly high. The present investigation showed that the bilinear failure envelope of a discontinuity surface could be constructed using a single direct shear test providing that the basic friction and the asperity angles are known.