Shear Tests of Rocks and Shear Tests of Discontinuity Zone

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The stability of the rock mass depends not so much on the strength of the material, as on the presence and orientation of cracks systems. The shear strength will change depending on cracks state and their filling. The clay mass formed along the fracture surface during crushing and grinding of the initial rock (*fault gouge*) can lead to a significant decrease in friction, especially when watering. This phenomenon has repeatedly become the cause of major accidents, primarily at hydraulic engineering facilities. In this regard, the evaluation of shear strength and, in particular, shear strength along a crack for rocks is often more important than an uniaxial compressive strength. The results of the experiment can be used to calculate the stability of slopes and artificial structures.

Another important phenomenon that can be estimated during such tests is the dependence of dilatancy on normal force. The crack surface always has a roughness that will lead to crack opening when sheared. But as the pressure increases, which prevents the crack from opening, the dilatancy will decrease: the roughness will begin to smooth out during shear. This phenomenon is taken into account by specialized models for rocks. For example, in the Hoek-Brown rock model there is a parameter σ_ψ. It is a normal stress at which dilatancy does not appear. Accordingly, the current angle of dilatancy ψ_m will change from its initial value (in the absence of normal stresses) to 0 at a stress σ_ψ.

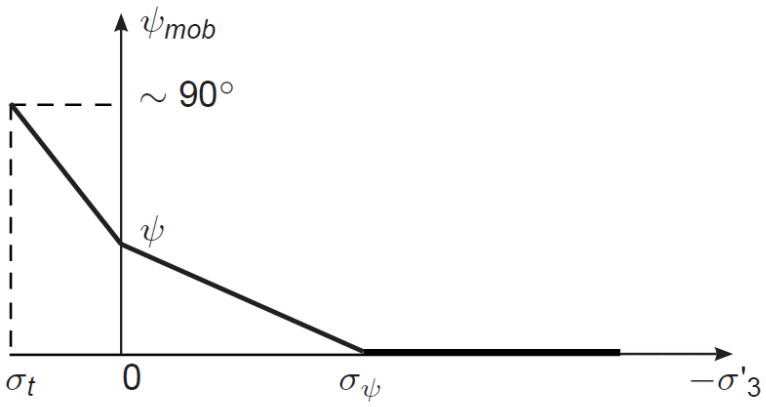

Figure 1. Change in the angle of dilatancy depending on the compressive stresses

Carrying out direct shear tests on rock samples represents significant difficulties. First, the shear strength of such samples is several orders of magnitude higher than the shear strength of granular soils. Therefore, standard shear carriages and loading devices cannot be used. Specialized equipment with increased load capacity is required. Secondly, due to the very high rigidity of the samples, vertical and horizontal displacements during the experiment can be less than a millimeter,

which requires the use of measuring devices with high resolution. In addition, a high-speed data processing system is required. Otherwise the feedback system will not be able to maintain the set test parameters such as shear speed and vertical stress with the required accuracy.

High rigidity of the samples can lead to a significant concentration of stresses at individual points, as a result of which significant deviations from the assumed stress state can occur. This can be avoided by using sample fixation by encapsulation method. To do this, a free-shaped sample is oriented in the cell of the instrument in the required way and fixed with a hardening binder (cement mortar, epoxy resin or similar materials). The actual cross-sectional area is measured after completion of the test. This method makes it possible to ensure a tight contact of the sample with the walls of the cell before the experiment and to reduce the cost of making samples of regular geometric shape with high accuracy.

Figure 2. Sample fixation process by encapsulation method (ASTM D 5607-16)

This testing method is not regulated by the Russian system of normative documents, but the requirements of GOST 21153.5-88 can be applied to it. ASTM D 5607-16 contains comprehensive guidance on how to perform this test. Besides the test procedure, the document describes possible ways to indirectly characterize the rock mass basing on the description of the resulting crack.

OOO “Geotek” offers a testing system for direct shear tests of discontinuity zone of rocks, complete with kinematic loading devices that implement axial forces up to 100 kN. The installation allows to test free-shaped samples with a maximum size of 100 x 100 mm with fixation by encapsulation. The testing system includes the necessary measuring equipment. Tests are carried out in an automated mode with control of all test parameters in real time.