Shear Tests of Macrofragmental Soils

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When macrofragmental soils are used in large earthwork structures or as natural foundations, their mechanical properties could be determined with triaxial compression tests. Their undeniable advantage is the ability to reproduce accurately any stress states and sufficiently high confining pressures. But in embankments such a level of pressure is not always achieved, and technical difficulties in preparing and conducting triaxial compression tests make it irrational. It can be more efficient to use instruments for direct shear tests and direct simple shear tests.

To determine the shear strength parameters of macrofragmental soils, direct simple shear instruments are the best, since with a single fixed shear surface the test result depends too much on the actual position of individual large particles. In the instruments with multiple possible shear surfaces the critical surface will be determined probabilistically during the test, which significantly increases the repeatability of these tests and better corresponds to behavior of these soils in the body.

Also, an important advantage is the possibility of high-precision direct determination of the angle of dilatancy ψ, which makes it possible to simulate soil structures made of certain type of soil by numerical methods. This is especially important, since in the case of coarse soils, the value of the dilatancy angle can reach 15°, and it has a decisive effect on the shear strength. This is clearly seen from tests with limited volumetric strains, that can also be carried out in similar devices. Determination of the shear stiffness parameter - shear modulus G is also allowed with limited precision. Thus, the use of this instrument allows to calculate embankments, backfillngs, earthwork structures using their actual parameters instead of parameters assigned indirectly according to technological characteristics, such as the coefficient of consolidation.

In the section of special equipment OOO “Geotek” proposes an automated direct simple shear testing system for macrofragmental soil samples with a diameter of 300 mm and a height of 150 mm. The maximum shear displacement is 80 mm, which is enough for a precise determination of shear strength, and the range of vertical and horizontal loads of 100 kN allows to solve any practical problems.

Instruments for shear testing of macrofragmental soils are presented in the range of the world's largest testing equipment manufacturers. Besides testing macrofragmental soils and building materials, these instruments often allow to evaluate their interaction with geotextiles

and geogrids. The widespread use of these materials in civil and transport construction requires to assess the effectiveness of their use.

Any geosynthetic material in the body of an earthen structure performs a number of functions, the main of which is reinforcing. Polymer fibers take up tensile forces, which makes it possible to increase the resulting stiffness of the embankment, reduce its thickness, and optimize the distribution capacity. But this requires the cooperation between soil and reinforcing element, that is estimated using the coefficient of interaction of layers K_d. Different sources propose different methodologies, but the task remains unchanged - it is necessary to quantify the effect of geosynthetics on shear resistance. At the same time, the wide variety of earthen building materials used in construction does not allow to use any reference values depending on the fraction, material and degree of grain rounding with reasonable certainty.

The interaction of the soil and reinforcing layer can be assessed in a direct shear instrument placing a layer of geotextile between upper and lower halves of the sample. During the experiment both frames remain stationary. A vertical load is applied to the top cap, and a horizontal load is applied to the geotextile through a clamp. As a result, the pull-out resistance determined by the type of geotextile, type of soil, moisture and other factors is estimated. With the experiment the coefficient of interaction of layers can be determined.

Experiment with geogrids is technically more complicated, since with the correct choice of grid cell size and soil fraction individual particles become blocked in the cells, as a result of which the non-cohesive soil becomes “cohesion”. Obviously, this reinforcing layer has a way higher coefficient of interaction, because its roughness is determined by the size and roundness of soil particles. In this case, it is preferable to use a direct simple shear instrument, in which the position of shear plane is not fixed.

For the direct assessment of the influence of geotextile on the strength of macrofragmental soil the triaxial compression instrument should be used. However, these tests are tray experiments in their essence: a sample of structurally anisotropic material is placed in the instrument cell, the stress state can in no way be considered homogeneous, interpretation requires a special mathematical tool. Nevertheless, our colleagues have some experience in conducting such tests, for example, at RWTH Aachen University (Aachen, Germany).

OOO “Geotek” proposes the automated testing system “Spec-line” for shear tests of the samples of macrofragmental soils up to 300mm in diameter.

The system includes boxes for simple shear and direct simple shear and also the equipment for creating vertical and horizontal loads. Tests are carried out in an automated mode with control of all test parameters in real time. Cells for samples of other sizes can be made on a special order.