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Stress-Strain States Differences in Specimens during Triaxial Compression and Direct Shear Tests

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Abstract

This article compares the soil strength parameters obtained from data of triaxial compression and direct shear tests, both with dense samples of fine sand. Direct shear device and triaxial device have significant differences in stress – strain state, which is developed in the specimen during test. In order to evaluate the stress-strain state, the direct shear and triaxial tests were simulated with finite element program PLAXIS 3D.

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Keywords: direct shear, triaxial compression, shear strength parameters, sand, stress-strain state.

1. Introduction

When the shear stress becomes equal to the peak shear strength along specified plane, the soil will fail. In general, for soil stress states at failure are more often subscribed by the Mohr-Coulomb failure criterion with two shear strength parameters: φ – angle of internal friction and c – cohesion. Generally, the direct shear and triaxial devices are used to determine shear strength parameters of soil in laboratory [1].

In triaxial device cell the specimen is enforced by principal stresses. Vertical stress is the major principal stress σ_1. In a traditional triaxial test confining pressures $\sigma_2 = \sigma_3$ are kept a constant, while the major principal stress σ_1 is

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increased incrementally until the sample fails. It is assumed that end effect on results will be eliminated when the height of specimen is twice its diameter [2,3].

In the direct shear test the stresses affecting the failure plane are determined directly by applying a normal and shear forces to the sample. The device consists of two rings or rectangular boxes between which shearing plane is formed. Vertical force provides the normal stresses, and the horizontal force causes shear stresses.

These two devices have apparent differences in the stress condition that is developed in the specimen during the test. The main differences are failure plane and principal stress. In direct shear device the failure plane has pre-assigned location, whereas in triaxial device the failure plane is uncertain. In direct shear device the normal and shear stresses on failure plane are calculated directly from acting forces. In the triaxial device the intermediate and minor principal stresses are equal and are normally specified constant, the major principal stress σ_1 is increased incrementally until the sample fails. Whereas in direct shear device values of intermediate and minor principal stresses are not known.

In order to analyze and evaluate the stress-strain state, the direct shear and triaxial tests were carried out in laboratory and imitated using software [4,5].

2. Laboratory tests for soil shear strength determination

Direct shear and triaxial tests were carried out with samples of sandy soil, which according to reference [6], soil is fine sand (FSa). Samples with 6% water content were prepared by compacting them. Samples mass density was ρ = 1,871 g/cm^3 and void ratio of e = 0,52. Sand particles has angular shape. For direct shear tests samples 7,14 cm in diameter, 3,41 cm in height were used. The tests were carried out under the normal stress 50, 100, 150, 200 kPa, constant axial strain rate 0,5 mm/min. The samples under the same normal pressure have been sheared at least three times. The test is finished when horizontal displacement of the ring reaches 5 mm. The sample is loaded via hinge by chosen vertical load applying the lever mechanism. Such loading transmitting to sample ensures the constant vertical load on the top of sample, i.e. developing constant normal stress per whole loading history. The normal load is measured at the bottom of the sample during test [7]. The sample is sheared by a constant velocity by moving lower part of the ring. Thus, the shearing velocity is controlled and lateral force is permanently measured.

Triaxial tests were carried out with soil samples, the height/diameter ratio of which was 2. The diameter of samples was D = 5 cm, and height was H = 10 cm. The tests were carried out under the constant cell pressure 50, 100, 200 kPa and the constant axial strain rate 0,1 mm/min. The samples under the same cell pressure have been sheared at least three times. The pore pressure had no influence on test results, tests were carried out in drained condition.

Typical curves of shear stress versus shear displacements for dense sand specimens in direct shear test (Fig. 1) are similar to curves obtained relating deviator stress versus axial strain in drained triaxial compression tests (Fig. 2). The shear stress increased with shear displacement to maximum value τ_f (peak value) and then decreased to a value τ_r (residual value).

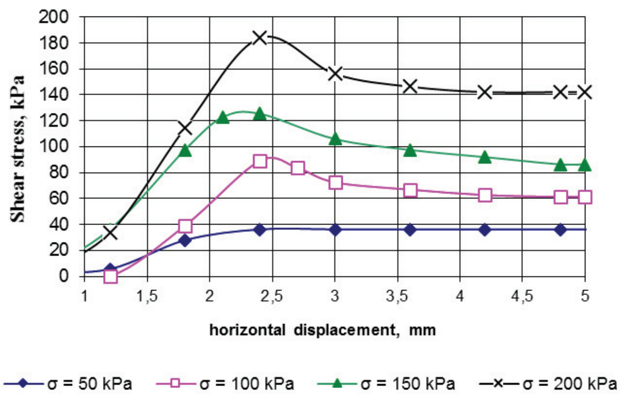

Fig. 1. Shear strength characteristics of sand in direct shear tests.