Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 172 (2017) 218 – 225

Procedia Engineering

www.elsevier.com/locate/procedia

Modern Building Materials, Structures and Techniques, MBMST 2016

Experimental and Numerical Analysis of Direct Shear Test

Neringa Dirgėlienė[a]*, Šarūnas Skuodis[a], Andrius Grigusevičius[b]

[a]Department of Geotechnical Engineering,
[b]Department of Structural Mechanic, Vilnius Gediminas Technical University, Saulėtekio al. 11, Vilnius LT-10223, Lithuania

Abstract

An experimental and numerical investigations of the direct shear test have been performed under constant vertical stress (q = const) and constant sample volume (h = const). During the determination of soil shear strength in a laboratory by different test methods soil is loaded in a different way. This fact has an influence on stress-strain distribution in the sample. The finite-element method analysis also shows that during direct shear tests distribution of stress and strain in the sample is non-uniform. If we know a real distribution of stress and strain in the sample, it is possible to determine the soil shear strength and deformation parameters in a more precise way or to rate the influence of different factors on soil properties.

Peer-review under responsibility of the organizing committee of MBMST 2016

Keywords: direct shear test; finite-element method, constant vertical stress; soil constant volume; stress-strain distribution.

1. Introduction

Shear strength is the principal engineering property of soil, which controls the stability of a soil mass under structural loads. Accurate determination of the soil shear strength parameters (angle of internal friction and cohesion) is a major interest in the design of different geotechnical structures. These parameters can be determined either in the laboratory or in the site. The triaxial compression and direct shear tests are the most common tests for determining the angle of internal friction and cohesion values in the laboratory. Special care must be taken to establish loading condition actually existing in the ground and to duplicate this condition in the laboratory.

* Corresponding author. Tel.: +370-5-2745220; fax: +370-5-270 0112.
E-mail address: Neringa.Dirgeliene@vgtu.lt

Peer-review under responsibility of the organizing committee of MBMST 2016
doi:10.1016/j.proeng.2017.02.052

Boundary conditions are not distinct when analysing soil samples by direct shear test [1]. Not all vertical stress apllied on top of shear box specimen is transmitted on soil. It is not obvious the regularity of change of normal stresses on a shear plane [2–6]. If a direct shear test is analysed, the stress distribution depends on the following: manner of vertical load transmission, position of the mobile part of shear ring, horizontal displacement of the mobile part of the ring. Some factors are not evaluated during the results interpretation, for example, friction between soil and device metal parts [3,7–10].

The numerical methods enable the determination of material parameters that would have been difficult to measure in the experimental study [4,5,11].

The aim of the current investigation is to analyse stress-strain distribution in the sample during direct shear testing depending on the manner of the vertical load transmission. The experimental direct shear test on sand have been performed under constant vertical stress (q = const) and constant sample volume (h = const). Experiments were simulated performing the numerical analysis by finite element method program COSMOS/M.

2. Laboratory experiments

The air-dry sand of the Baltic Sea coastal area was used to perform the experiments for determining the shear strength parameters. The average density of particles (ρ_s) value of marine sands is 2.66 Mg/m³ and ranges from 2.65 to 2.67 Mg/m³ [9].

The vertical stress magnitudes of 100, 200, 300 kPa have been applied. The soil is sheared under the constant horizontal displacement velocity of 0,5 mm/min until the horizontal deformation reaches the limit of 9 mm. The shear test is performed under two different cases (methods), namely: when constant vertical stress (q = const.) is applied; when constant sample volume (h = const.) is applied.

The shear tests have been performed for loose sand (density ρ = 1,491 g/cm^3). The peak soil shearing strength has been determined according to the maximum ratio of tangential and normal stresses, id est. according τ/σ = max [9].

3. Analysis of obtained results

The characteristic investigated sand shear graphs for loose soil (Figs. 1–2) have been processed for different testing methods, id est. for q = const and h = const [9].

In the case of initially loose sand when q = const there is no significant particle interlocking to be overcome and the tangential stress increases gradually to an ultimate value without a prior peak, accompanied by a decrease in volume (Fig. 1 a). In the case h = const shear stress increases and decreases immediately and after remains almost steady (Fig. 1 b).

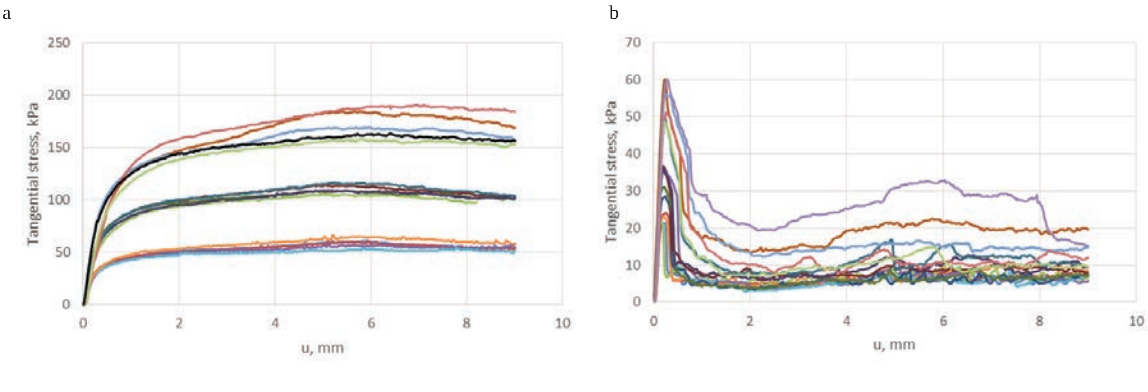

Fig. 1. Tangential stress at the applied normal stress when: a) q = const; b) h = const.

From Fig. 2 a one can find that the applied vertical stress of magnitudes of 100, 200, 300 kPa remained constant during all the test time. Aiming to keep the constant sample volume at the beginning of testing, the vertical loading