Some important aspects in evaluating cyclic triaxial tests on clayey soils

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ABSTRACT: Compared to static test, cyclic triaxial test on saturated clayey soils under partly drained condition can not be seen as element test, as even under ideal technical condition the distributions of stress and excess pore pressure in soil sample are inhomogeneous. In this paper, cyclic triaxial test is numerically studied by using a quasi-static model which is developed for describing long-term plastic deformation of saturated clayey soils under cyclic loading condition. In the investigation, real boundary conditions were taken into consideration and their influence was demonstrated.

1 INTRODUCTION

Cyclic triaxial test is a conventional method in investigating the mechanical behavior of soils under cyclic loading. It is well known, however, that cyclic triaxial tests on clayey soils under partly drained condition can not be seen as element tests, as the distributions of stress and excess pore pressure in soil sample are normally inhomogeneous due to the low permeability of clayey soil and applied load velocity (frequency). A direct derivation of constitutive relationship from tests is therefore impossible.

Based on the physical description of excess pore pressure and plastic deformation of saturated clayey soils under cyclic loading, a conceptual model is proposed upon quasi-static approach. Using some typical test results under cyclic undrained condition as well as under cyclic undrained-subsequent drained tests, this model is formulated and numerically implemented by using finite element method.

Using this calculation model, cyclic triaxial test is numerically simulated for clarifying the real distribution and development of stress and excess pore pressure as well as resulting permanent deformation of soil sample.

2 QUASI-STATIC MODEL

2.1 *General description and conceptual model*

The mechanical behavior of saturated clayey soils under cyclic loading is dependent on many factors, above all soil type. Here, it is focused on saturated clayey soils that show contracting behavior under shear loading. For such soils, excess pore pressure is expected under cyclic loading. Depending on cyclic number, excess pore pressure rises in the first stage and consists of reversible and "permanent" components ($u = u^c + u^b$). The "permanent" part results from the undrained plastic shear deformation and remains when load is removed. After some time (t_p see Figure 1) which depends on e.g. permeability, drainage path, loading and boundary condition, excess pore pressure reaches peak value and begins to dissipate in the second stage. Due to the dissipation of excess pore pressure, plastic volume strain occurs. Compared to "permanent" part, however, reversible part of excess pore pressure is normally much smaller than "permanent" part. Furthermore, this part of excess pore pressure can not dissipate due to its oscillating character.

The research in (Hu 2000) showed that "permanent" excess pore pressure is a decisive parameter for plastic deformation of normally consolidated clayey soils under cyclic loading condition. Both plastic deformations, undrained plastic shear deformation in the first stage and drained plastic volume strain in the second stage, are exclusively dependent on this parameter. Based on this, a quasi-static model was proposed describing plastic deformation behavior of saturated clayey soils under cyclic loading, see Figure 1 from (Hu 2000). In this model, maximum of cyclic stress is applied as loading parameter. The attention is focused on permanent deformation and individual cyclic loop is therefore not followed.