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Large Shear Box Testing on weathered zone of Flysch. The Case Studies of Panagopoula and Karya Landslides

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Abstract

This paper describes the landsliding behavior of highly weathered and tectonically decomposed flysch in characteristic landslides in Western Greece, focusing on its mechanical parameters, such as shear strength. Generally, the most serious landslide movements in Western Greece are often observed in the upper weathered zone of flysch and they often constitute translational and composite landslides.

Large shear box tests were performed on selected samples of weathered flysch zone, under different moisture and density conditions. Three varying normal stresses were applied in each sample to determine the effects upon shear resistance and displacement. The results show that an increase of moisture content ensue an appreciable decrease in apparent friction angle. Furthermore, a dilatant behavior in dense samples was exhibited in contrast with the loose ones. A clear effect of composition - structure as well as moisture - density is also observed on the shear strength variation.

Introduction

During the last decade, an increase of 25% of landslide phenomena has been recorded in the country, as a result of human activities, increasing urbanization and uncontrolled use of land areas that are vulnerable to landslides (Sabatakakis *et al*., 2012). Many of these landslides have been occurred in weathered flysch, a critical landslide-prone geological formation that have been reactivated in recent decades due to intense and prolonged rainfall. In this study, representative landslides, i.e., Panagopoula and Karya landslides, are examined and focusing on the mechanical behavior of the weathered flysch through shear strength tests.

Panagopoula comprises an extensive instability zone, including composite fault-related slides, located in the Gulf of Corinth, where periodically induced landslide events have been interspersed with creep activity (Koukis *et al*., 2009, Kavoura *et al*., 2016). In 1971 and 1972, translational and rotational slides occurred, affecting the transportation lines over about 250 m. The slides took place on structurally sheared and weathered flysch sediments and are still locally active in smaller areas (Sabatakakis *et al*., 2015).

Karya village, belongs to Municipality of Patras located about 12 km away from the city center and cited close to the edge of Panachaikon Mountain, with an altitude of 250m a.s.l. Significant failures were recorded in 1961, 1999 and 2001 including earth flows and translational slides on weathered flysch and mainly due to prolonged rainfalls (Sabatakakis *et al*., 2005, Koukis *et al*., 2007).

Methods

This paper presents the results of two series of large shear box tests on typical highly weathered and decomposed flysch formation, obtained from Panagopoula and Karya sites.

The soil samples were coming from exploratory boreholes as well as from flysch outcrops in characteristic sites of the extended landslide zones. Classical laboratory tests were conducted to determine moisture content, grain size distribution and Atterberg limits.

The Large Shear Box 300 (VJT2780A) apparatus (Fig.1) was used. From each type of weathered flysch, a series of tests were performed on prepared specimens with different water content and density in order study the effects of these parameters on the shear strength characteristics. Specimens were tested on dry, wet (partially saturated) and fully saturated conditions. Loose and dense specimens were also prepared to represent surficial and deeper zone of weathering.

Direct shear tests were performed on flysch sample grain fraction passing through the sieve No. 4 (<4.75mm) in accordance with ASTM standards (2004). Tests were performed using large shear box (300mm square about 160mm thick), soil samples under certain density - moisture conditions and three different normal stresses. The weathered flysch samples collected from the failure zone (weak zone) were classified according to USCS as clayey sands (SC) of medium plasticity with a small presence of well-graded gravels and a moisture content of 16-18%.

Figure 1. Large Shear box apparatus.

The different consolidation loads were left for one day in case of saturated conditions, whereas for a couple of hours until stabilization in case of dry tests. The shearing rate of the samples was very low in order to assure that no significant amount of pore water pressure would be developed at any stage of the test. All tests were regulated with the criteria to stop when the accumulated shear strain (γ) reached 10%.

Conclusions

Instability phenomena are very common in the weathered and tectonically highly sheared flysch, causing serious problems in many places in Western Greece. Large Shear laboratory tests in the weathered zone of flysch of representative flysch-prone landslides, show a definite decrease in the effective friction angle within the increase in water up to saturation state. Significant differences are also observed in the failure envelops of dense and loose conditions.

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