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# Simple shear tests on unsaturated soils

Sabatino Cuomo[a,*], Mariagiovanna Moscariello[a], Vito Foresta[a]

[a]*University of Salerno, Via Giovanni Paolo II, 132, 84084 Fisciano (SA), Italy*

**Abstract**

Rainfall induces landslides in several geo-environmental contexts through a variety of triggering mechanisms. In shallow covers of unsaturated silts or loose sands, static liquefaction may occur upon shearing or wetting. The paper proposes simple shear and wetting tests performed on remoulded specimens of air-fall volcanic pyroclastic silty sands from Sarno site (Italy), where huge flowslides occurred. Simple shear wetting tests reproduce the initial stress conditions in the field as well as the stress path of the most common triggering mechanisms which take place during critical rainfalls. The tests are carried out through the Unsaturated Simple Shear apparatus designed at the University of Salerno. First, simple shear tests are performed in dry and saturated conditions and the results compared in terms of shear strength and volumetric response. Then, wetting tests – under constant vertical stress or constant shear stress – are performed. The experimental results are presented and the future research is outlined.

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*Keywords:* Simple shear; wetting; failure; slope; landslide

## 1. Introduction

Shallow landslides are frequently triggered by rainfall in many geo-environmental contexts like Central America, New Zealand, Japan, Brazil and many other Countries. Soils of different grading and origin are involved in slope failures [1]. Typical examples are the shallow deposits of unsaturated pyroclastic soils [2,3] of Southern Italy, in a 3000 km$^2$ sized district where volcanic explosive activity of the Somma-Vesuvius volcano produced large amount of pyroclastic soils. Along steep slopes, pyroclastic soils are in unsaturated conditions and may experience static

* Corresponding author. Tel.: +39(0)89-964231; fax: +39(0)89-968732.
*E-mail address:* scuomo@unisa.it

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liquefaction upon shearing or wetting [2]. This entails that flowslides may occur or, alternatively, shallow slides may evolve into destructive landslides of the flow-type.

Flow-like landslides are complex slope instability phenomena since they exhibit multiple stages and distinct kinematic characteristics throughout the whole process [3,4]. The failure stage is related to: rainfall infiltration from ground surface; water spring from bedrock; ponding at ground surface; or a combination of the previous factors. Those boundary conditions increase pore water pressures, with consequent reduction of shear strength, and formation of localized shear surface or a diffuse failure [1,2]. In the post-failure stage, the acceleration of failed mass relates to undrained (totally or partially) conditions able to produce high pore water pressures during the soil shearing [2]. Most of the previous laboratory investigations about failure and post-failure stages were performed through triaxial tests. In this paper, the Unsaturated Simple Shear Apparatus (USSA) – designed at the University of Salerno [5,6] – is used. The experimental results are presented and the future research possibilities are outlined.

## 2. Materials and Methods

### *2.1. Experimental devices*

The Unsaturated Simple Shear Apparatus (Fig. 1) allows applying a vertical load to a soil specimen, and a "shearing mode" through the application of a controlled (i) horizontal force or (ii) horizontal displacement. A peculiarity of USSA is the shearing box consisting of a stack of twelve hollow disks which ensure zero lateral strain to the specimen. The disks are held together by two vertical screws doing the specimen assembly and removed before starting the shearing stage of the tests. The specimen housing has a circular inner cross section with a diameter equal to 51 mm. Cylindrical specimens 22 mm high are used. The specimen is sheared due to synchronized movement of two linear fluting grooves machined on the upper side of each disk, and two external holed metal straps fixed on bottom and top disks. The matric suction is measured or applied through the axis-translation-technique. Particularly, the suction is controlled at the bottom of the specimen, measuring the pore water pressure (suction) at the top. Being applicable both vertical load, shearing deformation and soil suction, the USSA is suitable to reproduce the in-situ conditions of a slope and the strain and stress paths induced by rainfall during the failure and post-failure mechanisms [1,2].

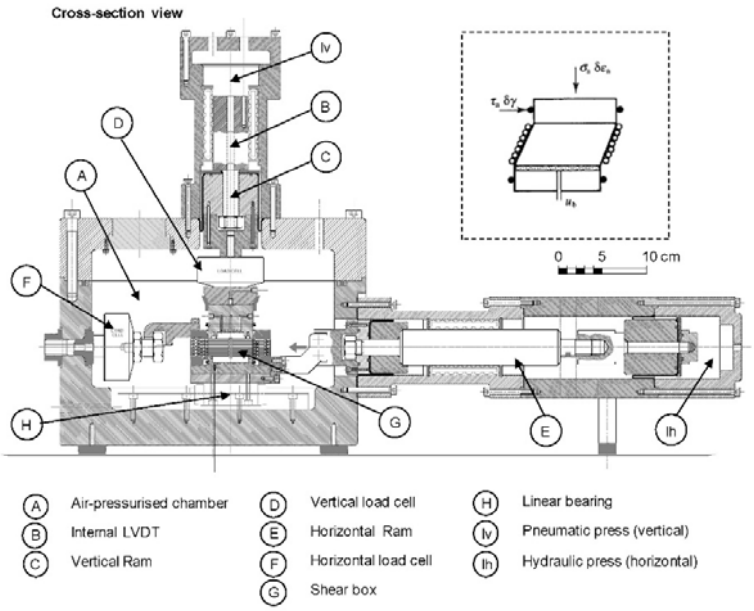


Fig. 1. Schematic view of the Unsaturated Simple Shear Apparatus (USSA) (modified from Sorbino et al. [5]).

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