Date of Submission	31.03.2021

IPL Project (IPL - 245) Annual Report Form 2021

1 January 2020 to 31 December 2020

1. Project Number (approved year) and Title:
   IPL-245 (2019) Laboratory physical modeling of rainfall, slope deformation and landslides triggering.

2. Main Project Fields
   (1) Technology Development
   A. Monitoring and Early Warning,
   (4) Mitigation, Preparedness and Recovery
   A. Preparedness, B. Mitigation

3. Name of Project leader

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   Core members of the Project
   Names/Affiliations: (4 individuals maximum)
   - **Prof. Eng. Pasquale Versace /** University of Calabria, DIMES, CAMILab, CINID (Interuniversity Consortium for Hydrology).
   - **Eng. Gennaro Spolverino /** University of Calabria, DIMES, CAMILab.
   - **Eng. Emilia Damiano** / University of Campania Luigi Vanvitelli, DICEA.
   - **Prof. Eng. Roberto Greco** / University of Campania Luigi Vanvitelli, DICEA.
   - **Prof. Eng. Lucio Olivares** / University of Campania Luigi Vanvitelli, DICEA.

4. Objectives: (5 lines maximum)
   The project aims to understand the mechanisms that control hydraulic processes in unsaturated soils, responsible for triggering landslides, by experimenting with a slope physical scale model.

5. Study Area: (2 lines maximum)
   Tests will be carried out at the University of Calabria using pyroclastic soils sampled around Vesuvio Vulcano area (South Italy)

6. Project Duration (1 line maximum)
   3 years

7. Report

1) Progress in the project: (30 lines maximum)

T3 test has been completed. A stratified deposit was reconstruct, formed by a layer of pumice, covered by a layer of volcanic ash, in order to determine the influence of these layers on the evolution of the landslide. The pumice layer is 5cm thick, while the ash layer is 15cm thick. Figure 1 shows the reconstruction of the two layers. During this test, no landslides occurred. The curves of the hydraulic conductivity function of the two soils shows that the pumice, in the range of suction of the test, have a higher permeability than the paleosol. With this configuration, we can say that all water that infiltrates in the paleosoil passes in the pumice and out of slope. This does not create positive water pressure and this can be an explanation of no failure.

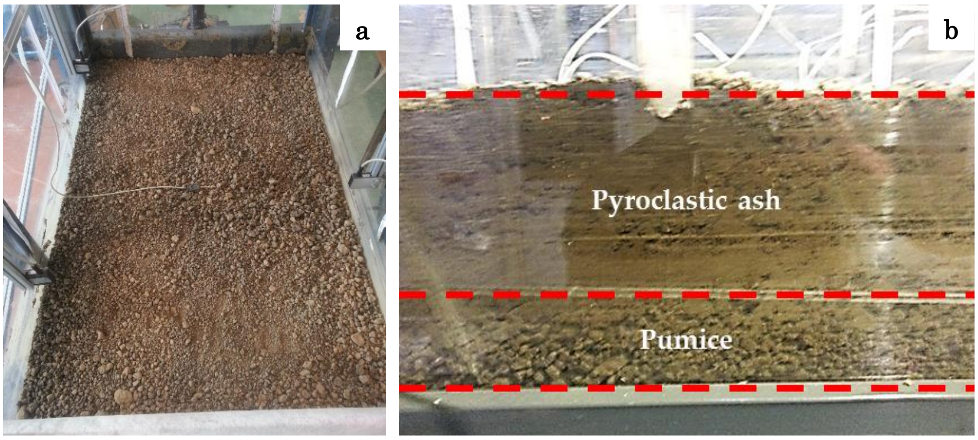

Figure 1: Reconstruction of the two layers.

An experiment was carried out to define a specific calibration relationship of the TDR probes. Time domain reflectometry (TDR) is one of the most widely used techniques for indirect determination of soil volumetric water content. In many cases, the application of TDR requires a specific calibration of the relationship to get quantitatively accurate estimates of soil water content. The probe was vertically placed in the middle of a cylinder (diameter 10 cm, height 14 cm), inside of which soil samples of assigned porosity and water content were reconstituted. The wet soil was gently mixed (Figure 2a), to get a homogenous water content distribution, and was placed into the cylinder in five layers of equal weight (Figure 2b).

Figure 2: a) Soil mixing. b) Placing the soil in five layers.

Then, the TDR probe was gently inserted into the soil. After at least two TDR measurements, the soil was removed from the cylinder, more water was added to obtain a higher water content, and the sample was placed again into the cylinder with the same procedure for mixing and reconstituting. The addition of water was repeated until the soil became a liquid mud, so that the reconstitution layer by layer of the sample was not possible anymore. For all the three investigated soils, the entire procedure was repeated with three different porosities (n = 0.50, 0.55, 0.60). An empirical calibration equation has been obtained, which can be used with acceptable errors. Furthermore, a four-phase (solids, bound water, free water, and air) dielectric mixing model, specifically calibrated to best fit the experimental data, has been obtained.

2) Planned future activities or Statement of completion of the Project (15 lines maximum)

Currently a new test (T4) has been prepared by reconstructing a stratified deposit. The reconstituted layered deposit was 270 cm long and 60 cm wide, and it consisted of a 10 cm thick layer of pumices interbedded between two layers of ashes. Both the upper and lower layers of ashes had a thickness of 20 cm. Aiming at detecting the effects of the layers on the infiltration process, the deposit was equipped with 10 tensiometers, located at four different depths, approximately along three alignments, orthogonal to the slope surface, near the center of the deposit, and 8 TDR probes located at three depths along the same alignments. The deposit was confined at all the sides by plexiglass panels, so to have impervious boundaries. The only exception was the flume cross section at the foot of the slope, where a seepage face boundary condition was realized, by means of a perforated metal panel, with circular holes with diameter of 0.5 cm, regularly spaced every 0.7 cm. The perforated panel was provided with gutters at the base of each soil layer, as well as in correspondence of the top soil surface, so to separately collect, at the foot of the slope, water outflow from the three layers and overland runoff.

3) Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)

Rainfall-induced landslides cause diffuse damage to people, structures and infrastructures. A good predictive model can allow the implementation of an equally good warning system, reducing the risk caused by such phenomena. The main beneficiaries will be the national civil protection, all and those, academic and public agencies, who implement warning systems o deal with disaster risk reduction.

4) Results: (15 line maximum, e.g. publications)

Spolverino G., Capparelli G., and Versace P. (2019). *An Instrumented Flume for infiltration process modeling, landslide triggering and propagation*. Geosciences 2019, 9(3), 108; https://doi.org/10.3390/geosciences9030108.

Capparelli G., Napoli P., Spolverino G., Versace P. (2019). *Laboratory Physical Model for infiltration processes modeling, landslides triggering and propagation*. ISBN 978-88-498-5635-4.

Capparelli, G., Damiano, E., Greco, R., Olivares, L., Spolverino, G. *Physical modeling investigation of rainfall infiltration in steep layered volcanoclastic slopes* (2020) Journal of Hydrology, DOI: 10.1016/j.jhydrol.2019.124199