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Early detection of pre-failure slope deformations in granular soils by using fiber sensing technique

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Flowslides and debris-flows in granular soils are among the most destructive type of slope movements due to their high speed of propagation and the great distance they travel. They are usually triggered by rainfall infiltration, and are characterized by an ab-rupt failure, preceded by small deformations. This is the case of the rainfall-induced landslides which periodically affect an extensive mountainous area surrounding Mt. Vesuvius in southern Italy. The area is highly urbanized and densely populated, and the detection and interpretation of pre-failure slope deformations are of great importance for risk mitigation. The setup of monitoring systems based on optical fiber sensors may represent a potentially powerful tool to develop Early-Warning Systems. The fibres allow for continuous long-distance measurements, high spatial and time resolution and immunity to electromagnetic interference.

A laboratory research have been performed to check the feasibility of Brillouin Optical Time-Domain Analysis (BOTDA) technique as monitoring system able to monitor and reveal pre-failure strains in slopes susceptible to fast slope movements. The fiber sen-sor was tested on small-scale model slopes consisting of loose unsaturated granular pyroclastic soils subjected to continuous rainfall until failure. The experiments demon-strated that the adopted system, thanks to its ability to record tensile soil strains with a spatial resolution of 20 cm and a time resolution of a few minutes, can effectively detect in time both the mechanisms of volumetric collapse and soil cracking which lead to slope failure. Moreover, it is also able to discriminate between the uphill and downhill slope deformations. However, a proper anchoring system is required in order to im-prove the mechanism of shear stress transfer from the soil to the sensor, avoiding rela-tive displacement between soil and fiber.

The low cost of the material, the quality of the data collected and, above all, the possi-bility of continuous measurements in space and time make the BOTDA technique a promising tool for the monitoring and early warning of natural slopes.