Low-cost interferometric optical fibre-based sensor for landslide monitoring: laboratory tests under different applications

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A. The problem

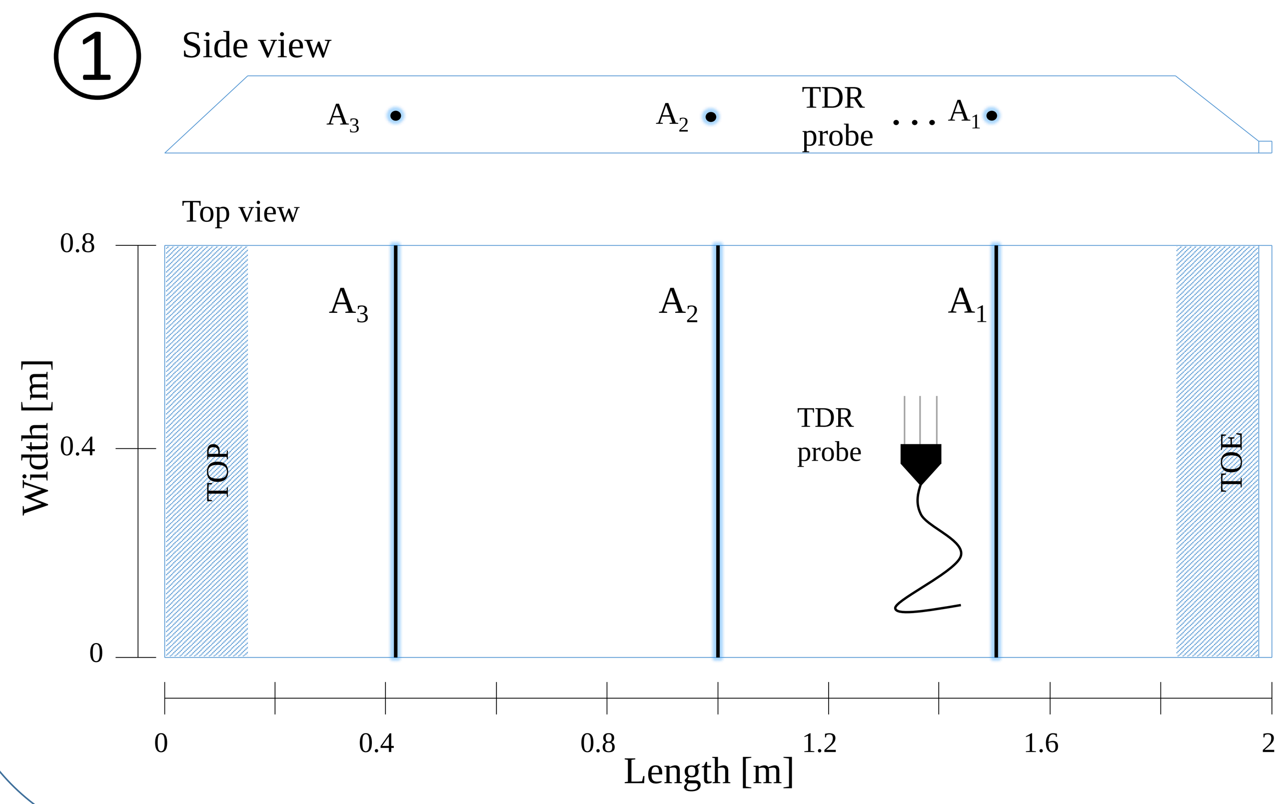
Shallow landslides are natural hazards that often bring about damage of property and loss of human lives following intense rainfall events. Upon activation, they could evolve into debris flows of calamitous nature as well. Thus the monitoring of areas prone to shallow landslides is an essential prevention technique. After their identification, a suitable monitoring system should be defined, preferably including an early warning module. Such systems are however identified with excessive costs which are often not justified considering the rather widespread nature of the phenomena and the damage induced to the system itself that is expected.

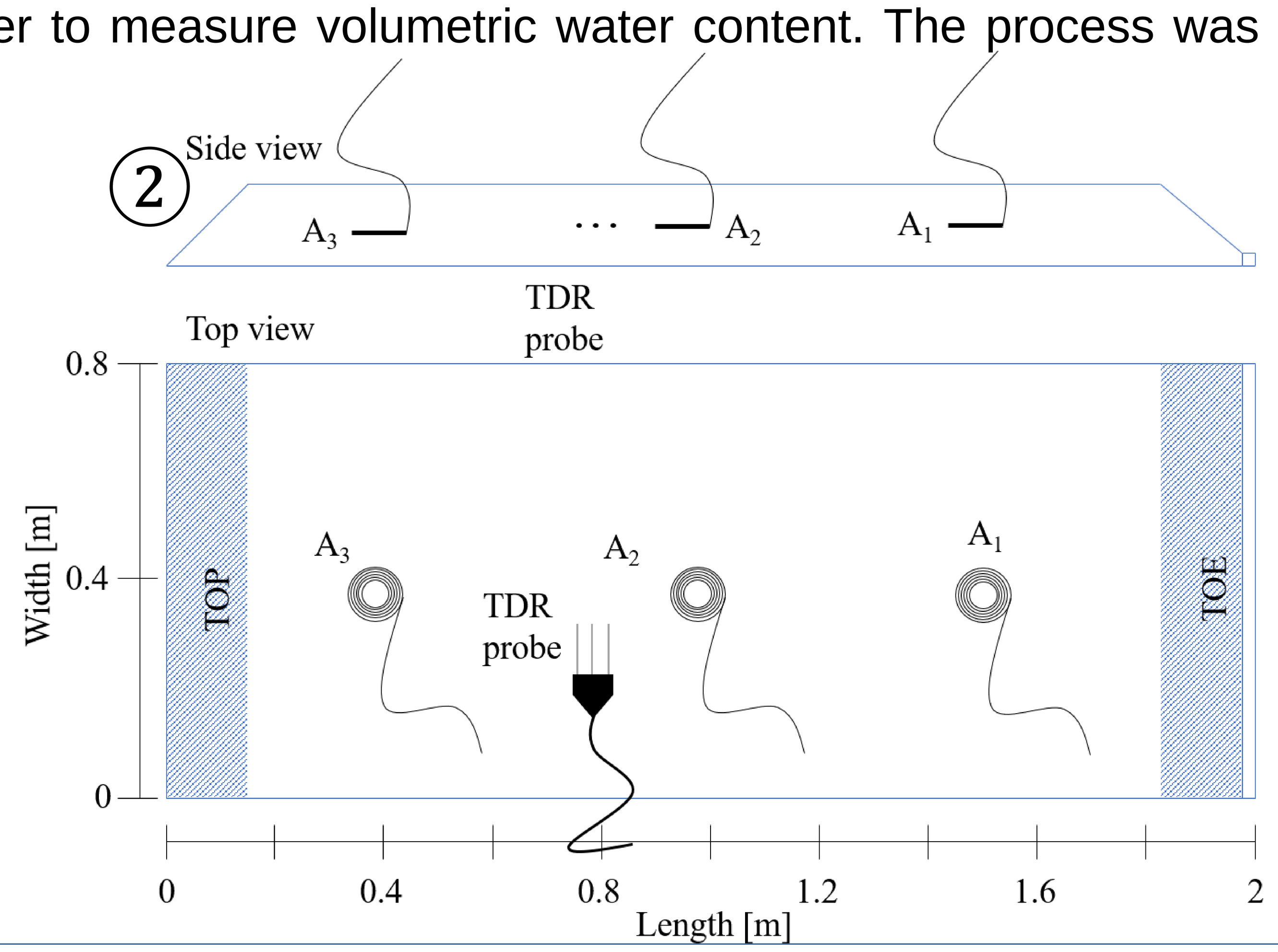
B. Methodology

An experimental approach for the development of a fiber-optic instability strain sensor based on an innovative low-cost interrogating technology. To this end, a series of controlled laboratory scale experiments were carried out, in which fiber optic sensors were deployed within a shallow uniform sand layer. During each test, the onset of a shallow instability in and artificial channel was simulated where the flume is instrumented with an rainfall sprinkler system. In order to investigate the drivers of initial instability signs and put the fiber optic sensor readings in relation to the ongoing processes, the experimental work incorporated additional sensing instruments: a TDR probe, a goeresistivity meter and videocameras. Experiments were carried out under various initial conditions as well as forcing precipitation of different intensity in order to explore how the instability conditions are dominated.

C. Experimental setup

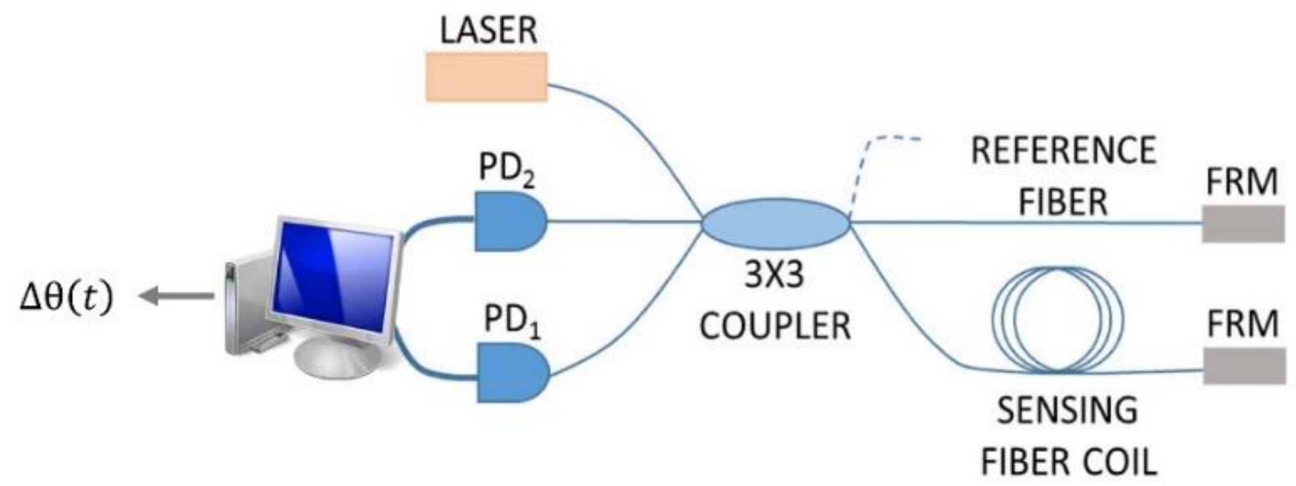
An experimental flume with an adjustable inclination plane was constructed in order to accommodate the experiments. Supporting monitoring tools were employed in order to monitor the process from different points of view. We used a TDR probe and a Georesistivity-meter to measure volumetric water content. The process was recorded with a HQ action cameras.

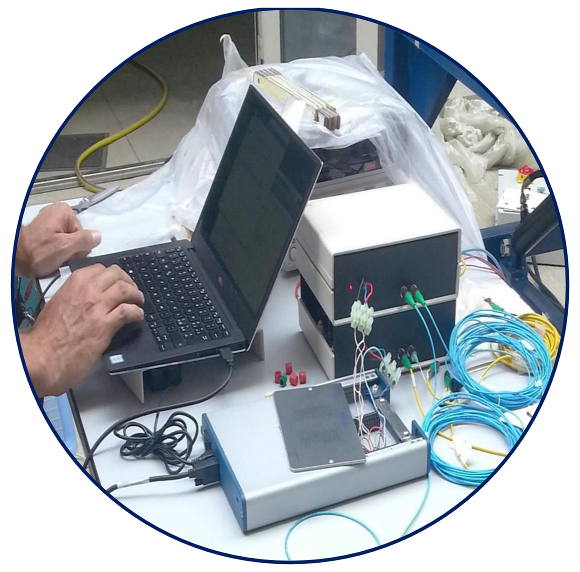




D. Optical fibre sensor

The optical fiber sensors used in this work are based on the measure of the phase difference of two light signals. One signal propagates along a cable in the terrain while the other one is free and serve as a reference. The sensing cable is subject to strain during the experiment and thus a difference in the two signals' phases is generated.





E. Results

The optical fiber sensors provided a cumulative phase difference as an output which enabled the visualization of the strain applied to the c able in time. Configuration ① demonstrates the direct strain imposed on the sensor cable, while configuration ② is able to detect high frequency response of the sensor due to the interparticle friction of grains. Spectral analysis illustrates this response.