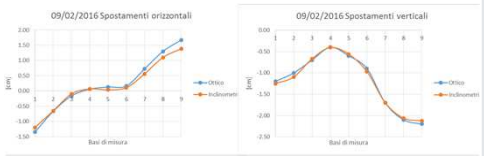
SAFE CERTIFIED STRUCTURE

Real time landslide monitoring system

Inclinometer experimental results

Displacements after 7 days and comparison with the optical georeferenced system.



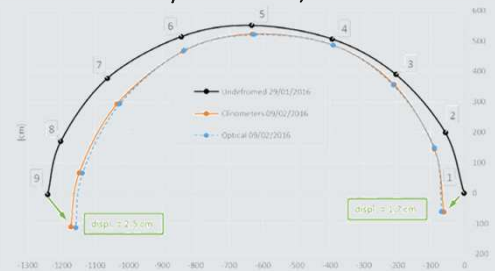
The Sacertis landslide monitoring system is based on a set of inclinometer cells permanently installed in the ground, connected to the web through the cellular network and powered by the electric grid (or by batteries recharged by solar panels). In more detail, this devices chain is composed of MEMS accelerometers measuring gravity acceleration and vibrations. By projecting the gravity acceleration vector on three axes it is possible to derive inclination. Multiple accelerometers periodically sends their tilt measurement to a head unit, which forwards these data using long range wireless transmission to a concentrator. The earth magnetic field is used as a reference in each sensor to estimate an absolute direction of the sensed movement.

These devices, tested in top University labs, are now installed in several facilities and are supported by an important ecosystem of global world leading companies (AXA, IBM, STMicroelectronics).

A cloud communication system, coupled with a real-time analysis of the recorded data, emulates the behavior of the landslide and generate alarms within a few seconds of the triggering event. The cloud environment assures the scalability of the entire system.

The sensor has already been tested in at least three different tunnels showing a precision of a few thousandth of one degree. The first test, carried out in an Highway tunnel at the break of the last diaphragm, showed more accurate results than the georeferenced measurements. The sensors streaming data are uploaded on the mathematical model in real time.

Comparison with optical georeferenced system. Florence, Jan 2016



The patented device consists of a ribbon, in which the inclinometers are inserted at a distance of one meter (different distances are also possible). The tape is protected from humidity and pollutants and unfolded into the borehole until it reaches the desired depth. At the end of this phase, and contemporarily to the extraction of the temporary hole casing, grout is injected into the hole to cement in place the system, so ensuring its adherence to the surrounding ground.

A GPS referenced gateway, set at the top of the device, gathers data and sends it to the cloud through the cellular network, where they are stored on the cloud platform, cleaned by noise and all influences of environmental parameters (temperature, Humidity, etc.), compared with historical data to monitor the evolution of the landslide and the results are accessible to the property. When pre-set alarm thresholds are reached, immediate warnings are issued to everyone concerned.

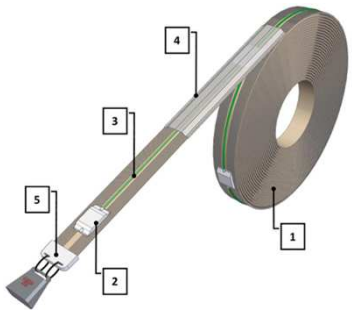
The cost of the device is in the order of the hundred euros per linear meter (net of installation costs) while the yearly monitoring service is in the range of one thousand dollars, according to the amount of data transmitted (i.e. the number of sensors). It is also possible to optimize the number of sensors at depths not critical for the landslide or where risk is highest.

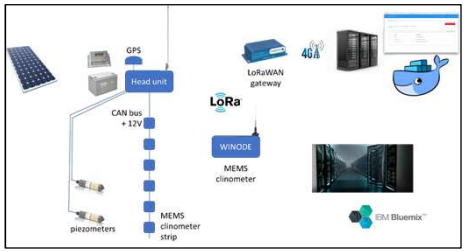
Based on the measured data, mathematical models of the landslide can be developed and calibrated . Similarly, catastrophic events such as floods or seismic actions can be simulated, and the relevant fragility curves developed. In this case, the cost of the service will be proportional to the complexity of the landslide and the number of generated data.

The same device, mounted horizontally, can monitor the vertical displacements of large areas subject to permanent loads (dams, tanks, new buildings on soft ground or adjacent to existing buildings, etc.).

New drilling

Existing clinometer pipe





The system

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