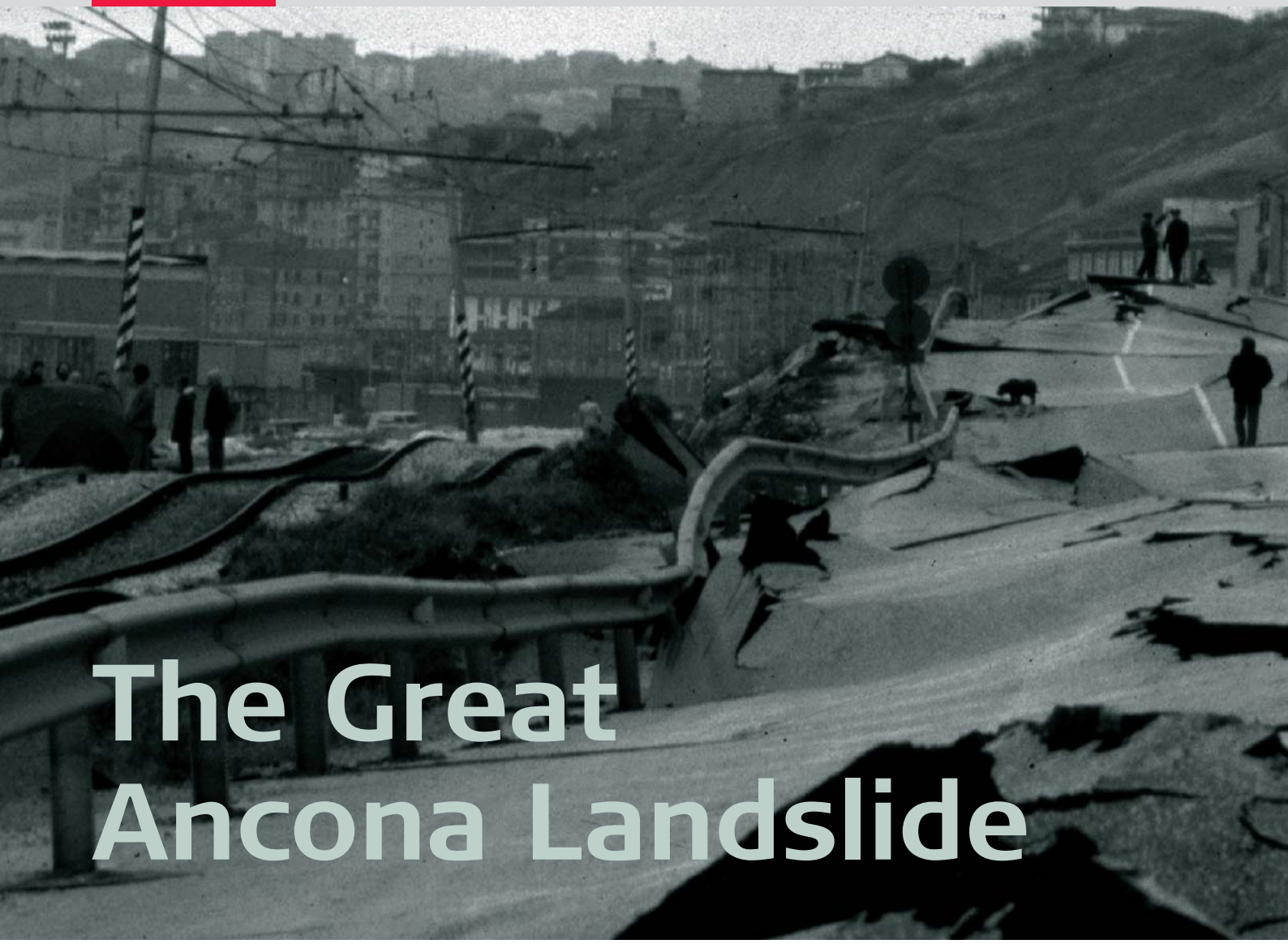

The Great Ancona Landslide

by Carlo Bonanno and Massimo Magnani

On 13th December 1982, a very large zone of the city of Ancona was devastated by a huge landslide, affecting 11 % of the urban area. Homes and infrastructure were seriously damaged, about 3'000 people had to be evacuated. The railway and state highway were blocked, and water and gas supplies interrupted. After years of study authorities decided that consolidation was not a feasible option. This was due to both the cost and the environmental impact, which would have devastated the areas' natural character. Therefore, the City Council decided to ensure the safety of the local population by designing and installing a complex integrated monitoring system to provide constant control of the landslip area.

The affected area of Ancona consists of an entire hillside, approximately 341.5 hectares in total. It ranges from an approximate height of 170 metres above sea level down to the sea itself. During the 15 days prior to the landslide on 13. December, 1982, the rainfall in the area was not exceptionally high in absolute terms but was persistent. This caused a significant rise in groundwater levels.

In response to the landslide, a series of specific laws were passed at both a regional and national level. This enabled the allocation of funds needed for the emergency operations, as well as to complete the clean-up and rehabilitation of the affected area and provide aid to the local people.

After the initial emergency operations, a detailed study was done of the landslide area, in order to draw up a plan for the repair or reconstruction of the affected homes. Preparation of a plan for continuous monitoring of the landslide area using geodetic and geotechnical instrumentation also began. This was used as the basis for a Civil Defence Emergency Plan.

The Monitoring Plan was subdivided into 2 parts; the first of these, relating to the geodetic instrumentation, was put out to tender in 2006. The contract was awarded to Leica Geosystems Italy for the supply and installation of a high-precision continuous integrated topographic monitoring system.

In association with the Ancona City Council engineers installation of the monitoring system began at the end of 2006 and was completed in the summer of 2007. In October 2007 local and national government representatives officially presented the system to the public. This coincided with the system start-up and calibration stage. This stage, currently still underway, has enabled those responsible to analyse the main results and to use them as a basis for setting the alarm thresholds in the Civil Defence Plan.

View of the "Great Ancona Landslide" today.

Three steps for maximum safety

Due to the large area to be monitored and the complex morphology of the landslide zone, the system was designed on the basis of three monitoring levels.

- The first (alarm) level is comprised of three main stations outside the landslide area each with a robotic total station, dual frequency GPS and dual axis inclinometer .
- The second level is comprised of five monitoring stations inside the landslide area, with identical instrumentation.
- The third level is comprised of a network of 26 single frequency GPS sensors and 200 prisms installed on homes, with all prism points measured by robotic total stations.

Each station in the 1st and 2nd level network was installed on reinforced concrete piles. Each pile is 1 meter in diameter, sunk into the ground to depths varying from 10 to 25 meters, with about 3 meters above ground level. Each concrete pile has a Leica TCA2003 robotic total station installed on top. The AX1202 GPS antennas together with the Leica GRX1200 GPS receivers were installed by means of stainless steel posts, 10 cm in diameter, with variable heights. Each station was completed with wiring for communication and power supply.

The 3rd level network stations, were created by installing single frequency GPS antennas and solar panels on the roofs of private homes. Each station was wired to protect the power supply and installed in positions allowing easy access for possible maintenance work. Approximately 200 prisms were installed on the homes in the area, for measurement by the seven Leica TCA2003 robotic total stations.

No significant movements by May 2008

The system runs automatically and is managed by the Control Center in the City of Ancona, about 3 km from the monitoring area. A WLAN – HyperLAN main communications line provides complete and continuous real-time control of all the field sensors. The Control Center has a network of computers running Leica GeoMoS and Leica GNSS Spider software. The software controls the sensors and performs analyses of the acquired data. Custom software modules were specially developed for the management of the alert, pre-alarm and alarm thresholds and the subsequent triggering of warning systems to protect the population. Remote access to the system is possible via the Internet to enable relevant personnel to manage and oversee the system at any time.

The Leica TCA2003 robotic total stations perform a measuring cycle to the prisms every 4 hours. The GPS receivers record measurement sessions lasting 6 hours, with a 15 sec. acquisition rate. Analysis of the results obtained between October 2007 and May 2008 revealed that no significant movements of the structures in the risk area occurred. One year after the start-up of the surface topography monitoring system, the engineers in charge have been able to analyse the first results. This period of fine-tuning of the system has been fundamental in allowing the definition of the alert, the pre-alarm and alarm thresholds.

Future implementations

The tender for the second functional stage of the monitoring project includes supply and installation of underground geotechnical sensors and extremely high precision surface dual axis inclinometers. The combination of different sensors and technologies allows for the most effective monitoring of complex gravitational phenomena, such as the Ancona landslide. This will allow the landslide phenomenon and its evolution over time to be studied by analysing the acquired measurements. Therefore helping to make targeted, effective planning of any future consolidation work possible.

In Ancona, the local government and local population have taken an active approach to living with a huge landslide. This new philosophy is a fresh, dynamic response to a complex problem: the solution moves beyond the usual static concepts of ordinary engineering solutions, unfeasible or unaffordable in this case, while simultaneously reducing the risk level for the people living in the affected areas. ■

About the authors:
Massimo Magnani is Engineering & Solutions Sales & Technical Support, Carlo Bonanno is Engineering & Solutions Sales Manager. Both work at Leica Geosystems SpA in Italy.

Installation "Great Ancona Landslide“

7 Leica TCA2003 robotic total stations
7 Leica GRX1200 L1/L2 GPS sensors
26 Leica GX1210 L1 GPS sensors
230 Monitoring prisms
40 Power supply systems
1 WLAN – HyperLAN communications system
1 Center for Real-Time Control and Management of the Monitoring System, with Leica GeoMoS and Leica GNSS Spider software