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Monitoring and modelling for landslide risk mitigation and reduction. The case study of San Benedetto Ullano (Northern Calabria - Italy)

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On 28 January 2009, a large rock slide in weathered metamorphic rocks activated at San Benedetto Ullano, triggered by abundant and prolonged rainfall. A detailed geomorphological survey, with periodic inspections during the entire phase of mobilization, was promptly started. Benchmarks were placed along fractures opened on the margins of the landslide, and measurements of surface movements were carried out by a team of volunteers. In addition, a network of real-time monitoring extensometers was implemented, combined with a meteorological station. Surveys and monitoring data allowed to implement an embryonic decisional support system (DSS) to handle the emergency [1]. Between February and April, the landslide showed minor displacements, with a retrogressive type of activity distribution, plus a tendency of enlargement towards the flanks. In early May, the first crisis ended up: the landslide extended for ca. 600 m in length, with an average width of ca. 130 m. Mobilization only involved minor displacements (few decimetres) at the margin of the village, affecting a depth of 15-35 meters along the longitudinal profile. A geological-technical scheme of the slope was drawn, based on data from a set of five exploratory wells, equipped with four inclinometers and one piezometer. Parametric, limit-equilibrium parametric analyses were then performed with respect to fluctuations of the water table: accordingly, the first activation of the landslide was expected - as actually observed - in the central portion of the slope when groundwater table approaches the surface [2].

Thanks to the DSS, further activations occurred in the following years could be properly managed by the Major through closing of roads and evacuation of houses. In fact, between 31 January and 1 February 2010, again due to abundant rainfall, the beginning of a new phase of mobilization was announced by the monitoring network. On 10 February, new mitigation measures were issued; on 11 February, slope movements caused severe damage to roads and infrastructure. The second crisis ended up in late June: the hydrological model FLaIR was then successfully tested against the known dates of activation of the slope movement, by using a local rain series [3]. Meanwhile, technical support was being assured to the Municipality to optimize geological prospections, monitoring, and design of remedial works of a master plan.

A third activation occurred during the night of 15 March 2013, when planned remedial works had not been completed yet. By applying the hydrological model SAKe [4, 5], this activation could be predicted, again permitting the prompt adoption of mitigation measures. Such activation was triggered by rains smaller and shorter than those that caused previous activations, perhaps indicating an apparent increasing fragility of the slope.

Changes in slope stability conditions before and after the construction of the remedial works are being investigated. Critical rain conditions and groundwater levels for landslide activation are in fact expected to change, depending on combined effects of natural weakening vs. artificial strengthening. Monitoring will allow to quantitatively verify the new relationships between rainfall, groundwater and slope stability.

References

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