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Landslide dynamics of the Rossena castle area (northern Apennines - Italy): field investigation, monitoring system and conceptual model

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Introduction

On the Po plane side of the northern Apennine, between the cities of Parma and Reggio Emilia, on the top of a basalt cliff the Longobard times massive castle of Rossena rises at about 500 m a.s.l., and a small village grow up in the surrounding area. This part of the northern Apennines is characterized by a great geomorphological diversity (*Coratza et al, 2004*) and has a long story of complex landslide: the poor geomechanical properties of heterogeneous and/or chaotic rock masses (abundant in this area) are one of the main causes of the high attitude to slope movement (*Clerici et al., 2002*), so that landslides are very common and affect about 25% of the total surface.

In the night of February 28^{th}2004, a complex landslide occurred when small amount of rainfall fell on 30-40 cm of snow. The event wasn't exceptional (only about 53 mm in a week) but it followed a very dry year in which, especially in the spring and in the summer, rains decreased of about 60-70% in this area, causing severe problems to human activities.

The castle remained intact, but some blocks collapsed vertically, mainly with decimetric movement, just below the wall of the old building, while topplings involved the outer blocks. Small rock falls and debris flows occurred respectively on the front of the cliff and in the covers that surrounds it, made of debris in a clayey matrix. The largest phenomenon is a deep translational landslide in the medium part of the slope. Several cracks, with throws between 1 and 2 meters, occurred in the ground, involving some houses and road. Many small landslides enlarged the main body, contributing to the damaging of part of the village.

Geological and geomorphological setting

In the area surrounding the Rossena landslide two main geomechanical units outcrop (*Mandrone, 2004*): a chaotic clay complex (made by a block in matrix sequence, a scaly varicolored clay formation and a mélange) and a more or less fractured and weathered, dismembered and allochthonous, ophilolitic sequence (represented by many masses of various dimensions of massive basalts, serpentine, pillow lavas and polygenic, more or less cemented, breccias).

The morphology of the area is characterized by ophiolitic bodies that stand out on the ground, due to erosive processes that removed the soft surrounding pelitic rocks. The most prominent body is the Rossena cliff on which the castle was built. A scree slope surrounds the entire cliff bottom: it is made mainly by clasts of centimetric size with a silty-clayey reddish matrix. The slope on the north-eastern side of the cliff develops downward for about 1 km up to a small stream. It shows an irregular profile characterized by counterslopes and scarps highlighting that the morphology is mainly due to landslides and mass wasting. Where the pelitic rocks outcrop, linear erosive processes, like rill erosion, caused the development of badlands.

Investigation and monitoring systems

Direct and indirect methods, planned and controlled by the Emilia Romagna Region – Provincial Technical Service of Reggio Emilia, was used to investigate the subsurface characteristics of the Rossena landslide.

The area of investigation was that near the road, the castle and the village. The program of investigation comprises 9 borings, 7 seismic tomographies and 4 electrical vertical soundings. Also in situ permeability tests were done and pieces from the undisturbed core drillings were sampled for laboratory analysis. So, Atterberg limits, grain sizes and shear test characterized the displaced materials and the bedrock. A ^{14}C analysis highlighted that older phenomena involved this slope at least from 10.000 years b.p..

A simple system of monitoring (3 wire extensometers and 1 inclinometer) was built up immediately after the event of February 2004. It was progressively substituted, in the following months, by a more complex one in which tiltmeters, inclinometers, extensometers (vertical and horizontal) and piezometers play an important role. The first system served to identify the rates of movement and to determine approximately the depths and shapes of landslide masses, so the second one could be adequately planned. In the future, after the structural remedial, the monitoring system will remain partially operative and it will give information on the functionality of the mitigation systems.

Conclusion

The northeastern slope of the Rossena village is interested by different types of landslide (*Crudes & Varnes, 1996*) that contribute to the development of a complex situation.

The higher part of the slope is characterized by a mainly translational landslide with surface of movement at about 10-20 meter of depth. Behind it, the external part of the cliff underwent to movements mainly of vertical type and toppling due to the unbuttress linked to the landslide mentioned above. In the middle part of the slope the movement becomes roto-translational with the surface of movement that can reach 40 meters below the ground surface, in correspondence of the large counterslopes. This landslide turns into slow flows extending to the base of the slope and partially controlling the stream path. It is difficult to identify the features of the main landslide in the lower part of the slope because of the masking due to the displaced material. In any case, also this portion was involved in the landslide (essentially by slow earthflows), even if only movements of moderate entity are testified by the cracks in the field.

In the future the results of this study will be used to minimize risks connected to this complex landslide through the project of structural remedial dimensioned on the base of the geological-geomorphological model.

References

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