APPLICATION OF THE PARSIFAL APPROACH FOR PROVIDING SCENARIOS OF EARTHQUAKE-INDUCED LANDSLIDE IN THE ACCUMOLI MUNICIPALITY

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The PARSIFAL (Probabilistic Approach to pRovide Scenarios of earthquake Induced Slope FAlLures) was applied in the territory of the Accumoli Municipality for a comprehensive analysis of the earthquake-induced landslide susceptibility after the 2016-2017 Central Italy seismic sequence that heavily involved this area. The PARSIFAL approach allows to take into account: 1) first-time landslides and reactivations of existing ones; 2) rock and soil slope failures; 3) different failure mechanisms; 4) a comprehensive mapping of earthquake-induced slopes susceptibility in terms of both exceedance probability of co-seismic displacements and pseudo-static safety factors. The results can be modulated in terms of given return periods of seismic shaking and hydraulic boundary conditions. The framework of PARSIFAL is structured into three slots: 1) Slope Analysis, 2) Slope Stability and 3) Resulting Scenario.

The Slope Analysis (first slot) consists in partitioning the territory in kinematic units, which can be defined as areas prone to slope failures according to a specific mechanism. To this aim, three parallel procedures are proposed: the first one regards first-time rock failures, the second one first-time shallow earth slides and the third one reactivations, for both rock and earth slopes. First time failure mechanisms of rock slopes deal with discriminating rock blocks that are suitable for different failure mechanisms (planar, wedge or toppling). Starting from structural dataset, geo-structural domains are established based on bedding planes and joint sets trend.

As it regards rock slopes, data of geo-structural domain were collected within the municipality of Accumoli through geomechanical surveys, according to the ISRM standards (ISRM, 1978); in particular, measurements were performed at 43 point within the study area. A GIS procedure on a cell-by-cell basis is implemented for performing a zonation of jointed rock masses and for verifying the compatibility of different failure mechanisms, i.e. planar sliding, wedge sliding and toppling, based on these data.

For the first-time shallow earth slides, only shallow translational slide mechanisms (i.e. involving different types of debris slope deposits) are considered, according to many evidence (Harp and Jibson, 1996), that shallow landslides are particularly prone to be activated by seismic shaking for the first time on steep slopes. In particular, debris slope deposits (i.e. regolith, colluvial and slope-waste deposits) have been analyzed and inventoried, for a total of 7200 m² of surface covered by these sediments in the entire study area.

Reactivations correspond to existing, properly inventoried, landslides defined in terms of geometry and failure mechanism to allow consistent stability analyses. To map the existing landslides, the PAI (Piano di Assetto Idrogeologico) and IFFI (Inventario Fenomeni Franosi Italiani) inventories were taken into account; in addition, detailed field observations were performed.

For the Slope Stability (second slot) the first-time earth landslides were considered as shallow sliding according to an infinite slope model. The 27 inventoried landslides (reactivations) were analyzed according to their own geometrical and kinematic features, through a geotechnical cross-section representative of the actual conditions of the landslide. The inventoried landslides were classified by considering morphological and geometrical features and analyzed through the Global Limit Equilibrium (GLE) method using the infinite slope model, as well as the simplified Bishop (1955) and the Janbu (1973) approach, depending on the shape of the sliding surface measured by the ratio between the landslide mass thickness (H) and length (L). The presence of potentially unstable blocks was then assessed within each cell; a mean volume of unstable blocks is also calculated based on the orientation and spacing of joint sets. There were analyzed 28 blocks: 6 for planar slides, 9 for wedge slides, 13 for toppling. The stability
conditions of each rock block were analyzed by a conventional pseudostatic approach for both planar sliding and wedge sliding mechanisms.

The yielding acceleration coefficients ($a_y$) were computed for each instability (First-Second generation, earth-rock slope) and they were considered as thresholds for calculating the cumulative co-seismic displacements following the rigid sliding block approach by Newmark (1965). Safety factor values were also computed, in case that the pseudostatic coefficient ($a_h$) was lower than the computed $a_y$.

By the Newmark’s method it was possible to calculate the cumulative co-seismic permanent displacement of a rigid mass forced by natural time-histories selected from strong-motion databases. The selection criteria were defined according to seismic source characteristics (focal mechanism, magnitude, hypocentral depth), recording-site conditions (free-field installation, Eurocode 8 ground type) and ground-motion parameters (PGA, energy content and target response spectra shape similarity) for a given level of seismic hazard in selected return periods. The earthquake-induced landslide occurrence was expressed in terms of the exceedance probability of the critical displacement ($P[D_{DD} | a(t), a_y]$) responsible of the slope collapse, herein assumed to be 10 cm for earth slides and 5 cm for rockslides (Romeo, 2000).

The final comprehensive result of this study consists in a synthetic mapping of possible earthquake-induced scenarios for the Accumoli Municipality. These outputs represent a crucial base-map for zoning unstable areas due to landslide phenomena, i.e. distinguishing attention zone (ZA) from susceptible ones (ZS), according to the guidelines by the Department of National Civil Protection annexed to ICMS 2008 for seismic microzonation studies.

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**References**


