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Comparing Newmark's method at regional and local scales: La Paca earthquake induced rock-fall case (Murcia, SE Spain)

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The Lorca Basin (Eastern Betic Cordillera, SE Spain) is one of the most seismically active regions of Spain. In this area there are well known cases of earthquake-induced slope instabilities associated to specific earthquakes (e.g., Bullas 2002, La Paca 2005). Furthermore, this area is characterized by moderate magnitude seismicity which mainly produces rock-falls and avalanches.

In this work we present the results of our research at regional and site scales. For the regional scale, we have used a geographic information system (GIS) to develop an implementation of the Newmark's sliding rigid block method. We have particularly proposed a new variation of Newmark's method to consider soil and topographic amplification effects. Subsequently, we produced "Newmark displacement" maps for both probabilistic and deterministic seismic scenarios in the Lorca Basin. Probabilistic seismic scenarios consider three hazard maps in terms of peak ground acceleration (PGA) on rock corresponding to the 475-, 975- and 2475-year return periods (exceedance probability of 10, 5 and 2% in 50 years, respectively) in the Murcia Region. Deterministic seismic scenarios consider the occurrence of the most probable earthquake for a 475-year return period (M_w=5.0) at every location, or either a complete rupture of Lorca-Totana (M_w=6.7) or Puerto Lumbreras-Lorca (M_w=6.8) segments of Alhama de Murcia Fault. The Newmark displacement maps allowed us to identify areas with the highest potential seismic hazard, and also locate areas for future particular studies. We have found that rock-falls produced during the last earthquakes in Lorca Basin (e.g., Bullas 2002, La Paca 2005) match very well with areas with values of Newmark displacement lower than 2 cm in all the seismic scenarios considered. Therefore, it seems that low values of Newmark displacements are very likely associated with rock-falls.

To support this hypothesis we have applied the Newmark method at a site scale. To do this, we have selected La Paca rock-fall which was generated during La Paca 2005 earthquake (m_{bLg}=4.7, I_{EMS}=VI-VII). We have used a terrestrial laser scanner in order to obtain a high resolution digital elevation model of La Paca rock-fall area. Moreover, we have performed a back-analysis based on field data to estimate the static safety factor previous to the earthquake and the critical acceleration. Furthermore, we have selected a representative strong ground motion record for La Paca earthquake from international databases. The critical acceleration and the peak ground acceleration values obtained from the strong ground motion record allowed us to estimate the actual soil and topographic amplification effects. Finally, we have calculated analytically the real Newmark displacement at La Paca rock-fall and we have compared this displacement with our GIS estimation in order to improve the calibration of Newmark's method at the regional scale.