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Assessment of earthquake-induced rockfall hazards

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Earthquake-induced rockfalls are responsible for a significant fraction of large, catastrophic landslides worldwide. The consequences of these rockfall events are often significant and can include, human casualties, disruption of infrastructure operation and property losses. This has motivated their investigation and has led to the development of methodologies for the evaluation of the seismic susceptibility of rock slopes.

In a 1994 article, David Keefer presented what has become the one of the most popular approaches in practice for assessing seismic rockfall hazards. Keefer's empirically-based approach identifies geologic and topographic factors that are characteristic of large seismically induced rockfalls. Yet this approach appears to be conservative. For example, despite having many slopes meeting the hazard susceptibility criteria of Keefer, review of the historical archives suggests that no significant rock failures occurred during the Boi, Andorra earthquake of 1919 (the highest magnitude seismic event in region over the last hundred years). Accordingly, we have developed a refined analysis procedure intended to further investigate areas identified as being susceptible to seismically induced rockfalls based on the Keefer criteria.

The proposed procedure is analytical and it is based on the evaluation of possible jointed rock mass. The three-step procedure involves: (i) the estimation of the horizontal peak ground acceleration (PGA) at the base of the slope from available seismic

hazard maps, (ii) estimation of topographic ground motion amplification at the crest of the slope based on existing guidelines and finally, (iii) the assessment of seismic stability by means of stereographic analysis. In this final step, the destabilizing inertial effects of the earthquake are represented by a horizontal pseudostatic force applied to the center of a potential failure mass.

Given the localization of main rock discontinuities and the identification of block volumes that are prone to release, the proposed methodology can be applied for the assessment of rockfall hazard, on the basis of dislodged rockfall mass. The evaluation of the proposed approach is made through its application on the Solà d' Andorra slope. The value of the PGA, as well as the characteristics of potential rockfalls are determined according to local conditions. The rockfall hazard due to a possible earthquake event is evaluated and the obtained results are discussed.