

Roadway management plan based on rockfall modelling calibration and validation. Application along the Ma-10 road in Mallorca (Spain)

Rosa Maria Mateos (1), Inmaculada Garcia (1), Paola Reichenbach (2), Gerardo Herrera (1), Roberto Sarro (1), Joan Rius (3), and Raul Aguilo (3)

(1) Geological Survey of Spain, Natural Hazards, Granada, Spain (rm.mateos@igme.es), (2) Consiglio Nazionale delle Ricerche, Istituto di Ricerca per la Protezione Idrogeologica, (3) Road Maintenance Service of Mallorca

The Tramuntana range, in the northwestern sector of the island of Mallorca (Spain), is frequently affected by rockfalls which have caused significant damage, mainly along the road network. The Ma-10 road constitutes the main transportation corridor on the range with a heavy traffic estimated at 7,200 vehicles per day on average. With a length of 111 km and a tortuous path, the road is the connecting track for 12 municipalities and constitutes a strategic road on the island for many tourist resorts. For the period spanning from 1995 to current times, 63 rockfalls have affected the Ma-10 road with volumes ranging from 0.3m³ to 30,000 m³. Fortunately, no fatalities occurred but numerous blockages on the road took place which caused significant economic losses, valued of around 11 MEuro (Mateos et al., 2013). In this work we present the procedure we have applied to calibrate and validate rockfall modelling in the Tramuntana region, using 103 cases of the available detailed rockfall inventory (Mateos, 2006). We have exploited STONE (Guzzetti et al. 2002), a GIS based rockfall simulation software which computes 2D and 3D rockfall trajectories starting from a DTM and maps of the dynamic rolling friction coefficient and of the normal and tangential energy restitution coefficients. The appropriate identification of these parameters determines the accuracy of the simulation. To calibrate them, we have selected 40 rockfalls along the range which include a wide variety of outcropping lithologies. Coefficients values have been changed in numerous attempts in order to select those where the extent and shape of the simulation matched the field mapping. Best results were summarized with the average statistical values for each parameter and for each geotechnical unit, determining that mode values represent more precisely the data. Initially, for the validation stage, 10 well-known rockfalls exploited in the calibration phase have been selected. Confidence tests have been applied taking into account, not only the success, but also the mistakes. We have further validated the calibrated parameters along the Ma-road using the 63 rockfall recorded during the past 18 years along the road. 81.5% of the rockfalls are well represented by STONE modelling. Results have been exploited by the Road Maintenance Service of Mallorca for the design of the following road management plan:

- (1) Phase 1. Short-term. Design a specific plan for the road- sections where rockfalls were registered and modelling results were obtained. A large investment will be expended for implementation of retention and protection measures.
- (2) Phase 2. Medium-term. Design a specific plan for the road- sections where rockfalls were registered but no modelling results were obtained. For these cases, new studies at local scale are necessary as well as the application of other modelling software which include higher resolution input data.
- (3) Phase 3. Long-term. Design a specific plan for the road- sections where no rockfalls were registered but modelling results were obtained. These are potential rockfall areas and local and specific ground studies are necessities.

References

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