Geophysical Research Abstracts
Vol. 16, EGU2014-15567, 2014
EGU General Assembly 2014

Risk analysis for roadways subjected to multiple landslide-related hazards

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Roadways through mountainous terrain often involve cuts and landslide areas whose stability is precarious and require protection and stabilization works. To optimize the allocation of resources, government and technical offices are increasingly interested in both the risk analysis and assessment. Risk analysis has to consider the hazard occurrence and the consequences. The consequences can be both direct and indirect. The former include the costs regarding the repair of the roadway, the damage of vehicles and the potential fatalities, while the latter refer to the costs related to the diversion of vehicles, the excess of distance travelled, the time differences, and tolls. The type of slope instabilities that may affect a roadway may vary and its effects as well. Most current approaches either consider a single hazardous phenomenon each time, or if applied at small (for example national) scale, they do not take into account local conditions at each section of the roadway.
The objective of this work is the development of a simple and comprehensive methodology for the assessment of the risk due to multiple hazards along roadways, integrating different landslide types that include rockfalls, debris flows and considering as well the potential failure of retaining walls. To quantify risk, all hazards are expressed with a common term: their probability of occurrence. The methodology takes into consideration the specific local conditions along the roadway. For rockfalls and debris flow a variety of methods for assessing the probability of occurrence exists. To assess the annual probability of failure of retaining walls we use an indicator-based model that provides a hazard index. The model parameters consist in the design safety factor, and further anchorage design and construction parameters. The probability of failure is evaluated in function of the hazard index and next corrected (in terms of order of magnitude) according to in situ observations for increase of two dynamic factors: the service load and the wall deformation. The consequences are then calculated for each hazard type according to its characteristics (mechanism, magnitude, frequency).
The difference of this method in comparison with other methodologies for landslide-related hazards lies in the hazard scenarios and consequence profiles that are investigated. The depth of analysis permits to account for local conditions either concerning the hazard or the consequences (the latter with respect to the very particular characteristics of the roadway such as traffic, number of lanes, velocity...). Furthermore it provides an extensive list of quantitative risk descriptors, including both individual and collective ones. The methodology was made automatic using the data sheets by Microsoft Excel. The results can be used to support decision-taking for the planning of protection measures. Gaps in knowledge and restrictions are discussed as well.