



Sinkhole risk modelling applied to transportation infrastructures. A case study from the Ebro valley evaporite karst (NE Spain)

Jorge P. Galve (1), Juan Remondo (1), Francisco Gutiérrez (2), Jesús Guerrero (3), Jaime Bonachea (2), and Pedro Lucha (2)

(1) Universidad de Cantabria, DCITIMAC, Santander, Spain (jpgalve@unizar.es; remondo@unican.es), (2) Universidad de Zaragoza, Departamento de Ciencias de la Tierra, Spain (fgutier@unizar.es), (3) TEC-CUATRO, S.A.

Sinkholes disrupt transportation route serviceability causing significant direct and indirect economic losses. Additionally, catastrophic collapse sinkholes may lead to accidents producing loss of human lives. Sinkhole risk modelling allows the estimation of the expectable losses in different portions of infrastructures and the identification of the sections where the application corrective measures would have a better cost-benefit ratio. An example of sinkhole risk analysis applied to a motorway under construction in a mantled evaporite karst area with a very high probability of occurrence of cover collapse sinkholes is presented.

Firstly, sinkhole susceptibility models have been obtained, and independently evaluated, on the basis of a probabilistic method which combines the distance to nearest sinkhole with other conditioning factors. The most reliable susceptibility model was then transformed into several sinkhole hazard models using empirical functions. These functions describe the relationships between the frequency of sinkholes and (1) sinkholes dimensions, (2) terrain susceptibility and (3) land cover. Although to evaluate hazard models more information on temporal occurrences would be needed, the quality and quantity of the data in which models are based and the distribution of the latest sinkholes of considerable magnitude occurred in the study area indicate that the models seem to be sound. Two collapse sinkholes 4 m across formed after the production of the models coincide with the zone of highest hazard, which occupy 15% of the study area.

Finally, on the basis of the hazard models obtained, sinkhole risk models were generated for a motorway under construction with the aim of quantitatively estimating the expected losses in different sections of the infrastructure in a given period of time. To produce the risk models, the vulnerability of the motorway was estimated considering the cost of the structure, sinkhole magnitude and frequency and the expectable damage based on past events.

The described procedure constitutes a useful tool to identify the sections of linear infrastructures (roads, railways, canals) where the application of structural corrective measures should be of top priority and may be also used to foresee the time needed to pay off mitigation measures by means of cost-benefit analyses.

Keywords: sinkholes, GIS, susceptibility, hazard, risk