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Numerical modelling of flexible rockfall protection systems

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Today's flexible rockfall protection barriers have reached a development stage above which a much greater effort is required to extend their rockfall retaining capacity. The corresponding numerical simulation enables a more efficient development or optimisation of new types due to a reduced number of expensive prototype field tests. In addition, the use of software provides the possibility to simulate projected barriers considering special load cases, which cannot be reproduced in field tests, as well as special geometrical boundary conditions for individual sceneries.

This contribution gives an overview on existing approaches to numerically simulate flexible rockfall protection systems. It shows typical numerical problems that have to be solved in order to obtain proper results and possible solution strategies.

Usually, the investigated barriers consist of steel posts to which supporting and restraining cables are connected. Special energy absorbing brake elements are integrated into the cables. The rock is caught by steel nets spanned by the supporting cables. Such a flexible system stops a rock gently within a long braking distance of several meters, which results in a considerable peak-load reduction of all barrier components and the foundation.

The large deformations causing geometrical non-linearity and the short-time simulation period recommend explicit finite element solving strategies like the central differences method. This provides a detailed view at the system's dynamic response accounting for large deformations and non-linear materials. It also can deliver information on the loading and degree of utilisation of any modelled system configuration. Special rope elements are necessary to move freely along the post ends as well as to enable kind of a curtain effect of the nets attached to the cables. The simulation of the falling rock should consider large three-dimensional displacements and rotations. When impacting the steel net at any location, a special contact algorithm prevents the net nodes from penetrating into the rock allowing only tangential movements. All sliding effects occur over long distances and also cause friction between the involved components.

The results of the simulations should be validated by full-scale rockfall field tests measuring the cable and support forces as well as accelerations and trajectory of the falling rock.