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Quantification of energy absorption of trees combined with rockfall trajectory analysis

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A tree can dissipate energy during a rock impact in several different ways, rotation and translation of the root system, deformation and oscillation of the tree stem and penetration of the rock at the impact location. To quantify these different energy absorption phenomena, numerical simulations of the rock-tree impact and full-scale rock-tree impact experiments were conducted. Those results could finally be implemented in a rockfall trajectory software to simulate the influence of a protection forest.

Full-scale rock-tree impact experiments were performed to investigate the tree-rock interaction. The falling rock was replaced by a trolley guided by prestressed steel cables and impacted the tree centrically. Accelerometers and high-speed cameras with a high resolution recorded the impact event to get information about the acting forces and displacements of the tree. A mechanical model was developed in the finite element code LS-Dyna and calibrated against the full-scale rock-tree impact experiments. To simulate the wood material a transversal isotropic material model is used, assuming that the material properties in radial and tangential direction are the same. The impacting rock is modelled as a rigid body, meaning that no deformations are allowed. The tree diameter and mass distribution including branches were taken from field measurements. To validate the numerical model real-size rockfall experiments performed by Cemagref (Grenoble) were used.

With the numerical model the energy absorption capacity as a function of different impact heights, shapes and eccentricity of the falling rock was investigated for the first time. The numerical model also enables a monitoring and the quantification, which

part of the tree structure dissipated which rock energy.

The results obtained from the numerical simulations are implemented in a 3D rockfall trajectory simulation software. With this software, forests can be simulated and their protection capacity against rockfall can be calculated.