RELIABILITY-BASED DESIGN OF ROCKFALL BARRIERS: INTEGRATION OF ROCKSTOP IN ROCPRO3D FOR TARGET RESIDUAL RISK

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OBJECTIVES

The current design approaches for rockfall barriers, based on specific values of the statistical distributions of trajectory height and impact energy obtained from trajectory analyses, neglects the full variability of rockfall processes and the resulting probability of failure. This simplification is critical because block size variability and slope topography make the distributions significantly different from site to site [1].
We present a reliability-based methodology integrated into the RocPro3D software through the RockStop tool [2], enabling engineers to compute annual failure probabilities and design flexible barriers for a target residual risk. The approach incorporates uncertainties in block volume, velocity, and trajectory height using outputs from 3D simulations. The tool can be used in two complementary ways: (i) to design a barrier that meets a prescribed failure probability, and (ii) to assess the residual risk of an existing barrier, given its nominal capacity and height. While the current implementation considers MEL (maximum energy level) and SEL (service energy level) values for barrier capacity, the workflow is designed to allow the future inclusion of a capacity curve, enabling more flexible and performance-based design criteria.
To demonstrate the importance of site-specific variability, comparative applications are presented on two Alpine slopes with contrasting geometries and block size distributions. Results show that designs based on fixed percentiles can lead to under- or over-designed barriers, while reliability-based design ensures consistent risk management aligned with tolerable thresholds.

MATERIALS AND METHODS

- Probabilistic framework for block mass, velocity, and trajectory height, explicitly accounting for site-specific variability in block size distribution and slope geometry.
- Integration of RockStop with RocPro3D outputs for automated failure probability computation.
- Two design modes: target failure probability or residual risk assessment for known barriers.
- Comparative case studies on Alpine slopes with different topographies and block size distributions.

MAIN RESULTS AND CONCLUSIONS

- Comparative applications on two Alpine slopes show that differences in block size distribution and topography significantly affect barrier performance and residual risk.
- Designs targeting an annual failure probability ensure compliance with tolerable risk thresholds, unlike fixed safety factors-based approaches that can lead to under- or over-design.
- Integration into RocPro3D makes it practical to use: RockStop's integration enables automated failure probability computation and design optimization within standard trajectory analysis workflows.
- Future-ready approach, as the current implementation uses MEL and SEL values. RockStop also allows inclusion of a specific capacity curve to support performance-based design evolution.
- Incorporating uncertainty and site-specific variability into reliability-based design is a key point for achieving risk-informed rockfall protection and optimizing barrier performance.

REFERENCES

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