

## Hybrid innovative protection structures with optimized foundations and field adaptation

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### ABSTRACT

In the French Alps the latest generation of high performance protection barriers and guidelines recommendations have been developed taking a relatively versatile and lightweight approach, from intensive experience for decades with more traditional protection structure.

Adaptation to the field with minimal foundations and anchoring requirements allow effective mitigation including installation in difficult ground conditions, slope accessibility or sensitive environment. Protections are designed to be simple and safe to install quickly in any location, including by rope access workers higher on the slope near the hazards source where energy are lower. System components have been kept as simple and strong as possible to ensure maximum lifetime, minimise maintenance and to facilitate repairs in the field when necessary.

Moreover many protective structures are exposed to both snow avalanches, and rockfall or debris flow. However conventional rigid or flexible barriers design with limiting standards reduce the performance of the protection. Indeed rockfall nets could often be damaged by avalanches and snow barriers by rock impacts for which they have not been designed. This requires significant maintenance costs and reduce protection level expected.

In addition to first experiments on hybrid defence structures, this paper provides new engineering methods with practical feedback and case studies on projects recently conducted worldwide.

