ONR 24810 – insights into practical implementation

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Introduction

The "ONR 24810:2021 Technical Rockfall Protection – Terms, Impacts, Design and Structural Development, Monitoring, and Maintenance" standard provides an important legal framework for rockfall hazard assessment and mitigation (Fig. 1). However, its practical implementation in alpine environments poses substantial challenges. These challenges stem from the complex natural variability in tectonic, geological, topographic, and climatic settings across Austria and the Alps (Fig. 2).

Fig. 1: Rockfall boulder and tree in rockfall fences (*Source: S. Melzner 2024*).

With the planned transition of ONR 24810 into an OENORM, it is crucial to evaluate its applicability in practice. An OENORM is a fully developed standard that is legally binding, while an ONR is not legally binding unless explicitly referred to in contracts, laws, or regulations. OENORMS are designed to align with European (EN) or international (ISO) standards where possible.

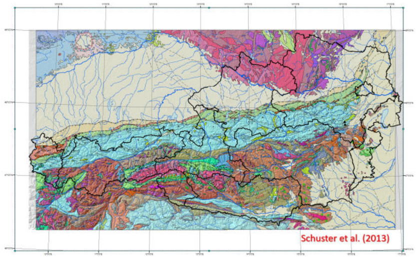

Fig. 2: Tectonic map of the Eastern Alps (*Source: Schuster et al., 2013*).

Two key issues arise when applying ONR24810:2021

1. **Statistical Characterization of Design Blocks**

The **representativeness of rockfall design blocks** is often compromised by mapping strategies and local site conditions.

2. **Calibration & validation of Rockfall Models**

The use of high-percentile design parameters (e.g., 95th-99th) without robust empirical validation can mislead users – particularly those with less experience – by suggesting unwarranted precision. This approach risks diverting focus from essential data collection and model calibration, and may conflict with risk-informed frameworks that accept small residual hazards.

Challenges in applying ONR 24810:2021

Statistical Characterization of Design Blocks

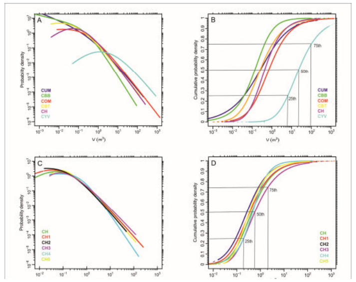

Fig. 3: Impact of mapping strategy on probability densities of rockfall sizes (A, C) and cumulative distribution function of rockfall size (B, D). Dashed curves in plots B, D show values of distribution function calculated outside the observed volume ranges approximating values of cumulative probability of 0 and 1. The three thin grey lines in the CDF plots (i.e. B, D) corresponding to 0.25 (25th fractile), 0.50 (50th fractile) and 0.95 (95th fractile) (*Melzner et al., 2020*).

The ONR24810 requires design block sizes V_{BB} to be derived from block size distributions using fractile values (95th, 98th and 99th) linked to event frequency classses. Event frequencies are often incomplete and therefore biased; the RockFreq tool offers a statistically grounded alternative by leveraging rock face structures and block volumes to mitigate this gap (Moos, et al. 2025).

Table 4 — Event frequencies and corresponding design block fractile

Event frequency class	Occurrence frequency n (1/a)	Fractile for the design block size
EF 4 (very high)	$n \geq 10$ (> 10 occurrences/year)	V_{98}
EF 3 (high)	$1 \leq n < 10$ (1 to 10 occurrences/year)	V_{97}
EF 2 (low)	$0{,}03 \leq n < 1$ (1 occurrence /1 to 30 years)	V_{96}
EF 1 (rare)	$n < 0{,}03$ (<1 occurrence/30 years)	V_{95}

Calibration and validation of rockfall simulations

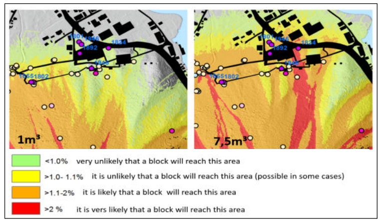

Fig. 4: Calibration and validation of 3D Rockfall simulation results with mapped boulder sizes (couloured dots) and historical rockfall events with no size information (lila dots with numbers) for two volume scenarios (1m³ and 7m³) (by S. Melzner 2015).

As shown by Melzner et al. (2019, 2020, 2023), local site conditions (e.g., steep cliffs, vegetation, and geological settings) and the mapping strategy influence the quality and representativeness of rockfall catalogues, which must be considered in statistical analyses (Fig. 3) and in the calibration or validation of rockfall simulations (Fig. 4).

Applicability of different 2D and 3D rockfall models

Rockfall simulations (Fig. 5 and 6) are essential for deriving key design parameters – such as impact energy and jumping heights - and for designing protection measures along the rockfall path.

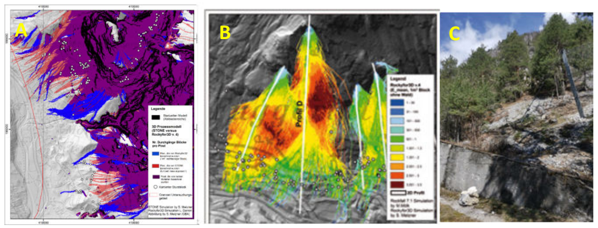

Fig. 5: Comparison of two 3D models (A) and one 2D and one 3D model (B). A fresh rockfall boulder (C) passed through a row of rockfall fences (S. Melzner and Preh 2012). (Photo by S. Melzner).

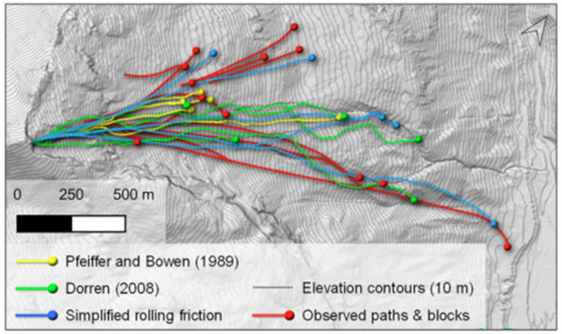

Fig. 6: Sets of five simulated trajectories from three rebound models compared aside the mapped observed rockfall paths shown in red (*Noël et al., 2023*). Yellow trajectory: Pfeiffer and Bowen (1989) friction; blue trajectory: stnParabel multiple model simulation freeware (Noël 2020); green trajectory: Rockyfor3D v5.2.15 (EcorisQ 2022, Dorren, 2008).

The simulation results of different models often differ from each other or in relation to a model version (Fig. 5) (*Noël et al., 2023, Melzner & Preh, 2012*).

With the increase in frequency and volume of climate-induced rockfall events, it is crucial to better understand the high-energy propagation dynamics of large rock fragments (*Melzner et al. (2020), Noël et al. (2022), Mölk and Preh (2024*). Conducting rockfall experiments for this purpose is often impractical due to the challenges of handling large rock fragments. *Noël et al. (2023)* therefore reconstructed rockfall trajectories of observed "large" rockfall events using a flexible reconstruction method described by *Noël et al. (2022)*. Designing rockfall protection fences using the 95th percentile jumping height from simulations with the design block may be misleading, as fragments are likely to exceed the simulated heights (*Illeditsch & Preh (2020, 2024*). Benchmark studies comparing 2D and 3D model results for jumping heights are lacking. Yet, 2D models are still commonly used in practice to design protection measures, even though they don't adequately capture terrain complexity.

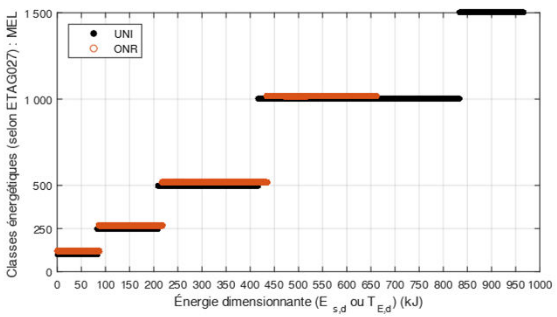

Fig. 7: Range of Energy Class Ranges (ETAG27-MEL) as a Function of Design Energy: Austrian (ONR) vs. Italian Rockfall Standard (UNI) for a CC3 scenario (*Garcia 2025*).

Conclusion and recommendations

The ONR 24810:2021 provides essential legal clarity. The absolute certainty demanded by law is not achievable in rockfall hazard assessment. Thus, the safety margins in the standard are critical. However, the standard's complexity can contradict practical realities – particularly under Austria's public procurement law, which prioritizes lowest-cost bidders, potentially compromising scientific rigor.

To bridge this gap between legal frameworks and engineering-geological realities, we recommend the following scientifically grounded adaptations:

1. **Improve Field Data Quality and Representativeness**
   - ✓ **Avoid selective mapping:** Excluding large, old boulders biases size-frequency distributions and underestimates hazard potential (*Melzner et al., 2020*).
   - ✓ **Discontinuity mapping**: Joint geometries determine the tensile and shear strength and are therefore essential for determining the failure mechanism, hazard classification and for the design of the primary protection measures with its required load-bearing capacity and anchorage (*DIN EN ISO 14689:2018; ÖNORM B 1997-1-1; Hormes, et al., 2018; Melzner et al., 2019; Lukačić et al., 2024*).
2. **Account for Fragmentation and Complex Trajectories**
   - ✓ **Include rockfall fragmentation in models**: Fragmentation significantly affects energy, jumping height, and lateral dispersion *(Fleris et al., 2020; Noël et al., 2023)*.
   - ✓ **Consider large-volume events**: Increased frequency requires standardized tools and procedures for their assessment *(Fleris et al., 2022; Noël et al., 2022; Melzner et al., 2023; Lukačić et al., 2024)*.
3. **Base Statistical Approaches on Data Quality**
   - ✓ **Choose statistical methods according to data representativeness**: Apply various statistical methods to different datasets, taking into account data collection strategies and study area settings. Define clear criteria for assessing representativeness and data quality (*Melzner et al., 2020, 2023b*).
   - ✓ **Define fractiles/percentiles based on peer-reviewed literature**: Ensuring consistency, reproducibility and the state-of-the-art in hazard assessment (*Melzner et al., 2020; Melzner et al., 2023b; Illeditsch & Preh, 2024*).
4. **Improve Model Transparency and Scenario testing**
   - ✓ **Acknowledge model variability**: Different software or versions can produce significantly different outcomes for the same input (*Noël et al., 2023; Melzner & Preh, 2012*)
   - ✓ **Conduct sensitivity tests**: ETAG27-MEL dimensioning methods must be stress-tested across a range of plausible rockfall scenarios (Fig. 7) (*Garcia, 2025*)
5. **Expert evaluation and flexible thresholds**
   - ✓ The new standard must specify that expert evaluation is required to define the suitability and limitations of applied models for each individual site.
   - ✓ Set flexible thresholds based on cost-benefit analysis consistent with quantitative risk concepts with regulated hazard thresholds that tolerate residual hazard.

References

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