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MONITORING EXTREME ROCKFALL IMPACTS: A 10,000 KJ FULL-SCALE TEST

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OBJECTIVES

Rockfall events pose a severe hazard to infrastructures, residential areas, and human life in mountainous regions. Among passive mitigation measures, rockfall protection embankments (RPEs) are the most energy-dissipative structures, typically employed for impacts exceeding 10,000 kJ. Despite their relevance, full-scale impact tests on reinforced embankments (RE-RPEs) are extremely complex, and literature reports only a few cases, with maximum energies of 4,200 kJ [1] and 6,600 kJ [2]. These tests provided only macroscopic observations about the resisting mechanism, as all sensor measurements failed under impact conditions. This work presents an innovative full-scale impact test on a RE-RPE reinforced with the Terramesh system by Maccaferri at an unprecedented energy level of approximately 10,000 kJ developed in the framework of the PERSEIDI project (CUP: C39J21046780001) (Figure 1). The primary objective was to design and implement a sensor network capable of accurately recording key impact parameters under extreme conditions and to validate its effectiveness during the test.

MATERIALS AND METHODS

- 19-ton block launched at 33 m/s via cableway, impacting the embankment's upper layers.
- Abaqus/Explicit numerical model calibrated on prior tests to predict measurements and prevent signal saturation.
- 32-sensor network embedded in the embankment plus a block-mounted stand-alone system: accelerometers, load cells, strain gauges, and gyroscope.
- High-speed cameras synchronized with sensor data for full impact monitoring.

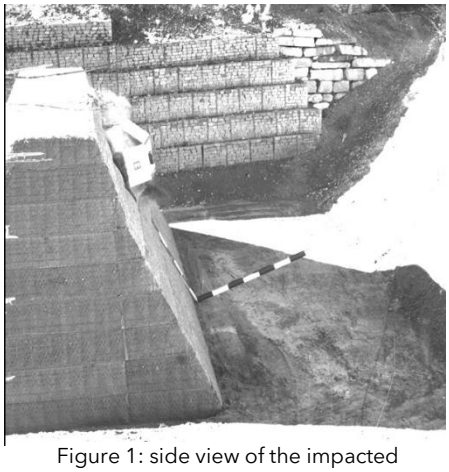

Figure 1: side view of the impacted embankment

MAIN RESULTS AND CONCLUSIONS

- Impact performed as designed, bringing the RE-RPE to near-collapse.
- Sensor network performed reliably under extreme conditions, delivering clean, accurate data.
- Peak block acceleration ~60 g; embankment and foundation load cell readings matched numerical predictions.
- First validated monitoring of a rockfall impact at 10,000 kJ: a new benchmark for RE-RPE research.

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