Innovative Techniques for Monitoring Areas Prone to Rockfall Hazard

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In recent years, heightened attention to hydrogeological risks has arisen due to increased awareness of their destructive potential and the imperative to implement preemptive measures safeguarding communities, structures, and infrastructures. Of particular concern among landslide events is rockfall, especially for entities overseeing land management, such as ANAS, Autostrade per l'Italia, and RFI, tasked with ensuring the secure operation and oversight of extensive linear infrastructure positioned alongside rocky cliffs, including roads, highways, and railway lines.

Given the expansive reach of areas susceptible to rockfall, reliance solely on structural interventions like mesh nets and rockfall barriers proves impractical for prevention purposes. Consequently, non-structural measures, such as territorial surveillance and geotechnical-structural monitoring, are increasingly supplementing structural efforts.

This study presents findings from an innovative monitoring initiative conducted on a carbonate rocky cliff along the SS18 road in Acquafredda, Municipality of Maratea (Potenza), Southern Italy. The objective of this monitoring was to comprehensively assess the rocky cliff in a spatially expansive manner, rather than relying on a traditional point-based monitoring technique, such as topographic surveys with total stations and geotechnical-structural monitoring with displacement sensors such as crackmeters and inclinometers.

The implemented monitoring strategy involves comparing various point clouds acquired over an 8-year span (2015-2023) using photogrammetric surveys employing Remotely Piloted Aircraft Systems (RPAS) and Terrestrial Laser Scanners (TLS). The point clouds were captured utilizing Riegl laser scanners (VZ400 and VZ2000i) and Italdron 4HSE drones equipped with a Sony Alpha camera, as well as DJI Matrice 210 with an X7 sensor, GNSS, and total station for georeferencing. Post-processing involved specific software applications (Agisoft Metashape for photogrammetry and Riscan Pro for TLS point cloud), resulting in high-resolution point clouds comprising several hundred million points.

The overlay and comparison of combined point clouds acquired at different intervals facilitated graphical and analytical interpretation of relative movements in both two-dimensional (section comparison) and three-dimensional fields (surface comparison and displacement mapping). Additionally, it enabled to evaluate the presence of debris material on the slope and in proximity to existing infrastructures.

Analysis of point cloud models acquired in 2015 and 2023 revealed widespread relative movement rates of points on the slope, particularly significant displacements near the foothill area adjacent to passive structures. Movement rates were categorized using a chromatic scale: green indicating no detected movement, yellow-orange signifying predominantly centimetric movements, and red indicating predominantly decimetric movements.

The results obtained from this comparison are highly promising, suggesting a departure from the conventional monitoring approach. While this technology may not offer the precision of traditional methods, it certainly proves to be more pragmatic for monitoring rockfall events, offering valuable insights into the dynamic nature of these geological phenomena.