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Advanced Tailings Dam Monitoring with Microseismic and Ambient Noise Seismic Interferometry: Insights from Field Measurements

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Introduction

The increasing demand for more accurate and continuous geotechnical monitoring solutions in critical infrastructure such as tailings dams has brought passive seismic methods to the forefront. Traditional instrumentation, while essential, may fail to detect early internal structural changes. In this context, microseismic monitoring and ambient noise seismic interferometry emerge as complementary technologies capable of revealing both precursor events and subtle variations in the mechanical properties of the dam structure. This work presents the concepts, technological implementation, and field application of these methods using the M²S, an integrated system for real-time seismic monitoring.

Method

Microseismic monitoring detects small natural or induced seismic events, providing insights into stress redistribution, fracturing processes, and geotechnical responses to a diversity of actions that can affect the structure. In parallel, ambient noise seismic interferometry relies on the cross-correlation of continuous seismic noise recorded by sensor pairs to monitor changes in wave velocity, independent of discrete events. Together, these methods provide a dynamic and multidimensional view of the internal behavior of tailings dams. The M²S System integrates multi-station data acquisition, automated event detection, ground motion analysis, and interferometric processing, enabling continuous, field-deployable surveillance.

Results and Conclusions

A real-world case study is presented from a tailings dam equipped with seven microseismic stations. Results show the system's capability to identify microseismic patterns associated with internal stress redistribution, as well as the detection of variations in S-wave velocity correlated with changes in reservoir water level and pore pressure. Notably, the interferometric analysis revealed an increase in soil stiffness and effective stress as a result of the reservoir drawdown. These findings underscore the importance of combining seismic and geotechnical data for early warning and risk mitigation. Ongoing developments in sensor technology and data integration are set to further enhance the robustness and practicality of the M²S System.