Submission code: 4KDW4Z7XB8

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When a Leak Was Not a Leak: Reinterpreting Self-Potential Data Based on Structural Information

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Introduction

The detection of internal seepage is essential for dam safety assessments, especially following the enactment of stricter regulations after major failures in Brazil (2015, 2019). Among geophysical tools, the Self-Potential (SP) method is widely used to detect fluid flow through electrokinetic potentials generated by water movement in porous media. However, interpretation can be strongly affected by the lack of knowledge about internal features, such as drains, filters, or conductive zones. This study presents SP data acquired from a dam and interprets the results in two stages: one without structural information and one incorporating details of a known internal drain. The comparison demonstrates how neglecting such data may lead to erroneous leakage diagnoses.

Method

Self-Potential data were collected along the dam crest using five parallel survey lines (L-1 to L-5), spaced uniformly. Measurements were taken at regular intervals, with each point representing the electric potential difference between a fixed reference electrode and a roving electrode. Data were pre-processed using smoothing techniques and interpreted based on known electrokinetic theory, which links fluid movement through porous media with measurable voltage gradients. The initial interpretation was performed without any structural input. A second stage of analysis re-evaluated the same data considering the presence of an internal drain located near X ≈ 250 m, installed during dam construction. This allowed comparison of the SP anomaly behavior under both structural assumptions.

Results and Conclusions

In the initial analysis, a distinct negative anomaly was observed between X = 230–275 m, particularly on L-1, and mirrored—though attenuated—on L-2 to L-4. Strong downward gradients were interpreted as signs of uncontrolled seepage. Based on these patterns, a preliminary diagnosis of leakage risk was issued, with a recommendation for corrective measures. However, during the second interpretive phase, the same anomaly was found to correspond with the known location of the internal drain. The observed potential trough was thus consistent with convergent flow toward a designed drainage feature, rather than a defect. Additionally, the recovery of potentials beyond X = 295 m aligned with expected hydraulic redistribution patterns in a properly drained system. The agreement between survey lines reinforced data reliability, while L-5 likely intersects a structurally distinct but non-critical zone. This study confirms that while SP is an effective tool for detecting subsurface flow, interpretation without structural context may lead to false positives. The integration of geophysical data with engineering and design information is therefore essential for reliable dam diagnostics.