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Simulation of Shear-Wave Velocity Decrease from Integrated Microseismic and MASW Data in the Serra Grande tailings dam

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Introduction

The Serra Grande dam, operated by AngloGold Ashanti, is located in the municipality of Crixás - GO, and was commissioned in 1989 to store tailings resulting from gold mining activities. The primary construction method employed was upstream raising, a constructive technique banned nationwide under Law No. 14,066/2020 due to its high potential for risk and/or damage. As a result, the structure has been undergoing a decommissioning process since 2020. To enhance the safety of this process, a microseismic monitoring system with ten geophones was installed, and a terrestrial MASW survey was conducted prior to the commencement of material handling operations.

Method and/or Theory

The MASW survey was conducted in 2023 using a multichannel seismograph connected to a linear array of 48 geophones spaced at regular intervals of 2.5 meters. A total of 14 seismic lines were acquired, with data recorded from both active sources and passive sources derived from natural seismic noise. The combination of these datasets enabled the construction of dispersion curves and the subsequent inversion to generate 1D shear wave velocity (Vs) profiles along each line. These data were used to monitor the dam structure and infer Vs along the 3D structure. In parallel, a microseismic monitoring system was installed, consisting of 10 high-sensitivity geophones distributed along the dam structure. The integration of microseismic and MASW data provides complementary insights into the dynamic behaviour of the dam, enabling the identification of potentially unstable zones and supporting the ongoing decharacterization process with enhanced spatial and temporal resolution.

Results and Conclusions

The generated mesh enabled the construction of 2D and 3D models of Vs distribution, which are updated monthly using microseismic data. For a more detailed analysis of the results, the dam was subdivided into three sectors: left abutment, right abutment, and central portion. Based on the soil classification criteria established by the Uniform Building Code (UBC), a colour scale was defined and applied to the monthly variation models. As a result, four soil classes were identified within the dam structure, categorized according to Vs intervals: Class E – soft soils – Vs < 180 m/s; Class D – stiff soils – 180 < Vs ≤ 360 m/s; Class C – very dense soils or soft rock – 360 < Vs ≤ 760 m/s; Class B – rock – 760 < Vs ≤ 1500 m/s. The monthly variations in Vs observed across the structure were minor and did not indicate any significant changes in the dam's integrity. The monthly Vs models revealed that the lowest velocity zones, classified as Class E, are concentrated in the tailings beach zone. This result is attributed to the properties of the material, primarily composed of sandy silt. To further investigate the potential effects of Vs reduction on the overall structure, numerical simulations were conducted by applying synthetic Vs drops of 8, 12, 20 and 30% to all geophones. These scenarios aimed to assess which sectors of the dam would be most responsive to such variations. The results indicated that the tailings beach region is the most susceptible, exhibiting a significant decrease in Vs values under all simulated conditions. Some zones located near the downstream toe of the dam, which already present slightly lower Vs values compared to the rest of the embankment, also showed significantly low values and indicate attention zones in case of actual velocity drop. The integration of both geophysical methods has proven to be a valuable tool for anticipating the structural behaviour of the dam in the event of a significant reduction in shear-wave velocity.