Strength, liquefaction and cone penetration test results in unsaturated silty tailings

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# ABSTRACT

The behaviour of two silty tailings is investigated, focusing on their potential for static liquefaction and characterisation using the cone penetration test (CPT) under unsaturated conditions. The study emphasises loose states and high degrees of saturation.

The tailings are first characterised using triaxial tests under constant suction and constant mass (closed system) conditions to analyse stress-strain behaviours. Water retention properties are evaluated using filter paper and pressure plate tests. The consideration of the closed system condition is novel and critical, as rapid instability and deformation can occur, preventing the escape of air and water from the tailings.

A bounding surface plasticity model is adapted for the closed system condition and calibrated using triaxial test results, achieving good agreement. Simulations are conducted to identify factors influencing instability and to model rising water tables under constant total stress in the field. Results are incorporated into practical charts that relate peak and post-liquefaction strengths, as well as collapse lines, to initial states under unsaturated conditions.

CPTs are performed on the tailings in a calibration chamber, correlating cone resistance to tailings states for both saturated and unsaturated conditions. A cavity expansion analysis, incorporating the bounding surface model, is performed and compared with CPT results. A linear relationship between cavity wall pressure and cone resistance is identified, enabling the creation of interpretation charts for unsaturated tailings.

Two behavioural types are observed based on the ratio of air volume to total tailings volume (${v\_{a}}/{v}$). For ${v\_{a}}/{v}$ < 0.15, a closed system condition applies, requiring fast cone penetrations. For ${v\_{a}}/{v}$ ≥ 0.15, suction contributes consistently to effective stress, resulting in a pseudo-drained condition where penetration rates are less critical. These findings enhance the characterisation of silty tailings under varying air and water content.