Centrifuge modelling of the behaviour of geosynthetic-reinforced soils above voids

Talia Simone da Silva

Understanding the deformation mechanisms of soils and geosynthetics in response to the formation of a void below a geosynthetic-reinforced soil is crucial to provide efficient designs of geosynthetic-reinforced soil systems such as embankments and landfill liners.

Centrifuge modelling of the soil and geosynthetic behaviour was conducted using a trapdoor to simulate the formation of a void in a controlled environment at realistic stress levels. A plane-strain model allowed visual observations of the deformation mechanisms using Particle Image Velocimetry. Granular soils and model clay liners were tested, as would be relevant to embankments and landfills respectively. These soils were tested with and without the reinforcement to evaluate the benefit provided by the geosynthetic.

Detailed analysis of the centrifuge test results showed that arching significantly reduces the stress at the base of the soil when a void forms; this mechanism is due to stress redistributions and not the formation of a physical arch. A new method to reliably predict this reduction was provided by calculating the coefficient of lateral stress on the failure plane based on the observations of a continuous convex arc of major principal strains above the void, and the assumption that this is indicative of the stress behaviour.

The observed results were also used to address the limitations in the current design methods related to the fill behaviour. Expansion in the soil was confined to a parabolic zone above the void estimated from the soil dilatancy, rather than a single, unique coefficient of expansion in the deforming soil. The zone of subsidence was characterised by the combination of a vertical prism and funnel to the surface, with the surface settlement profile better described by a Gaussian distribution rather than the parabolic profile used previously.

An adaptation to the design methods for use with compacted clay liners was proposed by considering the clay as a beam with the maximum strain related to curvature and not elongation, and calculating the applied stress on the geosynthetic ignoring the clay arching.

Analysis and interpretation of the centrifuge tests has thus given new insight into the soil and geosynthetic behaviour based on visual observations relevant to how these systems deform in practice. This has allowed the recommendation of more efficient design procedures and consequently will facilitate better predictions of geosynthetic-reinforced soil behaviour above voids.