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Abstract

Numerical modelling of soil-steel composite structures behavior under ultimate loads

Soil-steel composite structures (SSCSs) employ a construction technology where a flexible shell interacts synergistically with surrounding backfill. Typically composed of corrugated steel plates (CSPs) joined by high-strength screws, the mechanical behavior of SSCSs is inherently complex due to the intricate interaction between the backfill and the CSP, resulting in significantly non-linear structural characteristics.

This research presents the outcomes of numerical modelling to examine SSCS behavior under ultimate and moving loads. The study considers both single-span and multi-span structures, investigating the impact of geotextile reinforcement and stiffening ribs, as well as the effects of spacing between structures on bearing capacity and failure modes. A displacement-imposing approach is utilized to evaluate the ultimate bearing capacity with kinematic forcing ensuring numerical convergence for more precise determination of maximum load capacity.

Analysis of geotextile layer positioning indicates that reinforcement is most effective when placed at shallower depths, closer to the load's zone of influence. These insights are valuable for designers aiming to optimize geotextile placement to enhance SSCS performance. Furthermore, a double layer of geotextile significantly improves bearing capacity compared to a single layer. The addition of stiffening ribs around the crown of the shell also notably increases bearing capacity.

The investigation into shell spacing in multi-span SSCSs reveals that narrow spacing between shells significantly diminishes load-bearing capacity. Computational results identify the primary cause of failure as reaching the limit values of internal forces due to steel strength. Analysis of the effects of lateral shells on a central shell at varying spacings under quasi-static moving loads shows that both vertical and horizontal displacements increase substantially when the shell spacing-to-span length ratio is below 0.5. Maximum stress is observed when shells are placed directly adjacent to each other without spacing. Extreme deflections and stress shift in the direction of truck movement. However, the influence of lateral shells on the central shell's performance under moving loads is negligible when the spacing-to-span ratio exceeds 0.5.

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