Multi-Hazard Modelling of Dual Row Retaining Walls

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The recent 2011 Tōhoku earthquake and tsunami served as a stark reminder of the destructive capabilities of such combined events. Civil Engineers are increasingly tasked with protecting coastal populations and infrastructure against more severe multi-hazard events. Whilst the protective measures must be robust, their deployment over long stretches of coastline necessitates an economical and environmentally friendly design. The dual row retaining wall concept, which features two parallel sheet pile walls with a sand infill between them and tie rods connecting the wall heads, is potentially an efficient and resilient system in the face of both earthquake and tsunami loading. Optimal use of the soil's strength and stiffness as part of the structural system is an elegant geotechnical solution which could also be applied to harbours or elevated roads. However, both the static equilibrium and dynamic response of these types of constructions are not well understood and raise many academic and practical challenges.

A combination of centrifuge and numerical modelling was utilised to investigate the problem. Studying the mechanics of the walls in dry sand from the soil stresses to the system displacements revealed the complex nature of the soil structure interaction. Increased wall flexibility can allow more utilisation of the soil's plastic capacity without necessarily increasing the total displacements.

Recognising the dynamically varying vertical effective stresses promotes a purer understanding of the earth pressures mobilised around the walls and may encourage a move away from historically used dynamic earth pressure coefficients. In a similar vein, the proposed modified Winkler method can form the basis of an efficient preliminary design tool for practice with a reduced disconnect between the wall movements and mobilised soil stresses.

When founded in liquefiable soil and subjected to harmonic base motion, the dual row walls were resilient to catastrophic collapse and only accrued deformation in a ratcheting fashion. The experiments and numerical simulations highlighted the importance of relative suction between the walls, shear-induced dilation and regained strength outside the walls and partial drainage in the co-seismic period. The use of surrogate modelling to automatically optimise parameter selection for the advanced constitutive model was successfully explored.

Ultimately, focussing on the mechanics of the dual row walls has helped further the academic and practical understanding of these complex but life-saving systems.