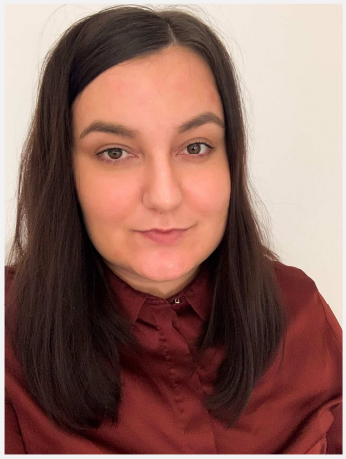
CERIS Civil Engineering Research and Innovation for Sustainability

Coupled numerical-experimental approach to dynamic characterization of geomaterials



Summary

A numerical-experimental technique coined by the CEN-DynaGeo Project is extended to geotechnical applications in Civil Engineering, namely the bender element testing of saturated and unsaturated geomaterials, and of unbound granular layers in pavements and track beds.

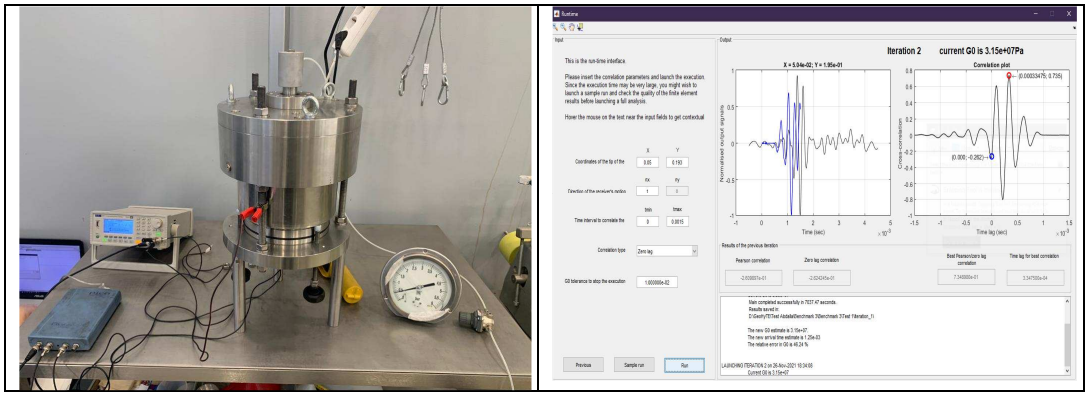
On the numerical side, this PhD programme develops innovative numerical solutions for the efficient modelling of transient wave propagation in single-phase (continuous), biphasic (saturated) and triphasic (unsaturated) geomaterials. Novel hybrid-Trefftz finite elements are formulated, implemented, and validated, and a set of boundary conditions between single- and multi-phase media is designed to model their interaction. A novel Dual Reciprocity Method is extended to elastodynamic problems to enable their solution using time-stepping algorithms, considerably increasing the computational efficiency. The hybrid-Trefftz finite elements are embedded into GeoHyTE, a novel computational platform for the automatic extraction of the shear modulus from the output signal of bender element tests.

On the experimental side, a novel, modified Rowe cell is fitted with bender elements and used to study the shear modulus of geomaterials under controlled state conditions (density and moisture). The device accommodates various types of boundary conditions and samples of different dimensions, and offers flexible positioning of the receiver bender elements. These features are optimized based on numerical data, to maximize the strength and legibility of the output signal.

A novel bender element sensor is developed for the measurement of the dynamic shear modulus of unbound granular layers. To enable the insertion of the device in the granular layer, a protection system is designed to shield it from the compaction pressure, while ensuring good contact between the bender element and the geomaterial. The design of the sensor is optimized using numerical models that capture the dynamic interaction between the bender element, protection system and geomaterial.

Keywords

Dynamic testing of geomaterials, bender element, hybrid-trefftz finite element, model updating, unbound granular material, modified rowe cell.



Bender Element test setup in the Modified Rowe Cell; Dynamic analysis performed with GeoHyTE software for the automatic identification of the small strain shear modulus of geomaterials.

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