CERIS Civil Engineering Research and Innovation for Sustainability

CEN-DynaGeo – Coupled Experimental and Numerical Approaches Toward Reliable Dynamic Characterization of Multi-phase Geomaterials

Summary

The expansion of construction projects in seismic regions with poor soil conditions has led stakeholders to call for faster, cheaper and more reliable geotechnical engineering solutions. The legal and financial implications of faulty geotechnical information are vast. The US Transportation Research Board reports that faulty information accounts for 15% of the construction claims and 25% of the project change orders issued by the Federal Highway Administration. A study of the Australian construction industry similarly identified deficient geotechnical information among the 20 key risk factors in construction practice.

Dynamic lab testing of geomaterials typically involves either resonant column apparatus or piezoelectric transducers. Developed earlier, well understood, and standardized, the former technique induces torsional resonance in cylindrical samples and is used to measure small strain shear moduli and damping. As compared to the resonant column, piezoelectric transducers are simpler, cheaper, faster to install, easier to use and, in many circumstances, yield similar results. Moreover, depending on their polarization, they can induce both shear waves (bender elements) and compression waves (extender elements).

However, the wave propagation induced by piezoelectric transducers is more complex, hindering the standardization of the experimental setup and the interpretation of the output signal, limiting their use in the industry. Regarding the experimental setup, open issues include the best location of the transducers, their optimal geometry and the nature of the excitation. The three main difficulties in the interpretation of the output signal are: the dissimilarity of the input and output signals, due to high frequency material damping, radiation (into the surroundings) and spurious boundary reflections (back into the sample); the residual motion of the emitter transducer, which continues to vibrate after the electrical signal ends; the solid continuum assumption in the moduli computation, which may be inadequate for multi-phase media. Consequently, purely experimental approaches to the piezoelectric transducers testing only offer partial knowledge of the input and output signals, forcing the analyst to guess what goes on between the readings.

The objective of the project is to change the way piezoelectric testing is approached, by coupling experimental and numerical techniques to improve the characterization of wave propagation in geomaterials. Numerical modelling enables us to use model updating procedures to fully exploit the lab data, and to assess the impact of various setup options on the quality of the output signal.

Once confirmed experimentally, the conclusions will enable the optimization of the experimental setup and lead to CEN standardization. The transducers geometry will be optimized to reduce the residual motion of the emitter and to increase the quality of the readings of the receiver. Prototypes will be produced and tested, and the best solutions patented. Finally, model updating techniques will be used to study the correlation between the simulation and experimental data for the automatic recovery of shear moduli. This feature will be included in a computational toolbox open to the geotechnical community, improve the quality of the output signal, leading to a set of recommendations for the CEN/ISO standardization. Optimized transducers will be produced and tested, and the best solutions patented. An open computational toolbox for the automatic interpretation of the output signal will be created, using a novel, highly convergent model updating technique.

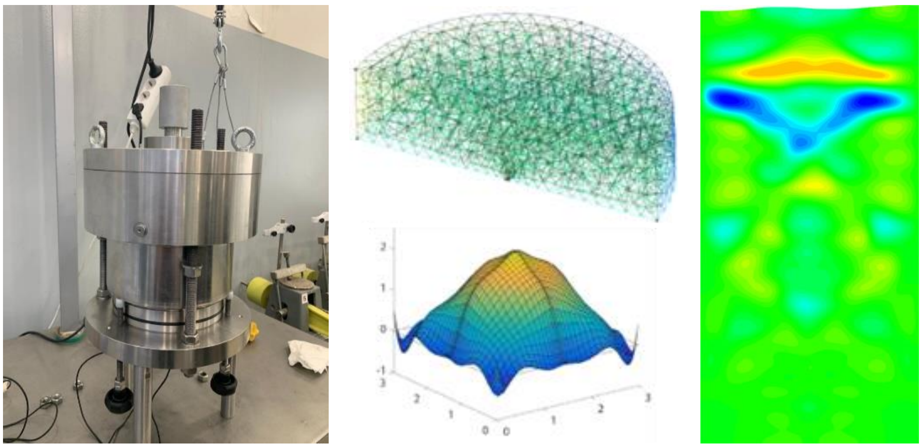
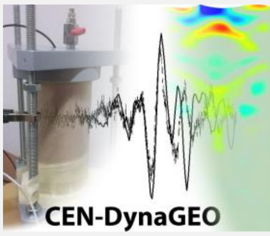


Figure 1. a) Innovative Rowe cell fitted with bender elements; b) Sample mesh for the computational modelling of a soil sample in the modified Rowe cell; c) Particular solution field in a heat propagation problem modelled with hybrid-Trefftz finite elements; d) Propagation of a shear wave through a saturated soil.



Project Reference

PTDC/EAM-GTC/29923/2017

Leading Institution

IST-ID – Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento (Portugal)

Partners

UMinho – University of Minho (Portugal)

CERIS Principal Investigator

Ionut Dragos Moldovan
(dragos.moldovan@tecnico.ulisboa.pt)

CERIS Research Team

João Teixeira de Freitas

Funding

FCT – Fundação para a Ciência e a Tecnologia

Period

2018-2022

Total

233 723.75€

CERIS

142 323.06€

Project Website

sites.google.com/view/cen-dynageo