Abstract ID 424

HEALTH MONITORING OF ROAD INFRASTRUCTURES USING BENDER ELEMENTS EMBEDDED IN PAVEMENTS

Ionut Dragos Moldovan[(1)], José Neves[(2)], Carolina Melendez[(3)], Manuel Parente[(3)], Miguel Azenha[(3)], Roxana Banabic[(4)], Cosmin Chiorean[(4)], Hélder Silva[(5)], João Moutinho[(5)], Erol Tutumluer[(6)], António Gomes Correia[(3)]

[(1)]Lusófona University
[(2)]Instituto Superior Téncico, University of Lisbon
[(3)]University of Minho
[(4)]Technical University of Cluj-Napoca
[(5)]Built Colab
[(6)]University of Illinois

dragos.moldovan@ulusofona.pt, jose.manuel.neves@tecnico.ulisboa.pt, id8649@alunos.uminho.pt, map@civil.uminho.pt, miguel.azenha@civil.uminho.pt, roxanabanabic@gmail.com, cosmin.chiorean@mecon.utcluj.ro, helder.silva@builtcolab.pt, joao.moutinho@builtcolab.pt, tutumlue@illinois.edu, agc@civil.uminho.pt

Keywords: Unbound granular layer; bender element; structural health monitoring; shear modulus; INTENT project

Summary: The expansion of road networks in regions with poor soils has led owners to call for improved and continuous monitoring solutions. Accurate and timely geotechnical information enable better planning of retrofit interventions, with huge savings to the €30B/year EU highway maintenance budget.

Currently, most pavement monitoring solutions are based on periodic inspections of the asphalt course. However, the pavement foundation (subgrade, capping, sub-base) and the granular base course are essential components of the road structure. The foundation acts as a construction platform for the upper layers and the base course sustains the construction of the asphalt layer and spreads the loads to reduce the stresses in the foundation. The failure of the base course will inevitably compromise the pavement and is much harder to detect visually than the damage of the asphalt course.

Despite the importance of the unbound granular layers, little quality assurance testing is carried out on the finished product and on its long-term behaviour. Continuous monitoring techniques have been proposed, but they are still in an incipient phase. Instrumentation embedded in the granular layers includes strain gauges, to monitor their deformation; pressure cells, geophones and LVDTs to support the assessment of the stiffness; and temperature and moisture probes for ancillary measurements. No continuous monitoring technique has been reported to directly measure the dynamic stiffness of the geomaterial, despite this being highly relevant for damage detection.

The objective of this work is to introduce the national project INTENT, aimed at developing a new embedded sensing device, based on the bender element technology, for the continuous monitoring of the dynamic stiffness of unbound granular layers, and to use it, along with conventional sensors and advanced numerical models, to fuel machine learning algorithms for continuous monitoring of pavements.

The bender elements developed in this project enable the continuous measurement of the stiffness of the granular layers during construction, ensuring that pavement design requirements are met, and during the service life of the structure, enabling retrofit actions in the early stages of damage. They can be embedded in any layer with minimal disturbance, and their signal analysed automatically to extract the shear modulus of the layer. They are coupled with conventional sensors to get a comprehensive picture of the condition of the layer, and the data analysed in real time by machine learning algorithms for damage detection. Advanced numerical models will help machine learning algorithms distinguish the between gradual loss of stiffness and/or gradual increase of permanent deformation under cyclic loading (concept of fatigue) and the sudden, catastrophic deterioration of the geomaterial (concept of failure). A damage progression prognosis toolbox is developed to compare the expected and measured rates of degradation of the geomaterial and estimate its future condition.

Project INTENT is a joint research effort of six universities, two research laboratories one industrial partner located in four countries. It currently involves more than 20 researchers.