Job: Research Grant for Master

Job/Fellowship Reference: 2022.06879.PTDC

Main research field: Civil Engineering or Transportation Engineering or Geotechnical Engineering or Structural Engineering

Sub research field: Geomechanics

Stating date: 01.06.2023

Salary: €16,135.68 per annum (€13,735.68 net annual salary)

Job summary:

A call will be open shortly to award one research grant to develop research activities within the I&D Project *INTENT – Intelligent health monitoring of road infrastructures using bender elements embedded in pavements*, 2022.06879.PTDC, funded by the Portuguese Science and Technology Foundation (FCT). The recipient is expected to conduct research in the field of Computational Geomechanics at the Lusófona University in Lisbon and the Instituto Superior Técnico of the University of Lisbon.

Research Field: Civil Engineering/ Geomechanics

Requirements for admission: Master (MSc) in one of the following areas (or equivalent): Civil Engineering or Transportation Engineering or Geotechnical Engineering or Structural Engineering. Fluent in written and spoken English. The classifications of the candidates at the Undergraduate (U) level and at the Master (M) level should be such that 0.6*U + 0.4*M >= 14, on a 0 to 20 scale. At least the MSc classification must be recognised by the Portuguese Authorities[1]. Evidence of prior scientific experience is an advantage.

Work plan: 1) Development of hybrid-Trefftz finite element models for transient wave propagation in geomaterials; 2) Development of fatigue degradation models for pavements; 3) Development of machine learning algorithms for damage detection; 4) Development of a toolbox for the automatic data acquisition and interpretation, damage progression forecast and early warning system for pavements. A summary of the Project INTENT can be found in the Appendix.

Applicable legislation and regulations: Law Nº. 40/2004, of 18 August (regulation of the scientific research activity); Regulation of the research grants of the FCT (https://former.fct.pt/apoios/bolsas/regulamento2012.phtml.en)

Work place: The main research work will be developed at the School of Engineering of the Lusófona University, under the scientific supervision of Professors Ionut Moldovan and Elói Figueiredo, and University of Lisbon, under the scientific supervision of Professor José Neves.

Duration of the Grant: The grant will have the duration of 12 months, beginning on June 1st, 2023, with yearly extensions up to a maximum of 36 months.

[1] If the candidate does not already have the MSc degree recognized in Portugal, a fast-track recognition is possible for candidates with MSc degrees granted by Universities from the European Union, as well as the following countries: Andorra, Brazil (only degrees classified by CAPES with *conceito* equal or superior to 5), Moldova, Norway, Russia Federation, Switzerland, Turkey, Ukraine, United Kingdom. More details cam be found here: https://www.dges.gov.pt/en/pagina/degree-and-diploma-recognition

Monthly salary: The yearly salary will be €16,135.68. The net monthly salary amounts to €1,344.64 (net salary €1,144.64).

Selection criteria: The selection methods will be the following:

50% for the final grade of the course, calculated according to the formula 0.6*U + 0.4*M, where U and M represent the classifications of the candidates at the Undergraduate and Master levels, respectively (for integrated Master (MI) the formula is 1*MI);

20% for publications (5 points for ISI journals, 2 points for non-ISI journals, 1 point for international conferences, 0.5 points for national conferences);

30% for the interview. Preference factors: Interest in following up with a PhD program, experience in numerical modelling in Geomechanics and basic knowledge of experimental Geomechanics. Only the first three eligible candidates (considering the previous two criteria) will be invited to the interview.

In the event that the candidates do not have the appropriate profile for the proposed functions, the jury reserves the right to close the competition without any recruitment.

Application period and structure of the application: The call is foreseen to be open next April. Any potential candidate that sends a declaration of interest at the email address below will be personally announced when the call is open.

Applications must be made through an application letter together with the following documents: *Curriculum Vitae, certificates of graduation degrees* and *other documents considered relevant by the candidate*.

Applications should be submitted by email to dragos.moldovan@ulusofona.pt

Notification of results: the final results will be sent by email to the candidates.

APPENDIX

SUMMARY OF THE INTENT PROJECT

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 must sustain the traffic loads once construction is completed. Likewise, the base course sustains the construction of the asphalt course 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 (sub-base and base), 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 project is to develop a new embedded sensing device, based on the bender element technology, for the continuous monitoring of the dynamic stiffness (shear modulus) 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 can be 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 and the sudden, catastrophic deterioration of the geomaterial. A damage progression prognosis toolbox is developed to compare the expected and measured rates of degradation of the geomaterial and estimate its future condition.

Innovative coupled numerical-experimental techniques are used to power up these solutions. Hybrid-Trefftz finite element models are ideal for simulating the propagation of high frequency shock waves through geomaterials, as typical of bender element experiments. They are used to optimize the design of the bender element sensors and for the automatic interpretation of the output signal. A non-linear finite element model capable of simulating the strain accumulation and stiffness degradation under cyclic loading is used to inform machine learning algorithms on the expectable fatigue degradation patterns.

The project combines complementary competences and equipment from 6 research institutions in Portugal, Spain and USA. The team is experienced in finite element models, structural health monitoring, pavement engineering, dynamic behaviour of geomaterials, sensing and electronics.