



School of Computing, Engineering, and the Built Environment Edinburgh Napier University

PHD STUDENT PROJECT

Application instructions:

Detailed instructions are available at :

<https://www.napier.ac.uk/research-and-innovation/doctoral-college/how-to-apply>

Prospective candidates are encouraged to contact the Director of Studies (see details below) to discuss the project and their suitability for it.

Project details

Supervisory Team:

- DIRECTOR OF STUDY: Dr Juan Bernal-Sanchez (Email: j.bernal-sanchez@napier.ac.uk)
- 2ND SUPERVISOR: Dr John McDougall

Subject Group: Built Environment

Research Areas: Civil Engineering, Soil Mechanics, and Geotechnical Engineering

Project Title: Geotechnical Seismic Isolation Technology for Global Earthquake Resilience and Environmental Sustainability

Project description:

The key idea is that Rubber-Soil mixtures (RSm), derived from car tyres, can be used to modify the foundation and protect civil structures against the action of earthquakes at beneficial economic and environmental costs. Thus, the seismic protection can be engineered in locations where earthquakes are most common, and consequences are least affordable. This is a distinctive Civil Engineering project in that it has direct consequences on human suffering.

The main reason for doing this topic is that it can aid in tackling two issues: i) the impact that strong earthquakes (17 major annually) cause on civil structures, and the human population, in both developed and developing countries, and ii) the high contamination associated with the disposal of scrap tyres (up to 40 million tonnes disposed only in the UK), with direct mitigation of carbon emissions.

The dynamic behaviour of RSm has been studied at Edinburgh Napier University and other institutions (Bernal-Sanchez et al., 2022; Fonseca et al., 2019, Anastasiadis et al., 2012), however, most of these studies are limited to studying the geotechnical mixture on the basis of soil element tests, not considering the foundation-soil interaction. Only a few investigations have studied the performance of Geotechnical Seismic Isolation systems with RSm under dynamic disturbances via scaled testing (Tsang et al. 2021). Also, one common element to the previous studies is that RSm was placed underneath the construction which incurs one important issue: it precludes its implementation in existing constructions. To overcome the issues found in the design configuration, RSm technology will be also tested in a vertical disposition, being laterally added to the existing scaled structure.

The project will build partly on the doctoral work developed at ENU (Bernal-Sanchez, 2020) that investigated the dynamic properties of RSm and their impact on seismic force attenuation. This work was undertaken in ENU (Edinburgh) labs using a dynamic triaxial rig and in labs at IIT Bengaluru (India) using resonant column apparatus. More recently the research team has tested the seismic response of a modified ground soil using a shaking table, and this will be one the main equipment to be learned and used during the PhD of the potential applicants.

The main aim of this PhD will be to investigate the dynamic behaviour of RSm under simulated excitations, by means of advanced scaled-model testing as well as computational simulations, to prove the suitability of this sustainable technique to protect new and retrofit existing constructions. The applicant will also learn from alternative forms of prediction of the inter-particle behaviour applied to Ground Seismic Isolation technologies using grading entropy theories or Discrete Element Method analysis, currently being studied and developed by academics at ENU.

Perspective applicants are encouraged to contact the supervisor before submitting their applications. Applications should make it clear the project you are applying for and the name of the supervisors.

References:

- [1] Anastasiadis, A., Senetakis, K., Pitilakis, K. (2012). Small-Strain Shear Modulus and Damping Ratio of Sand-Rubber and Gravel Rubber Mixtures. In: *Geotechnical and Geological Engineering* 30(2):363–382. DOI: 10.1007/s10706-011-9473-2.
- [2] Bernal-Sanchez, J., McDougall, J., Miranda, M. , Barreto, D. (2022). Dynamic Behaviour of a Geotechnical Seismic Isolation System with Rubber-Sand Mixtures to Enhance Seismic Protection. In: *3rd European Conference On Earthquake Engineering & Seismology*.
- [3] Bernal-Sanchez, J. (2020) *Cyclic Performance on Rubber-Soil Mixtures to Enhance Seismic Protection*. Dissertation, Edinburgh Napier University. Available at: <https://www.napier.ac.uk/-/media/worktribe/output-2683555/cyclic-performance-of-rubber-soil-mixtures-to-enhance-seismic-protection.ashx>
- [4] Fonseca, J., Riaz, A., Bernal-Sanchez, J., Barreto, D., McDougall, J. (2019) Particle-scale Interactions and Energy Dissipation Mechanisms in Sand–Rubber Mixtures. *Géotechnique Letters* 9(4):263-268.
- [5] Tsang, H.H., Tran, D.P., Hung, W.Y., Pitilakis, K., Gad, E.F. (2021). Performance of Geotechnical Seismic Isolation System using Rubber-Soil Mixtures in Centrifuge Testing. *Earthquake Engineering and Structural Dynamics*, 50(5):1271-1289.

Candidate characteristics

Education:

A first-class honours degree, or a distinction at master level, or equivalent achievements in Civil Engineering with a good fundamental knowledge of geotechnical and/or earthquake engineering.

Subject knowledge:

- Geotechnics,
- Soil Mechanics,
- Geotechnical Earthquake Engineering,
- Dynamic Analysis,
- Structural Dynamics.

Essential attributes:

- Experience of fundamental geotechnical engineering and testing
- Competent in structural and earthquake engineering
- Knowledge of how to manage a fundamental laboratory investigation
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management