Department	School of Engineering and the Built Environment
Supervisors	Dr Juan Bernal-Sanchez, Dr John McDougall, Dr Daniel Barreto
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 is 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 technogies 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.

Academic qualifications

A first degree (at least a 2.1) ideally in Civil Engineering with a good fundamental knowledge of geotechncial and/or earthquake engineering.

English language requirement

IELTS score must be at least 6.5 (with not less than 6.0 in each of the four components). Other, equivalent qualifications will be accepted. Full details of the University's policy are available online.

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

Indicative Bibliography	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. 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. 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 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. 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.
Enquiries	For informal enquiries about this PhD project, please contact Dr Juan Bernal-Sanchez, J.Bernal-Sanchez@napier.ac.uk
Web page	https://www.napier.ac.uk/research-and-innovation/research-degrees/application-process