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****Please read accompanying guidance notes****

Department	School of Engineering and the Built Environment
Supervisors	Dr John McDougall; Dr Daniel Barreto; Dr Juan Bernal
Funding Status	Funded PhD Project (Worldwide)
Application Deadline	14/04/2022
Project Title	Sustainable Earthquake Protection for the Developing World

PROJECT DESCRIPTION

The key idea is that rubber soil mixtures (RSM) derived from shredded car tyres, can be installed (actually retrofitted), at beneficial economic and environmental costs. Combined with innovative timber construction, predicated on the unparalleled seismic resilience of the pagoda, 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 a direct consequence on human suffering.

Geotechnical researchers in SEBE have been exploring innovative and more environmentally friendly ways of managing seismic disturbance. The project team are well equipped to deliver on this aim. McDougall & Barreto have a track record in technical innovation, leading project development and funding success [1, 2].

The project will build partly on the doctoral work of Bernal, who investigated the dynamic properties of RSM and their impact on seismic force attenuation. This work was undertaken in SEBE labs using a dynamic triaxial rig and in labs at IIT Bengaluru using resonant column apparatus. Bernal spent 3 months at IIT on a Newton Babha funded expedition. More recently we have tested the seismic response of a scale model superstructure on a shaking table. This was devised to elucidate the practicalities of retrofitting RSM using degradable sacks, in order to avoid RSM segregation.

Also building on existing SEBE expertise in timber engineering and as a direct consequence of recent MEng dissertation work, we have initiated a programme of timber structure testing to reveal the relative importance of some of the factors contributing to the resilience of Japanese pagodas: Dougong (unpinned timber joints able to dissipate energy), Shinbashira (a central free hanging column able to sway in opposition to, and thereby dampen, an oscillating structure), tiled eaves (provide stabilising mass and control ground conditions below). A key element of this workstream is the interpretation of the frictional interaction of Dougong. We have subjected a multi-storey unpinned scale model structure to seismic shaking in the laboratory to reveal the stick-slip and hence dynamic response.

The work proposed is strongly fundamental, considering the qualitative and quantitative performance of RSM and timber structures. As indicated, previous work has been driven by challenges of installation – 'bagged' RSM. If the project outcomes are realised then a significant programme of local guidance and training will be required. Such a programme would be of great interest in and benefit to developing countries situated in earthquake zones.

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

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• 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 **Desirable attributes:** Click here to enter text.	
Indicative Bibliography	[1]J McDougall (2007) A hydro-bio-mechanical model for settlement and other behaviour in landfilled waste. Computers and Geotechnics 34 (4), 229-246 [2] D Barreto, C O'Sullivan (2012) The influence of inter-particle friction and the intermediate stress ratio on soil response under generalised stress conditions. Granular Matter 14 (4), 505-521 [3] J Fonseca, A Riaz, J Bernal-Sanchez, D Barreto, J McDougall (2019) Particle–scale interactions and energy dissipation mechanisms in sand–rubber mixtures. Géotechnique Letters 9 (4), 263-268 [4] VE Dimitriadi, GD Bouckovalas, YK Chaloulos, AS Aggelis (2018) Seismic liquefaction performance of strip foundations: effect of ground improvement dimensions. Soil Dynamics and Earthquake Engineering 106, 298-307
Funding notes	This project may be funded by a scholarship of the School of Engineering and Built and Environment. Please see School-funded PhD scholarships - RESEARCH AND INNOVATION (napier.ac.uk) for information on the scholarships and how to apply for them.
Enquiries	For informal enquiries about this PhD project, please contact Dr John McDougall [j.mcdougall@napier.ac.uk; 0131 455 2533
Web page	https://www.napier.ac.uk/research-and-innovation/research-degrees/application-process

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