Department	School of Engineering and the Built Environment
Supervisors	Dr Daniel Barreto
Project Title	The influence of particle characteristics on the field-scale geomechanical behaviour of soils

PROJECT DESCRIPTION

It is well recognised that many geotechnical phenomena, such as liquefaction, crushing, dissolution effects and failure are affected by macro-scale properties such as initial density, anisotropy, permeability and compressibility, amongst others. On the other hand, it is well understood micro-scale properties such as particle morphology, roughness, particle shape and size distributions underlie many of these observed macro-scale behaviour. Much of this insight is the result of extensive experimental and numerical investigations. Of particular interest is the use of Discrete Element Method (DEM) simulations that account for the particulate nature of soils. There is significant advance on computational capabilities and techniques to realistically model particle properties such as morphology, particle shape and soil-fluid interactions. In spite of this, the efficient DEM modelling of anything beyond laboratory scale soil element tests still remains a challenge.

This project aims to develop and validate efficient and realistic numerical techniques that enable the simulation of boundary-value problems including retaining walls, excavations, embankments, etc. A truly innovative micro-to-macro approach that includes particle properties via DEM, fluids via computational fluid dynamics (CFD) as well as homogenization techniques [1-3] optmised by machine learning approaches [4] will be validated by laboratory experiments and available field data of relevant construction scenarios.

As part of this project you will help develop the required numerical techniques under the supervision of Dr Barreto, and performing a limited set of laboratory experiments to validate the DEM simulations. Apart from joining one of the world experts in DEM you would be joining a dynamic research team whilst contributing to enable the next generation of DEM simulations for use in real life and large-scale industrial and engineering applications.

Prospective applicant 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 soil mechanics, geotechnical engineering and computer programming.

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 laboratory soil element testing
- Competent in the use of numerical tools based on the discrete element method (DEM) and/or computational fluid dynamics (CFD)
- Knowledge of numerical modelling techniques in geomechanics.
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes: Evidence of relevant publications and/or research outputs, as well as an MSc. in geotechnical or related discipline would be advantageous.	
Indicative Bibliography	[1] Guo, N., & Zhao, J. (2016). Multiscale insights into classical geomechanics problems. International Journal for Numerical and Analytical Methods in Geomechanics, 40(3), 367-390. [2] Coetzee, C. (2020). Calibration of the discrete element method: Strategies for spherical and non-spherical particles. Powder Technology, 364, 851-878. [3] Di Renzo, A., Napolitano, E. S., & Di Maio, F. P. (2021). Coarse-grain dem modelling in fluidized bed simulation: A review. Processes, 9(2), 279 [4] Tejada, I. & Antolin, P. (2021). Use of machine learning learning for unravelling hidden correlations between particle size distributions and the mechanical behaviour of granular materials. Acta Geotechnica.
Enquiries	For informal enquiries about this PhD project, please contact d.barreto@napier.ac.uk
Web page	https://www.napier.ac.uk/research-and-innovation/research-degrees/application-process