UNIVERSITY OF Southampton

Title: Three-dimensional density quantification of the interface between displacement piles and soft carbonate rocks using computed tomography

Supervisors: David Richards, Madhusudhan Murthy and Fernando Alvarez Borges

Type of project: Visiting Research Student - Experimental (12 weeks)

Workshop/technician time: 12 weeks use of the Geotechnics lab, TSRL and μ-VIS

Draft date: 01/08/2018

Wind power is a renewable, zero greenhouse emission energy source. The continued growth of wind power projects will contribute to the attainment of the Paris Agreement targets, the UN's Sustainable Development Goals, and the EU's 2020 targets. Recent developments have focused on offshore projects which allow for higher wind speeds, larger blade spans and arguably lower negative environmental impacts, but result in foundation costs of up to 50% of the total investment of offshore wind power ventures.

The critical loading condition for offshore wind turbine foundations is overturning moment. As projects move into deeper waters, the use of jacket structures supported by multi-pile systems has become more common. These displacement (driven) piles rely on vertical loading to oppose overturning moments, with tension (or uplift) being the dominant loading case.

Chalk is a soft carbonate rock prevalent across many areas being developed for offshore wind farms in the southern North Sea, the English Channel and the Baltic. Chalk is constituted by micron-sized calcareous fossils of varied sizes and shapes, like coccoliths and foraminifera. It thus shares characteristics with other weakly cemented biogenic carbonate rocks and sediments common throughout the world. The driving of piles for offshore foundations destructures and remoulds the chalk, forming a 'putty' interface around the pile. The uplift capacity of the pile is believed to be controlled by the characteristics of this remoulded interface. Limited of knowledge of these characteristics have led to design recommendations that may be over-conservative, which could result in substantial unnecessary costs in the development of offshore renewable energy projects.

Our recent investigations suggest that, for a given initial intact density, the density of the remoulded interface and the effective stress levels acting in the normal (perpendicular) direction are key parameters that affect the magnitude of frictional sliding resistance. However, the estimation of in-situ interface densities and normal effective stress levels remains elusive.

To contribute in the tackling of these uncertainties, this project will focus on the measurement of the density of the remoulded interface around an installed displacement pile. Specifically, the project will assess the remoulding and densification of chalk associated with the penetration of a reduced-scale pile installed in low-medium intact density chalk samples. The objective is to produce density profiles of the remoulded interface from high-energy micro-focus x-ray computed tomography (μCT) scans of the scaled physical models before and after pile installation. To this end, the visiting research student will have access to:

- The Geomechanics Laboratory, equipped with state-of-the-art geotechnical specimen preparation and testing facilities.
- Computer-controlled electromechanical testing machines and high-frequency small strain sensing equipment available at the Testing and Structures Research Laboratory.
- The custom 450/225 kVp Hutch CT system at the µ-VIS X-Ray Imaging Centre, equipped with a large, temperature controlled walk-in scanning/testing bay ideal for large and/or heavy specimens (Figure 1). The high-energy 450 kVp source and 2000x2000 pixels flat panel detector enable sub-millimetre density measurements at the central regions of large or highly attenuating specimens.
- High-end training in the use of industry-leading 3D image reconstruction and processing software (e.g. Avizo, VGStudio Max, Digisens, ImageJ) installed in high-specification (96-512 GB RAM multi-core dual-processor) workstations available at Image Analysis and Visualisation Suite of the µ-VIS X-Ray Imaging Centre.

This investigation will support current University of Southampton-based work on the development of a methodology that produces quantifiable high-resolution 3D images of pile penetration mechanisms in chalk. Future investigations will assess the potential correlation between the interface density profiles obtained in this project and the vertical capacity of the pile from tension tests, by employing soil mechanics concepts. Therefore, this project will contribute to the understanding of the underlying mechanisms that control the vertical capacity of displacement piles in chalk, and to the eventual formulation of more efficient pile design recommendations from which the offshore renewable energy industry will benefit.

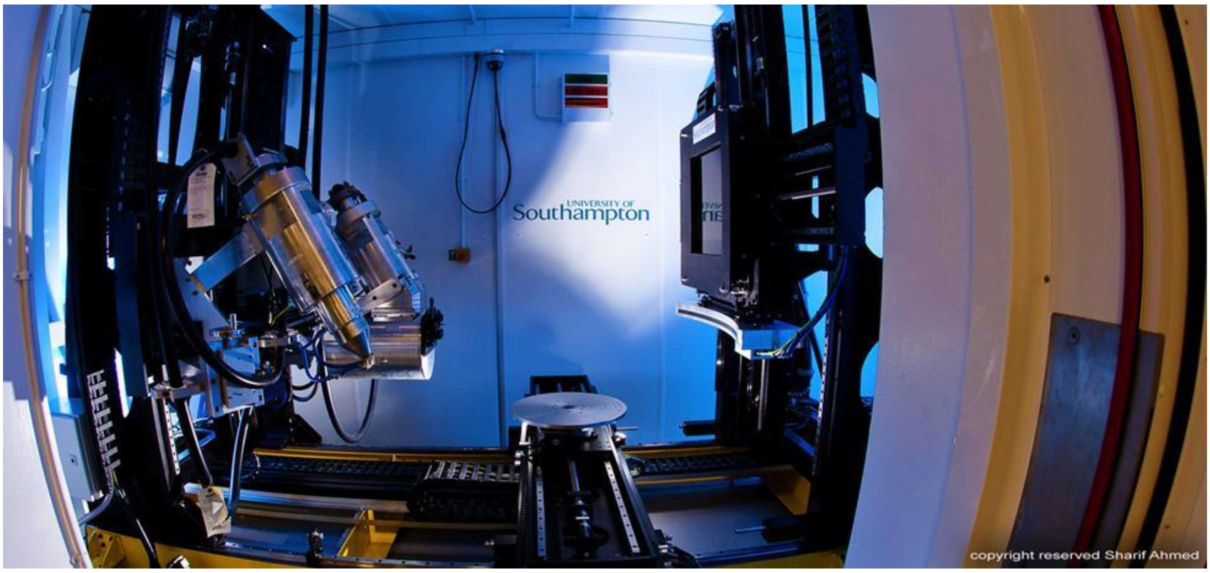

Figure 1. 450/255 Hutch scanning/testing bay.

A quien escribir: Prof. David Richards -djr@soton.ac.uk)

Que se debe enviar:

- IELTS result of 6.5 or above with no band below 6
- Student (short) letter of motivation (i.e. how this project fits with his/her undergrad/masters work and what are his/hers future research prospects).
- Student CV.

Fecha: 10 agosto 2018

Requisitos

1. Duration of the visit must not exceed 12 weeks to avoid incurring in academic fees.
2. Economic support from the University may come in the form of bench/administrative fee waiving, plus coverage of CT scanning expenses.
3. Student must produce a report/presentation at the final stages of the visit (and ideally a conference paper draft or similar).
4. Acceptance requirements are:
    - Letter of support from home supervisor and institution.
    - IELTS result of 6.5 or above with no band below 6.
    - Agreement letter from Southampton-based main supervisor (i.e. Prof David Richards -djr@soton.ac.uk), conditional upon the submission and approval of:
        - Student (short) letter of motivation (i.e. how this project fits with his/her undergrad/masters work and what are his/hers future research prospects).
        - Work plan (to be discussed with Prof Richards and co-supervisors via email and/or video call)
        - Student CV.