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PHD OPPORTUNITY – RESEARCH IN OFFSHORE RENEWABLES OCTOBER 2025 (3 YEARS, FULLY FUNDED)

PHYSICAL AND NUMERICAL MODELING OF SUCTION ANCHORS FOR FLOATING WIND TURBINES UNDER COMPLEX SEABED DRAINAGE CONDITIONS (MASE)

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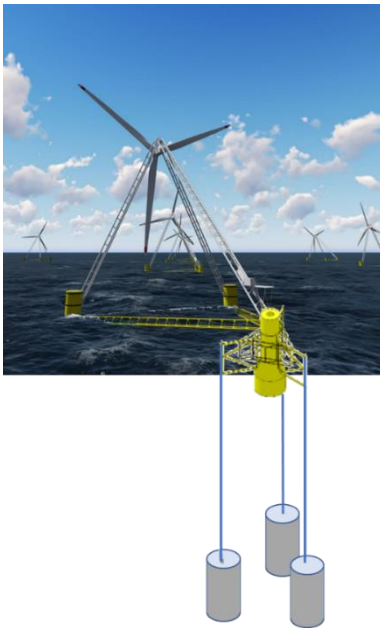
PhD specialty: Geotechnical Engineering, Offshore Geotechnics

1 | Context



Climate change caused by greenhouse gases is having an increasingly severe impact on human society. The urgency of identifying sustainable energy alternatives, such as solar, wind, and hydropower, has never been greater. Among these, wind energy stands out as a highly cost-effective, clean, and sustainable source of energy for societies worldwide. Approximately 70% of the Earth's surface is covered by oceans, representing an area of 140 million square miles with enormous potential for floating wind turbine applications. According to the International Energy Agency (IEA) [1], the global technical potential of offshore wind energy is estimated at 120,000 gigawatts (GW), enough to meet 11 times the projected global electricity demand in 2040.

In parallel, the development of floating offshore wind turbines is advancing in Europe and France. These turbines are approaching technological maturity and are nearly ready to be integrated into wind farms comprising dozens of units connected to the electrical grid. As floating wind farms transition from shallow-water sites to deep-water zones, suction anchors are emerging as an essential foundation solution, offering stability and reliability under demanding marine conditions [2]. However, due to the complexity of geological seabed conditions, suction anchors in deep-water areas face numerous challenges, including complex drainage conditions and variability in seabed soils. Stratified seabeds subjected to variable drainage conditions significantly influence the installation and operational performance of suction anchors. At present, the response mechanisms of suction anchors in deep waters under varying drainage conditions remain poorly understood [3].

Therefore, further research is necessary to better understand these mechanisms, optimize the design, installation, and operational performance of suction anchors in deep-water regions.

Keywords: offshore wind, winged pile anchor, installation, centrifuge testing, numerical simulation

2 | Problem Statement

Three main challenges arise:

• Installation challenges: In stratified seabeds with varying drainage characteristics, the efficiency of suction pressure is unpredictable, complicating the control of anchor installation and penetration.

• Load capacity challenges: Complex drainage conditions can significantly impact the uplift capacity of suction anchors as well as their performance under cyclic loading.

• Modeling and prediction challenges: Current numerical frameworks and models often oversimplify drainage behavior, leading to inaccurate predictions of suction anchor performance.

3 | Scientific Barriers

This study will adopt a combined experimental and numerical simulation approach, using a multi-scale perspective (from micro to macro levels) to address these issues. The aim is to reveal the mechanisms governing the performance of suction anchors in deep waters under variable drainage conditions and evaluate their short- and long-term behavior.

• Centrifuge experiments at 1g and Ng will be conducted to observe variations in suction pressure around the anchor, micro-scale fluid flow laws, and macro-scale characteristics of load capacity and deformation. The goal is to link micro-scale variations to macro-scale behaviors.

• Based on experimental observations, a new multi-scale numerical framework will be proposed to simulate the behavior of suction anchors in deep waters under variable drainage conditions. This multi-scale framework will leverage Coupled Eulerian-Lagrangian (CEL) large deformation simulation technology [4], accounting for solid-fluid coupling effects at the micro-scale. This innovative framework will simulate the installation process and the short- and long-term performance of suction anchors under various drainage conditions.

4 | Novelty

The innovation of this study lies in its multi-scale approach, both experimentally and numerically, aiming to establish the relationship between solid-fluid coupling effects at the micro-scale and load capacity and deformation characteristics at the macro-scale. The multi-scale modeling will offer a deeper understanding of how different drainage conditions influence the behavior of suction anchors.

5 | Expected Outcomes

• Accurate correlation between numerical simulations and experimental data.

• Validation of the effects of drainage layers on "Reverse End Bearing" (REB) resistance.

• Recommendations for short- and long-term performance optimization.

• Proposal of a new numerical framework for modeling complex solid-fluid coupling and large deformation soil-anchor interaction.

6 | Supervision

PhD director – Dr. Matthieu Blanc (HDR) has over 14 years of experience in centrifuge physical modeling applied to offshore geotechnics. In 2021, he was appointed as the director of the Geotechnical Centrifuges (CG) laboratory within the GERS department. Matthieu Blanc's current research explores topics related to physical modeling in geotechnics, particularly with the geotechnical centrifuge. He mainly works on soil-structure interactions under complex loading, such as soil reinforcement, and deep and shallow foundations. Recent applications are oriented towards foundations and anchoring systems for marine renewable energies. The ongoing challenge for each of these topics is to observe and understand the phenomena, and also to obtain appropriate experimental data to compare with numerical or theoretical models. Dr. Matthieu Blanc received in 2018 the Jean Kérisel Prize rewarding the young engineer/researcher in geotechnics served by the French Society of Soil Mechanics.

PhD supervisor – Dr Zheng Li. Zheng Li joined the GERS-CG laboratory at Université Gustave Eiffel in 2019. Zheng LI is carrying out his studies in the field of physical centrifuge modeling and numerical modeling. His research specializes in constitutive modeling, soil-structure interaction, and large deformation analysis, particularly in large deformation modeling of offshore structures such as soil-caisson interaction in sand and soil-pipeline interaction in clay.

7 | Collaboration

The experimental data of this Ph.D study will be supported by the PAREF project (https://www.ten.com/en/media/press-releases/technip-energies-universite-gustave-eiffel-valeco-and-open-c-foundation). The PAREF project is crucial to creating competitive and sustainable solutions for floating offshore wind turbines, adapted to deep waters.

The numerical simulation of this Ph.D study will focus on the multi-scale modeling of suction anchors, and this part of the research will be conducted in close collaboration with The Hong Kong Polytechnic University.

8 | Candidate's profile

We are seeking motivated candidates who possess a solid foundation in geotechnical engineering. Undergraduate/Master students in general engineering/civil engineering / geotechnical engineering / offshore geotechnical engineering are particularly welcome. Experience in programming and FEM modeling using Abaqus is preferred. Proficiency in the English language is essential for the role.

9 | Location and Funding

Location

The PhD will take place in the Geotechnical Centrifuges Laboratory on the Nantes campus of Gustave Eiffel University. Please visit the website of the lab for more information: https://cg.univ-gustave-eiffel.fr/en/

Funding

The research funding for this project requires joint efforts from the Ph.D. candidate and the supervisors, with the application process in two stages:

Stage 1: The supervisor conducts interviews to identify and select an outstanding Ph.D. candidate (March to April).

Stage 2: The supervisor and the selected candidate collaboratively develop a research plan. The candidate will then present to an academic evaluation committee to apply for Ph.D. research funding (around May). From historical statistical data, the application success rate is quite high.

10 | How to apply

To apply, please email:

- A CV
- A cover letter detailing your suitability and motivation for this position
- A copy of your transcript

Email to Dr. Matthieu Blanc: matthieu.blanc@univ-eiffel.fr; Dr. Zheng LI: zheng.li@univ-eiffel.fr

Please, do not hesitate to get in touch for further information.

References

1. IEA, Offshore Wind Outlook 2019, 2019.

2. K. H. Andersen et al., “Suction anchors for deepwater applications,” Frontiers in Offshore Geotechnics ISFOG 2005 - Proceedings of the 1st International Symposium on Frontiers in Offshore Geotechnics, pp. 3–30, 2005.

3. S. Grecu, L. B. Ibsen, and A. Barari, “Effects of drainage conditions and suction pressure on tensile response of bucket foundations: An experimental study,” Ocean Engineering, vol. 277, p. 114277, 2023.

4. S. Dutta, B. Hawlader, and R. Phillips, “Finite element modeling of partially embedded pipelines in clay seabed using Coupled Eulerian-Lagrangian method,” Canadian Geotechnical Journal, vol. 52, no. 1, pp. 58–72, 2014.