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

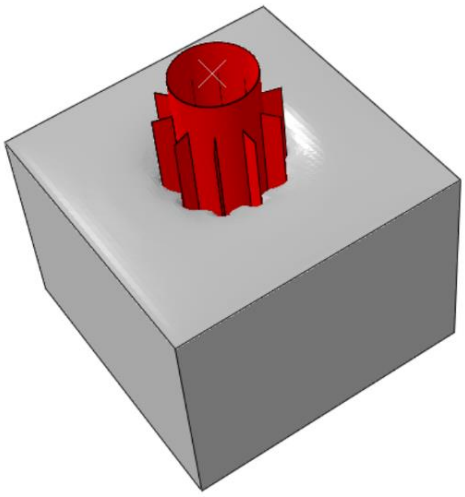
PHYSICAL AND NUMERICAL MODELING OF THE INSTALLATION OF WINGED OFFSHORE PILE ANCHORS BY VIBRO-DRIVING

Supervisors: Dr Matthieu Blanc, Dr Christelle Abadie, Dr Zheng Li
Collaborators: Technip Energies

Université Gustave Eiffel, Nantes, France

PhD specialty: Geotechnical Engineering, Offshore Geotechnics

1 | Project description



As the demand for renewable offshore energy grows, offshore wind farms and other marine structures require reliable anchoring solutions to ensure their stability in challenging seabed conditions. The development of advanced anchoring systems is critical to securing these structures and ensuring their long-term performance. One such promising solution is the winged offshore pile anchor, an innovative design that incorporates lateral wing-like appendages to enhance the anchor's load-bearing capacity, particularly against lateral forces induced by environmental loads such as waves, wind, and currents.

Winged offshore pile anchors are a novel modification of traditional pile anchors. By incorporating extended lateral wings, these anchors significantly increase the surface area in contact with the surrounding soil. This design improves resistance to lateral and horizontal forces, which are commonly encountered by offshore structures like wind turbines. The increased surface area provided by the wings allows for enhanced frictional resistance and better load distribution, making the anchor more effective in deeper waters or soils with lower bearing capacities.

While winged pile anchors show great promise in improving the overall stability of offshore structures, their installation process—particularly when using vibro-driving as the installation method—remains underexplored. Vibro-driving is a dynamic technique that reduces soil resistance during pile installation by applying vibrations to the pile. This method enhances the installation rate and reduces the required penetration force, making it highly attractive for deep-sea installation, where conventional methods can be inefficient. However, the combined effects of the winged anchor design and dynamic soil-structure interaction during vibro-driving create unique challenges that need to be understood and optimized for effective implementation.

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

2 | Project Objectives

The installation of winged offshore pile anchors by vibro-driving presents a complex challenge that requires a detailed understanding of soil-structure interactions under dynamic loading. This Ph.D project aims to investigate the soil-structure interaction during the installation of winged offshore pile anchors via vibro-driving. This includes understanding how dynamic forces from vibro-driving affect soil compaction, displacement, and pore pressure around the pile, particularly in the context of the winged design and its interaction with the surrounding soil. The project also aims to optimize the vibro-driving parameters for the efficient installation of winged pile anchors. Through parametric studies, the ideal combinations of frequency, amplitude, and installation speed will be identified which can enhance the installation efficiency of the winged pile anchor.

3 | Technical approach

The combined experimental and numerical modeling approach will be exploited in this PhD study to gain a comprehensive understanding of the installation process of winged offshore pile anchors using vibro-driving.

Research Axis 1: Experimental Centrifuge Modelling

The geotechnical centrifuge at the University of Gustave Eiffel (Nantes campus) is among the top-ranked in both Europe and worldwide. During this PhD, a novel reduced-scale vibro-driving system will be developed with the technical team of the geotechnical centrifuge. Then, an experimental campaign involving reduced-scale models will be performed in the centrifuge, enabling the direct modeling of the installation process of the winged pile anchor under vibro-driving force.

The centrifuge tests will provide essential experimental data for understanding how the winged pile interacts with the surrounding soil during vibro-driving, and how the dynamic loading influences the installation process. Additionally, the data gathered from centrifuge testing will be used to validate and calibrate the numerical models.

Research Axis 2: Numerical 3D Finite Element Modelling

In this Ph.D study, a numerical model will be developed to simulate the behavior of the winged pile during both its installation and subsequent loading phases. The model will integrate advanced constitutive models to accurately predict the complex soil-pile interaction, capturing the nonlinear response of the soil and the pile under vibro-driving forces. In particular, the study will focus on large deformations that occur during the vibro-driving process. Another key aspect of the numerical modeling is the coupling of soil-pore pressure interaction, which will be integrated with the large deformation simulation (Abaqus CEL simulation).

The numerical model will be validated against centrifuge test data and then a comprehensive parametric study will be carried out numerically, examining several critical aspects that influence the performance of the winged pile anchor system such as wing geometry, soil type, load orientations (horizontal, vertical, or inclined loads), performance under cyclic loading, etc.

4 | 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 Christelle Abadie. After completing her PhD in 2015 at the University of Oxford on the cyclic behavior of monopiles and the development of the HARM model, Christelle Abadie continued her research at the University of Cambridge as an assistant professor, focusing on geotechnics for sustainable infrastructure development in the context of climate change. Recruited at Gustave Eiffel University at the end of 2023, she continues to explore topics related to the emergence of new foundations for Marine Renewable Energies.

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.

5 | Collaboration

This Ph.D. research will be closely integrated with 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. This initiative aims to significantly reduce costs and accelerate industrial deployment. The Ph.D. student will regularly participate in PAREF project meetings, write corresponding project reports, and present the research outcomes.

6 | 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.

7 | 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 Ph.D. contract granted by Université Gustave Eiffel is for the time being 1858€ gross per month during the first two years, and 2125€ gross per month during the third year. Teaching vacations or industrial missions can complement these PhD contracts.

8 | 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 .matthieu.blanc@univ-eiffel.fr & christelle.abadie@univ-eiffel.fr

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