PROJET POST-DOCTORAL

FEASIBILITY AND COMPLEMENTARITY OF SEISMIC AND GEOELECTRICAL METHODS FOR IMAGING THE SUBSURFACE IN OFFSHORE AREAS, WITH A VIEW TO GEOTECHNICAL SUPPORT FOR THE SITING OF WIND TURBINES.

LOCATION: GUSTAVE EIFFEL UNIVERSITY - NANTES CAMPUS

DURATION: 18 months

START-UP: from 2024/10/01 to 2024/11/01

MAIN CONTACTS/MANAGERS : Donatienne Leparoux et Sérgio Palma-Lopes

dontienne.leparoux@univ-eiffel.fr ; sergio.palma-lopes@univ-eiffel.fr

SCIENTIFIC MONITORING COMMITTEE : : Loïc Michel (société SERCEL), Damien Pageot

FUNDING : projet régional PROSE+ / AAP du RFI WEAMEC 2022

Project Committee: *Leparoux D . Palma Lopes S., Michel L., Baltzer A., Rousset J.M.*

SUBJECT :

The growing number of offshore wind farm projects off the French coast, combined with the increasing number of anchoring techniques being developed (land-based wind turbines, floating wind turbines, etc.), means that foundations and anchorages need to be optimised to suit the subsurface conditions in offshore environments. Geophysical reconnaissance can provide important information. With this in mind, according to the recommendations of the CFMS (Berthelot et al., 2019), geophysical reconnaissance in the field of MRE is carried out at two levels: firstly during the preliminary pre-project and pre-project phase to define the siting area; then during the project phase (design and execution) to provide the most accurate information possible for the locations of the structures. The methods used to do this include surface wave seismic and electrical resistivity methods.

In addition, on the west coast of France, the geology of the environment can be highly variable, and conventional surface wave methods such as MASW (Multi Analysis of Surface Waves) are limited by the assumption of a 1D tabular environment. As far as direct current (DC) electrical resistivity methods are concerned, there is a significant loss of signal and resolution in the marine environment, as has been shown in practice since the 1980s, using different acquisition methods.

In this context, the PROSE+ project (**https://osuna.univ-nantes.fr/recherche/projets-de-recherche/prose-1**) (December 2022 - December 2025) aims to develop and experimentally validate quantitative 2D surface wave geophysical techniques associated with geoelectrical methods, based on the **initial developments developed numerically upstream of PROSE+ during the PROSE project** (November 2016 - March 2021)., https://www.weamec.fr/projets/prose/) :

For the Surface Wave seismic approach, this involves a 2D seismic inversion technique, adapted to the potential variation in the seabed, and based on Particle Swarm optimisation methods (Pageot et al., 2018).

With regard to the geo-electrical approach, the initial PROSE project has numerically demonstrated the benefits of an innovative acquisition mode that could significantly increase the resolution power (Palma Lopes and Côte, 2020).

Following these initial studies and numerical developments in the PROSE project, the pot-doctoral project proposed in the PROSE+ project comprises 3 phases:

1. To test and adapt the seismic methodology developed numerically, on experimental data from reduced-scale measurements in the laboratory. It could also be tested on seabed measurements at real sites acquired in parallel with this project. Experimental validation will make the technique available to geophysical companies to provide the lateral and depth variation of the S-wave velocity profile.

2. To test and numerically validate the "seabed with insulating screen" acquisition mode in a context representative of the geology of a near offshore zone on the west Breton coast; to conduct a literature review to propose a geoelectric imaging approach relevant to this acquisition mode (NB: the development of this approach is not a priori included in this post-doc).
3. To analyse the potential for combining the seismic and geoelectric approaches on a reference model characteristic of a near offshore zone of the west Breton coast (as defined in the previous phases), with a view to developing a joint approach that will make it possible to refine the resolution of the environments imaged over the first few metres of the seabed. The approaches envisaged are joint inversion (coupling by simultaneous or sequential geoelectric then seismic inversion) or data fusion (relevant mathematical model to be identified: clustering, fuzzy logic, etc.). For this third phase, the bibliographic analysis prior to this development could be started at the beginning of the project, in parallel with the seismic and geoelectric stages.

PARTNERS INVOLVED IN THE PROSE+ PROJECT

- The PROSE+ project is funded by the RFI WEAMEC.
- It brings together 3 academic partners (GERS/Gustave Eiffel University, the LHEAA/Ecole Centrale de Nantes and the LETG/Nantes University), all three members of OSUNA (Observatoire ds Sciences de l'UNivers de Nantes Atlantique), which manages the project, and is supported by Sercel, the company supplying the seismic recording technology.
- Ifremer is an external partner in the PROSE+ project.
- TOTAL Energies is an external member of the steering committee.

NUMERICAL and EXPERIMENTAL TOOLS :

- DC electrical resistivity:
  - Comsol Multiphysics, Res2Dmod/inv, Res3Dmod/inv, ERTLab, Matlab, Python, (FEniCSx or FreeFEM may be used if the person in post has these skills)
- Seismic:
  - MUSC (Non-Contact Ultrasonic Measurements) measurement bench https://geoend.univ-gustave-eiffel.fr/presentation/equipements/banc-de-mesures-ultrasonores-sans-contact-musc
- Finite Difference and Spectral Elements (SEM)

PREREQUISITES

- Thesis in subsurface geophysics
- Theoretical and experimental knowledge of seismic surface waves and, if possible, geoelectric methods,
- Knowledge and experience in digital modelling and geophysical imaging, ability and taste for applied digital work (understanding, adapting and using existing scientific tools),
- Knowledge of combining information (data fusion) would be appreciated.

REFERENCES FOR PROSE AND PROSE+ PROJECTS :

Pageot, D., Leparoux, D., Capdeville, Y. and Côte, P., 2018, September. Alternative Surface Wave Analysis Method for 2D Near-Surface maging Using Particle Swarm Optimization. In *3rd Applied Shallow Marine Geophysics Conference* (Vol. 2018, No. 1, pp. 1-5). European Association of Geoscientists & Engineers.

Palma Lopes S. & Côte P. , 2020, A new technique for increasing the sensitivity of marine DC-electrical resistivity acquisitions, , NSG 2020, Dec. 7-8, online.

P. BERTHELOT, A. PUECH, F. ROPERS, , « POUR LA CONCEPTION ET LE DIMENSIONNEMENT DES FONDATIONS D'ÉOLIENNES OFFSHORE », 2019, Rapport du Groupe de Travail «Fondations d'éoliennes offshore» du Comité français de Mécaniques des Sols et de Géotechnique (CFMS)VERSION 2.0, 217 pp

Leparoux D, Michel L, Pelleau P, Rousset J, Allemand T, Evain M, Sourice A, Schnurke P, Baltzer A, Vallishin O, Lehujeur M, Sea Bottom surface wave seismic for windfarm implantation and foundations, Oral Presentation, EAGE/SUT Workshop on Integrated Site Characterization for Offshore Renewable Energy, 20-23 -May 2024, Boston, Massachusetts

Leparoux D., Michel L., Pelleau P., Rousset J.M., Allemand T., Evain M., Baltzer A., Josse F, Schnurle Ph., Lehujeur M, Sourice A., Belov S., Geomechanical characterization of heterogeneous seabed for wind turbine anchorages/foundations using non-destructive geophysical approaches: Small-scale laboratory experiments and full-scale sea measurements, OCEANEXT 2024 « Meeting challenges of marine and coastal socio-ecosystems together, oral presentation, June 2024, Nantes Fr