PhD Thesis offer

Modelling the response of marine structures to wave impacts and assessing the related risks of failure

Shock test machine at ENSTA Bretagne

Wind turbines in a wave field

Keywords : dynamics of marine structures, fluid-structure interactions, water waves and sea states, probabilistic and reliability methods, marine renewable energy

Context and challenges

Structures at sea or in coastal environment, such as marine energy recovery systems, are exposed to severe stresses, such as wind, current and wave loads. The proper design of these structures (to ensure their integrity over their expected lifetime) requires a detailed understanding of these loads and the structural responses they induce. The proposed research project aims at accurately predicting the dynamic response of marine structures exposed to wave impacts, and assessing the potential resulting damages. Structural stresses can lead to the failure of marine systems, either by exceeding the ultimate strength of the material, or through the accumulation of fatigue. The robust design of marine structures needs to answer the following questions:

- How to model the loads and structural response induced by wave impacts?
- How to assess the risk of failure over the expected lifetime of the structure?

These questions are crucial in order to reduce uncertainties and design marine structures as “accurately” as possible (limiting the need for safety factors, which generally lead to oversizing). In the proposed thesis, the dimensioning of tubular structural components, used in the manufacturing of offshore wind turbines (bottom-fixed or floating), will be considered as a case study.

Objectives and methods

The goal of the proposed research is to develop different tools to model the hydro-elastic response of marine structures exposed to wave impacts, and to assess the related risks of failure over their lifetime.

The thesis work will focus on the following lines:

1) Developing a semi-analytical model to predict the hydro-elastic response of structures exposed to wave impacts. Tubular structures will be considered, as this type of structures is commonly used in offshore engineering (e.g. for wind turbine platforms). The modelling of hydrodynamic loads will be based on Wagner’s approach, coupled with a beam model to account for the structural deformations. The aim of this

tool is to provide accurate predictions with short computation times, so that it can be integrated and repeatedly called in a stochastic analysis.

2) Validation experiments. Experiments will be used to assess the predictive capabilities of the developed hydro-elastic model. These experiments will be carried out using the hydraulic shock machine available at ENSTA Bretagne. Various measuring devices (strain gauges, accelerometers, high-speed camera, pressure sensors) will be used to monitor the hydrodynamic loads and induced structural response.

3) Assessing the risks of failure. The hydro-elastic model will be integrated into a stochastic approach to predict the risk of failure of a marine structure, due to wave impacts. Two kinds of failure scenarios will be considered: (i) occurrence of a single extreme impact inducing stresses beyond the material strength, (ii) accumulation of a large number of impacts, leading to fatigue crack initiation. As a first step, a probabilistic approach will be developed to predict the distribution of impact-generated stresses for a given sea state (assumed stationary). Then, this 'short-term' probabilistic approach will be integrated into a long-term approach, considering the statistics of sea states locally expected in the area of operation. Ultimately, the global tool should be able to assess the failure probability of a marine structure.

Workplace and laboratory

The thesis will take place at the "Institut de Recherche Dupuy de Lôme" (IRDL, UMR CNRS 6027, www.irdl.fr), on the ENSTA Bretagne campus, in Brest, France.

Funding

The organizations asked for the funding of the project are the Regional Council of Brittany and the Metropolitan Council of Brest. The anticipated starting date of the doctoral contract is October 1st, 2022. The gross monthly salary is approximately 2150 euros or 2400 euros (the latter amount corresponding to a contract including complementary teaching activities).

Candidate profile

The candidate must have a Master of Science degree (university or engineering school) with a solid background in mechanics and/or applied mathematics. Skills in at least one of the following areas are advisable: structural mechanics, fluid mechanics, probability theory and statistics. Knowledge in the field of marine and offshore engineering will be considered favourably.

Application and contact

The application form must include a CV, a letter of motivation, the academic transcripts of the two last years of the M.Sc. program, and a certificate of studies (current year) or a degree certificate. The application deadline is May 20, 2022. Application documents must be sent by e-mail to the proposed supervisors:

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