EERA DeepWind 2016
13'th Deep Sea Offshore Wind R&D Conference

EERA DeepWind 2016
Trondheim, 20 - 22 January 2016

Field site experimental analysis of a 1:30 scaled model of a spar floating offshore wind turbine

C.Ruzzo[1], V. Fiamma[1], V. Nava[2], M. Collu[3], G. Failla[1], F. Arena[1]

[1] Mediterranea University, Natural Ocean Engineering Laboratory, Reggio Calabria, Italy

[2] Tecnalia Research and Innovation, Energy and Environment Division, Bilbao, Spain

[3] Cranfield University, Cranfield, United Kingdom

Abstract

- System identification of offshore structures is a crucial step in the concept selection and in the design process of floating structures.
- Traditional approach consists in testing small scale models in wave basins where controlled conditions can be artificially generated. However this procedure is very expensive and often poses limitations on the testing time and the model size.
- How to characterize the dynamics of a floating structure through experiments in the open sea only?
- This work proposes a novel approach to answer the previous question, including a first-stage validation on a 1:30 model of a spar-type floating offshore wind turbine in Natural Ocean Engineering Laboratory (NOEL) of Reggio Calabria (Italy).

Traditional approach

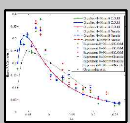
Model manifacturing (usually 1:50-1:150)

Wave tank rental (very expensive)

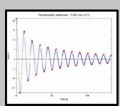
Still water conditions → Free decay tests → Damping coefficients

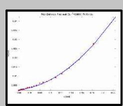
Regular waves → Response Amplitude Operators (RAOs)

Irregular waves: White noise spectrum → Response Amplitude Operators (RAOs); Arbitrary spectrum → Validation, extremes, etc.



Example 1: a 1:100 scaled model of a spar support for offshore wind turbine (left) and relative experimental heave RAOs (center) (Sethuraman & Venugopal, 2012).





Example 2: roll FDT for a small scale model of a ship and determination of the damping coefficients with Faltinson's method (Uzunoglu & Guedes Soares, 2015; Faltinson, 1993).

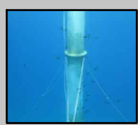
Proposed approach

1. Selection of an appropriate location

NOEL laboratory of Reggio Calabria (Italy), has been chosen due to very suitable site characteristics. During certain months, typical sea states are good scale models, in Froude similarity, of severe ocean sea-storms, having H_s = 0.2-0.4 m, T_P = 1.8-2.6 s and JONSWAP-like spectra. Consequently, scale factors between 1:10 and 1:50 can be chosen.

2. Semi-permanent installation of the model

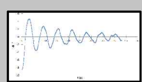
Case study is a 1:30 scaled model of the OC3-UMaine Hywind (Robertson & Jonkman,2011) where the NREL 5MW offshore wind turbine is represented as a fixed mass. It was installed in July 2015 and is still in operation. 6-DOF motions as well as wave elevation are measured.

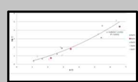


3. Identification of the model

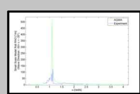
Non-controllable metocean conditions. Local sea states must be exploited:

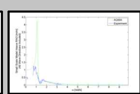
- calm water for free decay tests adopting an aggregate form of Faltinson's method for damping estimation.
- RAOs obtained piecewise in the wave frequency range. Wind waves are used for high frequencies (about 2.4-3.5 rad/s) while swells for lower ones (about 0.9-2.4 rad/s)





Roll free decay test executed at NOEL (left). Determination of the damping coefficient using various FDTs.





Heave and roll directional RAOs obtained from a database of 526 sea states. Horizontal motions were not investigated since their natural frequencies are too low.

Conclusions

The main differences between the traditional approach for the system identification of floating structures and the proposed one are:

- **Reduction of the costs**. Tests in natural laboratories are cheaper and may last longer than in wave tanks.
- **Larger scale factors.** Intermediate scale testing results in better scaling of hydrodynamic forces on the structures, especially with regard to viscous forces, depending on Reynolds Number.
- **Importance of the location**. The natural laboratory must present various wave conditions, including calm periods, small purely wind-generated sea states, swells with sufficiently long periods.
- **Limits of the natural laboratories**. It is not possible to investigate frequency ranges out of wave spectra domain and free decay tests are coarser than in wave tanks since water is never perfectly calm.
- **Further work** will be performed, including collection of more data, realization of new FDTs and investigation of output-only identification techniques (such as FDD) for further damping estimation.