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Stable Ships for Smooth Servicing of Offshore Wind Farms

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“Man cannot discover new oceans unless he has the courage to lose sight of the shore.”
(Andre Gide)

Introduction

There is a rapid increase in the number of offshore wind farms in European waters to help meet renewable energy targets. Wind turbines are being installed in progressively more exposed areas of the North Sea and the Irish Sea, with the eventual aim of placing them in the Atlantic Ocean. As offshore wind farms require regular maintenance, being able to access the wind turbines during rough sea conditions is a key issue for profitable operation.

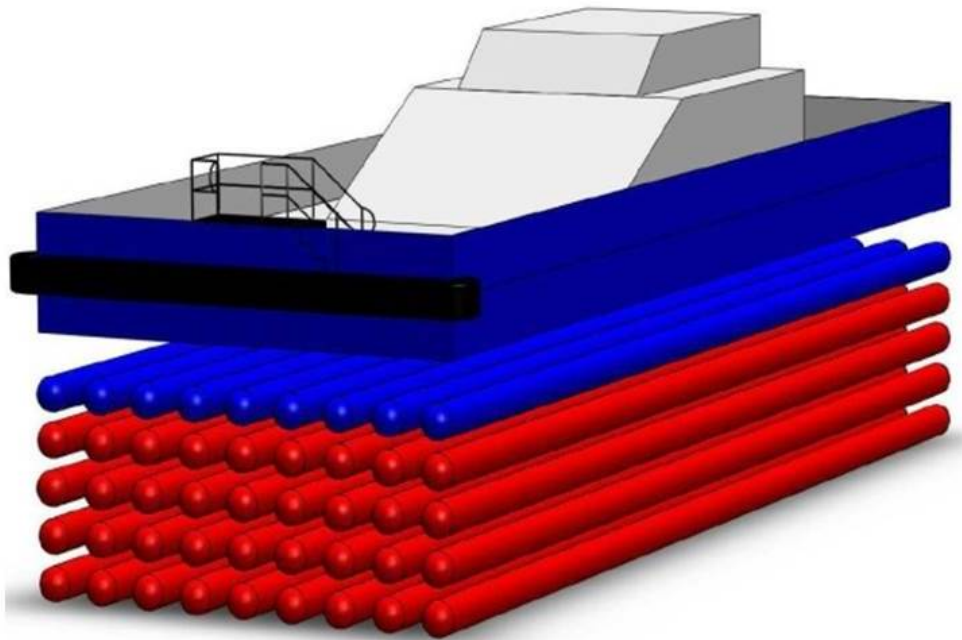


Figure 1: Artists Impression of the Concept Ship Design, Consisting of a Large Number of Buoyant Tubes. Image: Matthew Shanley.

The operation involves transferring personnel from the service ship to the wind turbine. The current wave height limit for this is 1.5 m, slightly less than 5 feet, increasing this results in significant savings over the lifetime of the wind farm. Each wind farm service

ship has 12 maintenance crew. Imagine you are one waiting on port for the sea and weather conditions to be right so that you can head out to the wind turbine. You've been waiting for two weeks, you can see the wind turbine from land but the sea is so rough that stepping from the ship to the turbine is impossible. The only way to transfer the maintenance crew to the turbines is from the front (bow) of the ship, out at the wind farm this is the best way for the ship to maintain position. Standing at the bow of a ship is much like standing on the end of a seesaw; which means that accessing the wind turbine can only occur during reasonably calm conditions. Quantitatively, this results in the average of the highest one-third waves being 1.5 m, which is described as a sea state code of slight to moderate. This research aims to develop designs that can operate in the sea state code of rough, with an average height of the highest one-third of the waves being 3 metres or more.

What We Hope To Do

I will address the issue of wind turbine access by examining a concept hull design for an offshore wind farm service ship as shown above in Figure 1. The ship's unique hull design is composed of buoyant tubes that give the ship buoyancy, and allow water to flow around them. The effect of this on the proposed design minimises the ships motions, by reducing its response to the wave motion. The design was first analysed using specialist software and then physical model testing was carried out. The physical model testing took place in a large, 25 m long tank of water capable of generating ocean waves.

Ship Design

The ship is intended to be a wind farm service provider, 24 m long, with a capacity for 12 passengers. These specifications come from Det Norske Veritas (DNV), regulations, a leading regulatory body for wind turbine operation. Their rules for classification of ships 'Offshore Service Ships, Tugs and Special Ships', specify the requirements of ships for windfarm maintenance.

Numerical Analysis

The numerical modelling of the concept hull design was carried out using a specialist software, in order to better understand the dynamics of the design. The software used was a computational fluid dynamics (CFD) package that calculates the movement of water and the movement of a floating bod. The design was modelled using symmetry; hence, only

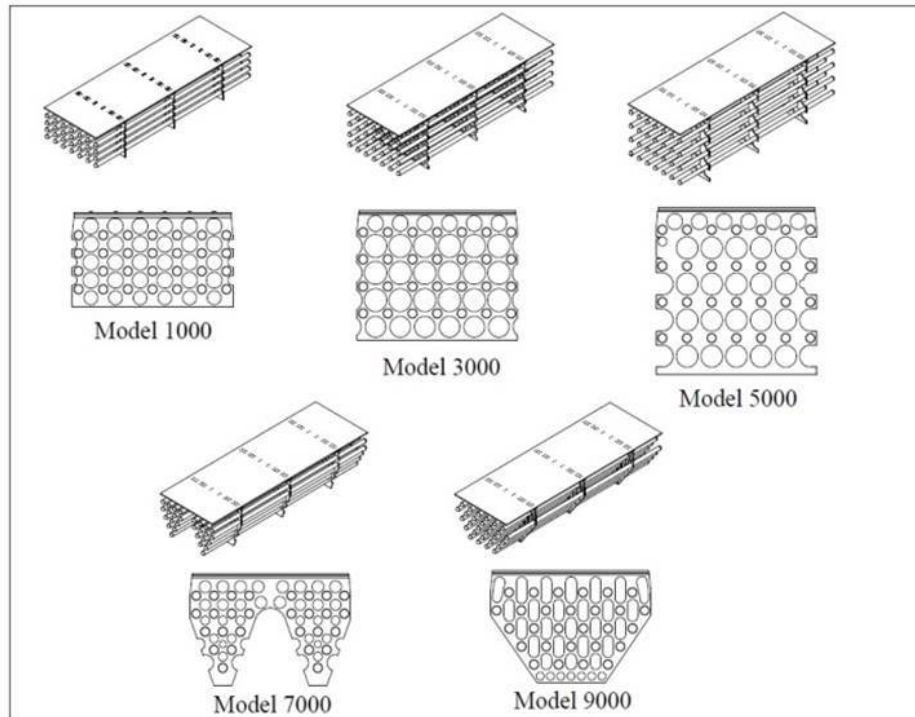


Figure 2: Model Configurations tested during the Physical Modelling Analysis. Image: Matthew Shanley.

a “slice” of the design was modelled; this reduced the computer power required to carry out the simulations.

Physical Analysis

The physical modelling of the concept hull design was carried out at 1:25 scale, and took place in the wave tank at Beaufort Research in University College Cork. The entire hull was constructed and a number of variations of the concept were tested; the vertical spacing between the tubes was altered, the overall layout of the tubes was also altered from the box layout in Figure 1 to a catamaran style layout and a staggered layout. Figure 2 below shows the model configurations in more detail. Each of the designs was tested also with a “heave plate”, a large flat piece that resists the ships vertical motion.

The variations in design included;

- Changing the spacing of the buoyant tubes
- Changing the horizontal spacing of the tubes but keeping the overall width constant
- Adding a “heave plate”, a large flat piece that resists the ships vertical motion

I used the wave tank to generate a range of waves to interact with the model and I then recorded the models motions. From these measurements I was able to calculate the ships

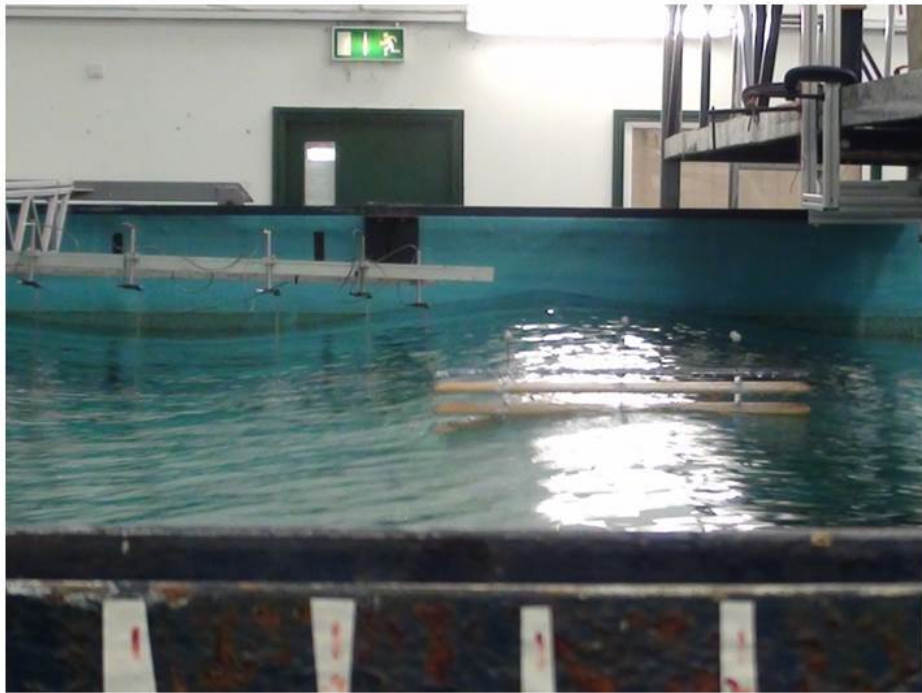


Figure 3: Physical Modelling of the Hull Form in a 1 m Deep Wave Tank. Image: Matthew Shanley.

Response Amplitude Operators (RAO). RAO is a measure of how much a wave moves a ship up and down (heave) or tilts the ship backward and forwards (pitch), relative to the wave height.

The model is shown below in Figure 3 at the crest of a wave. The model was tested in the Beaufort-HMRC wave tank. The tank is 25m long and 18m wide with a depth of 1m. The waves are generated by forty bottom-hinged (at 0.7m depth) flap-type paddles with active absorption and at the opposing end of the tank, there is a wave absorbing beach. The model was constructed primarily from 4mm polycarbonate, balsa wood coated with Original Yacht Varnish, 4mm stainless steel bolts and lead ballast. The model was slack moored to maintain position and avoid additional forces being imparted on the model.

Results

The results from my work show that some parts of the design work well. The deeper the ships structure extended below the waterline the better and the ships with a heave plate performed very well. However the tubes at any spacing or configuration added very little to reducing the ships response to waves.

Comparison Response Amplitude Operators (RAO) from the results of the numerical and physical analysis show close agreement. RAO as explained earlier is a measure of how much a wave moves a ship up and down or tilts the ship backward and forwards.

The close agreement between numerical and physical model testing reinforces the accuracy of the type of numerical analysis carried out (computational fluid dynamics) which is gaining a significant amount of positive press from similar validation studies related to floating bodies. This result is a validation of using a numerical wave tank set up in CFD for testing novel hull forms. Unfortunately, it took longer to do fewer simulations with the numerical method than the physical one.

Conclusion

This article has described a design that was analysed as part of my Ph.D. in order to develop a ship that allows maintenance crews to access offshore wind turbines in rough seas. This will address the rapid increase in the number of offshore wind farms in European waters, and the maintenance requirements that these have.

The model testing showed little improvement over a conventional ship of the same size. Although the results from the work carried out show that some parts of the design work well, such as a deep draft and a heave plate, the tubes themselves had very little effect.

An important conclusion from the testing carried out is the dependability of CFD numerical wave tank modelling. This illustrates that a CFD numerical wave tank is a powerful tool in accurately modelling unusual shapes.

The concept tested was not an improvement on the conventional ships but some aspects of the ship showed potential for significant improvement if developed. Further work will focus on these features and the development of them for an advanced design. However, any one of the twelve maintenance crew mentioned earlier would probably not trust such strange ships at first, but they shall warm to them when they work and make their lives easier.

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