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Resilient Integrated-Coupled FOW platform design methodology

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Motion damping of floating offshore wind turbines using porous materials

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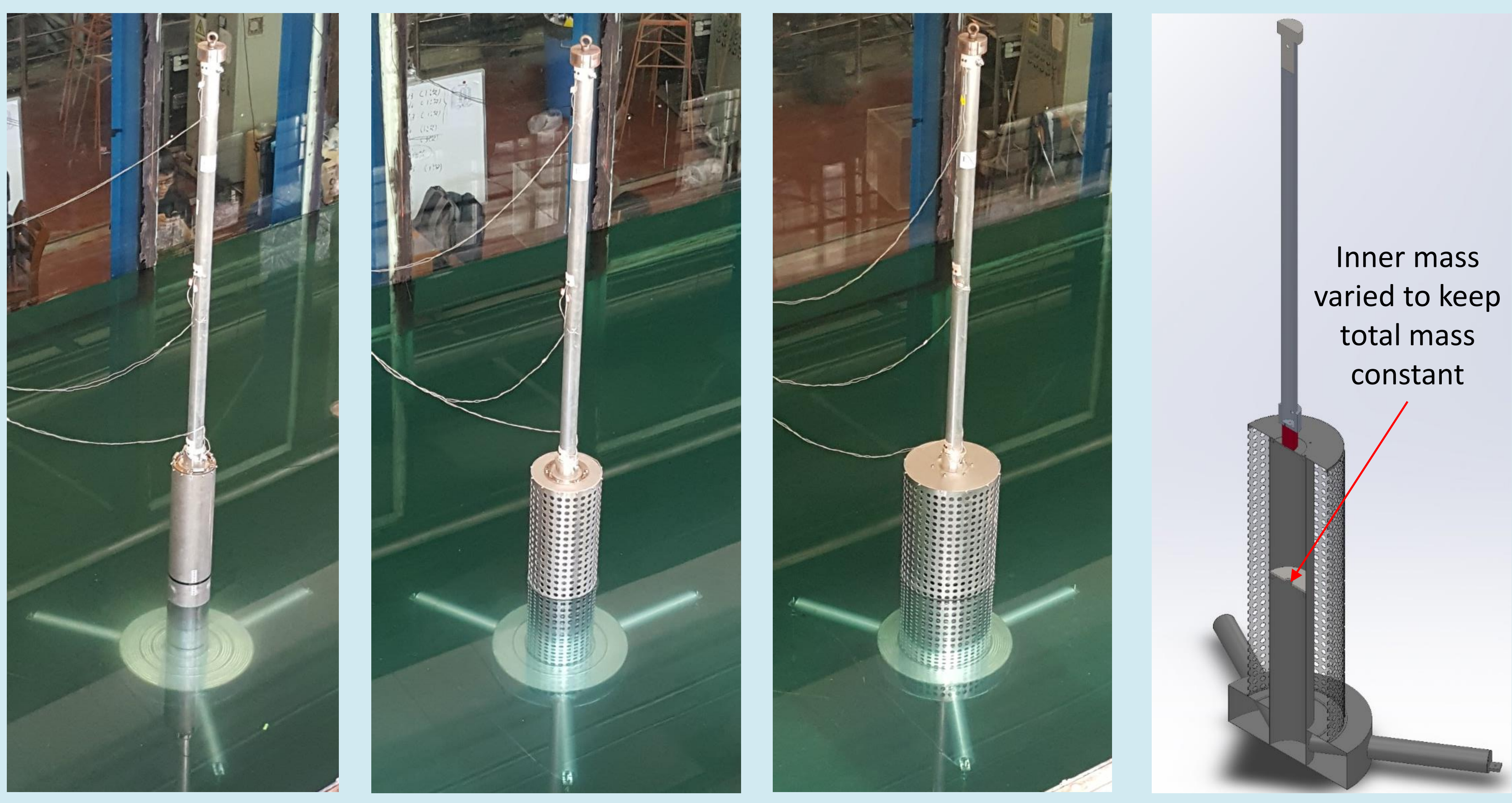
Introduction

- A key challenge for developing cost-competitive floating offshore wind is design of stable platforms
- Increased platform motions lead to reduced energy yield and increased fatigue loads on the turbine
- Adding a porous outer layer to a floating platform can reduce platform motions without significant increase in size and cost.
- This work describes model tests with a TLP wind turbine with a porous outer layer.

Semi-submersible floating wind turbine. Credit: NREL

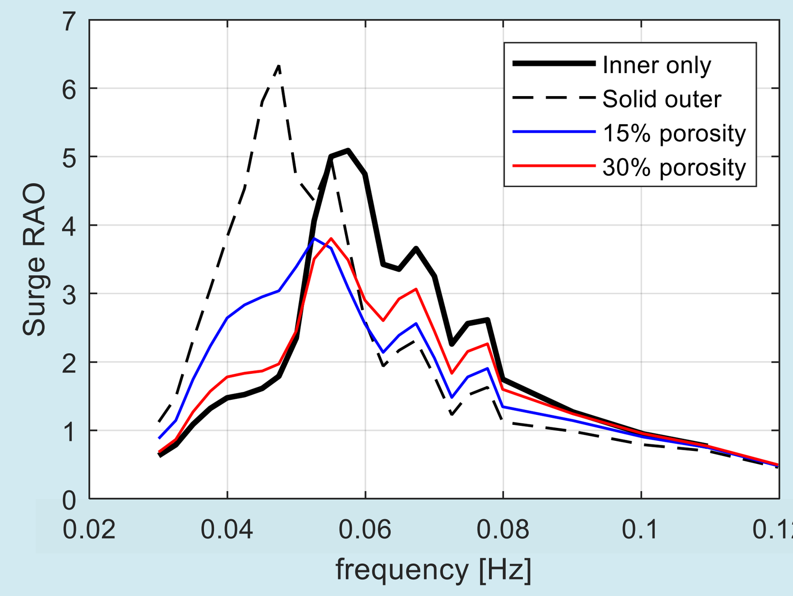
TLP model design

- Simplified 1:50 scale TLP model, based on NREL OC4 design, with rotor-nacelle represented as lumped mass
- Comprises solid inner column and porous outer column
- Tested in 7 configurations:
  - Base case: no outer cylinder
  - 6 outer cylinders: 2 diameters x 3 porosities (0%, 15%, 30%)
- Total mass and COG constant in all configurations
  - Outer cylinder weight compensated by variable inner mass
  - Pitch and roll motions negligible so change in moments of inertia not important
- Main objective is to validate numerical predictions and demonstrate proof of concept - model is not intended to be realistic design.
  - Freeboard of central column and outer cylinder increased to improve linearity
  - Base cylinder diameter increased to accommodate changeable outer cylinders

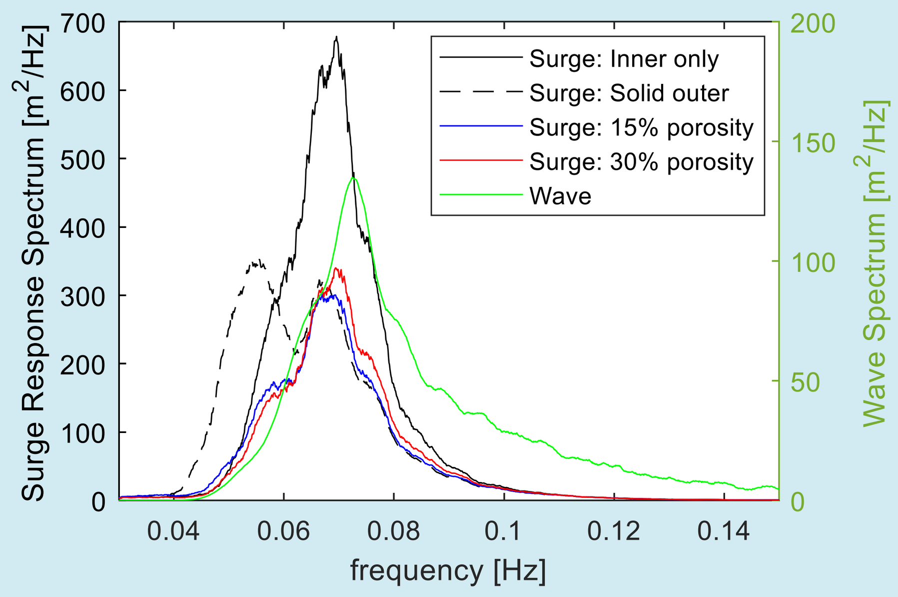


Tank test results

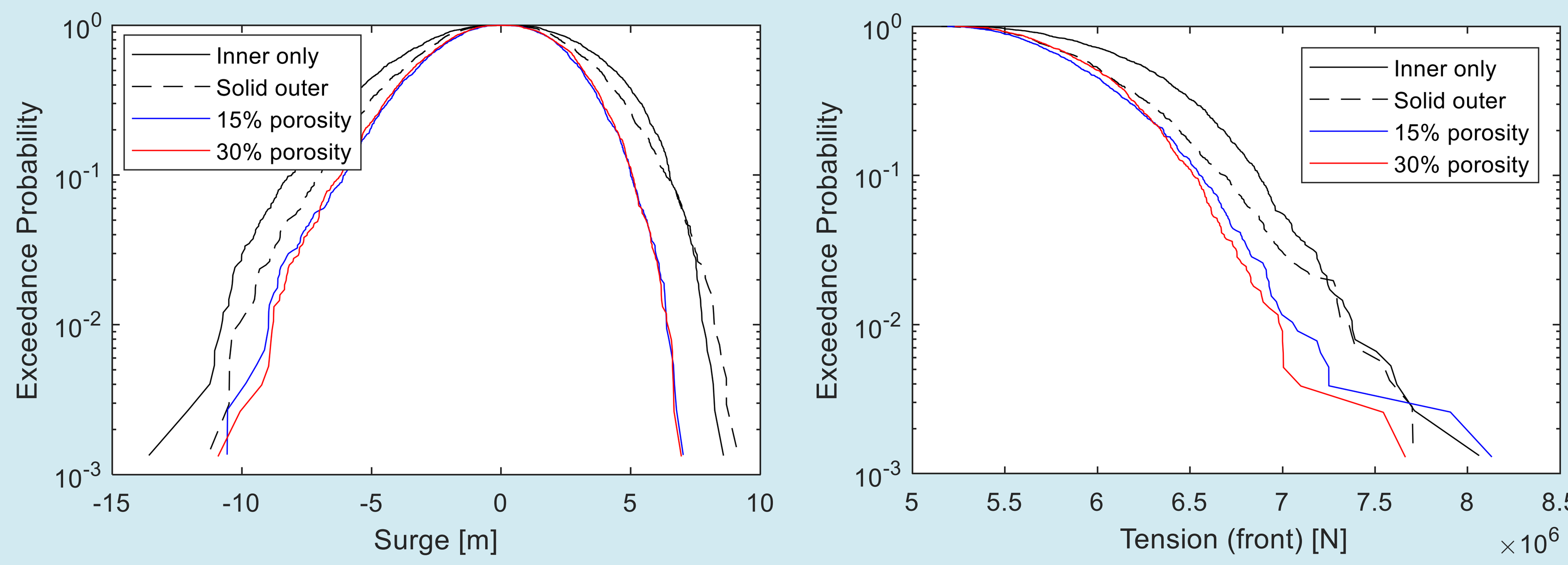
- Two sets of tank tests were conducted at Dalian University of Technology (China) and the FloWave tank at University of Edinburgh
- Measurements were made of
  - 6-DOF platform motions
  - Mooring line tensions
  - Tower bending moments.
- Tests comprised regular and random waves and focused groups
- Adding solid outer cylinder moves resonant response to lower frequency and increases peak response
- Damping from wave radiation and vortex shedding is small at low frequencies
- Increasing porosity of outer cylinder increases damping and reduces peak response



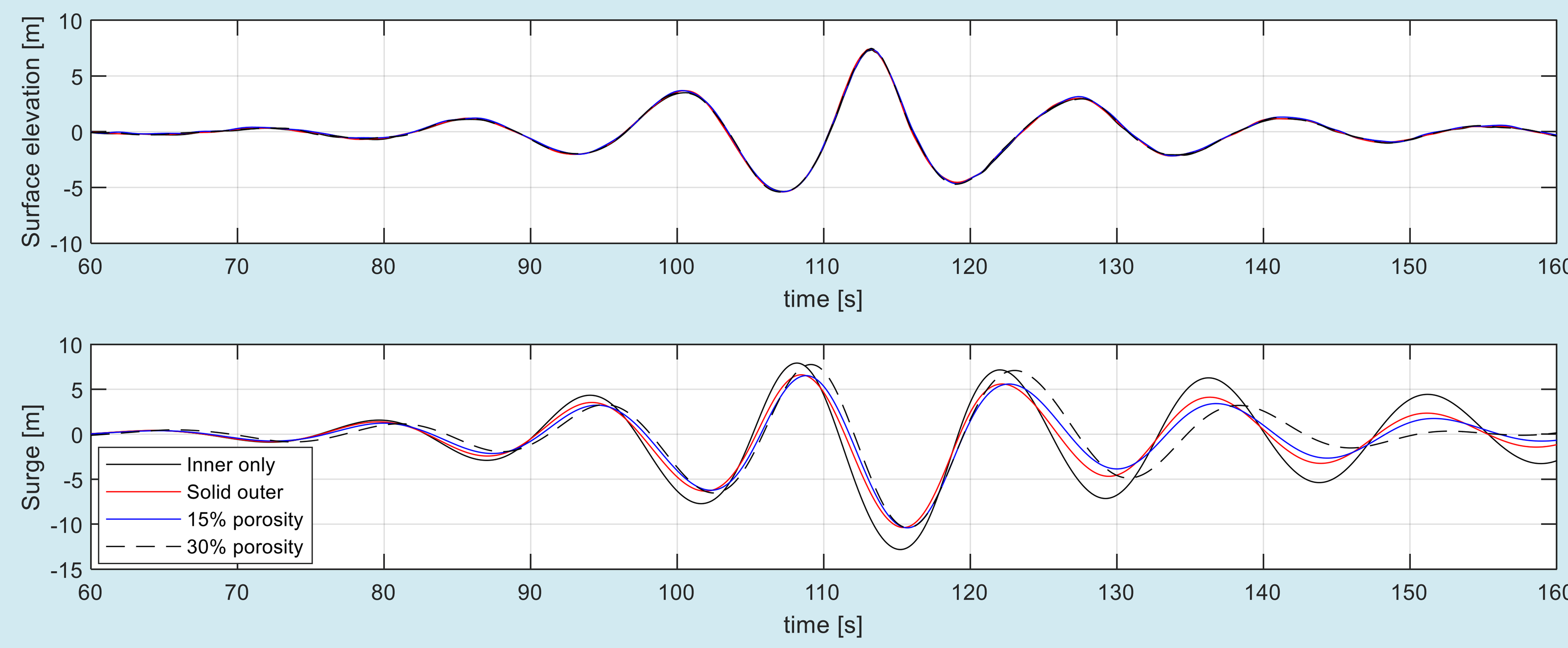
Surge RAOs in regular waves for 4 configurations



Surge response spectra in a sea state with Hs=8m, Tp=14s



Exceedance statistics in a sea state with Hs=8m, Tp=14s. ***Left:*** *surge motion.* ***Right:*** *Front line mooring tension.*



Surge response in a focused group with H=12.8m, Tp=14s

Conclusions and further work

- Results from tank tests indicate that adding a porous outer layer to a floating platform can reduce motion RAOs, leading to reduced loading and potentially increased energy capture
- Tank test results will be compared to numerical predictions from an iterative boundary element method (BEM) model [1, 2]
- The BEM model will be used to investigate more practical designs and quantify impact on motion response and structural loads

References

[1] Mackay E, Johanning L. A BEM model for wave forces on structures with thin porous elements. Preprint available from: DOI: 10.13140/RG.2.2.33116.41601

[2] Mackay E, Shi W, Gabl R, Davey T, Ning D, Johanning L. Numerical and experimental modelling of wave interaction with fixed and floating porous cylinders. Preprint available from: DOI: 10.13140/RG.2.2.16339.20002

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