Motion damping of floating wind turbines using porous structures

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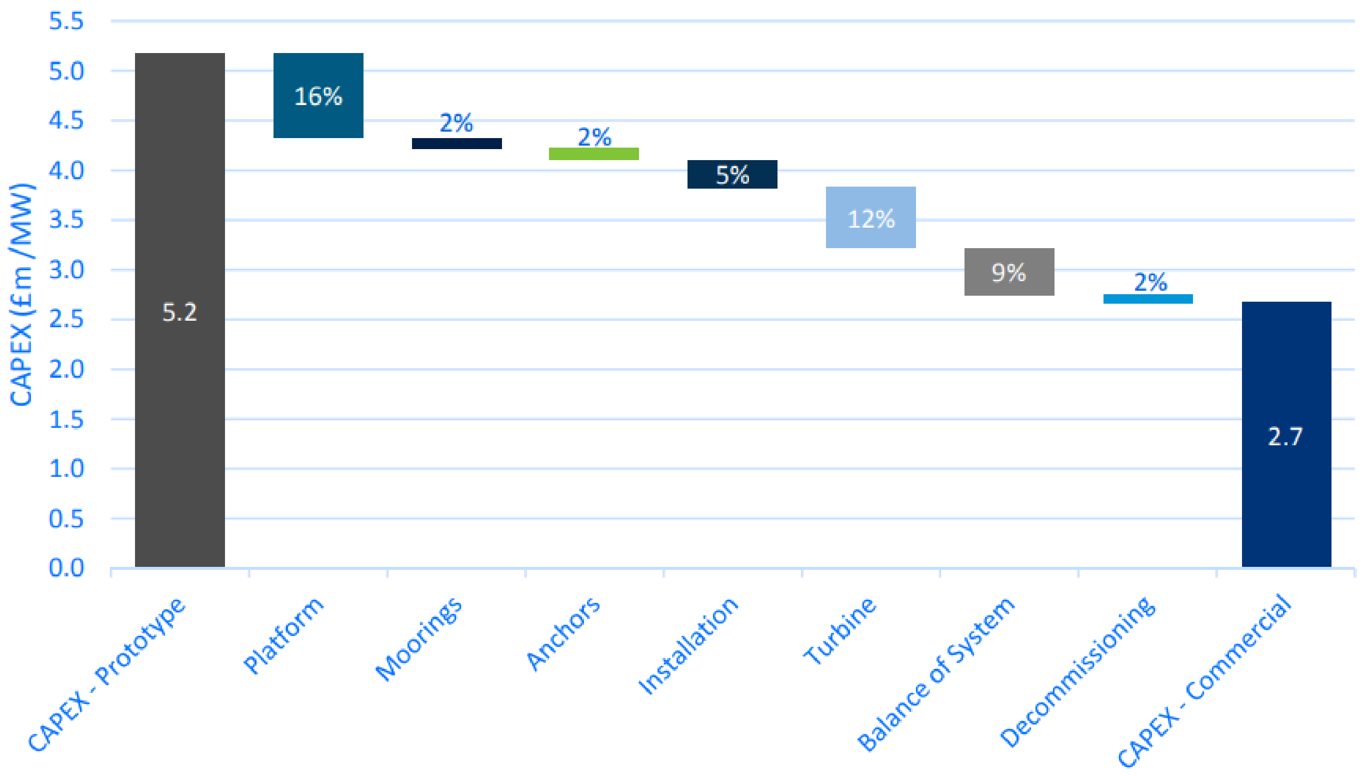
Cost reductions for floating offshore wind

- Key challenge: platform stability
- Increased motion leads to:
  - reduced energy capture
  - increased loading / decreased lifetime



Floating Offshore Wind: Market and Technology Review.
UK Carbon Trust, 2015

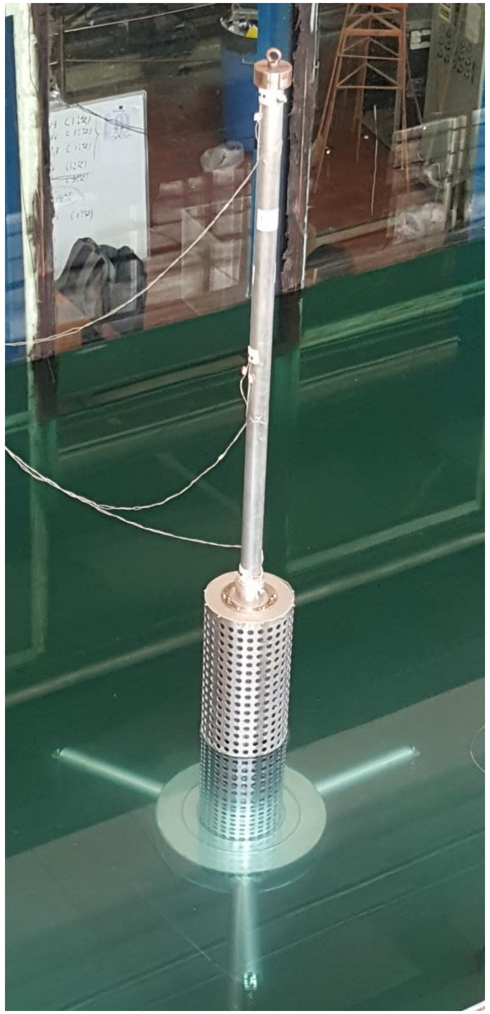
Porous structures in ocean engineering

- Used for energy dissipation and load reduction
- Applications:
  - Fixed & floating breakwaters
  - Tuned liquid dampers
- Can porous materials be beneficial for FOWTs?



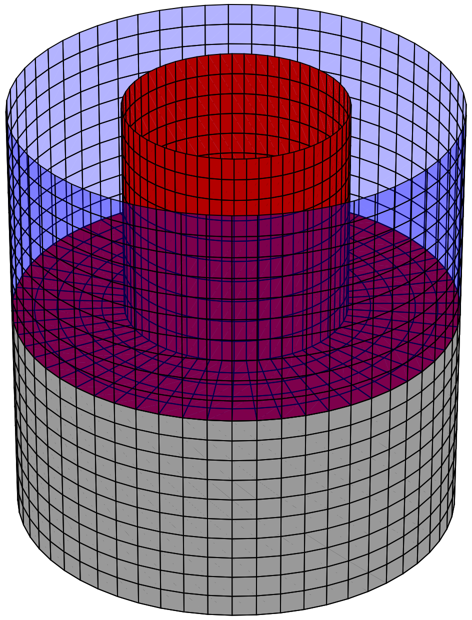
Approach:

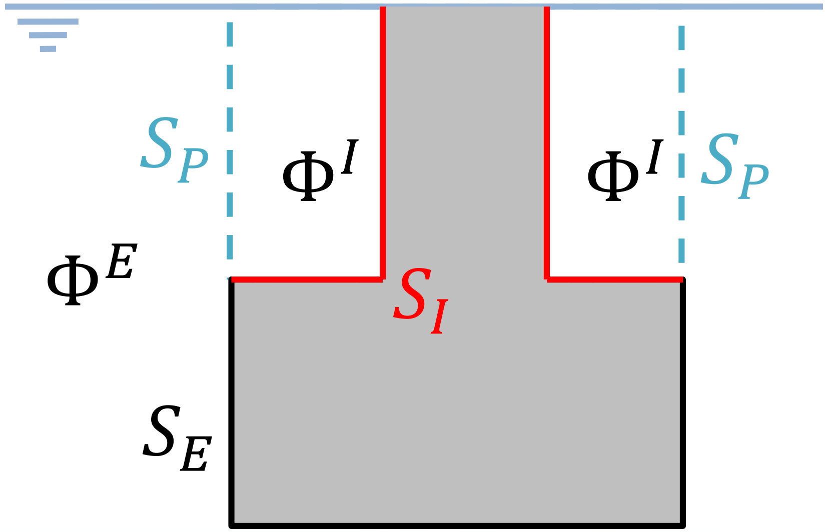
1. Develop BEM model for floating porous structures
2. Validation cases:
   a) Flat porous sheets
   b) Fixed porous cylinders
   c) Floating porous cylinders (TLP)
3. Design exploration and optimisation



BEM for porous structures

- Green’s theorem used to formulate integral equations on external and internal surfaces
- Standard boundary conditions on free-surface, sea bed and solid surfaces
- Additional boundary condition on porous surface:
  - Continuity of velocity
  - Pressure drop as function of flow velocity
- Equations for inner & outer domain coupled via porous surface
- Iterative solution required for quadratic pressure drop across porous boundary

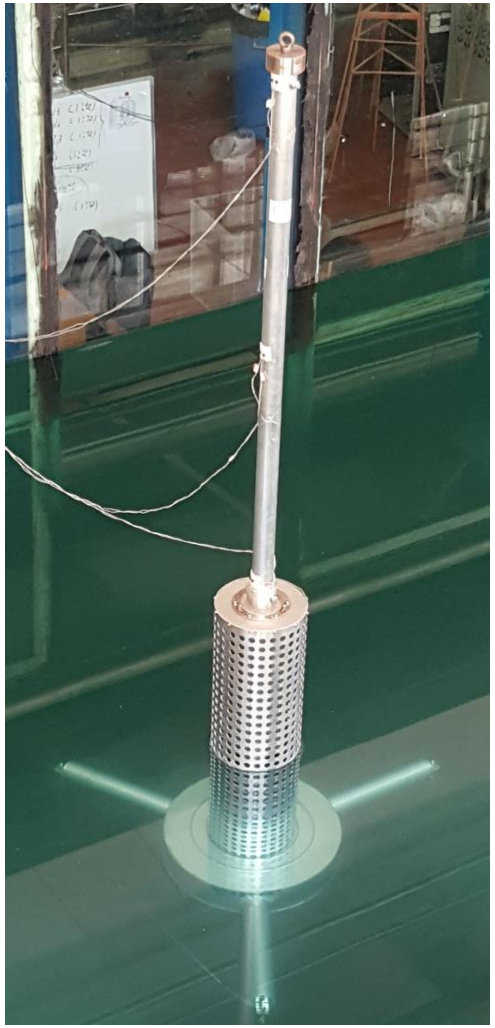




Tank tests @ DUT

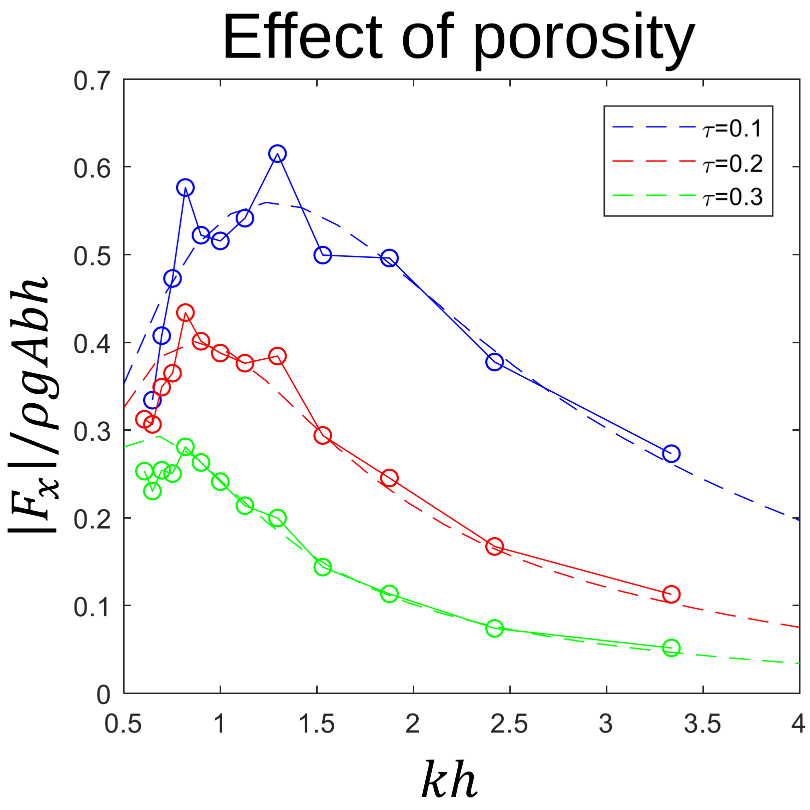
Flat porous sheets

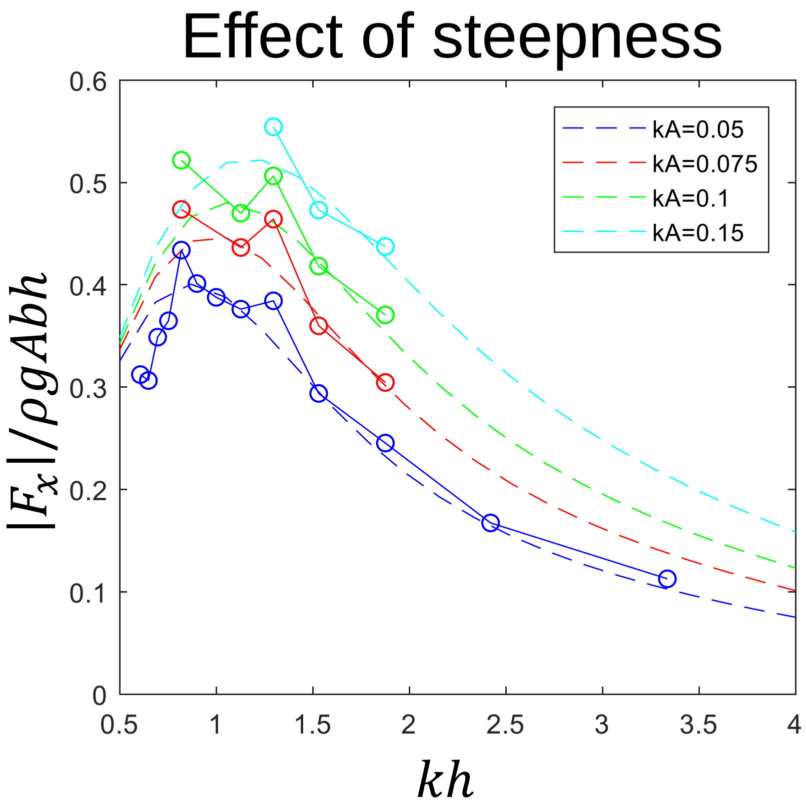
Fixed porous cylinders



Floating porous cylinders
(1:50 TLP wind turbine)

Fixed porous cylinders

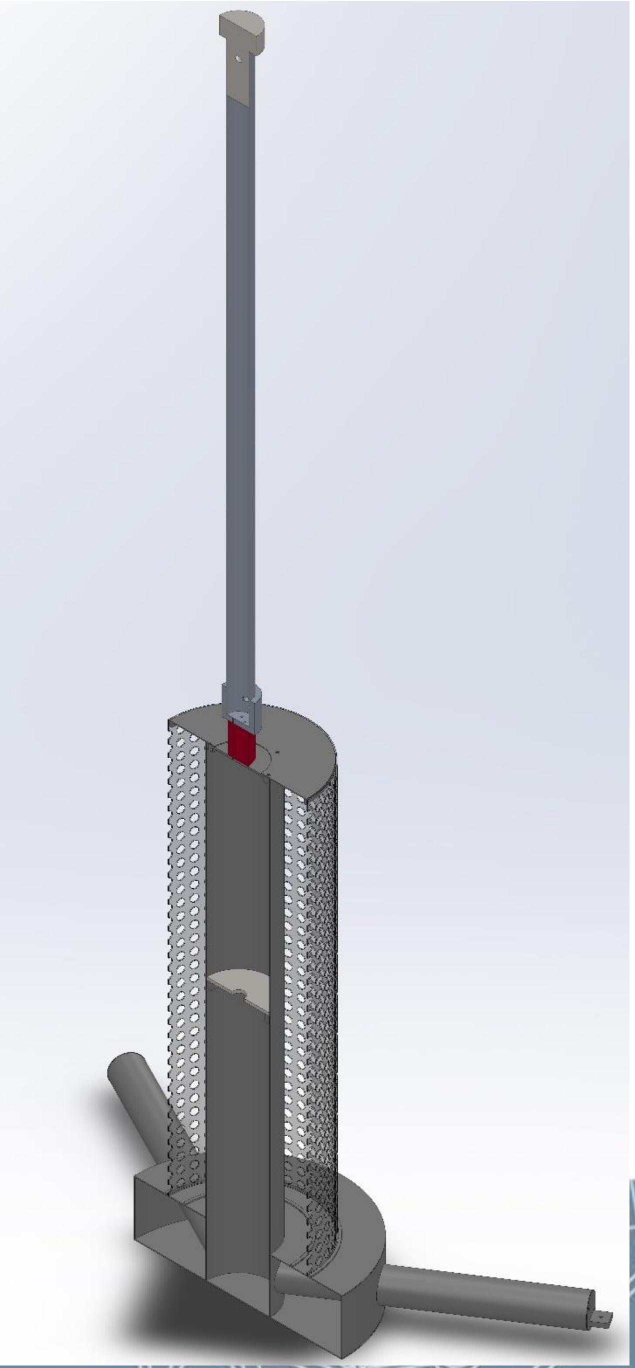




Non-dimensional surge force vs. non-dimensional frequency

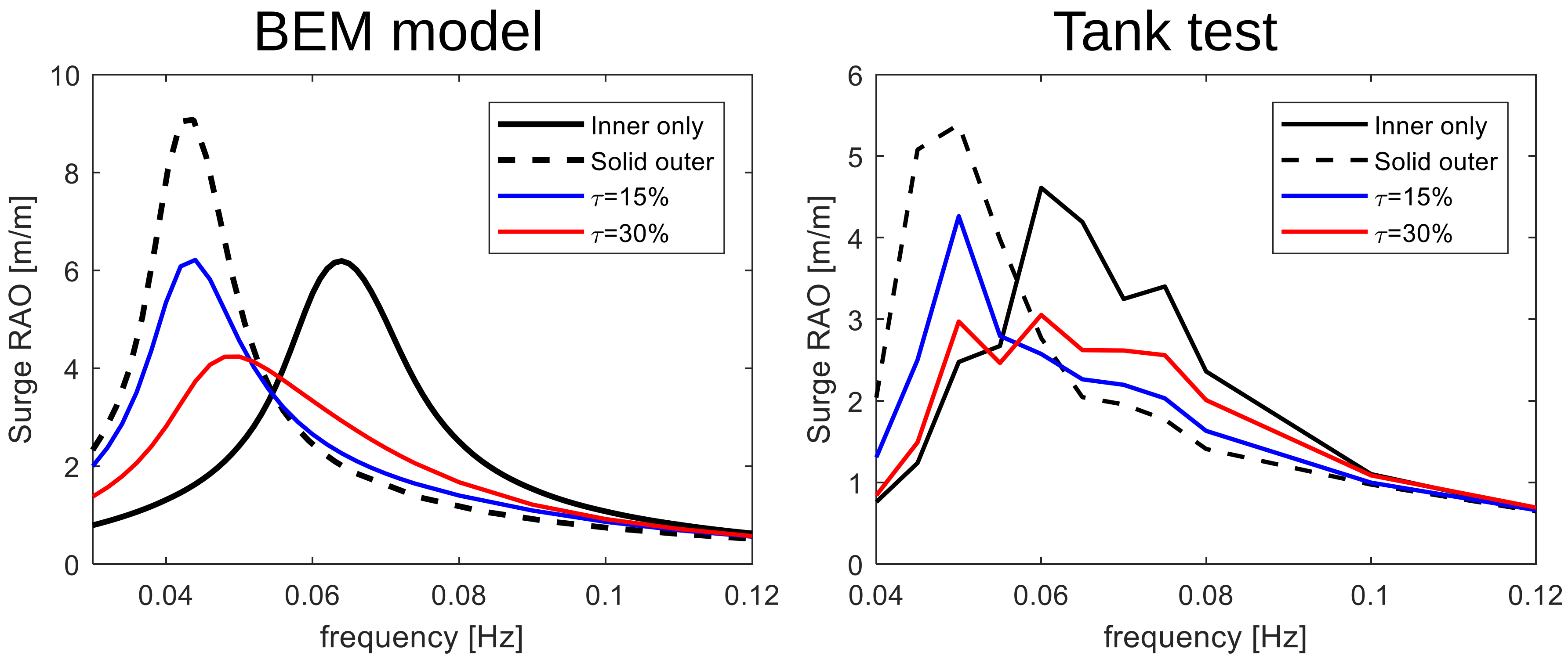
TLP model design

- Simplified 1:50 scale FOWT model
- Changeable porous outer cylinder
- 7 configurations:
  - 2 diameters x 3 porosities + base case
- Outer cylinder weight compensated by inner mass
- Total mass and COG constant
- Pitch motion negligible so change in moment of inertia does not affect motions

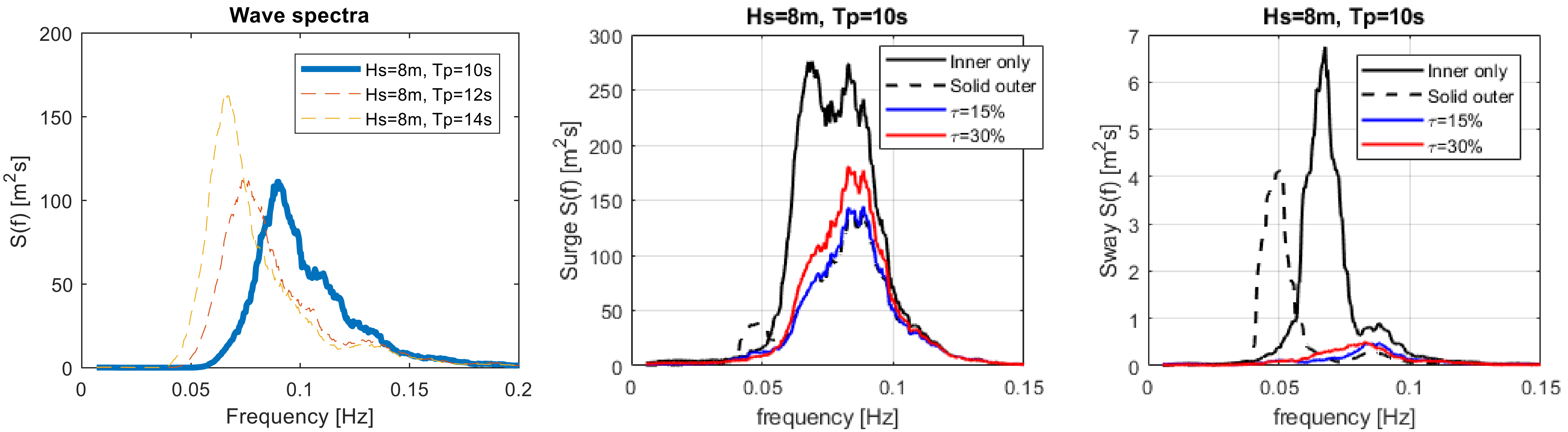


Regular wave RAO

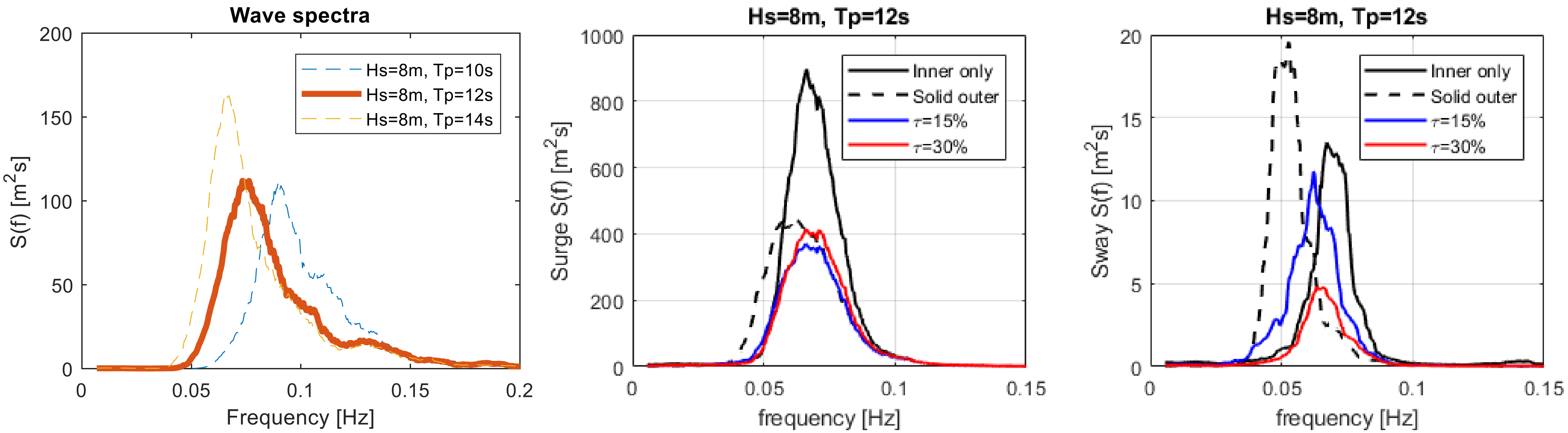
- Solid outer moves resonant peak to lower frequency
- Response for lower porosity close to solid outer
- Higher porosity in between, but with lower peak



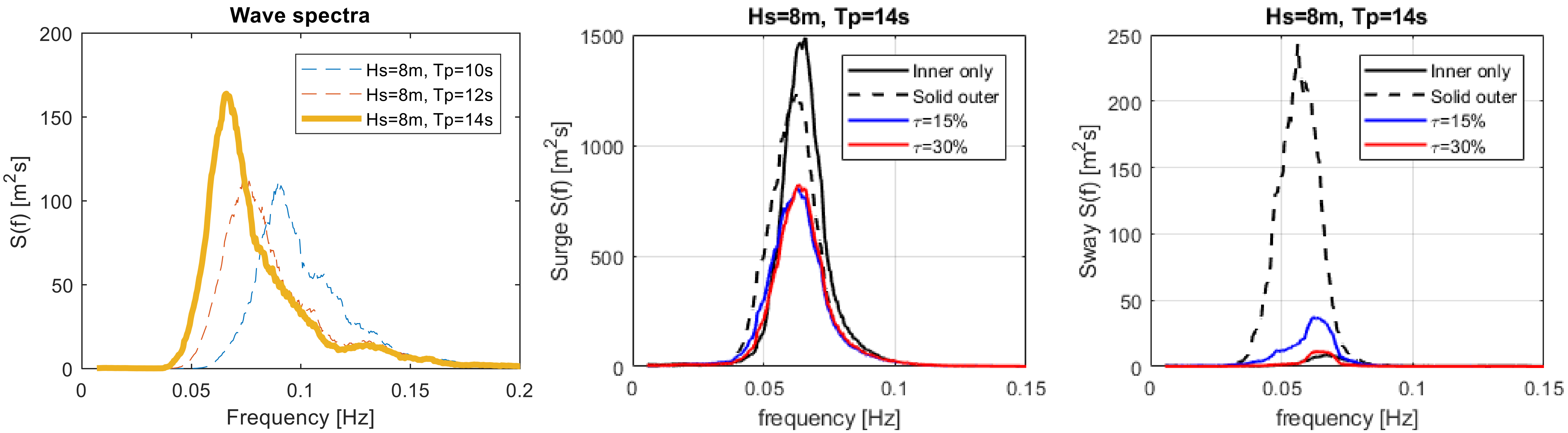
Irregular wave response: Hs=8m, Tp=10s



Irregular wave response: Hs=8m, Tp=12s



Irregular wave response: Hs=8m, Tp=14s



Conclusions

- BEM model gives good predictions of wave loads on fixed & floating structures
- Porous structures may be able to reduce platform motion and lead to cost reduction for FOWT

Next steps

- Further tests with TLP at FloWave
- Design optimisation & detailed analysis

Questions?

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