Hybrid Modelling for Engineering Design of Floating Offshore Wind Turbine Foundations - Model Coupling and Validation

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# FloatStep research project

Support commercial breakthrough of Offshore Floating Wind technology by:

- Reducing cost by structural optmization

- Enabling accurate design by validated engineering tools

- Reducing risk from extreme waves by detailed flow simulations

- Reducing risk during installation and operation by lab tests and full scale data

A digital test environment for testing floating wind turbines

MIKE 3 Wave FM

MIKE21-MA

CFD - OpenFOAM

Physical test facilities
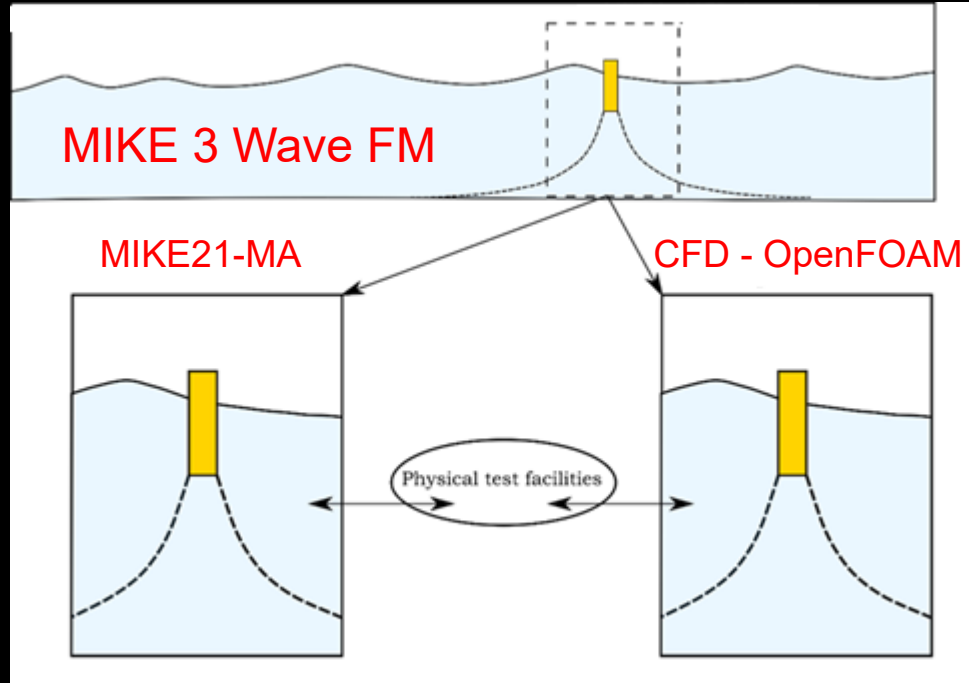
Large-scale wave propagation
+
small-scale floater response
=
COUPLING

Coupling MIKE 3 Wave FM with OpenFOAM – Proof of Concept
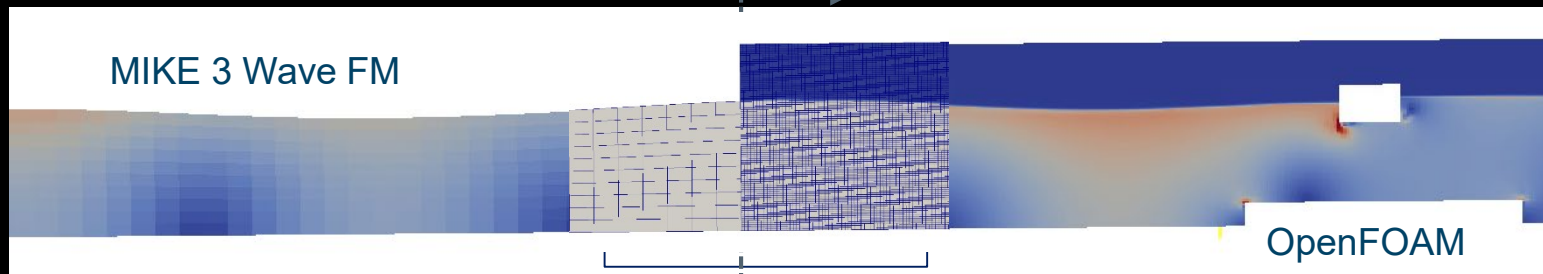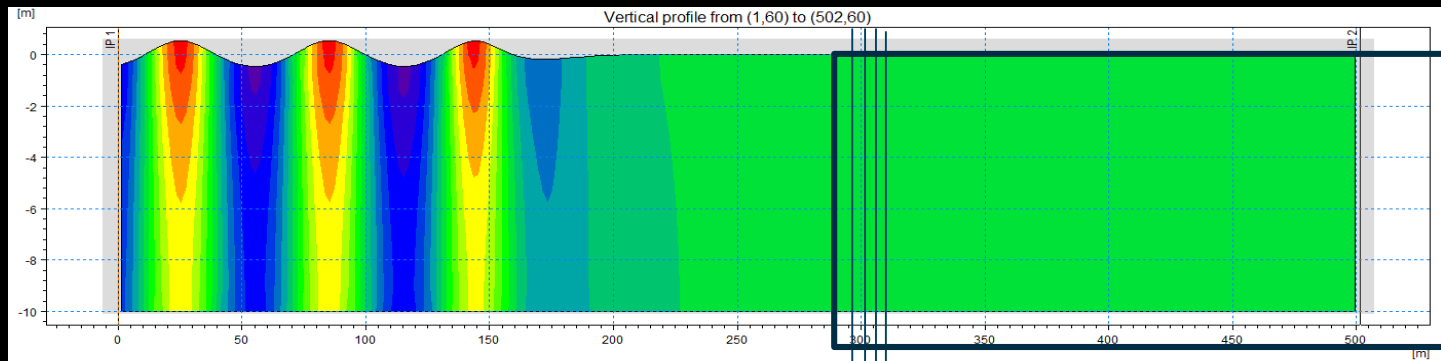
Experimental campaign at DHI laboratory (2017)

Team: DHI + DTU + Stiesdal OT

Floater: semi-sub configuration
          spar configuration

Turbine: 1:60 DTU 10MW

Tests: decay tests,
         only waves
         waves+wind

Data: water surface elevation,
        floater 6DOF
   nacelle 6DOF

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CFD model validation - plan

| Experimental test	Numerical model
• Regular waves Parameters: Hs=0.175 m, Tp=1.83 s Duration of the test = 1500 s • Focused waves Parameters: Hs=0.175 m, Tp=1.83 s Duration of the test = 60 s	Open source `interIsoFoam` 2-fluid transient solver Free surface tracking with isoAdvector Morphing mesh capability Suitable for parallel computation Standard 6 DoF- rigid body coupling (*on-going improvement!)

CFD model validation - setup
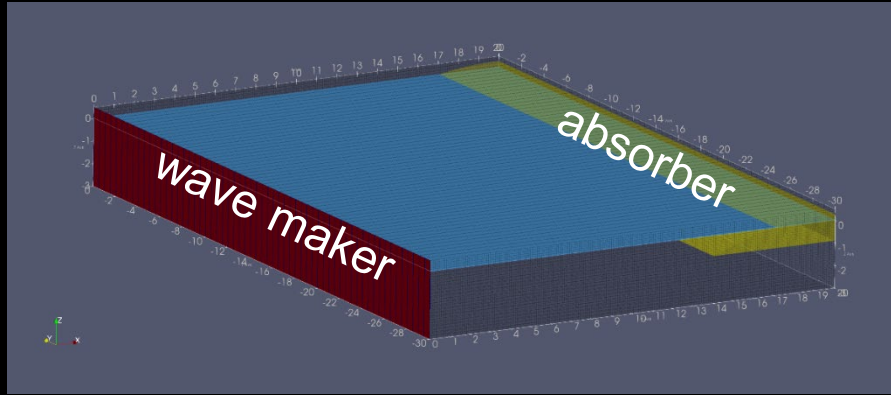
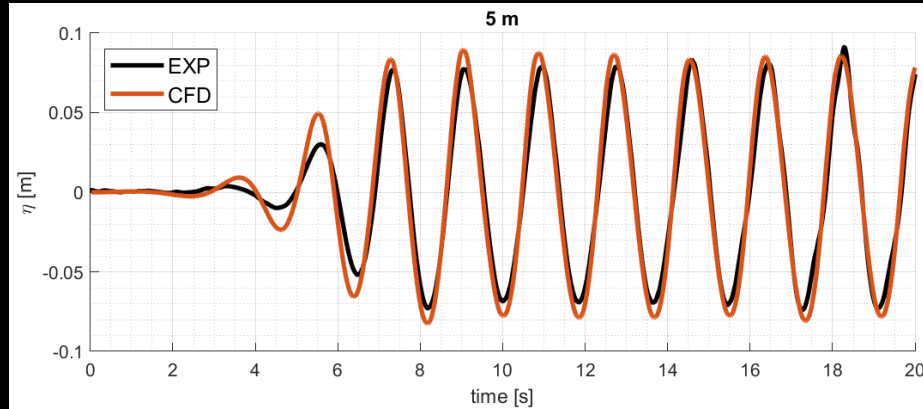
- 20 m length, 30 m width
- 3m water depth
- Wave maker with 60 paddles
- Absorption with artificial porous beach
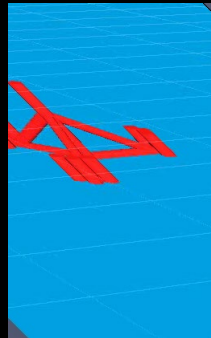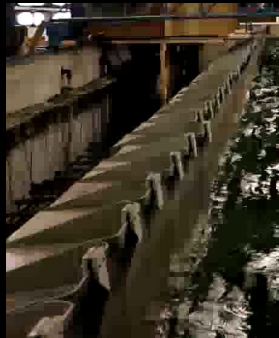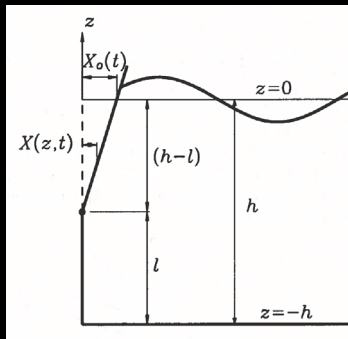
$$S = a \cdot U + b \cdot \mathrm{U} \cdot |U|$$
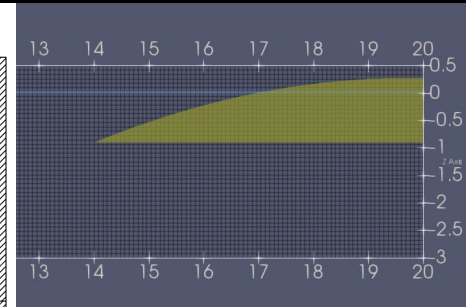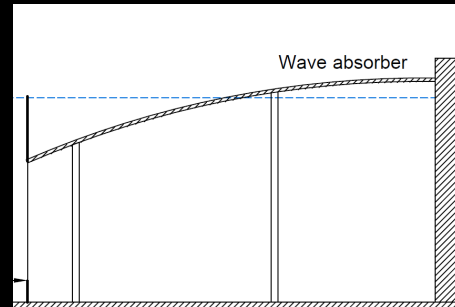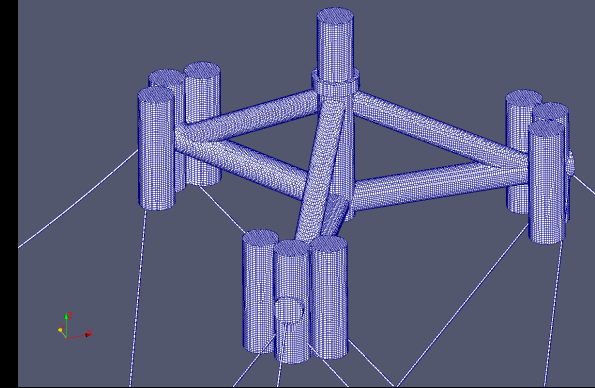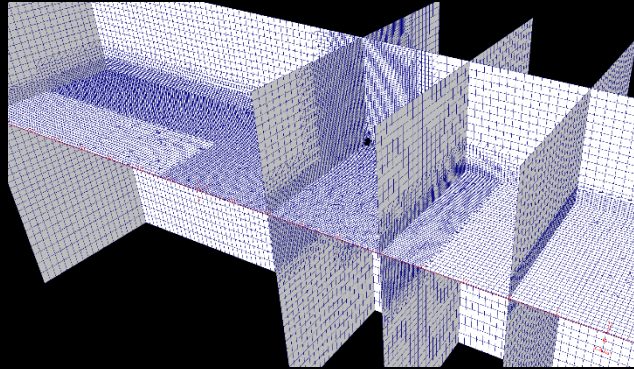
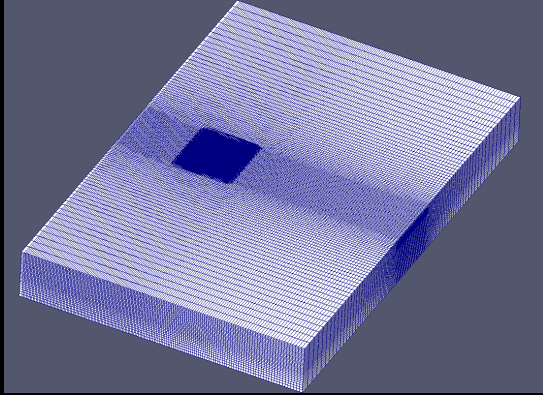# CFD model validation - waves
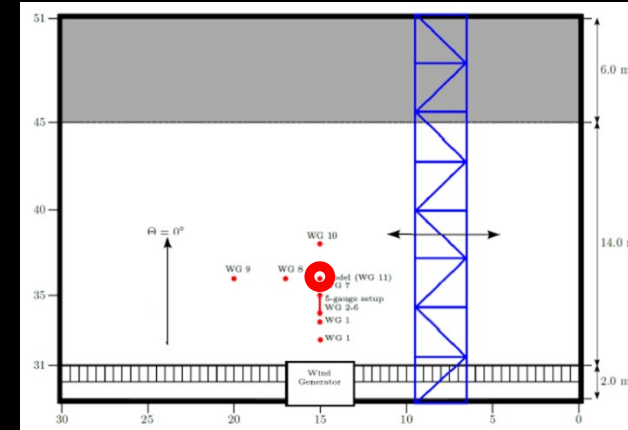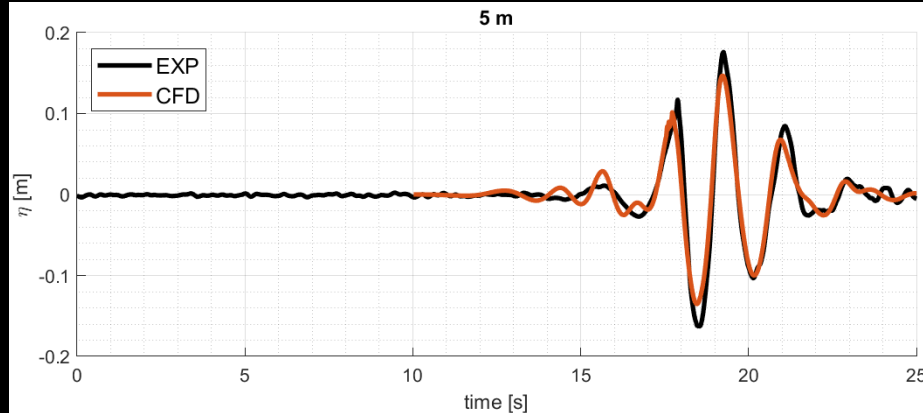
Regular waves
Parameters: Hs=0.175 m, Tp=1.83 s

Focused waves
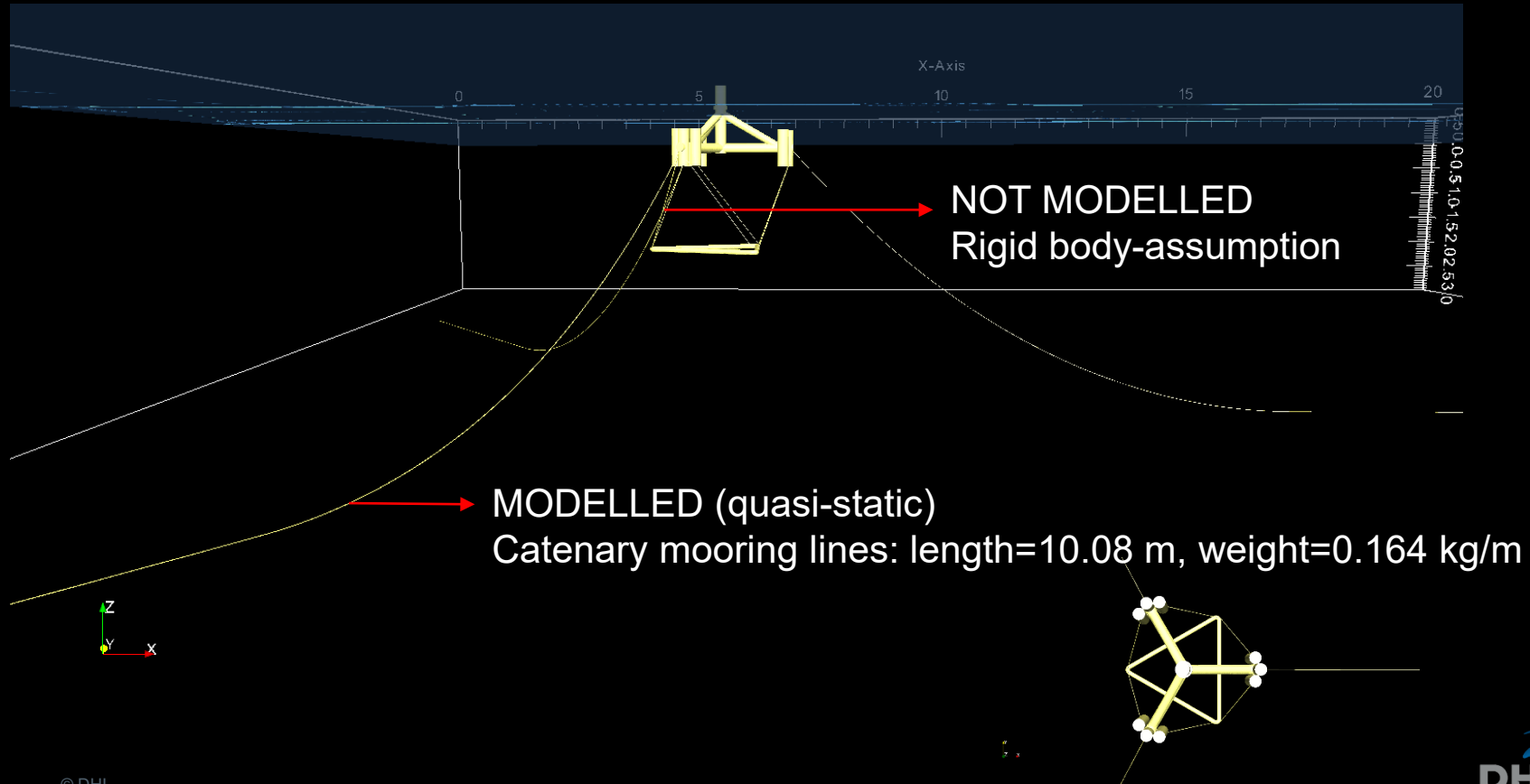Parameters: Hs=0.175 m, Tp=1.83 s
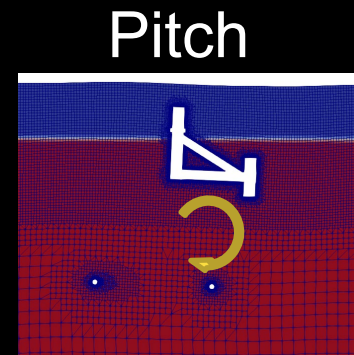
© DHI

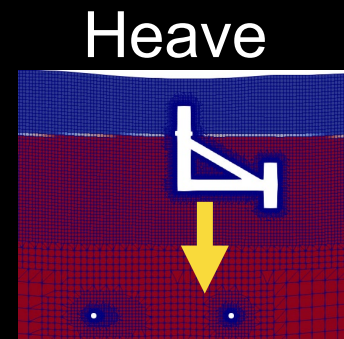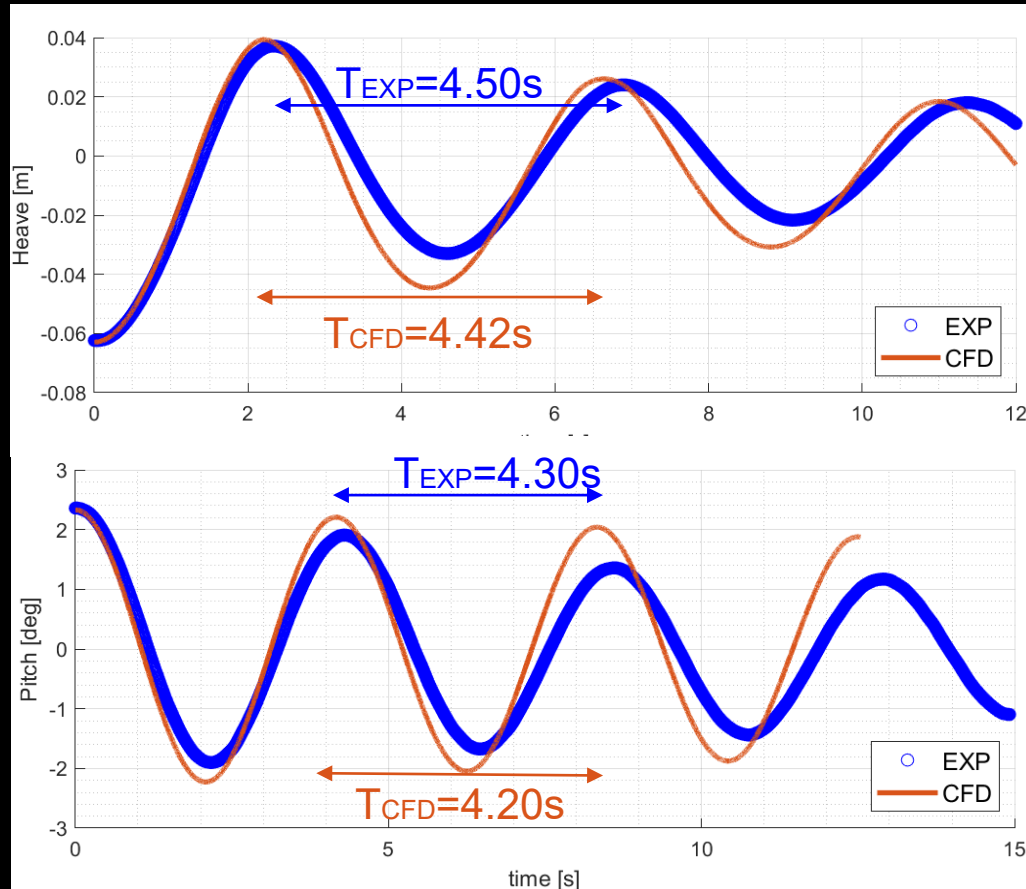# CFD model validation – floater mesh

- Domain: 4M cells, base resolution 0.5 cells/Hs
- Refinement free surface: 7 cells/Hs
- Refinement floater: 18 cells/diameter of side tank (11cm)

CFD model validation – mooring lines

NOT MODELLED
Rigid body-assumption
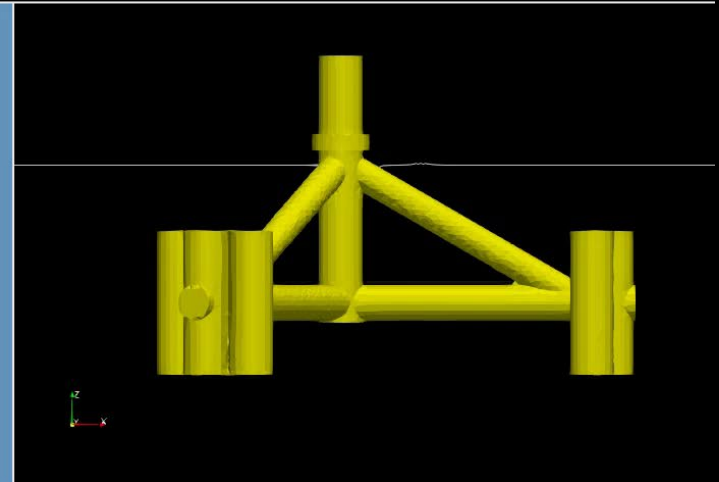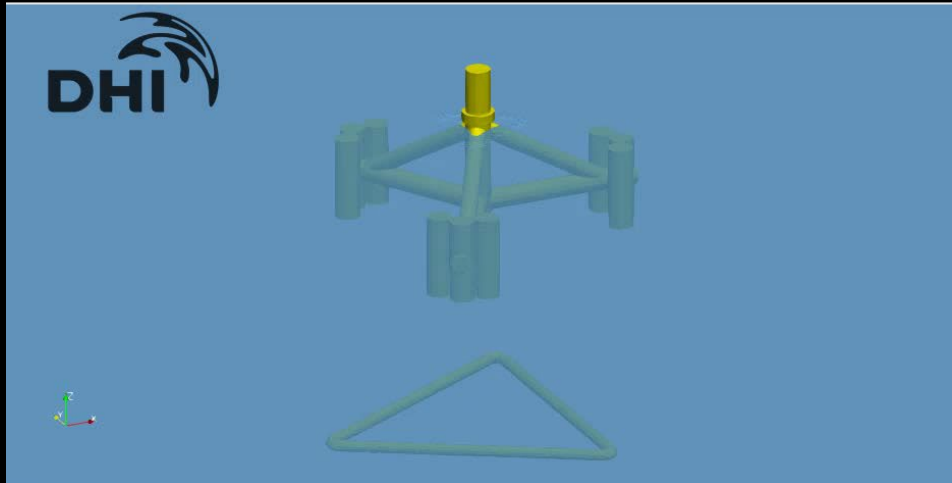
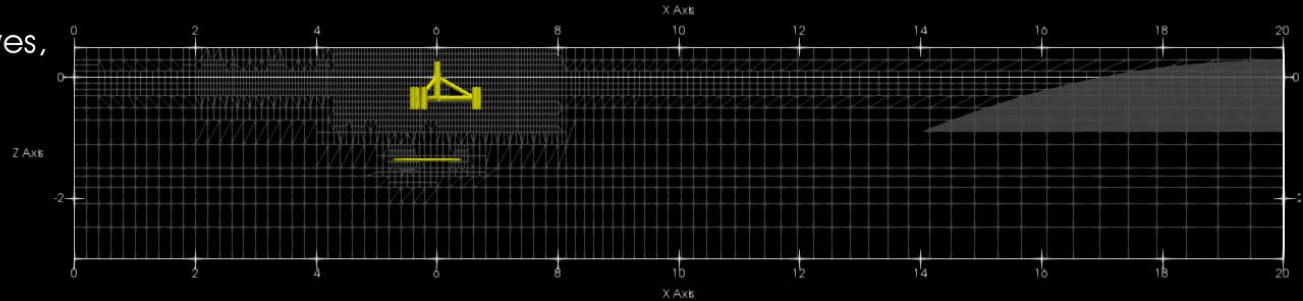MODELLED (quasi-static)
Catenary mooring lines: length=10.08 m, weight=0.164 kg/m

© DHI

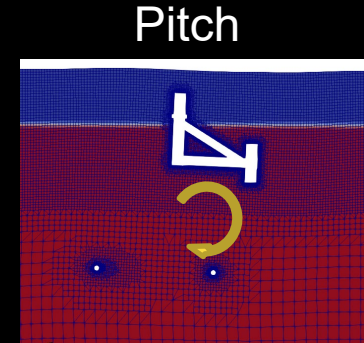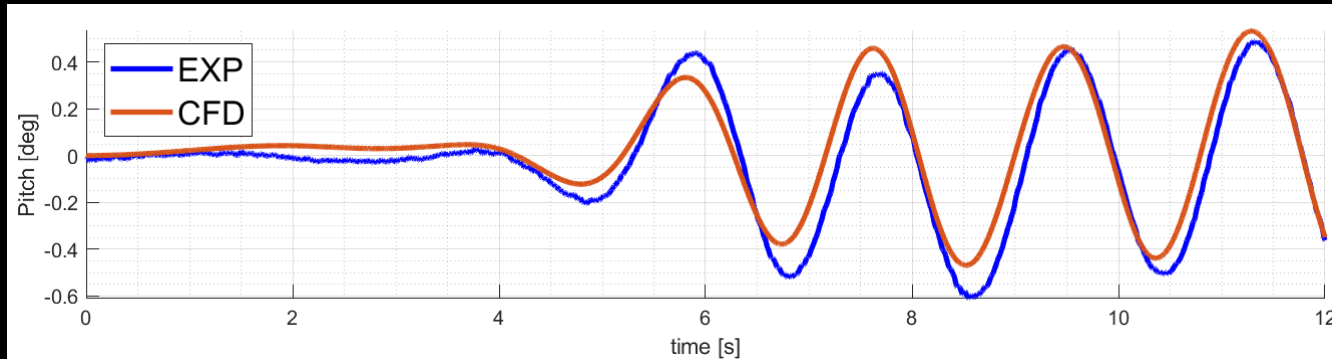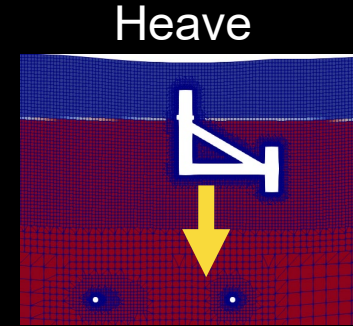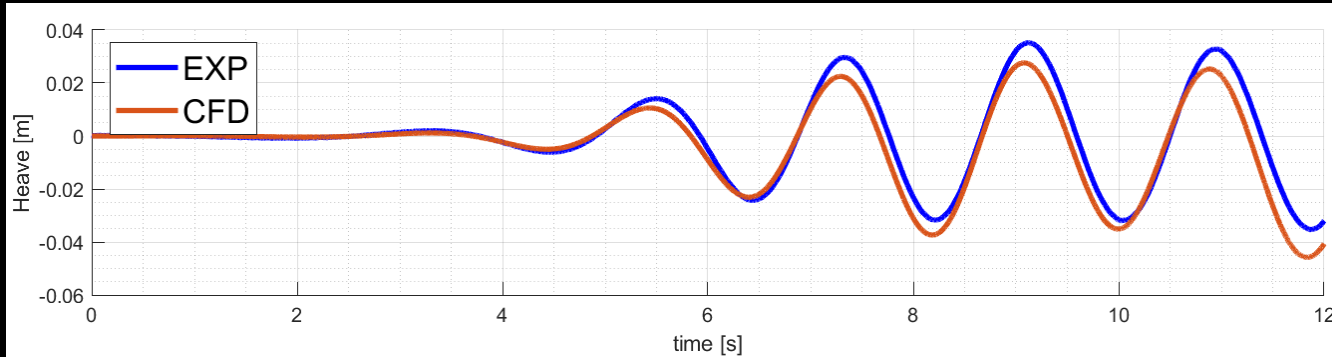# CFD model validation – moored decay tests

Heave

Pitch

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CFD model validation – test with regular waves (1)

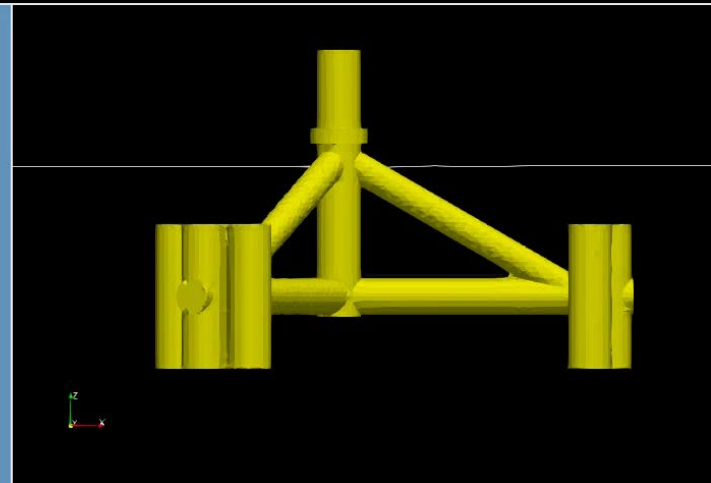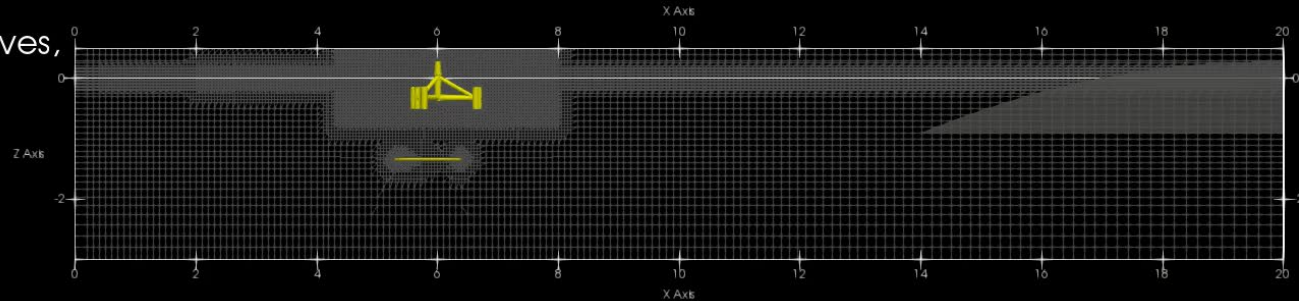Test 177 (Regular waves, H=0.175m, T=1.83s)

Time = 0.1 s

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CFD model validation – test with regular waves (2)

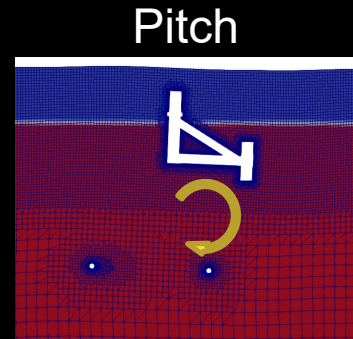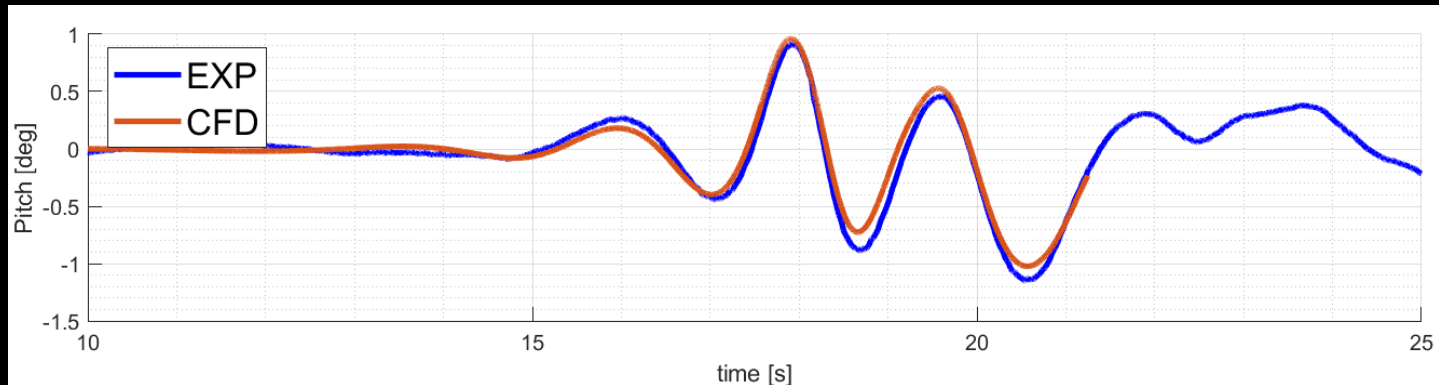© DHI

CFD model validation – test with focused waves (1)
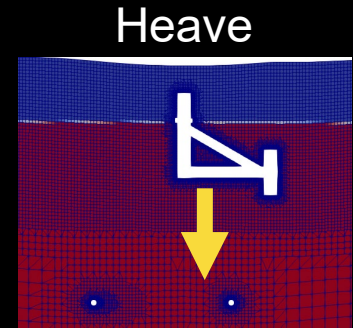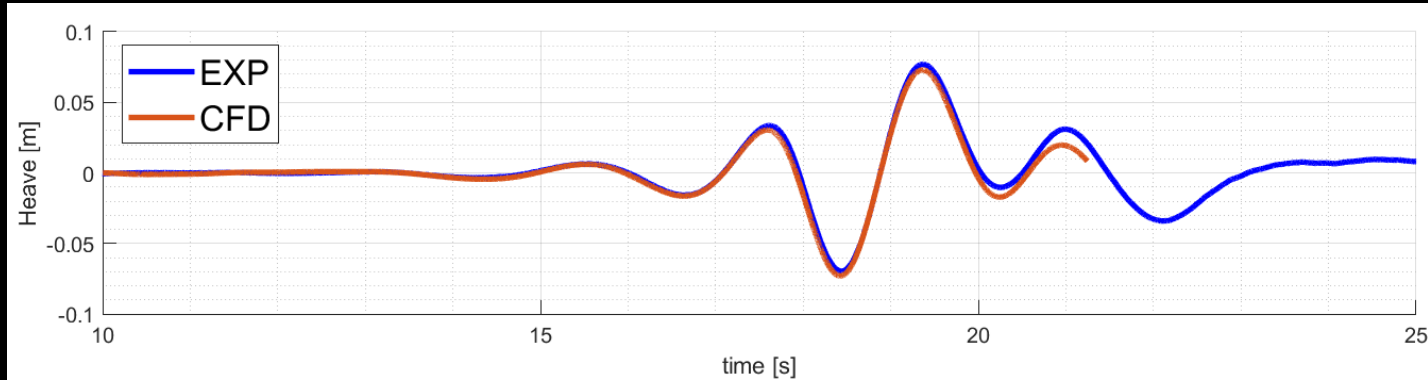

Test 179 (Focused waves, Hs=0.175m, Tp=1.83s)
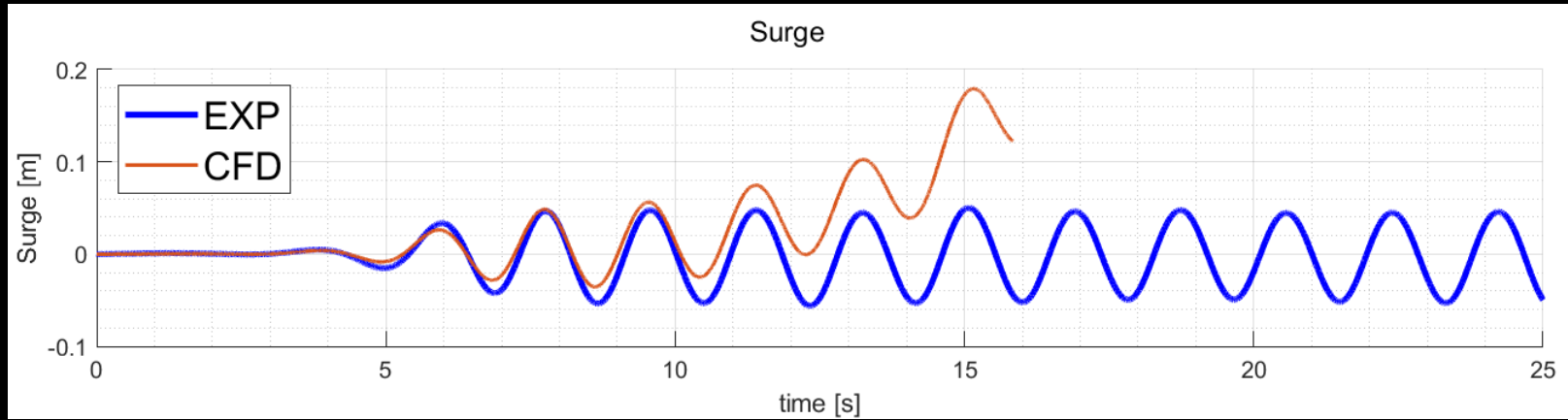
Time = 10.1 s

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CFD model validation – test with focused waves (2)

Heave

Pitch

© DHI

CFD model validation – problems with surge

mooring lines not working correctly?

2nd-order drift effects?

Lessons learnt/Future work

- Results are in a good agreement with the experiments for surface elevation, heave and pitch

- Solver is stable, but time-consuming to setup.
  Example: Mesh resolution of floater ←→ Volume ←→ Mass ←→ Response

- Solver is computational time-demanding. Examples:
  10 hours = one period of regular waves on 32 cores
  96 hours = focused test on 32 cores

- Future work: fix surge, tests with wind, added mass issue, test the coupling

Thank you

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