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MONOPILE IN FINITE WATER DEPTH: WAVELOADS AND RESPONSES BASED ON EXPERIMENTS

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Industry Meets Science 15/06/2017

Layout

- Main Objectives

- Protoype BFWT

- Model

- Instrumentation

- Test Program

- Ringing and slamming example

- Plan for 2018

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Main Objectives

Based on model tests in the Ocean Basin with a monopile (Ø7m) study physics and obtain validation fata for numerical codes:

- Second order model
- CFD calculations
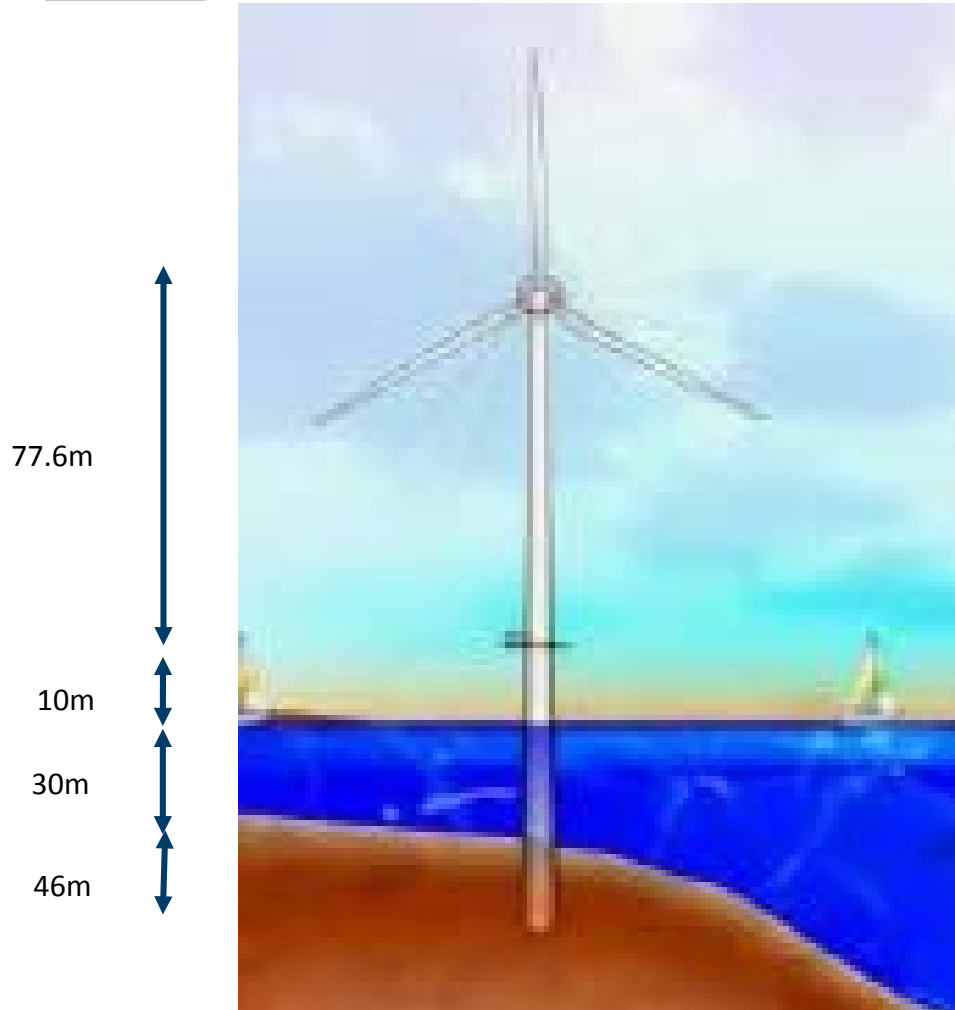- Short crested waves
- Slamming loads
- Ringing response
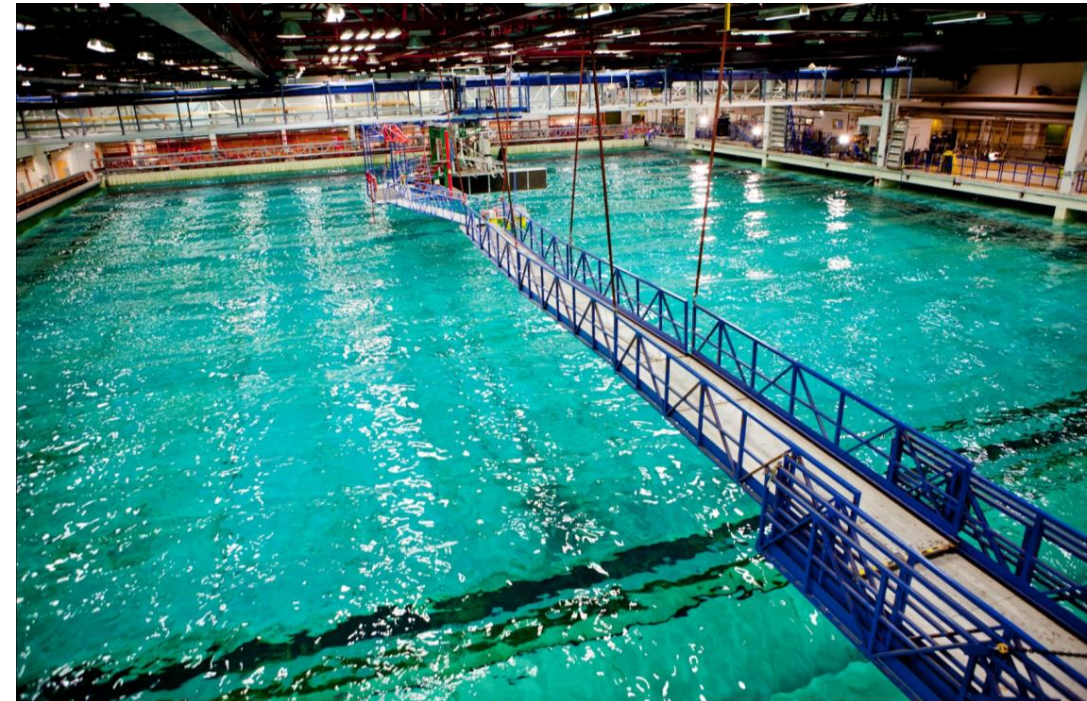
Main Objectives

Wish-list for validation data

- Wave profile and kinematics (with and without model)

- Distributed forces acting on pile

- Deflection of pile

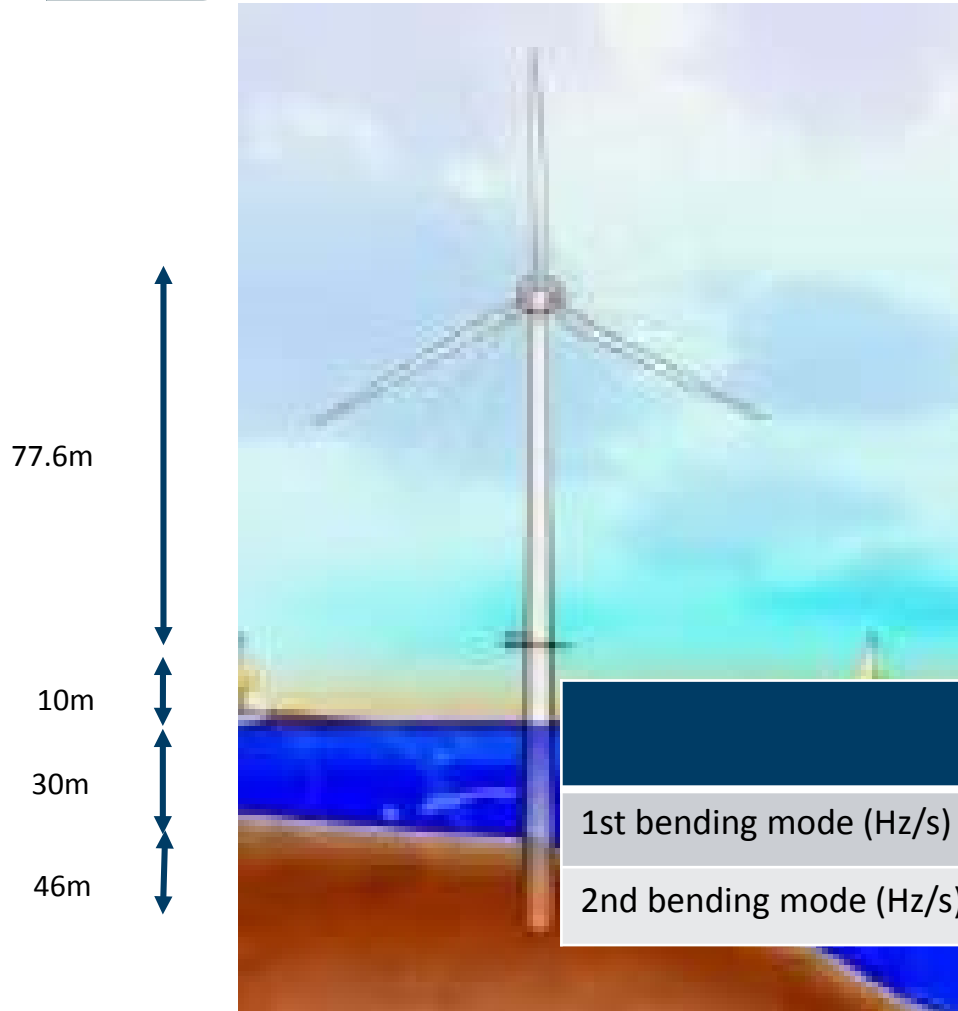- Global response (base shear and OTM)

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Prototype

77.6m

10m

30m

46m

- Designed for the experiments
- Based on NREL 5MW reference wind turbine and OC3 monopile design
- 7m Ø from embedded to base of tower
- 30m waterdepth
- Site 15 (L. Li *et al.,* 2013)
- Soil interaction
  - modelled with different soil springs
  - Simplified to single rotational spring for model tests

Prototype
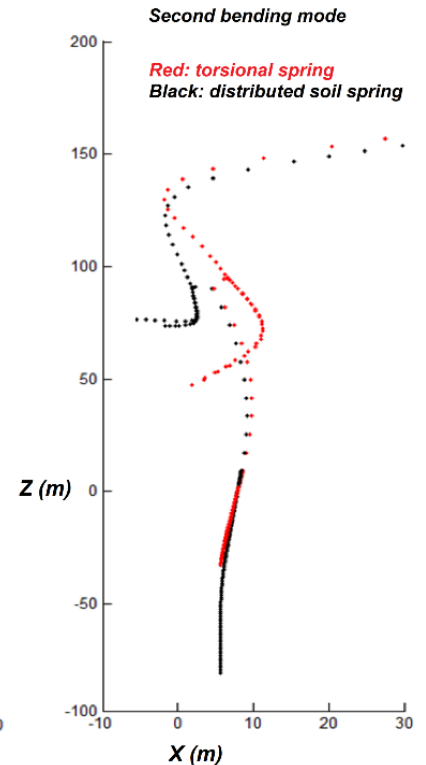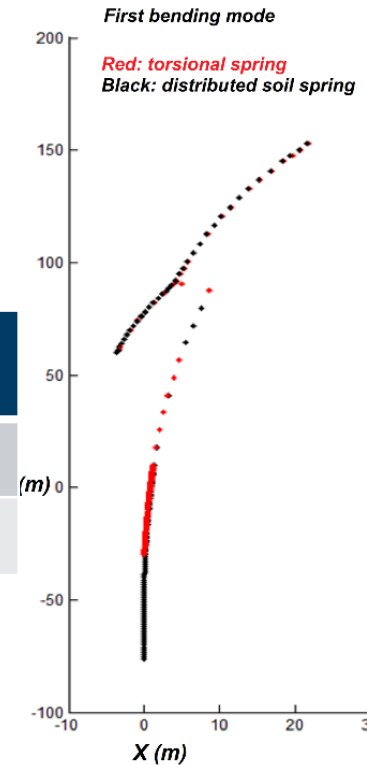
- RNA
  - Mass of nacelle: 2.4e5kg at (0,0,87.6m)
  - Mass of hub: 5.4e4kg at (-5,0,90)
  - Mass of blades: 5.37e5kg
  - Total mass: 3.48e5kg,

- Eigenmodes

	Distributed springs	Single rotational spring
1st bending mode (Hz/s)	0.261/3.83	0.261/3.82
2nd bending mode (Hz/s)	1.239/0.81	1.423/0.70

77.6m

10m

30m

46m

First bending mode

Red: torsional spring
Black: distributed soil spring

X (m)

Second bending mode

Red: torsional spring
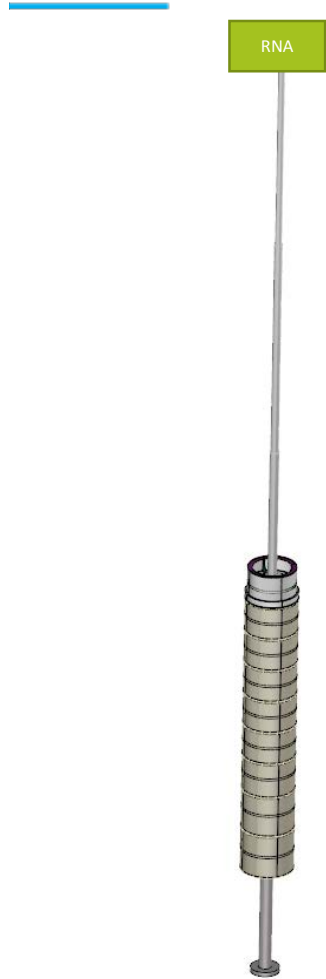*Black: distributed soil spring*

Z (m)

X (m)

Model
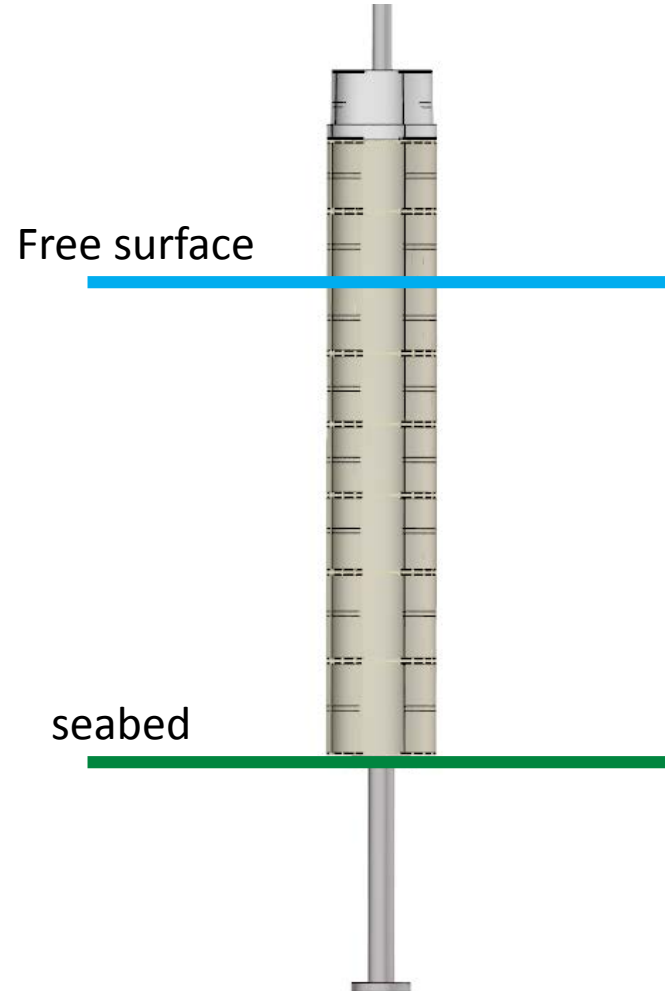
- Scale: 40

- Simplifications

  - No wind and no rotor. Only mass of RNA.

  - Increase of structural damping by use of drag disc

  - Single rotational spring at seabed

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Model

Stop outer shells at 20m above FS.
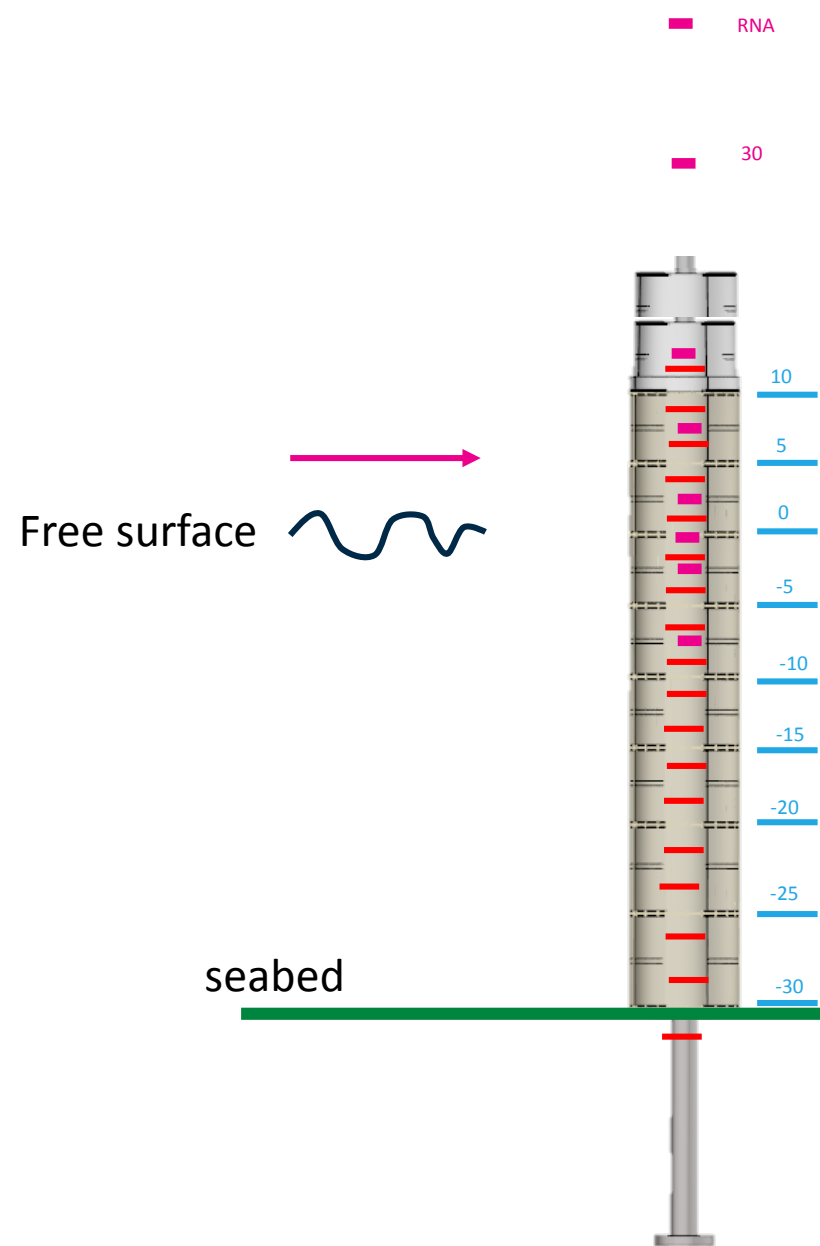Expected Amax=12.5m

Free surface

seabed

Model

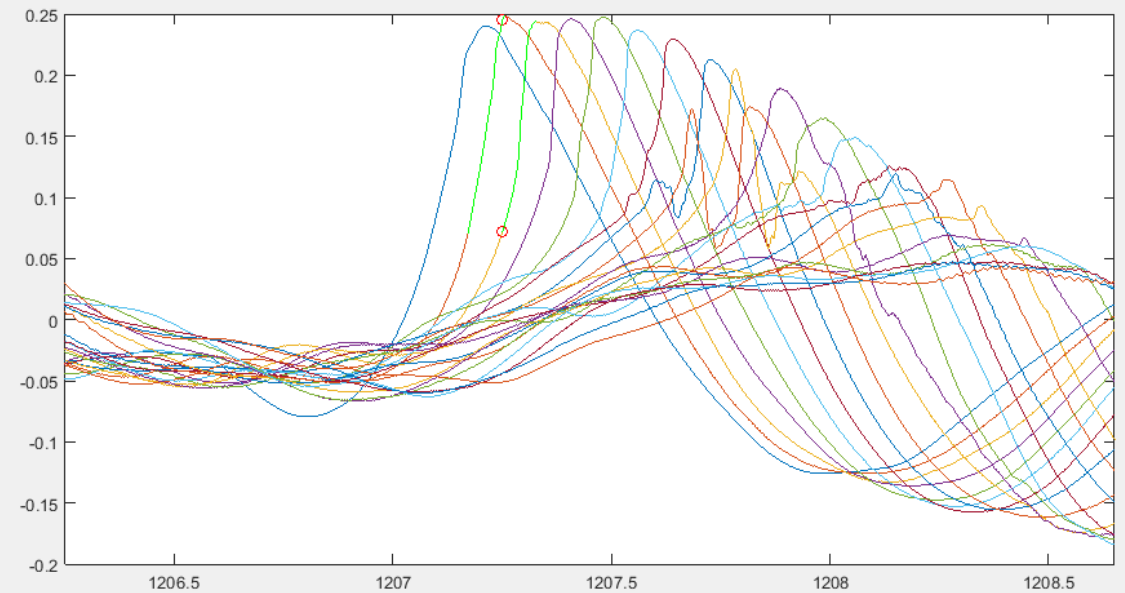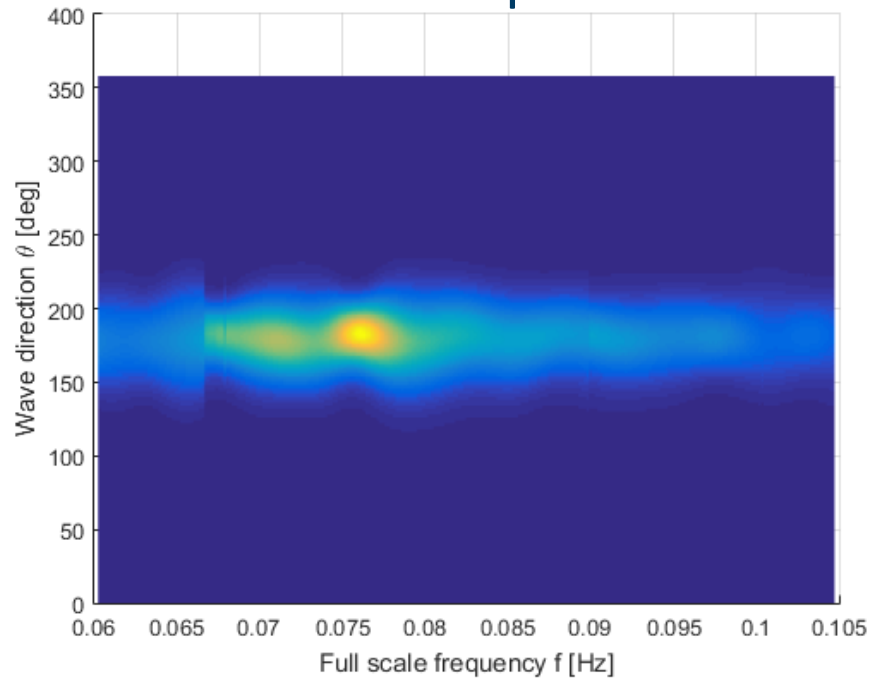Model properties documented by pullout and decay tests

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Instrumentation

- Moment and shear force measurements

- Acceleration at different sections

- High speed video

RNA

30

Free surface

seabed

10

5

0

-5

-10

-15

-20

-25

-30

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Instrumentation

- Longitudinal harp for long crested waves

- Circular harp for short crested waves

Test Program

- Dry and wet documentation tests
  - Pullout: Document structural stiffness
  - Decay tests: Natural period, mode shape and damping

- Regular wave tests
  (force distribution and global response)
  - Steepness 1/30: T=6, 7, 8, …, 14
  - Steepness 1/40: T=6, 7, 8, …, 15

- White noise => RAO
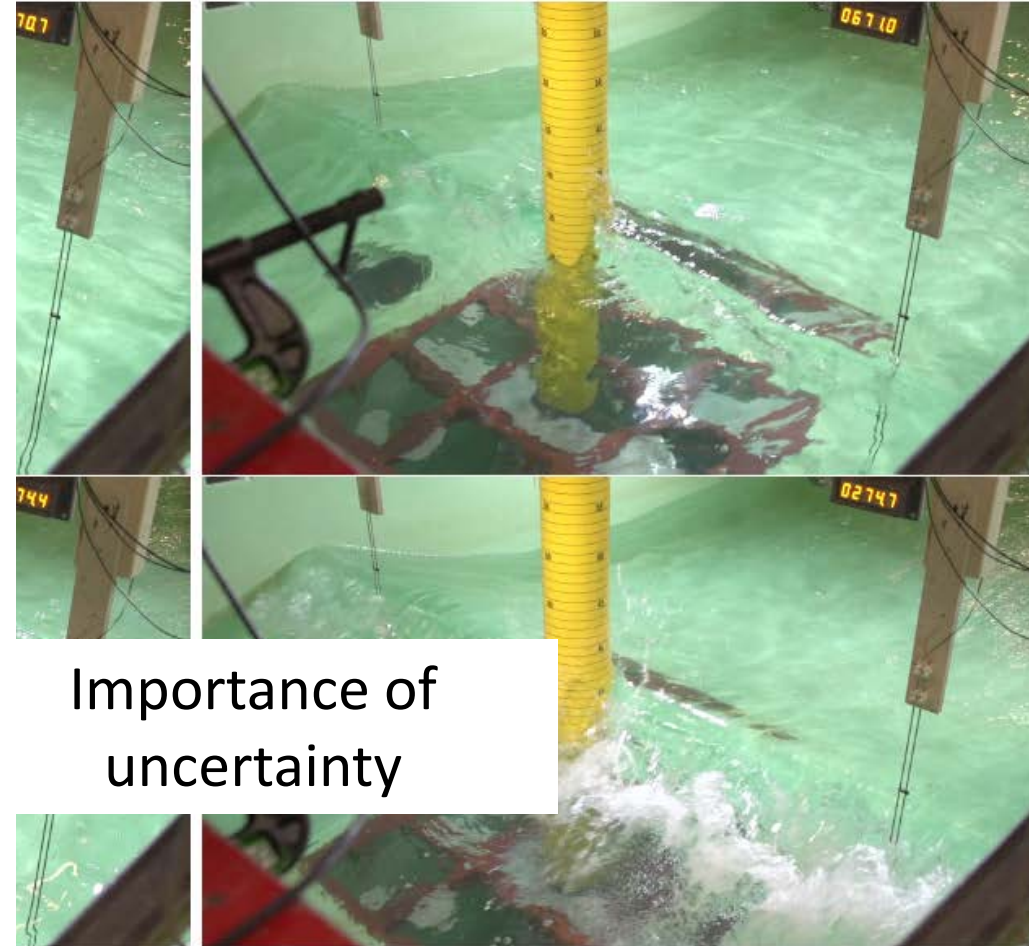 - 2 different to study possible non-linearity

REGULAR WAVES, BM3, Full scale

PINK NOISE, BM3, Full scale
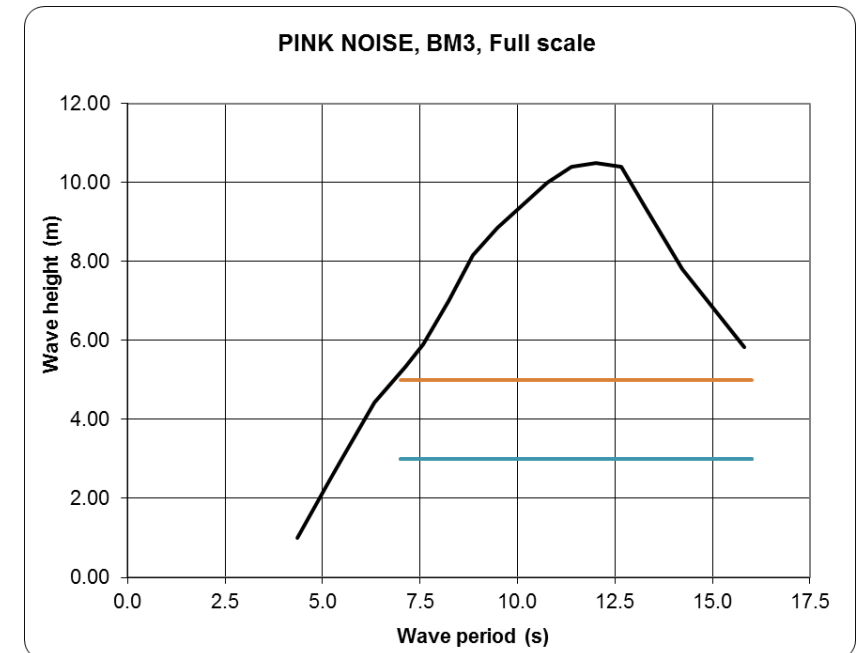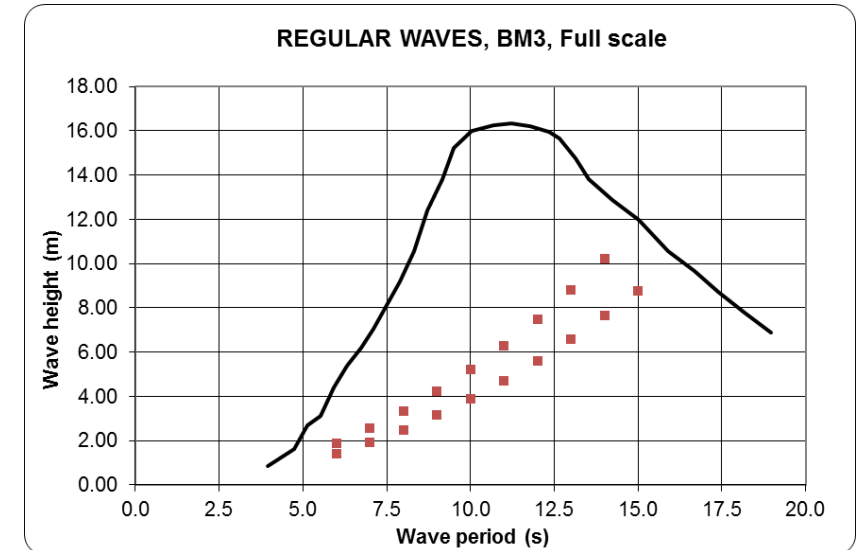
Test Program

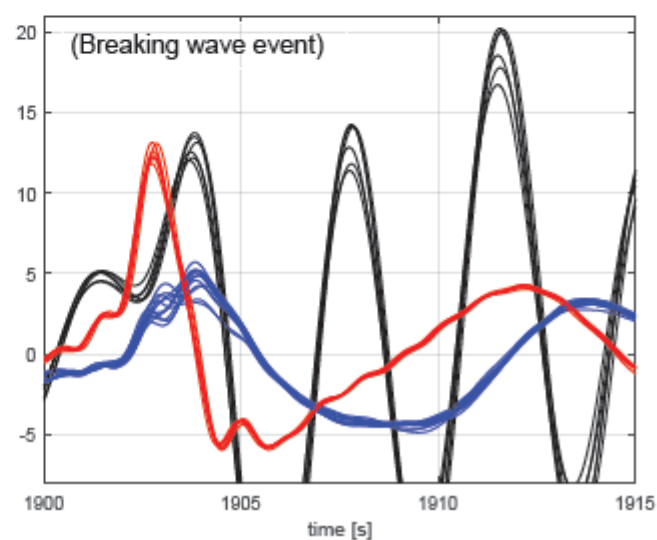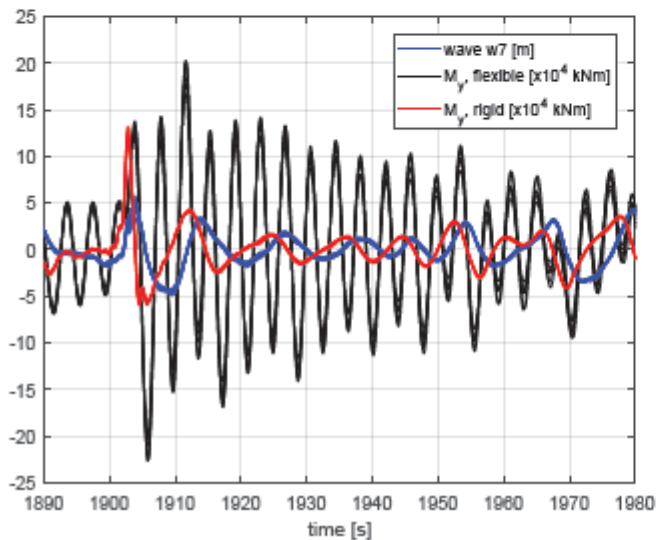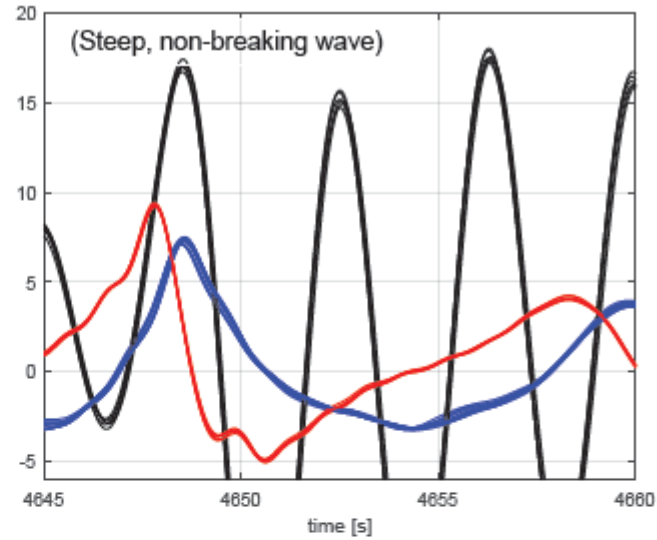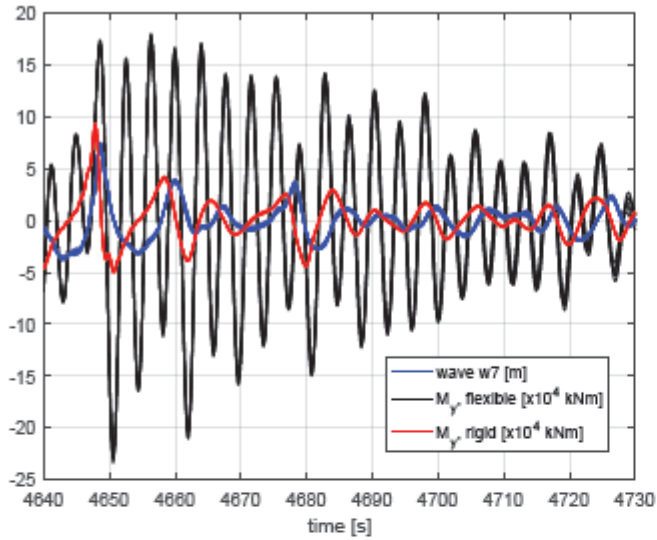- Irregular wave tests
  - 3h realizations
  - Spectrum: TMA ($JONSWAP*\phi\left(\omega\right)$)
  - One fatigue, two 25yr, 1 intermediate and five 50yr conditions.
  - Long and short crested $\cos^N(\theta)$, with N=8
  - Ewans spreading for one condition
  - 9 repetitions of long and short condition for uncertainty analysis
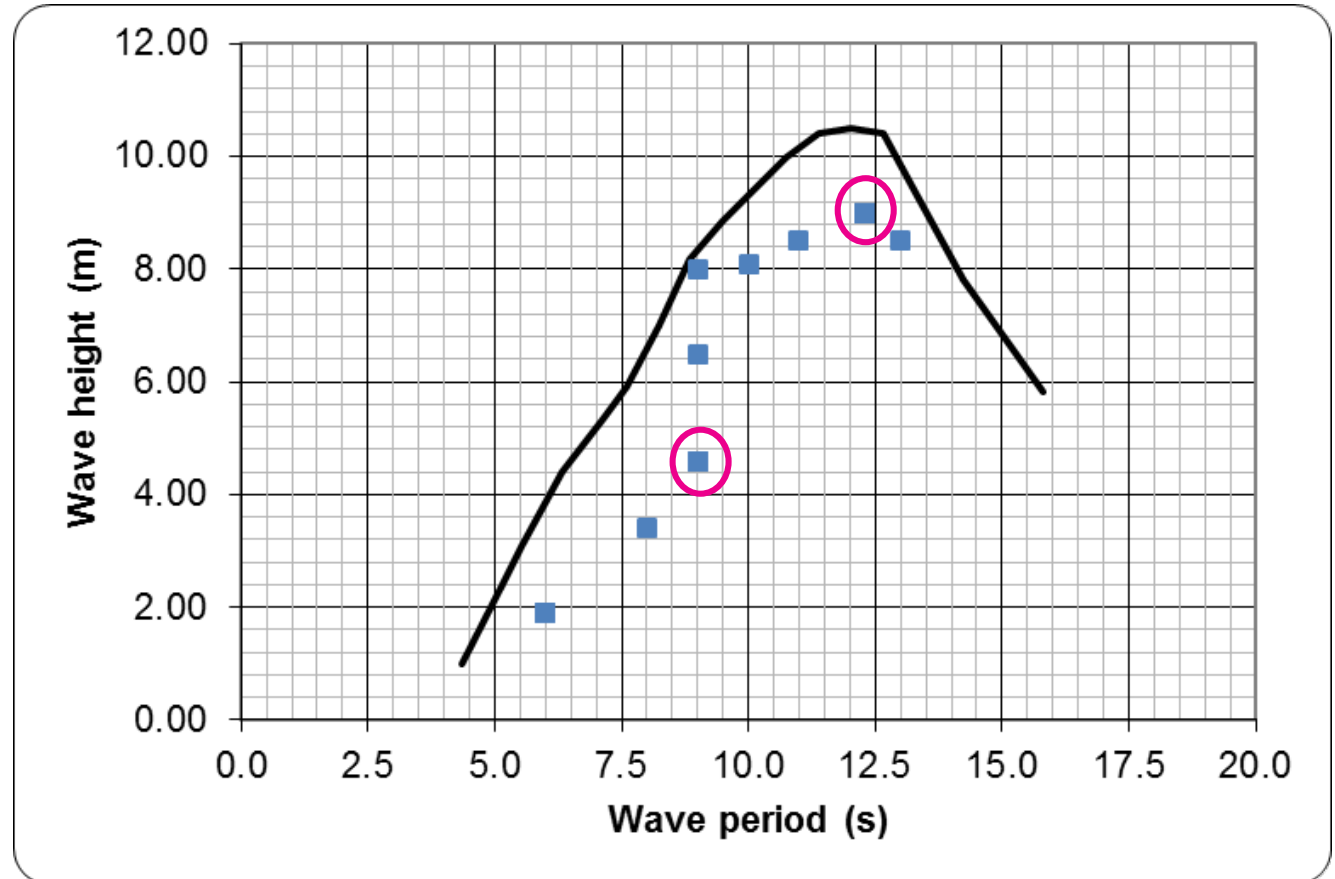
Latheef 2013: Storm: $15^o \leq \sigma_\theta \leq 30^o$ and they test 0°, 15°, and 30°.
Siwansen 2016: $\sigma_\theta = 5.7^o, 12.5^o, and\ 19.1^o$ and calls it narrow, medium, and broad, respectively.

Ringing and slamming example

Importance of uncertainty

E. E. Bachynski *et al., 2017 in Applied Ocean Research*

Teknologi for et bedre samfunn