Pile driving of large diameter monopiles: Current practice and challenges

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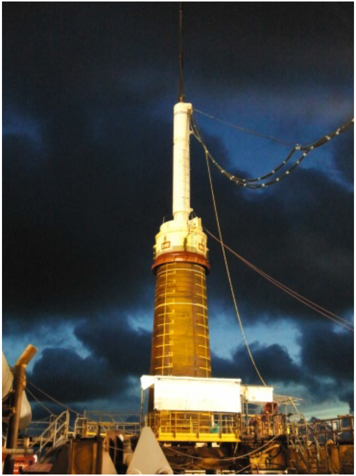
TUDelft IHC IQIP

Introduction



Increasing demand for offshore wind energy

[1] [Smith, 1962,]

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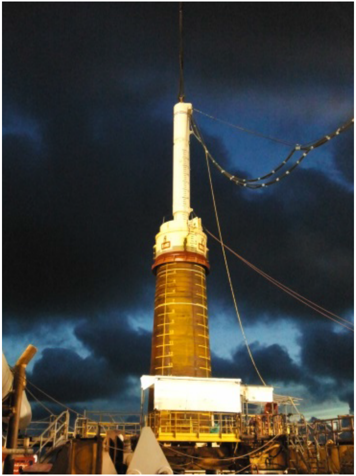

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Large-diameter monopiles

$D \approx 8$ m (2016)

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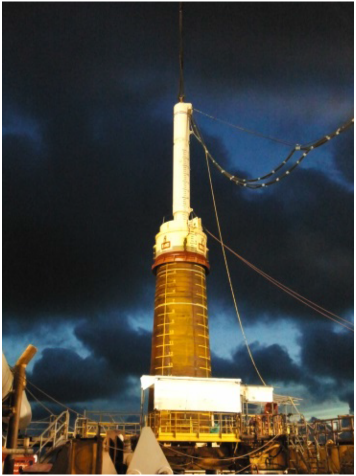

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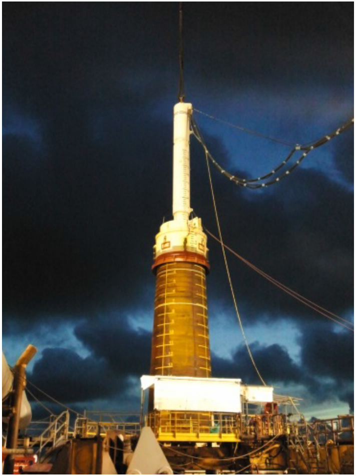

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Large-diameter monopiles

$D \approx 8$ m (2016)

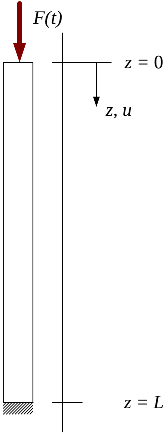
A **drivability study** is performed based on the model of Smith[1]

- Hammer type
- Number of hammer blows
- Induced stress levels

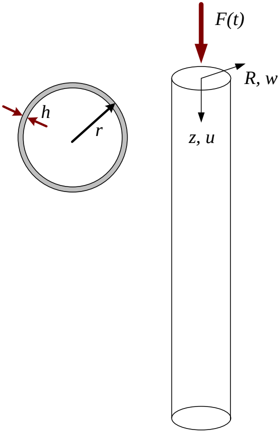
[1] [Smith, 1962,]

Mathematical modelling

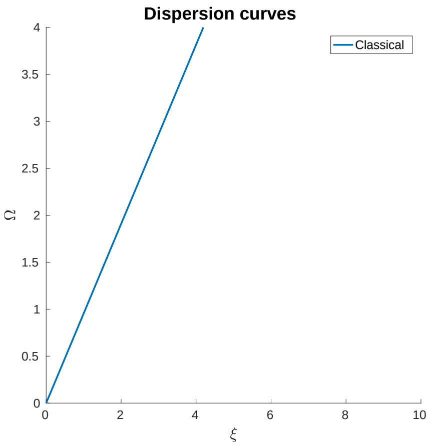
Classical



Axisymmetric shell



Dispersion curves



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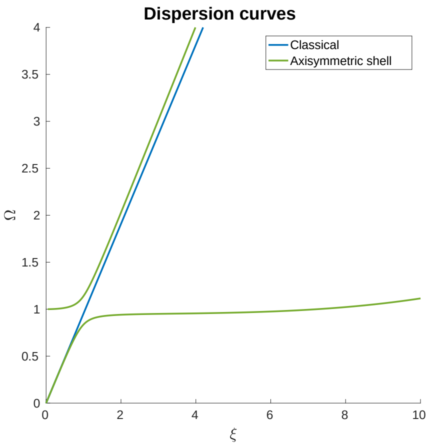
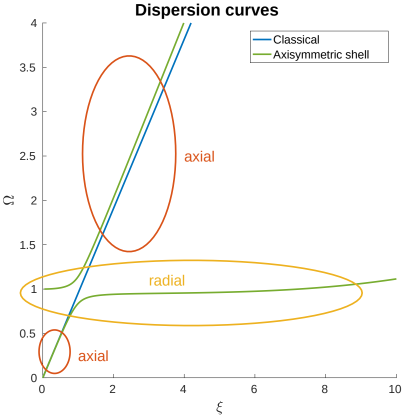


Ring frequency

In a cylindrical shell, strong coupling of axial and radial motions occurs around the **ring frequency**[2]

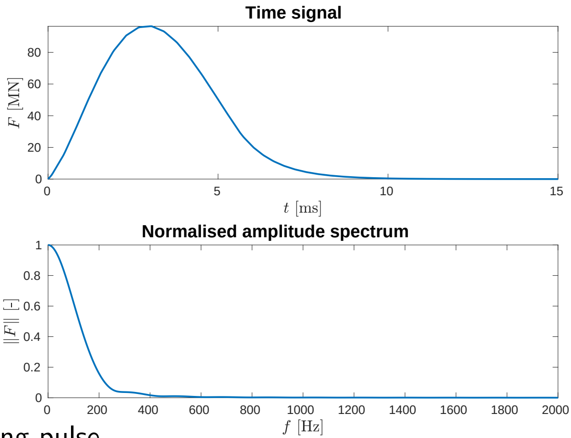
$$f_r = \frac{1}{\pi D}\sqrt{\frac{E}{(1-\nu^2)\,\rho}}$$



[2][Hodges et al., 1985, Bozich, 1967,]

Hammer characteristics

Examples of force signals created with the hammer model of Deeks and Randolph.[3]



Long pulse

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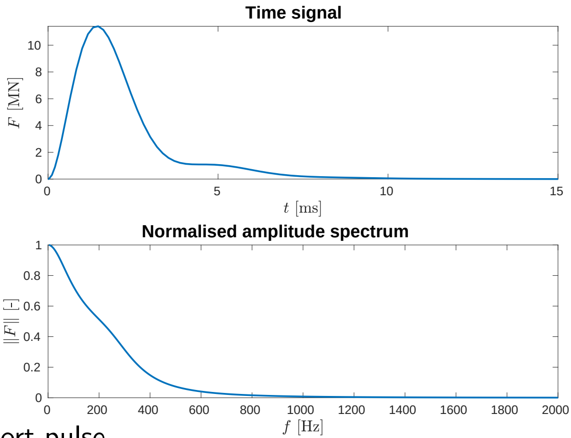
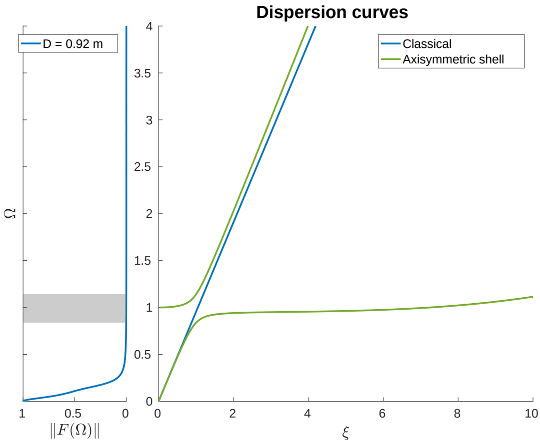


Short pulse

[3] [Deeks and Randolph, 1993,]

Small diameter pile

Steel pile with $D = 0.92$ m. $f_r = 1900$ Hz. $E_w = 0\%$



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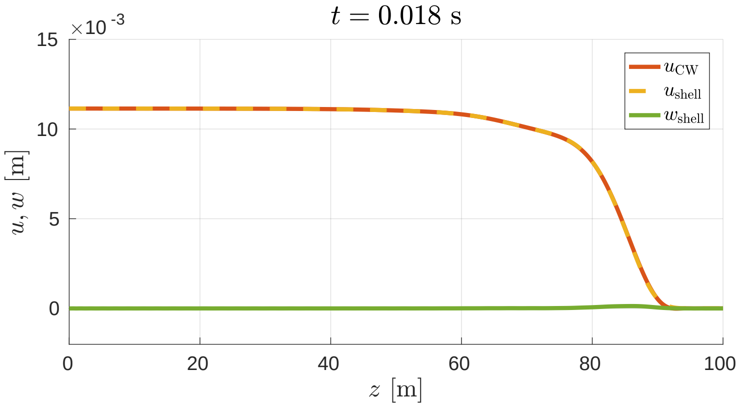
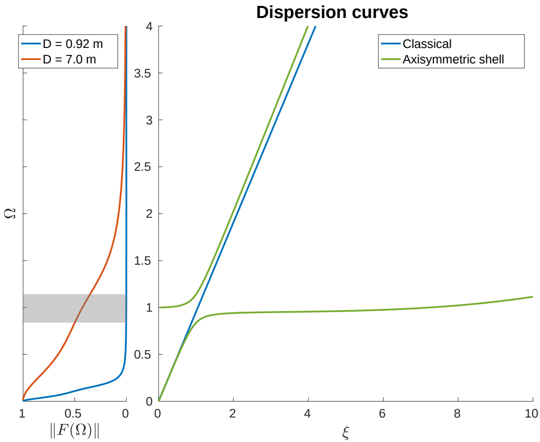


Large diameter pile

Steel pile with $D = 7.0$ m. $f_r = 247$ Hz. $E_w = 10\%$



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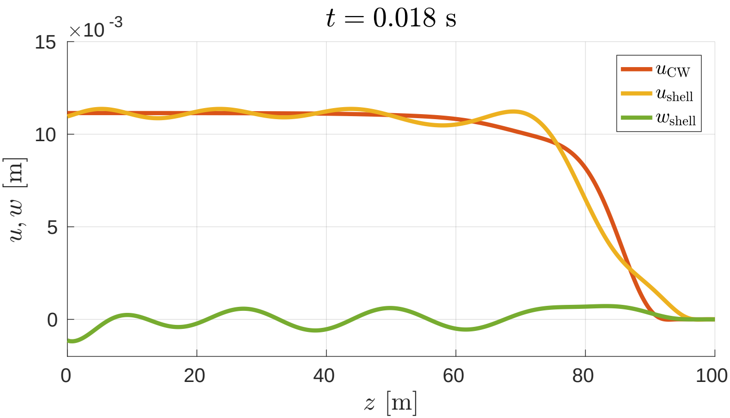
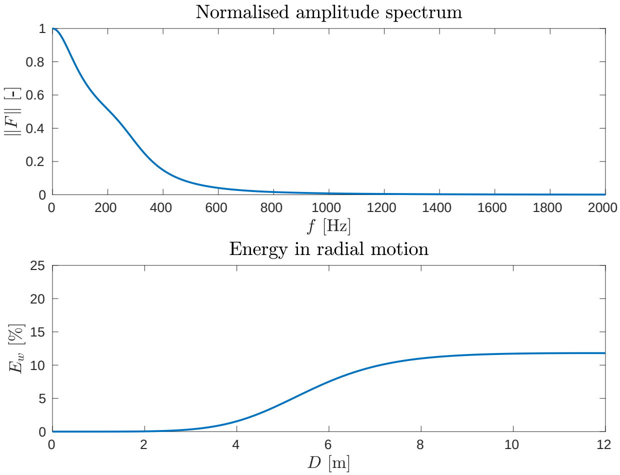


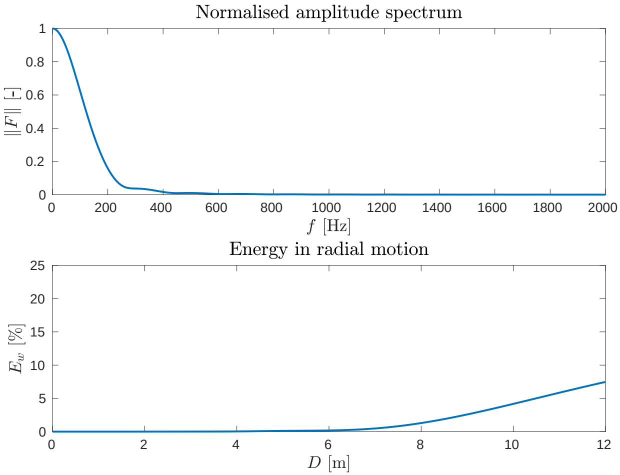
Energy in converted to radial motion

Short pulse:



Energy in converted to radial motion

Long pulse:



Summary

When?

The force signal contains energy around the ring frequency, which decreases with increasing pile diameter.

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When?

The force signal contains energy around the ring frequency, which decreases with increasing pile diameter.

What?

- Energy around the ring frequency is put in radial motion not axial motion
- Slow propagation of this energy because of low group velocity
- Oscillations of u and w with the ring frequency

Open questions/challenges

- What is the effect of the radial motion on
  - drivability?
  - bearing capacity?
  - stress levels?
  - number of stress cycles?

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- What is the effect of the radial motion on
  - drivability?
  - bearing capacity?
  - stress levels?
  - number of stress cycles?
- Should we avoid it or take advantage of it?

Acknowledgments

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NWO Netherlands Organisation for Scientific Research

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