Optimization of monopiles with genetic algorithms

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Importance sampling
to reduce number of load cases

- ✓ 120 load cases instead of 1700 (93% reduction)
- ✓ Target lifetime of optimization met with only 1-7% difference
- ✓ Fast and accurate method for use in computer-aided optimization

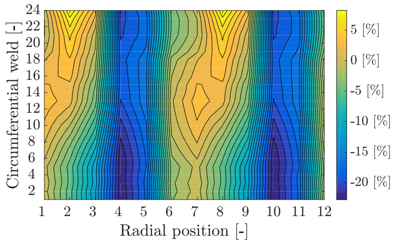
Reduction of load cases with importance sampling

- A cumulative distribution function (CDF) is set up for fatigue damages caused by every load case
- 120 load cases are sampled from the CDF
- Aero-hydro-elastic simulations are performed for these load cases with ROSAP and LACflex
- Fatigue damages are estimated with importance sampling and a correction factor f_k

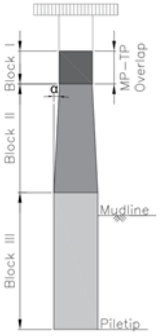
$$D_{est} = \frac{1}{n}\sum_{i=1}^{n} \frac{D_i^{LC}}{g_i}$$

$$D_{corr} = f_k \cdot D_{est}$$

$$f_k = \mu_k + n \cdot \sigma_k$$

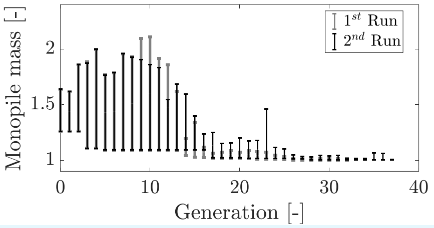


Genetic algorithm

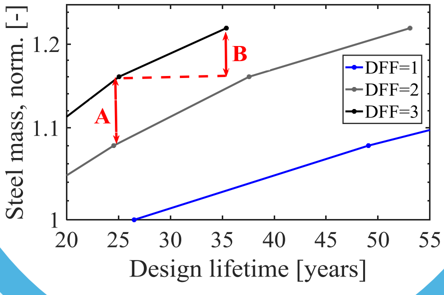


- Minimize monopile mass
- 5 design variables
- Constraints: fatigue damage, weldability, resonance, buckling
- Aero-hydro-elastic load simulations in the time domain with 120 load cases and importance sampling
- Optimization for different design lifetimes: 25, 50, 75, 100 years (DFF=1)

Case study
8 MW turbine
DLC 1.2 + 6.4
1700 load cases



How does steel mass increase if **monopiles** are designed for a **longer lifetime**?



Motivation

Knowledge about the scaling of steel mass of monopiles is needed to decide for which service life an offshore wind farm should be planned. It is impossible to perform computer-aided optimization with aero-hydro-elastic simulations of several thousand of load cases.

Research objective

Develop a smart method to reduce the number of require load simulations during the design optimization while keeping the complexity of load and structural analysis at industrial standard.

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Acknowledgements: Results of this work have been obtained by Matthieu Rhomberg during his master thesis in cooperation with Ramboll, NTNU and TU Delft. Input from several experts from Ramboll is greatly acknowledged. This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 642108.