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# Optimal Design of Stiffeners for Bucket Foundations

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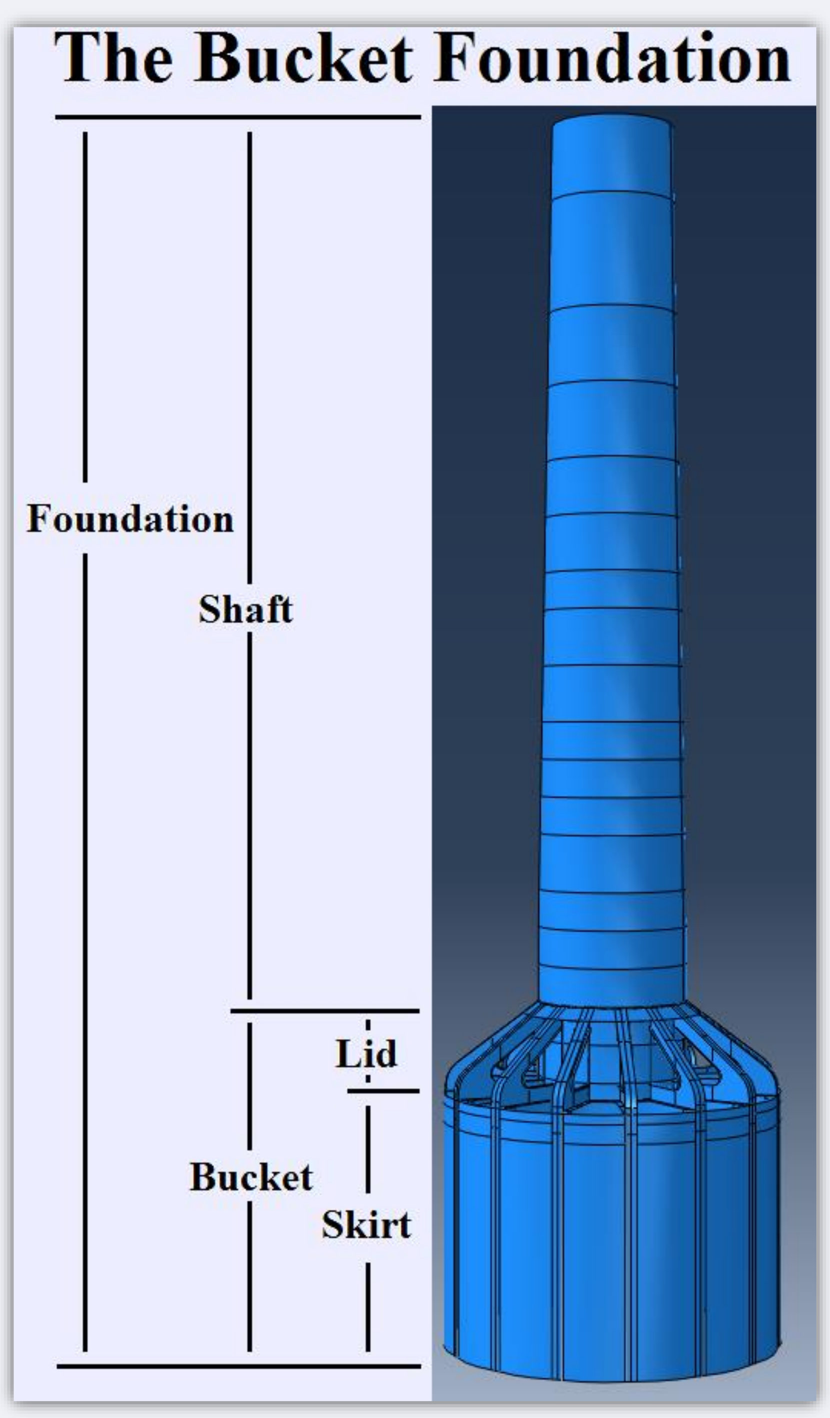
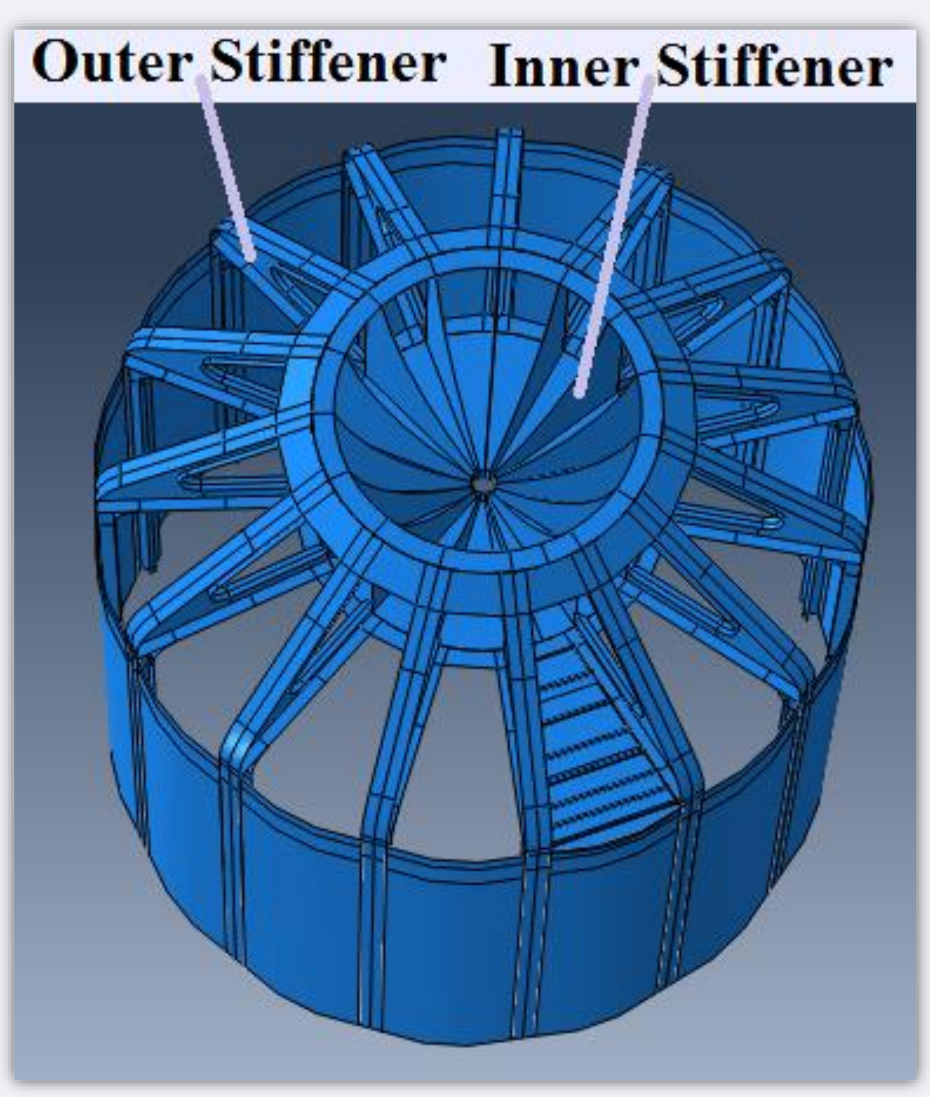
## Abstract

The potential for structural optimization of the bucket foundation's outer stiffeners is investigated using the commercial optimization software *Tosca Structure*. Results show that shape optimization of the initial design can reduce stress concentrations by 38%. Additionally, topology optimization has led to a new design concept with a mass reduction of 25% when compared to the initial design.

## Introduction

The Bucket Foundation - developed by Universal Foundation A/S - is a novel foundation concept that can potentially reduce the cost of energy for offshore wind farms. The project "Cost-Effective mass production of Universal Foundations for large offshore wind parks" aims to move the Bucket Foundation from a research, development, and demonstration phase into commercialization and industrialization within 2016-2017. As part of this project, the objective of this work is to further reduce the cost of the bucket foundation by reducing the mass of the stiffeners, while considering mass production and manufacturability.



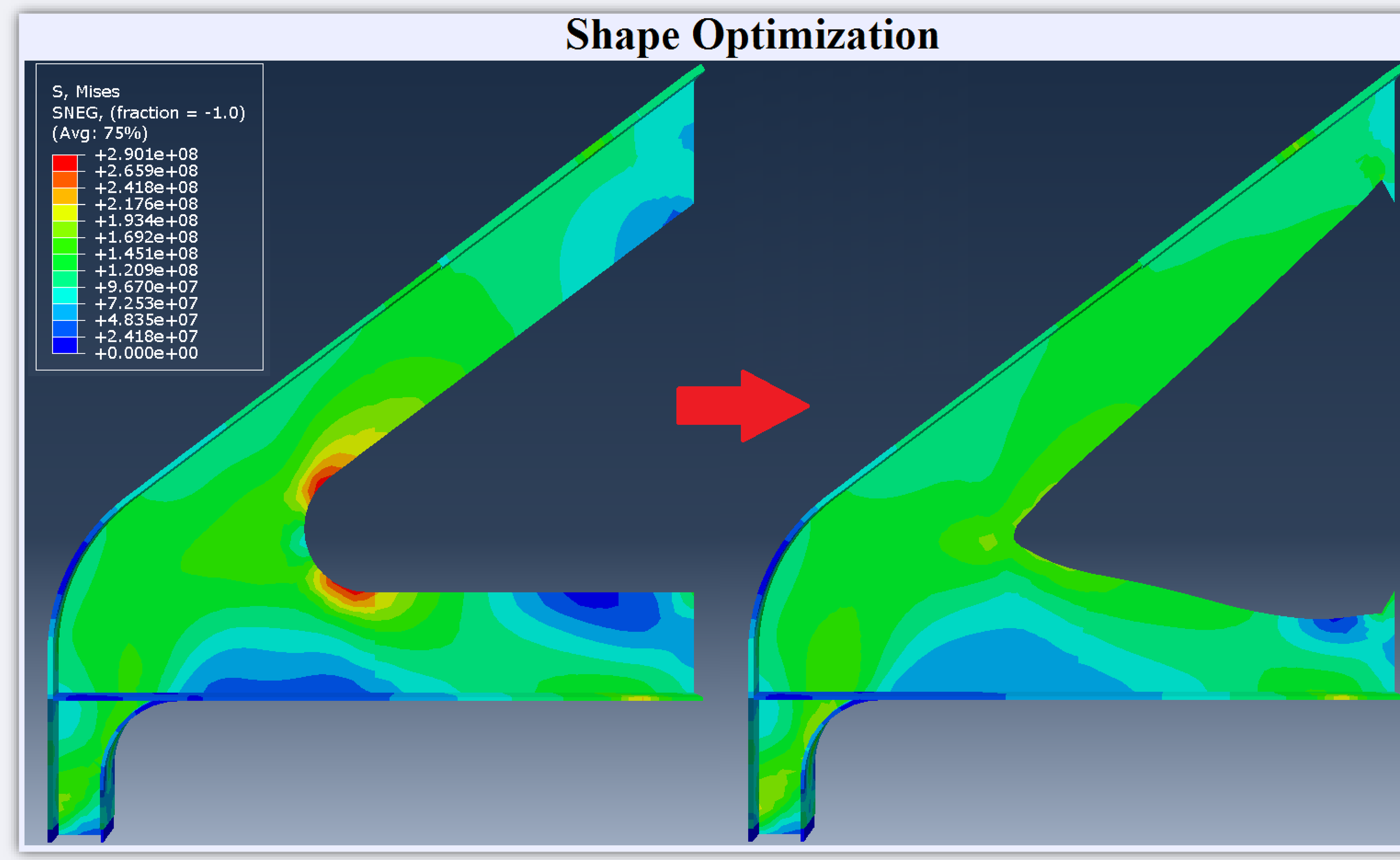




## Methodology

A bucket foundation design has been provided by Universal Foundation A/S and is modelled using the finite element software *Abaqus*. The model assumes fixed boundary conditions at the skirt (thereby neglecting soil interactions) and is loaded with an extreme static horizontal load at the top of the shaft. Both shape and topology optimization problems are then developed and solved using *Tosca Structure*.

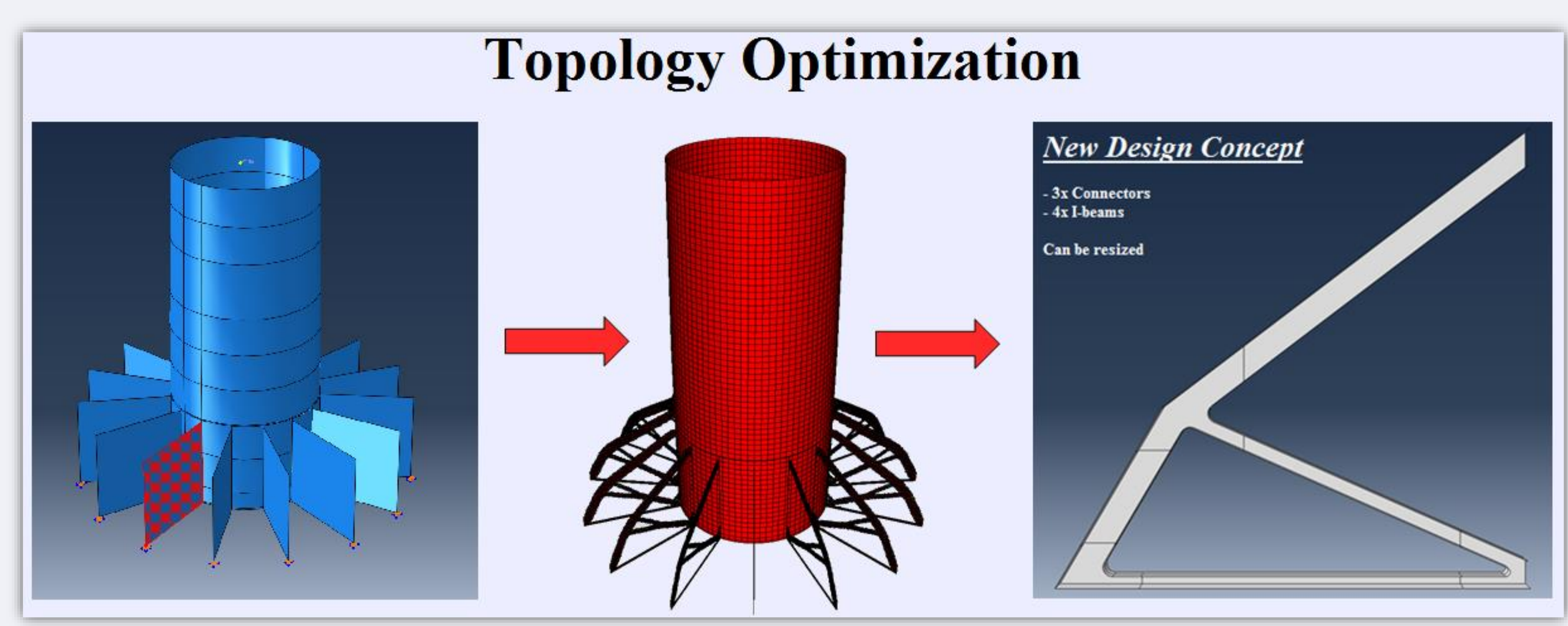
## Shape Optimization

The shape optimization problem is formulated as minimize the maximum von Mises stress in the outer stiffener, subject to a volume constraint, with the design variables being the position of the nodes in the stiffener's inner edge.




## Topology Optimization

The topology optimization problem is formulated as minimize the structure's compliance, subject to a volume constraint, with the design variables being the density of the shell elements representing the outer stiffener's design area. The result is then manually interpreted as a new design concept.




## Conclusion

Results show that shape optimization can **reduce** the maximum von Mises **stress** in the outer stiffener **by 38%** without adding mass to the design. Additionally, topology optimization has led to a new outer stiffener design concept with a **mass reduction of 25%** (19 tons total).

Future work with shape and sizing optimization of the new outer stiffener concepts can potentially reduce mass further and initial investigations into optimization of the inner stiffener and lid suggest a potential mass reduction of over 30 tons, using the same methods.

## Acknowledgement

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