Numerical Analysis of a Floating Wind Turbine

Global Load Effects in the Tower Structure

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Scope

The main scope of this thesis is to investigate the effect on fatigue in steel tower structure for an increased elevation level between concrete and steel on a floating offshore wind turbine design. Important parts of the thesis are:

- Build a proper SIMA model for analyses
- Map contributions to fatigue
- Perform relevant sensitivity studies
- Give a recommendation whether or not an increased elevation level will be beneficiary for the design

Methodology

Analyses are performed for the floater OO Star 10 MW. It is made of concrete material, which is less sensitive to fatigue than steel. A steel tower is mounted on the concrete floater.

Three similar designs are tested. The floater is slightly modified in order to maintain needed stability, and the elevation level between concrete and steel is increased:

1. Case 0: Original design. Elevation level between concrete and steel equal to x.
2. Case 20: Modified design. Elevation level between concrete and steel equal to x+20 metre.
3. Case 40: Modified design. Elevation level between concrete and steel equal to x+40 metre.

The wind turbine is taken as the 10 MW DTU reference turbine. Environmental loads (wind and waves) are modelled based on metocean data for a severe location.

The coupled dynamic analyses are performed in time-domain by use of the software SIMA. Rainflow counting technique is used on the stress series, and value for damage is found by use of a S-N curve.

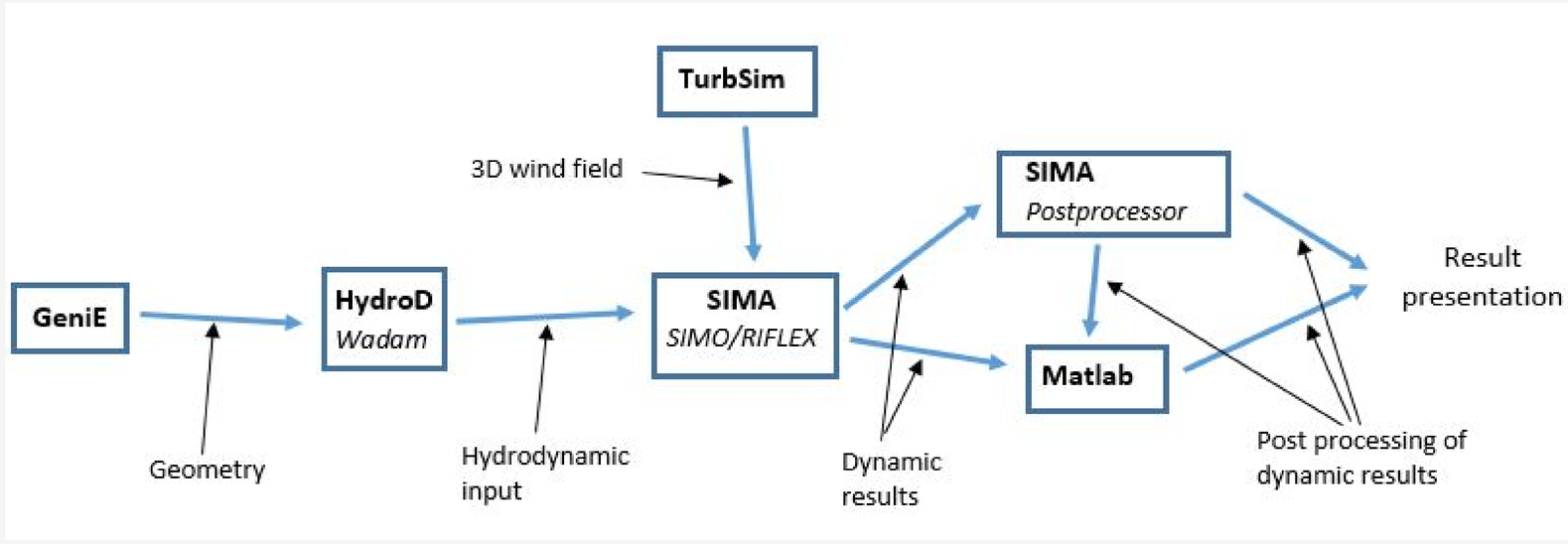
Acknowledgements

This thesis is written in cooperation with the company Dr.techn.Olav Olsen AS.

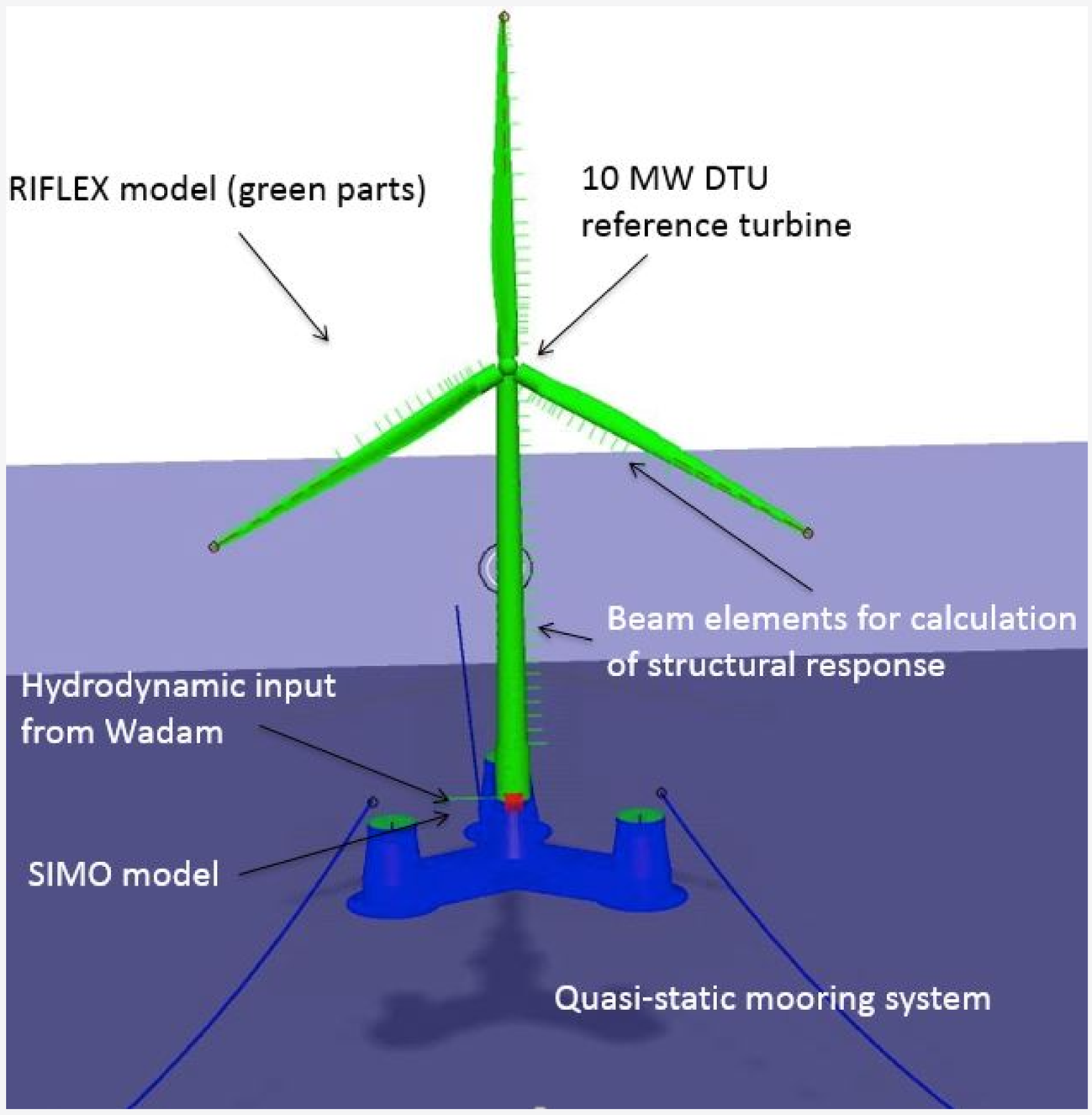
Main supervisor at NTNU is Trygve Kristiansen. Co-supervisors are Erin Bachynski and Kjell Larsen.

NTNU supervisors, and people at Dr.techn.Olav Olsen AS, have been of great support during the thesis work.

Software Workflow



SIMA Model



Results and Conclusion

Note: Due to confidentiality, detailed presentation of the results can not be given.

Results from coupled dynamic analyses are found to be:

- There are three main contributions for fatigue; wind forces, first order wave forces and 3p effects.
- Fatigue damage is sensitive for structural damping and waterplane stiffness.
- Fatigue damage is not sensitive for second order wave forces and viscous hydrodynamic damping.
- Maximum fatigue damage is reduced by 10.8 % for Case 20 compared to Case 0. Case 40 reduces the maximum fatigue damage by 13.3 % compared to Case 0.
- Total material cost (steel plus concrete) is reduced by 3.1 % and 4.7 % for Case 20 and Case 40, respectively.

It is concluded that an increased elevation level between concrete floater and steel tower will contribute to a larger fatigue lifetime and a lower material cost for the system.