Sensitivity analysis on increasing rotor diameter on offshore wind turbines with suction foundation.

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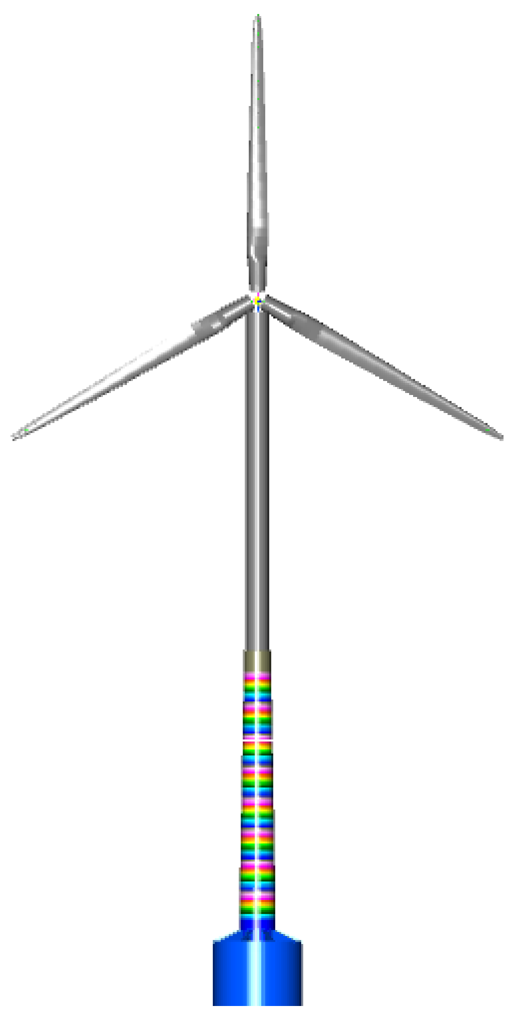
Introduction

Offshore wind turbines has less potential to affect the surrounding environment. Better wind speeds are available, which will result in higher contribution in terms of electricity supplied per turbine. Transportation at sea also gives an opportunity for greater dimensions to the turbine, because land based limitations for transport is removed.

Suction foundation offers a cheaper foundation for the turbine. The steel weight can be reduced by up to half compared with traditional monopoles and is easier and cheaper to install. This thesis investigates the limitations for the second bending mode of the support structure as the rotor diameter increases. Will the second bending mode contribute to reduced fatigue life of the foundation

Method

Fedem Windpower is used for time domain analysis of the structure. Support structure was provided by Statkraft and the turbine is the NREL 5MW reference turbine which is frequently used for wind turbine analysis.



Eigen-value analysis:
An eigen-value analysis is performed in FEDEM to identify the 1st and 2nd eigen-modes and its belonging periods

Sea state:
An irregular sea state based on the JONSWAP spectrum is used in the simulation. Different site specific combinations of significant wave height, Hs, and peak period,Tp, is used in the simulation.

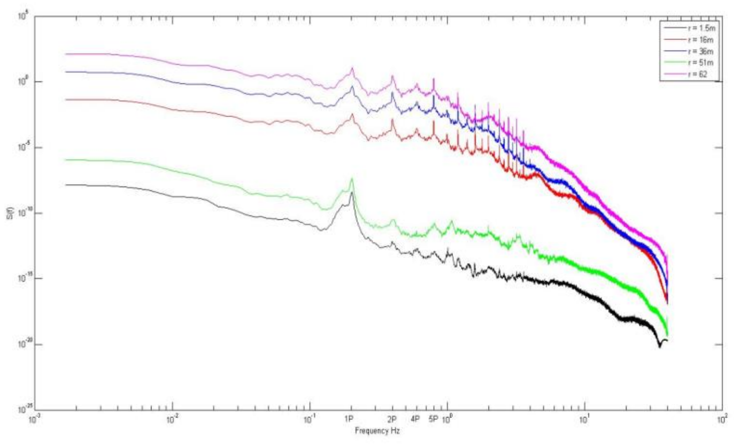
Turbulent Wind:
Three-dimensional turbulent wind field is generated in TURBSIM with a mean wind speed ranging from 2 m/s to 18 m/s at a reference height of 10 meters. The turbulent wind is based on IEC Kaimal spectrum with a turbulence intensity of 18%

Post processing:
The output of the simulations is in the time domain. The results are post-processed in MATLAB to convert the time series into spectral desnsity power spectrum in the frequency domain. This is to make the data easier to analyse. Fast Fourier Transform algorithms is used to convert the time series. Response spectra for different radius at the blade is calculated. Also the response and moment spectra at the mudline is calculated to check if the excitations from the blades propagates to the foundation.

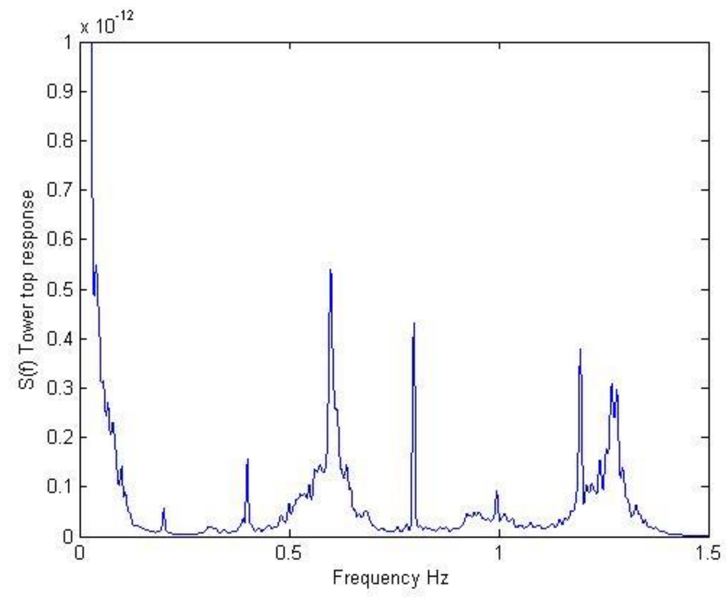
Results

For a mean wind speed of 8 m/s, significant wave height if 2 m and a peak period of 5 s

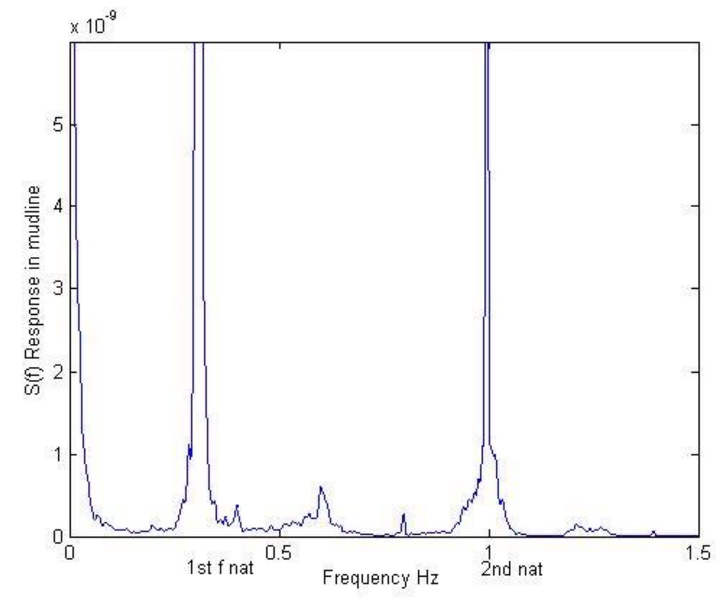
Blade response:
The response power spectrum for blades at different radi at the blade plotet in log-log scale . The response increases with higher radius of the blade. The spectrum also shows peak at the rotational frequency of the turbine and its multiplum. This means that the blades will experience a response peak at the 1P, 2P, 3P… rotational frequency of the turbine where 1P is the rotational frequency of the rotor.



Tower response:
The power spectrum of the reponse at the top of tower shows that it experience a peak at 3P. This is expected from a three bladed turbine because a blade passes the tower at the 3P frequency. We can also se that the top of the tower experience a peak response at 6P to 7P



Foundation response:
The power spectrum of the rotational response at the connection to the bucket shows that it will have a large peak at the 1st natural frequency of the support strucure. Both the periods of the waves and the 1P frequency is relatively close to the first natural frequency and and will create oscillation around this natural frequency.
We can also see a large peak at the 2nd natural frequency of the tower. This is probably the 6P blade response that propagates down to the foundation of the structure.



Conclusion

The work is not completed, and there are still analysis that needs to be completed before a conclusion can be made. The following conclusion is made based on the results that are finnished.

- Larger blade diameter will give a larger response at the 1P frequency and its multiplums
- The responses from the blade will propagate to other parts of the structure. Not only at the expected frequency where a blade passes the tower, but also at higher multiplums of the rotational frequency.
- The second natural frequency of the support strucure plays an important role for the dynamic response. While waves with low frequency will contribute to oscillation around the 1st natural frequency, the excitation of the blades will contribute to oscillation around the 2nd natural frequency.

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