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Influence of foundation model complexity on the design loads for offshore WTG on jacket foundation

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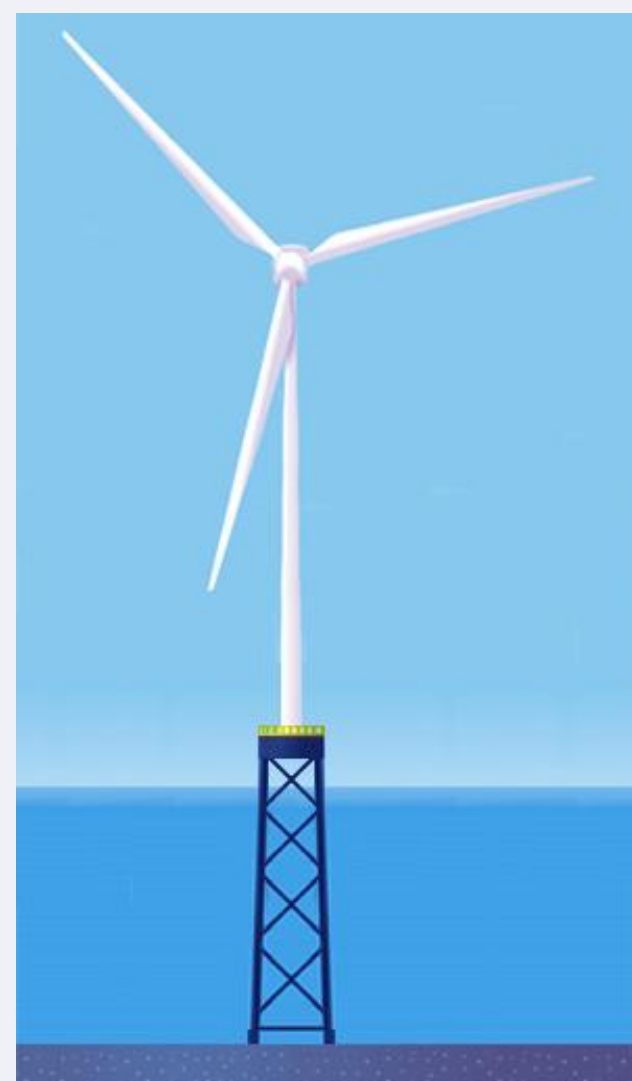
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Abstract

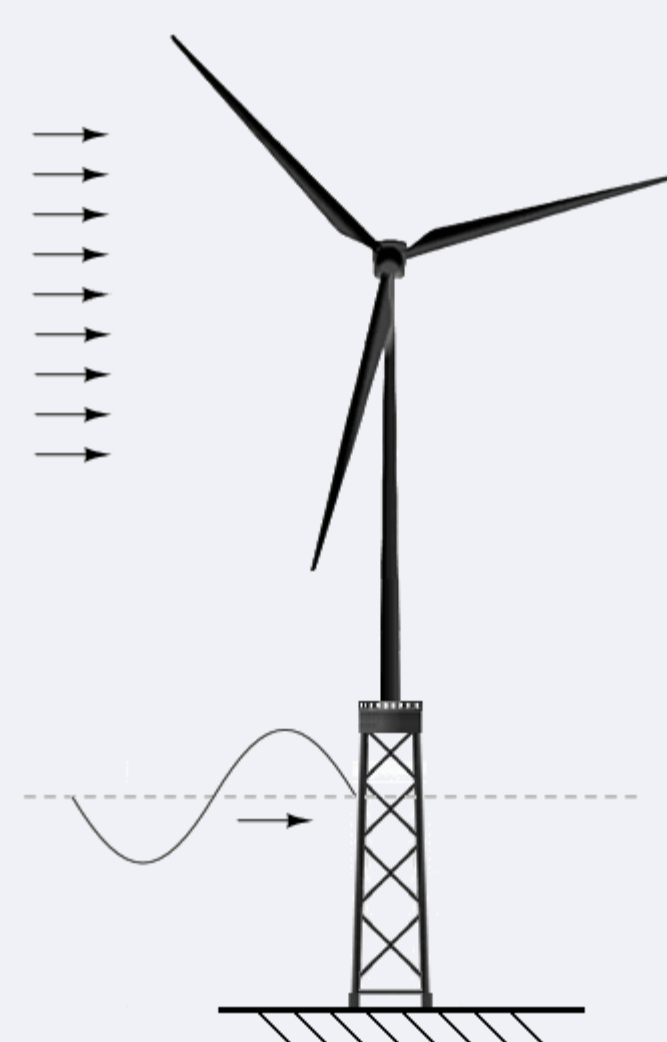


The present work investigates the influence of using different ways of interfacing wind turbine model and foundation on loads in the combined structure. In the design procedure for offshore wind turbines it is common that foundation and wind turbine design loads are obtained in two sequential steps where firstly; the wind turbine designer defines the interface forces and moments in the interface point to the foundation based on either fixed or flexible boundary condition at the interface, and secondly; the foundation designer then uses those loads combined with additional wave and current forces to obtain the design loads for the foundation. The dynamic interaction between the wind turbine and foundation is left out in that procedure.

Herein, three different design methodologies are applied to the same offshore wind turbine with identical turbulent wind (18 m/s) and irregular waves ($H_s=6$ m/ $T_p=10$ s). The 5MW NREL reference turbine [1] on a jacket foundation from IEA Wind Task 30 OC4 [2] is used, and the differences in the design loads are compared using the aeroelastic code, HAWC2 [3].

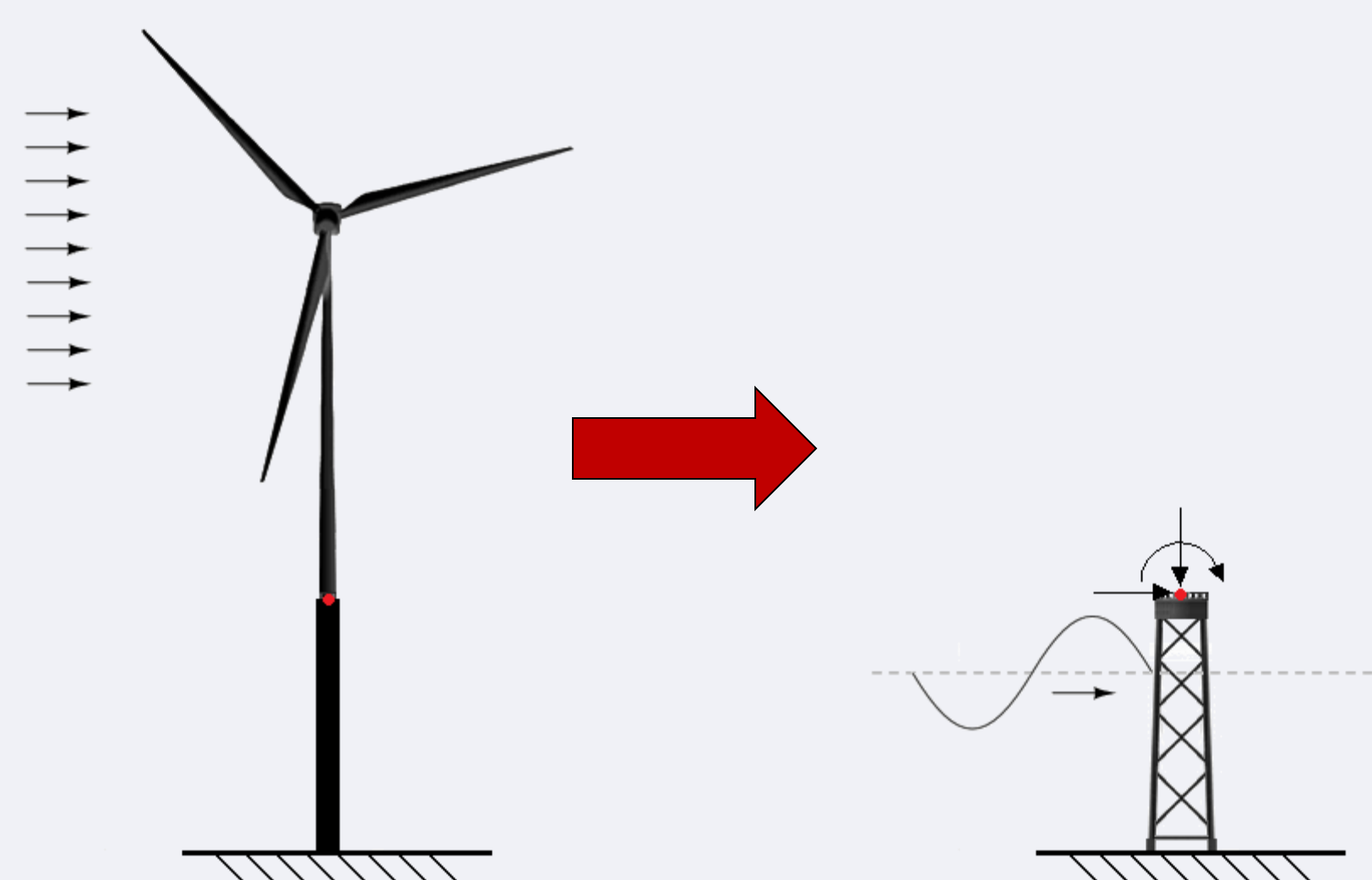
Modelling approaches

1) Fully Coupled model



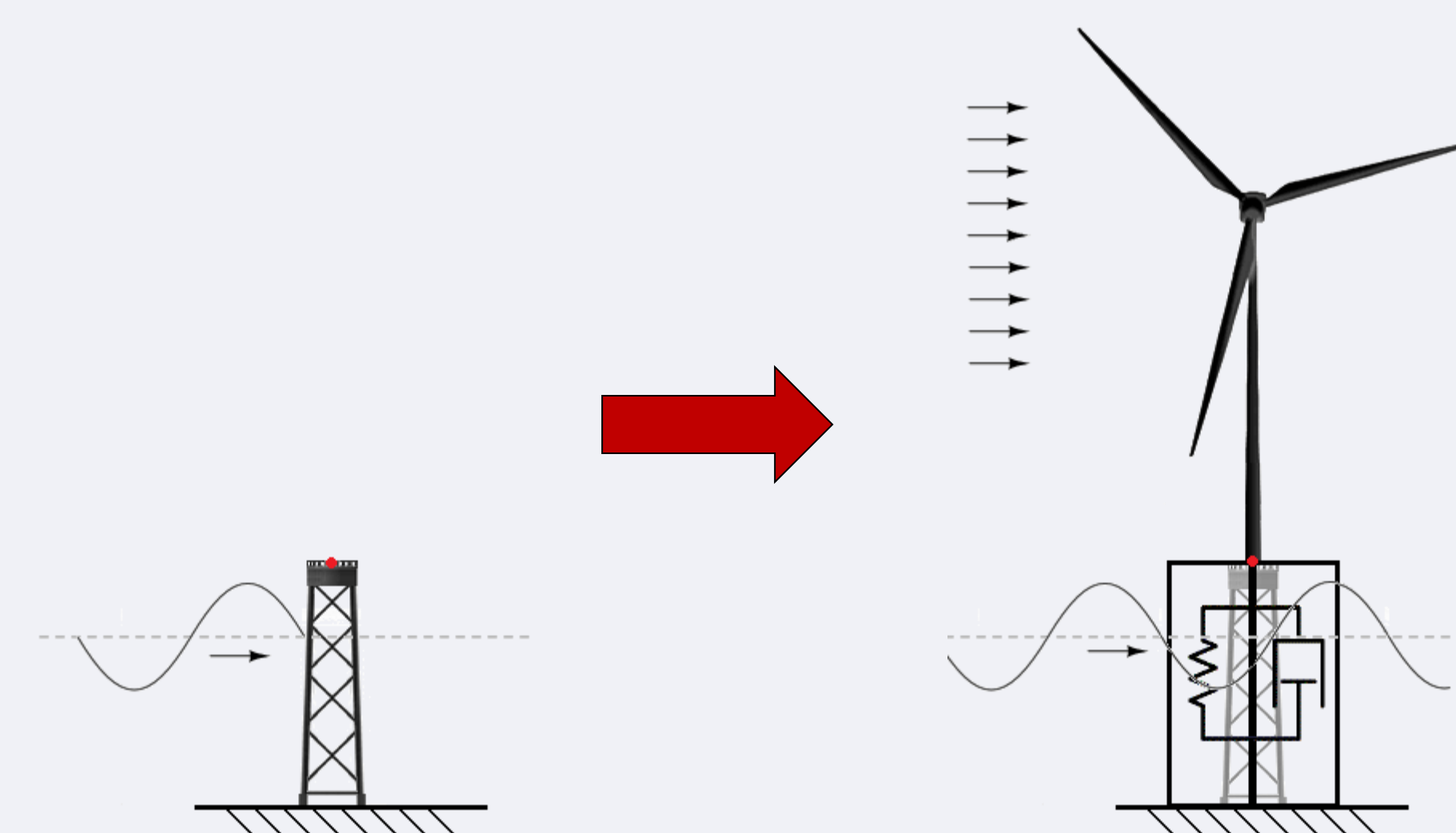
In the fully coupled model, both jacket foundation and wind turbine are combined into one HAWC2 model. This is considered to be the most accurate solution but it also has the highest computational cost. (reference case)

2) Sequential coupled model



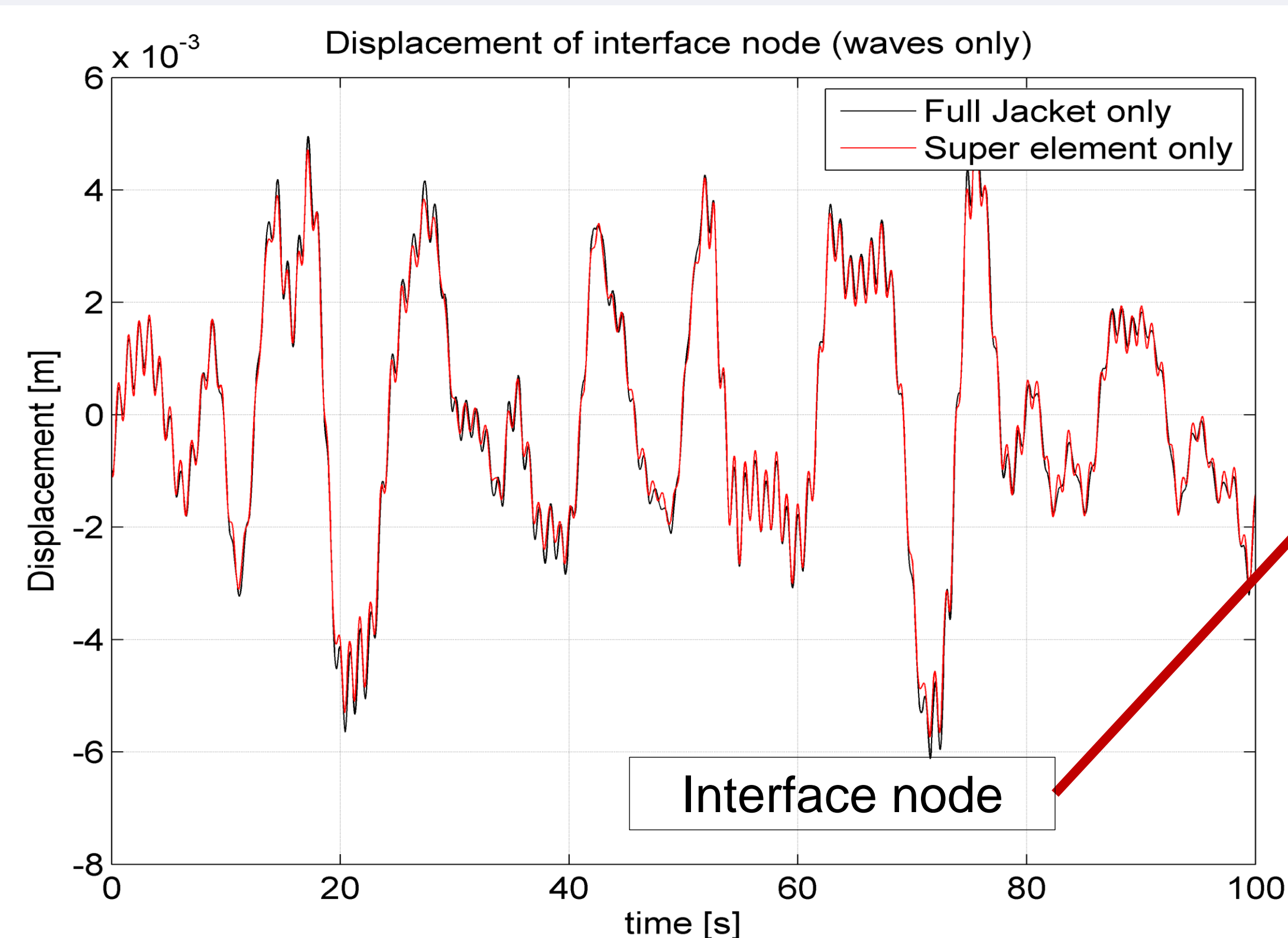
In the sequential coupled model, the load calculations are split into two separate steps. First the turbine loads are obtained from a simulation with a full flexible turbine on an equivalent monopile that represents the stiffness of the jacket. Then the loads are transferred at the coupling point (interface point between jacket/monopile and tower base) to the jacket which is simulated with wave loadings.

3) Super Element/model reduction model

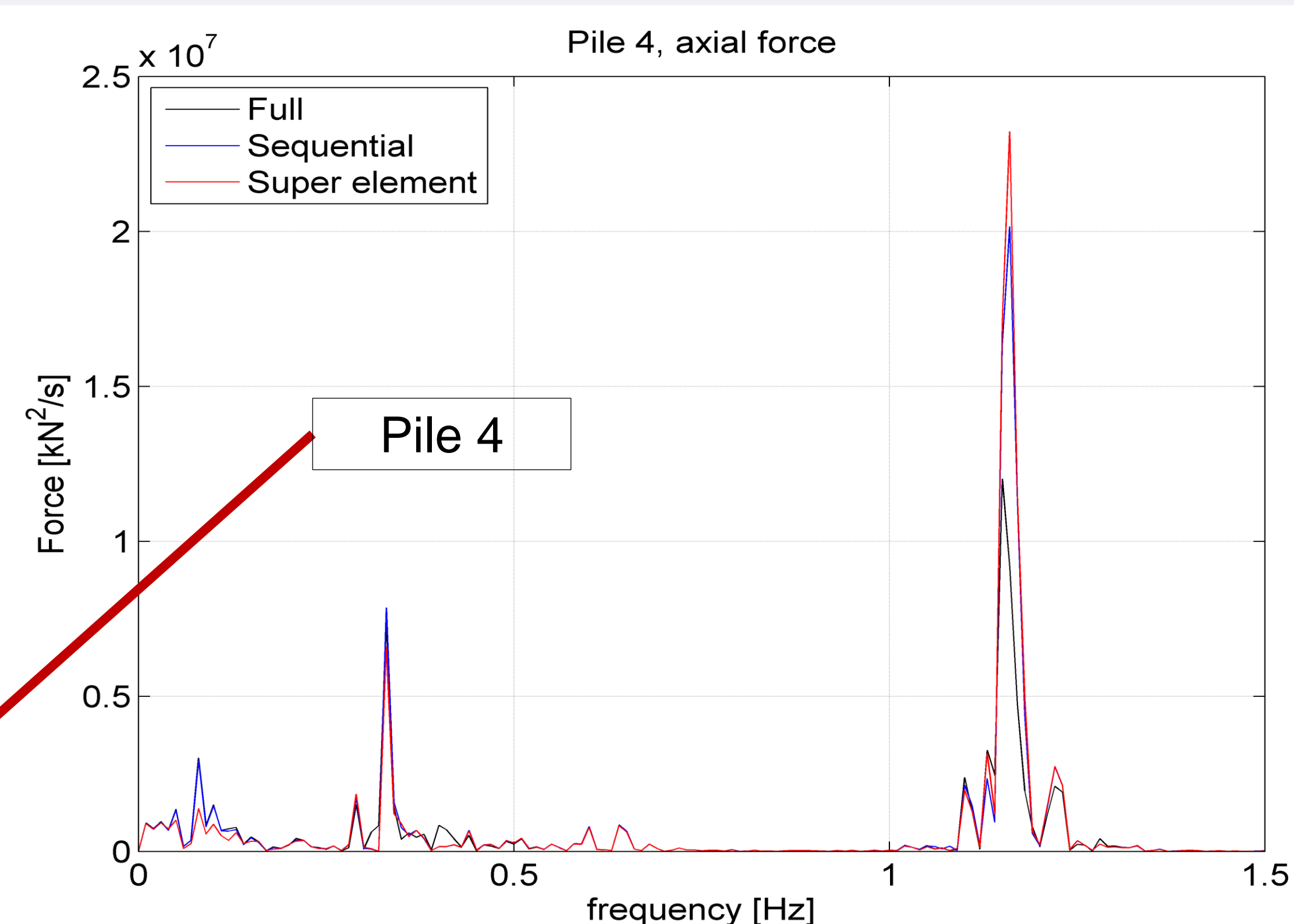
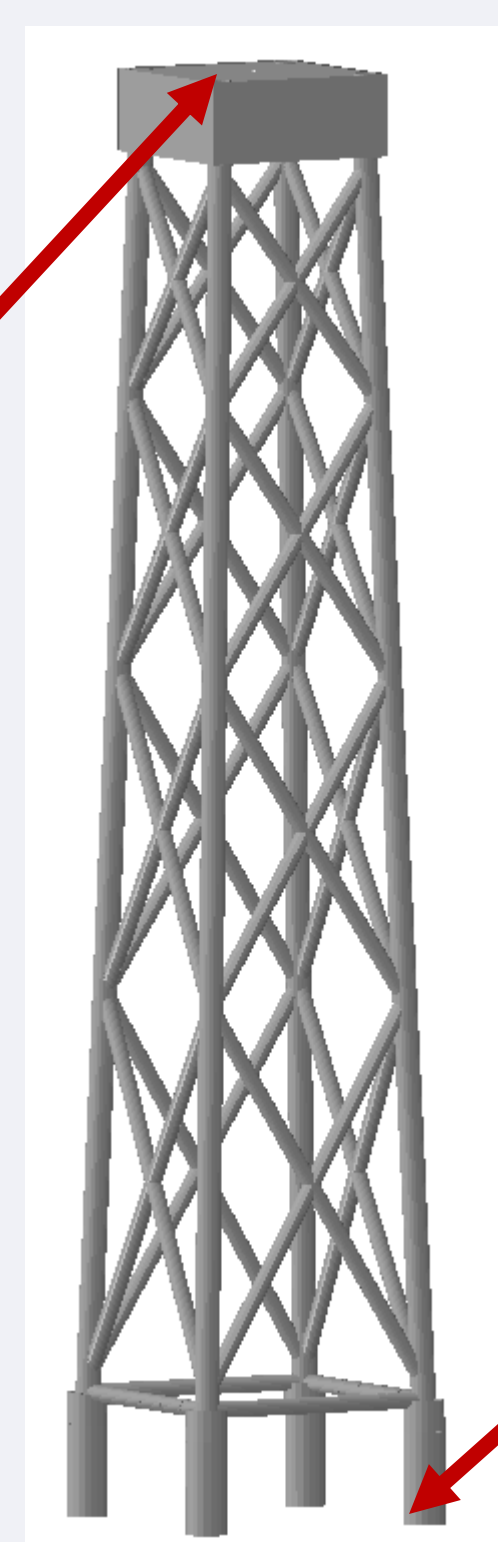


In the super element model, the HAWC2 jacket model is condensed into a newly developed super element and then combined with the wind turbine model at an interface point. The super element is based on a reduction of states of the full foundation model, leaving only a small number of new states (6 in this case) compared to the number of original states (1200), and thus saves computer time during the design load simulations.

Results



The figure shows the displacement of the interface node for the full jacket model exposed to wave load compared with the response of the super element exposed to the equivalent wave load. The match is almost perfect which indicates that the super element implementation in HAWC2 is valid.



The figure shows the power spectrum of the axial force in one of the piles at mud level compared between the 3 methodologies. The high peaks at approx. 1.2 Hz deviate between the models which is probably due to different damping ratios of the models. This needs further investigation.

Conclusion

The super element methodology has been implemented in HAWC2 during this study and the preliminary results indicate that the super element approach is very promising. However, further investigation into which and how many reduced DOFs are necessary in the super element is needed. A comparison between reaction forces simulated by the 3 methodologies shows that the correlation between the 3 methodologies is good, however, both the super element and the sequential approaches overestimate structural loads. The reason for this needs further investigation.

References

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