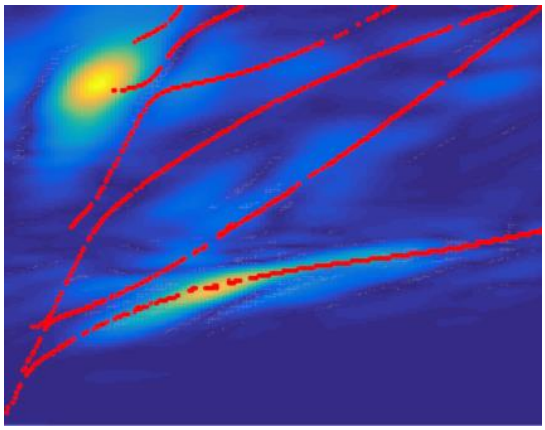
European Wind Energy Master
Offshore & Dredging Engineering

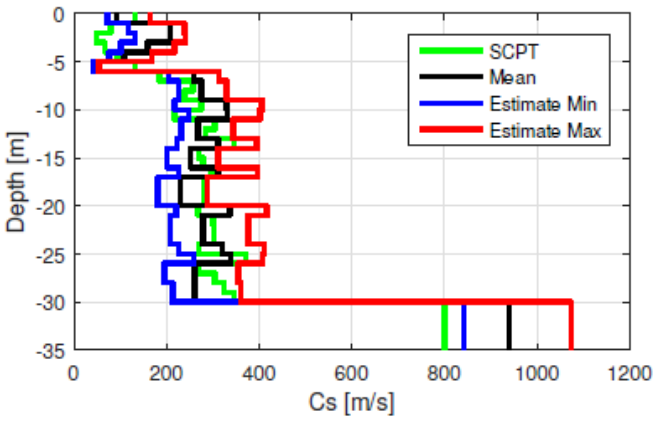
Technische Universiteit Delft

Seismic Inversion Identification of Soil Stiffness and Damping for Offshore Wind Turbines

Innovation is needed to bring down the cost of offshore wind energy. An improved method for estimating the soil stiffness and damping would allow less conservatism in the design and allow costs to be reduced. Currently, cone penetration tests (CPT) and borehole sampling are used to estimate the soil properties. Non-invasive in-situ measurements can determine the soil properties in an undisturbed way, providing a more accurate characterization of the soil properties. This report focuses on the multichannel analysis of surface waves (MASW) technique. The measured dispersion of a propagating seismic wave is used to characterize the variation of stiffness with depth while a modified half-bandwidth method is used to estimate the damping variation with depth. Both require solving an inversion problem with a global optimization strategy.

The equations governing wave propagation in layered visco-elastic media are used to form a theoretical model. A decoupled approach is used to identify first the soil stiffness profile and then the damping profile. To estimate the stiffness profile, modal inversion is performed with a genetic algorithm. The misfit function is based on the determinant of the secular function, including a determinant normalization. Synthetic inversions were first applied to verify that the technique is successful. Surface wave data from the Westermeerwind offshore wind farm is analyzed and several estimates are made for the stiffness profile versus depth using different inversion settings. It is shown that these estimates agree well with a seismic cone penetration test (SCPT) estimate for the same site. An inversion is also performed on a set of measurements taken at the North-Sea Gjøa site. It is shown that the inversion is in good agreement with the published predictions for the stiffness at this site.





The damping profile is inverted based on a modified half-power bandwidth method. A wavelet compression is used to select a smart set of root locations which leads to an efficient inversion. Synthetic inversions show that the method is successful in estimating the soil damping profile, although further research will have to determine the success of this method on measured data.

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