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The overall theme of this research is aimed at developing a better understanding of the behavior of piled foundations for bottom-fixed offshore wind turbines. The currently existing pile design and analysis methods were developed several decades ago for the offshore oil and gas industry and are inadequate for use in large offshore wind applications due to the nature of loading experienced by the piles in such a structure. These currently available methods are quasi-static in nature, and thus not appropriate for performing dynamic time-domain simulations as is required for analyzing the performance of a wind turbine. Additionally, several important soil-structure interaction phenomena are ignored by the existing techniques, a significant short-coming which could possibly lead to non-conservative designs or incorrect fatigue life estimations. A more comprehensive pile model which is dynamic in nature and which accounts for as many soil-structure interaction phenomena as possible is therefore needed to fully and appropriately analyze an offshore wind turbine system including the piled foundation.

This PhD project will aim to develop such a model. Detailed self developed dynamic 3D finite element simulations of a soil-pile system will be created and utilized to define a simple, yet comprehensive model of the dynamic soil-pile system which can be implemented into existing aero-elastic wind turbine analysis software packages. The addition of a properly dynamic soil model to existing wind turbine solvers will allow for a complete analysis of an offshore wind turbine system from pile tip to blade tip. The dynamic soil model will make use of an arrangement of various nonlinear springs and dampers to as fully as possible describe the stiffness and damping of the system at any given instant in time. The model will allow for more nonlinear behavior than the currently available techniques while not significantly increasing the required computational effort.

The ultimate aim of the project is to investigate the effects of a more descriptive soil model on the performance and design of the foundation, the support structure, and the full wind turbine system by comparing the results of time domain simulations of an offshore wind turbine with and without the developed dynamic soil model. Possible impacts to the sizing of the piles and to the fatigue life of the support structure are of particular importance.