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Fluid-Soil-Structure Interaction of Offshore Wind Turbine: An Analytical Approach for Natural Frequency Estimation

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Abstract

With the increasing demand for renewable harvested energy, the size of the turbine blade keeps on increasing which makes the turbine tower much taller and slender. Owing to the advantage of stable wind velocity and space availability, the offshore wind turbines have become prevalent. Wind turbine tower undergoes various dynamic loading in regular operation such as rotor excitation (1P), vibration due to passing of blade (3P), in addition to wind, storm, wave (in case of offshore) and earthquake. Thus, estimation of natural frequency of a wind turbine is of utmost importance to avoid any frequency matching with the regular excitation, 1P and 3P. In this paper, a transfer matrix-based analytical methodology has been proposed to estimate the natural time period of an offshore wind turbine with a mono-pile foundation. Fluid-structure interaction has been incorporated within the study by using hydrodynamic mass throughout the length of transition piece and mono-pile and soil-structure interaction has been considered by providing linear elastic p-y springs throughout the length of monopile. A complete parametric study has been considered which shows the dependency of natural frequency on the various geometric and material properties of both tower and monopile and the material properties of soil. The natural frequency was found to be significantly affected by soil properties, which shows the importance of soil-structure interaction in the design of offshore structures.

Keywords: Wind turbine, Natural frequency, Transfer matrix