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Static and Dynamic Analysis Modeling for offshore Wind Turbine Foundation Structures

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ABSTRACT

In recent years, offshore wind farm in the world has been rapid development, but compared to land-based wind farm, its cost by 60% or more. Among them, offshore wind turbine infrastructure costs the equivalent of twice the land-based wind turbine. In order to effectively lower the cost of offshore wind turbine, would need to make an accurate calculation of the overall structure, and as a basis for design, offshore wind turbine to improve the safety and economy.

In view of this, the paper established the Soil-Foundation-Tower whole analytical model. In this model the non-linear material behavior of the subsoil is described using the Mohr-Coulomb model, contact pair is used to define interaction between the pile and soil, considering the geometric nonlinearity of the tower. The overall structure frequency and static response responses are analyzed using this model. This paper aims to through parameter sensitivity analysis to identify which design parameters have major impact on wind turbine structural safety, and comparing with present specification analysis method, promote the offshore wind turbine design capability.

KEY WORDS: offshore wind turbine, soil-structure interaction, contact pair, frequency analysis; Mohr-Coulomb model

INTRODUCTION

Offshore wind energy is becoming increasingly popular in the quest for renewable sources of energy. The continuous improvement in wind turbine technology means that the wind turbines have increased tremendously in both size and performance during the last 30 years(Simon-Philippe Breton,2009). In order to reduce the costs, the overall weight of the wind turbine components is minimized, which means that the wind turbine support structures become more flexible and thus more sensitive to dynamic excitation. Since the first natural frequency of the offshore wind turbines is close to the excitation frequencies of the rotor system, it is of outmost importance to be able to evaluate the natural frequencies of the wind turbine structure accurately as the wind turbines increase in size. For achieve reliable responses of the wind turbine structure during working loads it is necessary to account for the possibilities of dynamic effects of the soil-structure interaction(Martin Achmus and Yu-Shu Kuo,2009; B. Bienen, M.J,2006)

The aim of this paper is to establish static and dynamic analysis model and evaluate the dynamic soil-structure interaction of foundations for offshore wind turbines, with the intention that the dynamic properties of the foundation can be properly included in a composite structure-foundation system. The work has been focused on one particular foundation type; the monopole foundation. The frequency dependent stiffness (impedance) of the monopole foundation has been investigated by means of a three-dimensional coupled Infinite Element/Finite Element model, where the soil is Mohr-Coulomb plastic model.

NUMERICAL MODELING OF MONOPILE FOUNDATION

For the investigation of the natural frequency and the behaviour of static laterally loaded monopiles with large diameters, a three-dimensional (3-D) numerical model was developed. The computations were done using the finite element program system ABAQUS (Abaqus 2008).

PARAMETERS OF 3MW WIND TURBINE

The purpose of this study is to analyze the soil-pile interaction to natural frequency and the behaviour of static laterally load, For that, an idealized homogeneous soil consisting of medium dense sand was considered. A monopile diameter of D = 6.0 m and a wall thickness of 6 cm was assumed. A 3MW wind turbine was selected, Table1 shows the figures.