Numerical Simulation of Transition Piece - Monopile Impact during Offshore Wind Turbine Installation

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ABSTRACT

Monopile foundation is widely used for offshore wind turbines in water depths below 40 m. After the monopile has been driven into seabed, a transition piece (TP) is required to be installed on top of the monopile to connect the turbine tower. The impact between the monopile and TP may occur due to the random motion of TP in particular if a floating vessel is used for installation. In this paper, nonlinear time-domain structural analysis is performed to study the impact between TP and monopile. Vertical impact cases are presented and plastic material property was defined to consider the springback after the TP has been removed. A sensitivity analysis considering impact velocity, TP eccentricity and inclination angle about two axes is came out. The findings can be used to properly define the limiting crane tip motion, environment condition, as well as the dynamic behavior of the installation vessel.

KEY WORDS: Impact; offshore wind turbine; installation; permanent deformation; springback.

NOMENCLATURE

Optional, but do not use unless it is absolutely necessary. If used, place in alphabetical order, followed by any Greek symbols.

INTRODUCTION

Offshore wind turbines are promising technology that will be developed into an important energy source over the next decades. Up to now, the majority of installed offshore wind turbines in Europe has a monopile foundation. It is estimated that these dominant foundation in the next 5-10 years will be monopiles (European Wind Energy Association, 2012).

For monopile supported offshore wind turbines, a TP is required to be placed on top of the monopile to allow adjustment of inclination and serve as tower attachment (Fig. 1). The general procedure for installing monopile and TP includes 5 steps: (1) Upending the monopile to vertical position by onboard crane; (2) Lowering the monopile down to the seabed; (3) Hammering the monopile into the sea bed; (4) Lifting the TP from the vessel to the top of monopile and resting on temporary supports (5) Jacking up the TP to the correct verticality and fixing it by grouting (Li et al. 2013; Lotsberg, 2013).

The installation process is normally carried out by crane operation with fixed or floating base using jack-up and floating installation vessels (Fig. 2). The jack-up vessel can provide a stable working platform which can completely avoid the effect of wave loads during operation, and the motion of the lifted object mainly due to wind loads. But the preparation time of jack-up vessel for plugging piles, lifting, ballasting, pile pulling is time consuming and will thereby increase the costs. As the other option, floating installation vessel equipped with dynamic positioning system may not be as stable as jack-up vessel due to wave-induced motions, but it is more flexible and effective for transportation from one foundation to another. The motion of floating installation vessel in waves will significantly contribute to the motion of the lifted object.

Fig. 1 Transition piece installed on monopile foundation (E.ON Climate & Renewables, 2012)