

Monitoring the New Fixed Offshore Wind Turbine Foundation in the East China Sea

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We introduced a new fixed structure supporting offshore wind turbines on the Donghai Bridge wind farm in the East China Sea. It is a high-rise pile cap foundation with a cap supported by eight steel piles penetrating soil. This foundation serves as an in-situ test model for a new structure to support offshore wind turbines. To monitor the behavior of the new structure, stress/strain monitoring instruments were installed on four steel piles and in the cap; clinometers were also installed to monitor tilt angles. This instrumentation allows in-situ measurements of the wind speed and direction as well as measurements of the stresses on the piles and cap and the inclination of the tower. From these measurements, the impact of the waves and wind on the tower stress was characterized, as was the relationship between the wind conditions and tower inclination. Additionally, the behavior of the new structure during typhoon Haikui was captured.

INTRODUCTION

With the increasing development of the world economy and severe environmental problems, underground fossil fuel is not a viable way of covering humanity's vast and fast-growing energy needs. Renewable energy is one part of the broader approach needed to overcome the challenges associated with fossil-fuel-driven economies (Kaldellis and Kapsali, 2013; Zhou and Lin, 2013). Above sea level, the wind has higher velocity due to the reduced number of obstacles and smaller wind shear and turbulence (Farmakis and Angelides, 2011). These advantages have driven the fast development of offshore wind farms, especially in the North Sea where monopile foundations are usually applied as a result of their economic advantage in shallow water (Jonkman, 2007; Lombardi, 2010). In the last decade, the Chinese government has attached great importance to offshore wind power development. In 2010, the Donghai Bridge wind farm, the first offshore wind farm in China, was completed in the East China Sea; it consists of 34 offshore wind turbines (3 MW each). The wind farm is located southeast of Shanghai, approximately 8 to 13 km offshore and 1 km eastward from Donghai Bridge, as shown in Fig. 1. The wind turbines are arranged every 1000 m in the north-south direction and every 500 m in the east-west direction. This arrangement is based on the prevailing wind direction, minimizing wake effects and obtaining the highest efficiency from each generator.

The wind turbine blades sit at the top of the high tower, and this causes large horizontal loads and bending moments; therefore, it is crucial to design a highly safe foundation according to hydrogeological conditions. One major design challenge of the

offshore wind turbine foundation is to satisfy applicability and stability under long-term cyclic loads (Bhattacharya, 2014; Zaaier, 2009). The fatigue life of the structure is a critical safety component and must be fully understood. It is also important to ensure that the rotor frequencies are kept away from the system's natural frequency to avoid resonance (DNV-OS-J101, 2004; Swagata and Sumanta, 2015). Additionally, some serious anthropogenic and environmental factors need to be considered, including the structure damping of an impulse response caused by a boat impact (Koukoura et al., 2015), earthquake loading (Yu et al., 2015), and extreme meteorological events.

The hydrogeological conditions in the East China Sea are quite different from those in the North Sea (Lin et al., 2007). A series of soft clay layers with a total thickness of more than 25 m covers the seabed. It is a very complex engineering problem to build offshore wind turbine structures on this soft clay. According to environmental protection requirements, it is necessary to minimize the feedback effects on marine ecology. Therefore, the

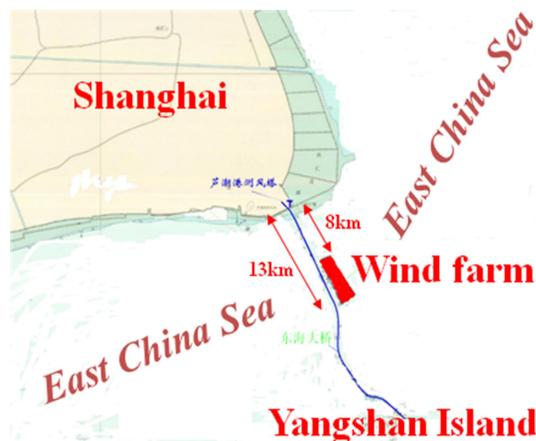


Fig. 1 The location of the Donghai Bridge wind farm

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