An Experimental Study on Overturning Stability of Hybrid Substructures for Offshore Wind Power

Young-Jun You, Youn-Ju Jeong, Min-Su Park

Structural engineering research institute, Korea Institute of Civil Engineering and Building Technology
Goyang-Si, Gyeonggi-Do, Korea

ABSTRACT

A recent trend is installing wind power systems out in the ocean. Many countries either have already constructed or are planning to construct huge wind farms competitively. Up until now, substructures for offshore wind power systems have mostly been built on a mono-pile type due to relative simplicity for construction and cost-effectiveness. However, the mono-pile type substructures may be faced with limitations of size or construction in the near future as the wind power turbines get bigger and the installation sites need to be farther from the shore in order to obtain high-quality wind power. A hybrid type substructure was designed to overcome these limitations. This substructure consists of multi-piles and a concrete base. The concrete base acts as a weight in a gravity type, which has good overturning stability, and the multi-piles plays a role of reducing the wave force, thereby reducing overturning moment. This study is about an experimental evaluation for overturning stability of the hybrid type substructure. A total of three specimens with a size scale of 1/25 including mono-pile, gravity, and hybrid types were fabricated and tested in a basin with 2 m, 3 m, and 100 m for width, depth, and length, respectively. A total of six regular waves were applied to these specimens. The test results of hybrid type were compared with those of mono and gravity types. The hybrid type substructure received less force by the waves than mono and gravity types, and this means that the hybrid type substructure secured better overturning stability than other types.

KEY WORDS: Offshore; wind power; overturning moment; substructure; hybrid.

INTRODUCTION

The global warming has caused engineers to look for more clean and renewable energy, and the “Paris Agreement” in last year will put pressure on the industries to make more efforts than before. Even though there are many types of renewable energy, offshore wind energy has drawn more attention all over the world since it was recognized as sustainable and nondestructive. Many offshore wind farms have already been built or are on planning phase. A notable feature in the trend of offshore wind power systems is that it is planned and built at farther distance from land and deeper water to increase power generation efficiency. This results in the size increase of towers and rotor-nacelles and substructures inevitably should follow this trend. There are several types of the substructures including gravity, mono-pile, jacket, and so on. The mono-pile type substructure takes the largest application cases among them. However, other types has been tested and are being installed more since the mono-pile type is only suitable in relatively shallow water and on relatively good soil conditions.

The cost for foundation and installation takes up 27% in total cost of an offshore wind system as shown in Fig. 1. As the water becomes deeper and the substructure type changes, the cost for foundation and installation increases as shown in Fig. 2, and this might affect the total project cost for constructing an offshore wind farm. Therefore, a substructure which secures stability and capacity and has cost competitiveness is needed when the mono-pile and gravity types are unfavorable.

South Korea has been giving much efforts in gaining renewable energy from offshore wind power. Some offshore wind power systems have been installed around Jeju island and several offshore wind farms are planned. Unfortunately, the soil and ocean conditions of any site are not very favorable. Rock foundation exists under about 40 m from the seabed at southwest of South Korea and any site is in the way of typhoons. For these reasons, a different foundation structure has been studied which consists of multi-piles and a gravity substructure at the bottom of the multi-piles. This is designed to reduce the wave forces and increase the capacity for overturning (Park et al., 2014).

![Fig. 1 Capital cost breakdown for offshore wind system (IRENA, 2012)](image-url)