ABSTRACT

The hybrid substructure system has been developed which can be more suitable to the environmental and geotechnical conditions of southwestern coast in Republic of Korea. In this paper, a modeling method for the hybrid substructure system with a concrete gravity based foundation and a tubular frame is studied and a wave load calculation method is investigated in order to consider slender members and large diameter members simultaneously. In addition, the structural integrity is checked for resonance and ULS (ultimate limit state) condition.

KEY WORDS: Hybrid substructure system; wave load calculation method; concrete gravity based foundation.

INTRODUCTION

South-western coast is one of the most suitable sites in Republic of Korea for offshore wind turbine construction. However, it is difficult to determine appropriate substructure system among various structure types such as a mono-pile, a tripod, a jacket, etc. because the water depth is about 20~30m and the ground condition is very soft clay layer. So, various R&D projects about substructure and foundation types and installation methods are ongoing in Korea. As one of those projects, the hybrid substructure system is proposed, which is composed of the concrete gravity based foundation to provide better ground resistance and the tubular frame near free surface to reduce wave forces.

There have been few studies about the hybrid substructure system because it is not a typical substructure system for wind turbines. In this study, modeling and wave load calculation methods are investigated. The commercial finite element analysis program, ANSYS and offshore design program, SACS and SESAM are used in order to check modeling issues such as connection modeling between the gravity based foundation and the tubular frame, effect of local joint flexibility, mass modeling of RNA (rotor nacelle assembly), etc. Hydrodynamic analysis modules, WAJAC and WADAM of SESAM are used to investigate wave load characteristics due to geometry of the gravity based foundation such as an inclined surface and an immersed upper plane of the foundation.

For practical analysis and design, it is important to make a reliable numerical model and to apply an efficient and reasonable analysis method. However, for offshore wind turbines, it is very hard to use diffraction theory which can be applied to a large diameter structure and complex geometry of the hybrid substructure system because a huge number of load cases and time domain simulation which need a lot of computational work are requested by codes and standards. So, in this study, practical wave load calculation procedure using Morison’s equation with a modified hydrodynamic coefficient is suggested. The proposed method can consider slender members and large-volume members simultaneously and predict wave loads reasonably and efficiently. Also, it can be supported by the wind turbine analysis program such as GH-Bladed, FAST, etc. So, the applicability of the hybrid substructure system can be improved. According to the wave load calculation method, the modeling method with beam elements which can be used with Morison’s equation is verified. Using the proposed modeling and wave load calculation methods, resonance and structural safety of the hybrid substructure system are checked.

HYBRID SUBSTRUCTURE SYSTEM

There are typical substructure types for the offshore wind turbine such as a mono-pile, a tripod, a jacket, a gravity based system, etc. However, it is needed to develop a new substructure system which is more economical and more suitable for the environmental condition of southwestern coast in Korea. For example, in terms of the water depth, a mono-pile can be a good structure type but it is not economical because of deep soft clay layer. On the other hand, a jacket structure can obtain more ground resistance with multiple piles but it is not economical in terms of construction costs.

So, while most R&D projects in Korea investigate typical wind turbine substructure system, this study focuses on the development of a new hybrid substructure system. It is composed of the tubular steel frame on the concrete gravity foundation to provide better ground resistance and reduce wave forces near free surface. The proposed hybrid substructure system and geometrical definition is shown in the Fig. 1.