

Study on Spudcan Soil-Structure Interaction of a Wind Turbine Installation Vessel

Haibin Jin

Department of Naval Architecture and Ocean Engineering, Seoul National University
Seoul, Korea

Kangsu Lee

Korea Research Institute of Ships and Ocean Engineering
Daejeon, Korea

Junhwan Choi

Department of Naval Architecture and Ocean Engineering, Seoul National University
Seoul, Korea

Beom-Seon Jang

RIMSE, Department of Naval Architecture and Ocean Engineering, Seoul National University
Seoul, Korea

A site-specific assessment should be performed before a wind turbine installation vessel (WTIV) operates at a given location. In the present study, structural assessments of a WTIV were performed in the southwest sea of South Korea. Spudcan penetration behavior was calculated, and a load path under the horizontal environmental load was predicted using International Organization for Standardization (ISO) 19905-1. The complex stress and strain state of the soil under the spudcan commonly is simplified, as a boundary condition, to a value of soil stiffness. These boundary conditions include pinned footings, fixed footings, and a foundation model based on the ISO. Soil-structure interaction effects can be considered when the boundary conditions are set as springs with a corresponding yield surface. From the present structural analysis results, a reduction in the stresses of the members at the leg-hull connection could be found. Yield first occurred in the leeward spudcan, after which the moment in the spudcan decreased. Also, penetration depth and soil capacity were found to have had significant impacts on the structural analysis results.

INTRODUCTION

To construct a wind farm at sea, a specialized wind turbine installation vessel (WTIV), as shown in Fig. 1, is needed because of its mobility and cost effectiveness. For the installation of wind turbines, a WTIV should be lifted above the sea surface in order to achieve a steady work environment.

In general, a WTIV has several latticework legs, which are supported by individual footings. These footings are usually inverted cones called spudcans, as shown in Fig. 2. Spudcans have been hot issues, as indicated by the interest shown in the literature. To ensure the safety of a WTIV during operation, spudcans must penetrate into the seabed until a safe condition is achieved. Thus, accurate estimation of spudcan penetration behavior is essential. During installation and operation processes under multilayer soil conditions, if there is a strong layer overlying a soft layer, punch-through might be encountered. Numerous studies on the behavior of spudcans and soil have been carried out since the jack-up system was introduced. Conventional solutions (Hansen, 1970; Det Norske Veritas, 1992; Society of Naval Architects and Marine Engineers (SNAME), 2008; International Organization for Standardization (ISO), 2016) entail the application of bearing capacity equations for homogeneous and multilayered soil conditions. Some numerical analyses and centrifuge model tests also have

been done to compare the results with those using conventional solutions (Zhao et al., 2011; Kellezi and Stadsgaard, 2012; Hu et al., 2014; Chakraborty and Kumar, 2015; Zheng et al., 2017).

Structural analysis of a WTIV should be performed to ensure its safety under extreme conditions. A WTIV, which has various uses because of its relatively short operating time and capacity to move, generally has four or six legs. This even number of legs makes hull stability and the global structural response different from those of a general jack-up rig. To perform structural analy-



Fig. 1 Wind turbine installation vessel

Received April 28, 2018; revised manuscript received by the editors January 7, 2019. The original version was submitted directly to the Journal.

KEY WORDS: Spudcan, bearing capacity, soil-structure interaction, soil stiffness, yield surface.