Research on Scouring Identification Model of Jack-up’s Pile Legs and Boots
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ABSTRACT

Based on numerical analysis and software development, a scouring identification model was developed to identify the jack-up platform damage according to the variation law of stress field in hot spot location of Jack-up’s pile legs and boots. Firstly, the whole finite element model including the jack-up platform and soil was constructed to accurately reflect the interaction between the pile leg and the soil. On the basis of investigating the relationship between the stress field and the scour depth of Jack-up’s legs and boots, the scouring identification model was built by applying neural network algorithm, and the non-linear mapping relationship was established between the stress field and scour depth by training a large number of samples. Finally, through the MFC application program-Visual Studio, the visual software for identifying the scour state of jack-up’s pile legs and boots was compiled, which is convenient for engineering application. From the comparative analysis between the results of numerical simulation and scouring identification model, it is concluded that the scour identification model proposed in this paper has high accuracy and can provide important reference for damage assessment of jack-up platform.

KEY WORDS: jack-up; scouring depth; stress field; neural network

INTRODUCTION

The changeable ocean climate, harsh environment, natural disasters such as ocean storms and earthquakes make the structure of offshore platforms more vulnerable to damage or even failure. For jack-up offshore platforms, the local hydrodynamic conditions around the pile will lead to different degrees of pile erosion. When the pile foundation is scoured and exposed, it may cause the platform to tilt or even collapse, eventually threatening the safety of the offshore platform. In addition to strengthening the monitoring of the marine environmental load and the structure of the offshore platform, it is necessary to study the performance and failure mode of the structure based on the analysis of the monitoring data, finally discover the hidden damages that may occur on the platform and evaluate the service life and early warning of the platform structure.

Since 1970s, scholars at home and abroad have made some progress in the research of dynamic mechanism of pile foundation scour, scour process, scour pit shape, scour depth calculation and the influence of different geological types on scour process. Chow and Herbich (2000) had studied the scouring process of different composite piles under the action of waves and currents through laboratory tests. It is found that the relative scouring depth S/H (S is the scouring depth, H is the wave height) increases with the increase of the wave steepness H/L and the relative depth h/gT^2 (h is the water depth, g is the gravitational acceleration and T is the wave period). Based on the analysis of the data from long-term monitoring of pile foundation scour under wave action, Bayram and Larson (2000) believed that the depth of scour pit formed around the pile is mainly affected by K-C parameters, while the width of scour pit is mainly determined by pile geometry and current characteristics. Sun et al. (2007) calculated the ultimate scour depth of pile foundation of typical platforms in Chengdao Oilfield by using the empirical formula for calculating the ultimate scour depth of pile foundation under the action of reciprocating flow, and proved that the formula has good applicability in Chengdao sea area. At present, the research on pile foundation scour is mainly carried out through on-site monitoring and model test, and model tests are dominant. In the existing model tests, it is difficult to accurately describe the actual scour process of pile foundation and the geometric size of scour pit under the action of wave and tidal current by using the established scale model. Therefore, it is necessary to estimate the scour condition of pile foundation by relying on the empirical relationship obtained from test data. Ma et al. (2018) carried out a series of experiments to study the time development of scour around pile groups under the unidirectional and tidal currents. Considering the impact of Darrieus-type tidal current turbine on the seabed scour process, Sun et al. (2018) proposed an empirical model to predict the maximum scour depth against different tip clearance and rotor radius. Based on experimental results, Lin et al. (2019) proposed an empirical equation for predicting the size of scour holes around the pile foundation of the turbine model. Han et al. (2019) focused on estimating the maximum local scour depth at multiple piles of sea/bay-crossing bridges by developing a new formula using compiled 58 laboratory data and 21 field data.

How to extract structural features for damage identification is an important challenge. In order to achieve this goal, scholars have made a lot of achievements, but there is still a long way to go before it can be applied to the actual structures (Ma et al., 2015). Traditional damage characteristics such as frequency and damping ratio have been recognized as insensitive to damage, while damage characteristics such as curvature mode (Zhao et al., 2008), flexibility mode (Nie et al., 2011) and strain mode developed based on structural dynamic characteristics had achieved good results in the experimental stage, but rarely in large structures. Because the natural frequencies of large structures will change greatly in different seasons during the inspection (Peeters and Deroeck, 2015), some methods that had achieved good