Study on Ultimate Strength of Semi-submersible Drilling Platform

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ABSTRACT

The research on the design method based on Ultimate Limit State (ULS) for the semi-submersible drilling platform was carried out. This paper introduced the ULS, analysis methods for ultimate strength. Then, based on the ABAQUS finite element package, numerical simulations on stiffened plates were performed, especially on analysis methods, effects of initial deflection, results analysis technologies and so on. The numerical simulation technologies were summarized. Furthermore, the structural models, load models and boundary conditions of the semi-submersible drilling platform were analyzed; the ultimate forces and damage modes of the target platform under the load modes due to split force between pontoons, longitudinal shear force and torsion moment about transverse horizontal axis were analyzed; the equivalent models and effects on the results and computational efficiency of stiffened models, and the engineering numerical techniques for ultimate strength of semi-submersible platform were proposed. The structural design technology for semi-submersible platform based on the ULS was proposed. The recommendation for the semi-submersible drilling platform structural design was put up.

KEY WORDS: semi-submersible drilling platform; ultimate limit state; structural design; ultimate strength; numerical simulation

INTRODUCTION

Since the recent twenty years, the ship structure design method is changed from the traditional allowable stress criterion design to the limit state design. The limit state design can make the design more accurate, economical and safe because it considered the various failure modes of structures in the service life. The limit state design are widely used for marine and land structures. The ultimate strength (ultimate moment) of ship hull girder are ruled by the ISO (2007), IACS(2008) and many classification society rules. Furthermore, the ISSC (2003,2006,2009) provided consecutive special reports of ultimate strength. It is a new and different topic for semi-submersible drilling platform to carry out the design based on ultimate limit state. This paper summarized the use of ULS in semi-submersible drilling platform based on the research findings of Marine Design & Research Institute and Jiangsu University of Science and Technology.

As the main drilling unit using to the deep sea drilling, the research and design of the semi-submersible drilling platform becomes a hot research topic at home and abroad. Chakrabarti(2007) calculated the residual strength of a semi-submersible drilling platform with brace damage by numerical simulation method, and discussed the difference of loading conditions and calculation methods between the offshore structures and the monohull ship structures. Estefen(2007) studied the damage mechanism of the stiffeners on the column frame of a semi-submersible platform, and compared the numerical solution of the ultimate strength of stiffened plate with the small scale experimental solution. Zeng(2005) and Yang(2011) calculated the ultimate strength of a semi-submersible platform using a simplified progressive collapse analysis method. Jiang(2010) calculated the ultimate strength of the local structures of semi-submersible platform using nonlinear finite element method. Liu and Zhang(2012,2014) analyzed the ultimate strength of stiffened plate, brace and upper hull structure of semi-submersible platform by non-linear finite element method. As the ultimate limit state design is a new and difficult topic, its studies are still in the initial stage, the analysis methods and standards of semi-submersible platform are in the research progress, meanwhile, there is little rules for reference.

ULTIMATE STRENGTH ANALYSIS METHOD FOR SEMI-SUBMERSIBLE DRILLING PLATFORM

Ultimate Strength Analysis Method for Ship Hull Girder

There are four major calculation methods of the ultimate strength for ship hull girder, they are direct method, Smith's method, Nonlinear finite element method and idealized structure unite method. Direct method is used to evaluate the ultimate strength of ship hull girder by empirical formula and theoretical deduction. It is also called empirical and analytical method. This method builds the calculation formula for ultimate strength of ship hull girder based on the experimental data and theory, and the ultimate bending moment of ship hull girder can be obtained by input relatively few parameters. Smith's method is put forward by Smith(1983). The main idea of the method is based on the plane section assumption, put the stiffened plate as the basic unit, and the hull transverse section is divided into many units to obtain the stress-strain relationship of these units. Then, increase the hull transverse profile curvature and calculate the contribution of these units under each loading step and obtain the ultimate bending moment of ship hull girder. Finite element method can simulate the structure progressive buckling process accurately. It can consider the material and geometric nonlinear problems, and the interaction between the structure can also be considered. So, adopting reasonable modeling