Investigation of the Accuracy of "Time Snapshot" Based Structural Analysis and Design of Jacket Type Platforms

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ABSTRACT

The focus of this article is the evaluation of the traditional method of time domain analysis regarding its assumption that the maximum stresses of the structural members appear at the same time and specifically, at the time of the base shear maximization. Two procedures are followed for the analysis of identical offshore jacket type models in order to gain adequate data for performing comparisons between them. The first, is the generally used method mentioned above, while the second examines every member independently during time domain simulation and reveals the maximum values of their internal forces and moments whenever they appear. Various comparisons between the two groups of results are performed, and the final conclusions are presented.

KEY WORDS: Time Domain; Time Snapshot; Offshore structures; Jacket; Simulation.

INTRODUCTION

The society's needs for energy often leads to the construction of offshore structures; traditionally for oil exploration and production, and for most recently for wind energy exploitation. According to EWEA (European Wind Energy Association, 2012), 235 new Offshore Wind Turbines in nine wind farms were fully grid connected in the year 2011. Offshore structures are subjected to the wave load, which is dynamic and thus, a need for dynamic analysis arise for their safe design. For the dynamic analysis two main approaches are used, frequency domain analysis and time domain analysis. In the case of Offshore Wind Turbines, a time domain approach is preferable primarily due to the nature of the wind load.

Several investigators have dealt with time domain simulation. Kurian et al. (2010) worked on the dynamic behavior of semi submersible platforms. Pollio et al. (2006) investigated the non linear dynamic behavior of risers in the time domain, using an implementation of the Runge-Kutta algorithm. Morooka et al. (2006) demonstrated that time domain can address better riser nonlinearities, while frequency domain analysis makes easier the handling of the solution obtained and requires less computational efforts, in general. Farnakis and Angelides (2011), performed a time domain analysis of a fixed bottom tripod type Offshore Wind Turbine, modeling the Nacelle and the rotor at the top of the structure's tower and imposing a time history of the Rotor load in the analysis of the tower's response. In the above time domain analysis, the authors performed a structural analysis followed by member check and code check for designing the structure. In this structural analysis the stresses were computed by applying the "Snapshot" inertia and static loads that are calculated for the time step where the maximum base shear occurs. This time step is identified in the current paper as "Critical time", and the structural analysis approach as "Time Snapshot Based" analysis. It is generally believed in the industry that the usage of a single critical time is a safe choice and this procedure is being followed by several designers.

In this paper, a different process regarding the usage of time domain results is tried through a powerful software tool which makes possible the observation and recording of the variation of the structural member internal forces during the simulation of the structure's response. The process that is used in this paper will be identified as the "Present method". In the present method, no time snapshot is performed and no critical time is considered. The analysis is based on the calculation and detection of the forces and moments throughout the structure for every time step of the simulation. Logically, this method is closer to reality and more accurate,. The results obtained through this analysis are compared to the results of the time snapshot based method, and the accuracy of the latter is evaluated. It should be noted that the present method requires a vast amount of computations, so it may be a little hard to be applied at ordinary designs, but considering the power of today's processors and the computers' speed, the computational issue may be considered unimportant.

The model chosen for this paper is a hypothetical, but realistic, jacket platform shown in Figure 1, that is considered to be used for oil drilling and production. The location of the platform is at a depth of 52.10 meters. The analysis takes care of the self weight, the equipment, the wave, the marine growth, the entrapped water into the submerged structural members and the buoyancy. The added mass of the structure due to the submerged members of the structure is also taken care of. The environmental data used correspond to extreme conditions and have a return period of 100 years. Since the purpose of the analysis is to compare numerical results, and not to design the structure, the analysis was made for one wave direction only, and there were not applied any