ABSTRACT

The paper focuses on CFD modeling of random breaking extreme wave events and resulting impact loads on a vertical structure. CFD simulations of wave impacts can be a valuable tool in the design stage of offshore structures. In the present paper the wave impact forces on a buoyant offshore structure has been analyzed. It is important to validate CFD model against experimental data in relevant sea conditions. Based on an extensive model test program at irregular sea state conditions, three extreme wave impact events were identified and selected as candidates to be modeled by means of CFD methods. The method applies a numerical model which reproduces the experimental conditions as close as possible. The two flap wave generation mechanism is modeled as moving wall boundaries in the CFD simulation, using a morphing mesh technique for the deformation of the computational mesh in vicinity to the moving wall boundaries. The motions of the flaps are based on the wave generator control signal used during the model tests. The time series of the waves are compared against model test results at several longitudinal positions. At the location of the extreme wave event, approximately 35 m from the wave generation flaps, the steepness of the wave event is reasonably well reproduced, while the height of the wave is slightly smaller than in the experiments. The time history of the wave impact force is also in reasonably good agreement with experiments, although with a smaller peak value. The effect of the design modification is well captured in the CFD simulations.

KEY WORDS: Wave impact; CFD validation; Design Comparison

INTRODUCTION

Semi-submersible platforms for which the weight are increased, due to for example, installation of additional heavy equipment, will need increased buoyancy to compensate for the additional weight. One way of increasing the buoyancy is to mount buoyancy tanks (BT) onto the platform legs. At extreme sea state conditions, the BTs are exposed to wave breaking impact events, which can be critical with regards to loads on the BT and forces acting on the mounting structure between the BT and the platform leg.

Extensive model test has recently been performed at MARINTEK (Pákozdi et al. (2015b)), where the loads acting on two alternative designs of a BT mounted to a semi-submersible platform leg was studied in steep irregular waves, corresponding to a $10^{-4}$ annual probability (Torsethaugen type sea state with $H_s = 20.7$ m and $T_p = 20.1$ sec). The present paper presents results from a CFD study where the aim was to reproduce some of the extreme wave impact events observed during the model tests.

The interest in use of CFD for study of wave impact events has grown during the past years. Increased performance of computational resources, improved physical models and numerical techniques, together with an increased confidence in CFD within the offshore community, has contributed to the usage of CFD. Some of the wave impact studies using CFD are summarized in the following. Most recent effort could be seen in Iwanowski et al. (2014). Wave in deck simulations were performed for both regular and irregular incoming wave conditions. The waves were modeled as Stokes 5th order waves based on careful fitting. For regular incoming waves, fairly good agreement between CFD calculations and experimental measurements were found. While for the irregular waves, the comparison were less satisfactory, especially for the recorded extreme wave event. One reason could be due to the Stokes 5th order input waves, which was found challenging to fitting with measured extreme irregular wave data. In the work by Lande and Johannessen (2011) the irregular waves are instead modeled by means of transient wave groups. Pákozdi et al. (2011) used a one way coupling approach between a fully nonlinear potential flow wave model and a RANS/VOF solver. The potential flow solver was used to calculate the transient wave inlet condition in the RANS solver.

The actual wave flap motion was modeled by Yang et al. (2011) for periodic waves. The generated waves was in good agreement with the experimental waves. Also, the impact pressure on a flat