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Experimental and Numerical Investigations on the Green Water Effects on FPSOs

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ABSTRACT

The paper deals with experimental and numerical investigations on the green water effects on FPSOs decks. The first part describes model tests performed in regular and irregular waves. The influence of the main parameters governing the green water on deck has been analysed : wave height, ship motions, bow shapes. The second part is concerned with numerical modelling of the water propagation on deck using a shallow water theory. The computed wave elevations are compared to experimental results with a fairly agreement. Further experimental and numerical investigations are currently in progress.

KEY WORDS : FPSO, Green-water, Model test, Numerical analysis.

INTRODUCTION

FPSOs are commonly proposed and used for offshore oil production. A major problem related to their hydrodynamic behaviour in severe seas is the influence of the wave diffraction and run-up at the bow and the associated water propagation on the deck. This so-called green-water effect can affect the ship motions, the mooring loads and the deck equipment, particularly at the turret position. Then protection devices would be required on deck to avoid damages. The problem appears more critical for severe head seas. The wave fields is diffracted at the ship bow. When the relative wave height becomes higher than the free-board the water can go on the deck. The water propagation on deck looks like a solitary wave induced by a water wall breaking. In previous investigations (Buchner B., 1995 and 1996) it has been shown that the heave and pitch motions of the ship have a large influence both on the wave over-topping at the bow and on the water propagation on deck. As the green-water phenomena is highly non-linear, both experimental and numerical analysis were performed. The goal of the model tests was to analyse the influence of the sea state characteristics on the water on deck (mass, height, velocity). Then the interactions between water on deck motions and ship motions were investigated from comparisons with a seakeeping numerical model. Numerical modelling concerns mainly the water on deck propagation using the shallow water theory. Some non-linear computations are performing with a Navier-Stokes solver and the VOF method to simulate the wave over topping at the bow.

MODEL TESTS INVESTIGATIONS

Model tests conditions

The model tests were carried out by Sirehna in the 3D wave tank of the Ecole Centrale of Nantes (France). The model scale was 1 :90 (Fig.1). The main characteristics of a FPSO at full scale are given in the table 1.

The model was free to move in pitch and heave, but was locked in surge. Preliminary computations were performed with a diffraction model (Berhault, 1992) to insure that this assumption is valid. As only the behaviour in head seas is analysed, the influence of the roll, sway and yaw motions are neglected. Three different bow shape and three free board heights were tested. The bow shapes configurations were designed to give the same displacement of the model (Fig. 2).

The reference free-board above sea water level (SWL) was equal to 6m. Table 2 gives the free-boards tested.

Measurements

The wave height was measured from wave gauges in front of the bow to obtain the diffracted wave field and the wave run-up along the ship wall. Wave gauges were also fixed on the deck along a vertical mild plate to measure the water elevation on deck (Fig. 3). Additional measurements were performed from a 2D optical flow system, developed by Sirehna, and from video records. The characteristics of the water flow on deck have been deduced : mass, water velocities, water height. In fact the external wave field is obtained in a fixed reference frame and the water on deck in the FPSO reference frame. Then corrections were required using the FPSO motions which were measured using a optical sensor.