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Numerical Simulation of Complex Green Water and Wave Loads on Offshore Structures

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ABSTRACT

This paper presents results from simulations of green water loading on an FPSO and simulations of the behavior of a subsea structure in the splash zone. In both types of simulations non-linear wave effects play an important role. For that purpose the improved Volume of Fluid method (iVOF) has been applied. The green water simulations have been carried out using a domain decomposition technique: The FPSO motions and far field solution are computed by means of linear diffraction theory. The complex flow around the bow is computed with iVOF. The simulations with the subsea structure have been carried out through a coupling between the iVOF method and a traditional time domain simulation tool. The actual response of the structure due to the complex non-linear wave loads has been determined in this way. The results of both sets of simulations have been compared with model tests and show satisfactory results.

INTRODUCTION

There is a need for calculation methods for local flow phenomena of wave impact loading and loading from green water on the deck of offshore floaters. (Non-linear) methods to predict the wave field around the vessel and the vessel motions exist, but when waves are getting steep and are overturning or flowing over the structure, other methods should be used to calculate the flow and resulting loads.

Green water loading is a highly complex and nonlinear process. In Buchner (2002) it was shown that numerical prediction methods for the prediction of green water loading need to take into account the following phases in this process, see Figure 1:

A. Nonlinear swell-up around the bow.
B. 'Dam breaking'-type flow onto the deck.
C. 'Hydraulic jump'-type shallow water flow on the moving deck, focusing into a high velocity water 'jet' when the water fronts from the sides meet.
D. Water impact and water run-up in front of the structure, eventually turning over.

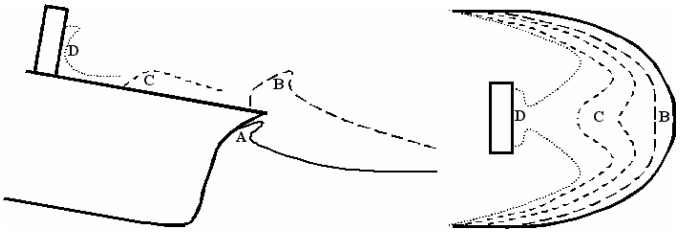

Figure 1: The main phases of the green water problem schematically in side view (left) and top view (right): from the non-linear relative wave motions in front of the bow, via the complex flow onto and on the deck to the impact on deck structures.

In Fekken, Veldman and Buchner (1999) the results were shown of the simulation with iVOF of the flow of green water over the deck of an FPSO and the resulting impact on deck structures. However, the computational domain was limited to the area on the deck. The (measured) freeboard exceedance around the deck was used as boundary condition and the deck was not moving in this approach.

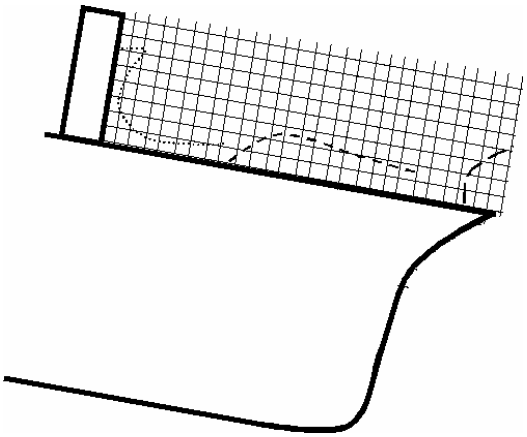

Figure 2: The approach of Fekken, Veldman and Buchner (1999) where water impact and water run-up are also taken into account.