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Evaluation of green water loads on high-speed containership using CFD

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Abstract

Green water phenomenon and the need for an effective simplified model of this problem to assist design process are introduced. Relevant models are revised and used as building blocks to develop a more efficient model. Green water experiments are described and the use of the results to derive defining parameters for the new hydrodynamic model to represent green water is explained. The model of dam-break with initial velocity is developed and simulated using CFD. Loading effects in both horizontal and vertical directions are analysed and compared with experimental results. For horizontal loading, results of the simulation of a conventional dam-break model are also included in the comparison. The comparison shows that a new model of dam-break with initial velocity is adequate to represent green water flow when investigation into green water loading effects is attempted. Improvement on the prediction of vertical deck pressure is possible if deck acceleration and its associated deck pressure component can be included.

Keywords: Green water; Deck loading; Horizontal load; Vertical deck pressure; Vertical wall; Containership; Dam-break; Water jet; CFD simulation

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Nomenclature

DP	deck pressure (transducer)
LC	load cell
WP	wave probe
h_t	maximum green water elevation from forecastle deck
Δt	time difference between recordings of two in-line wave probes
U	average velocity of green water flow
w_b	width of base of trapezoidal section
w_u	width of upper base of trapezoidal section

1. Introduction

In design of high-speed container vessels, external loading due to green water is of major concern since green water loading can cause various damages to structures, cargo, equipment, most critically on the forecastle deck, which is the most exposed part of the ship to heavy seas. When shipped on board, green water sweeps along the forecastle deck, and its horizontal load component can dislocate deck equipment, damage or even throw overboard deck containers, and directly put crew handling deck equipment at risk. The vertical component on the other hand can cause excessive set-down, leading to possible rupture of deck plating.

Successful prediction of green water behaviour and quantification of this loading will undoubtedly help designers to effectively cope with this problem. Much research has been carried out and models developed to represent green water. To model green water flow on deck, Goda et al. (1976) recommended the use of dam-break model to represent the water flow on deck. This work was later extended in more detail by Buchner (1995a,b, 1996, 2002) where he carried out research into green water on working FPSO's. Mizouguchi (1988) implemented numerical analysis based on experimental data to investigate the mechanism of water shipment on board and to understand the characteristics of the water flow on deck. Ogawa et al. (2000) adopted the model of 'flooded wave' to represent the water flow on deck. For spray wetting, Hamoudi and Varyani (1994, 1997, 1998) used dispersion factor to estimate the loading when a small quantity of water is thrown on board. Pham and Varyani (2003) and Pham et al. (2003) observed that water-jet model could be used effectively to solve green water loading problem. Varyani et al. (2004a,b) used CFD as a tool and put together the models of dam-break and water-jet to describe the flow water on deck as an effective method to deal with green water loading. This method was further verified and adopted for investigation into the application of different types of breakwaters, i.e. V-shaped, vane type, double skin with and without holes, and '*whaleback*' forecastle deck by Pham and Varyani (2004a,b) and Varyani et al. (2004a).

This paper aims at describing in more detail the application of hydrodynamic model proposed by Varyani et al. (2004b) in predicting the horizontal loading on deck container stacks downstream. The vertical loading on forecastle deck is also analysed. All the loading components are compared with experimental data. The agreement between