Offloading From Both Sides of a Super-container Ship to Land and Floating Harbor
Predicted vs. Experimental Results

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ABSTRACT

The feasibility of placing a large floating quay on the star-board side of a container ship for offloading from both sides is investigated. A 1:100-scale model test was conducted for the tree-body system in side-by-side arrangement including fixed land wall, a container ship, and a floating harbor with small gaps. The same system is also modeled by a 3D multi-body time-domain motion simulation program and the calculated relative motions and fender/mooring forces are compared against the model-test results. The numerically predicted RAOs, dolphin/fender forces, and motion time histories and their statistics reasonably correlate with those from experiment. The floating harbor system performs excellently for a typical operational condition, while they can exceed operational limits in the worst-possible wave condition. The developed computer program should be a useful numerical tool for the optimal design of future large-scale floating harbors.

KEY WORDS: Floating quay; Super-container ship; Operability of loading/offloading; Relative motions; Comparison against experiment; Time-domain simulation; Three-body system.

INTRODUCTION

With the expansion of global market, the amount of international trade and the size of container ships have grown rapidly during the past decade. In the meantime, the efficiency of offloading containers from the super-size container ship is a critical issue in the ever-increasing competition of commercial ports. In this regard, a new concept, a floating harbor system, has been proposed to expand the capacity of a harbor with fast and eco-friendly construction. The floating quay is a large box-type floating barge with a number of cranes mounted on it. The benefits of the floating quay include (i) less sensitivity against tidal variation, (ii) easier and faster construction and less cost, (iii) independency of soil condition, (iv) adjustable positions, and (v) eco-friendliness and easier removability. On the other hand, the floating system may be more difficult to operate in more severe sea conditions due to possibly larger relative motions. The survivability of the floating quay in extreme environments is another important issue to be resolved.

In Alaska, a prototype floating harbor (213m x 30.5m) has been used for more than ten years in view of very unstable molten foundation. Recently, a series of experiments relevant to the floating-harbor system have been conducted in Korea Ocean Research and Development Institute (KORDI) shallow-water 3D wave basin with the scale of 1:100. The size of the prototype floating quay is 480m x 160m x 6m. It is moored to sea bed by four dolphin posts with fenders. In one of the experiments, a super-size container ship, which is 15000TEU class, is placed between the floating quay and the fixed quay wall. The container ship is moored by a set of hawsers and fenders to the fixed quay.

In this research, the 3-body experiment is investigated by a time-domain coupled dynamic analysis program, and the simulated results are compared with the experimental results. A similar system was also investigated by Kim et al.(2006) by using the earlier version of the same program. The multi-vessel-mooring coupled dynamic analysis program, CHAR2D, has been developed by the research group of the second author during the past decade (e.g. Ran(2000), Kim et.al. (2001), Tahar and Kim(2003), Kim et.al. (2005))

The coupled dynamics of two floating vessels in side-by-side arrangement have been studied by Buchner et.al.(2001), and Buchner et.al.(2004), Lee and Kim (2004), and Koo and Kim (2005). Buchner addressed the increase of hull damping when operating close to wall or neighboring vessels. They also addressed that the second-order wave-induced mean drift forces can be significantly over-estimated especially near the resonance pumping mode in the gap. Concerning the gap resonance, Lee and Kim(2004) examined various remedies to suppress the exaggerated gap pumping mode. Along the same line, to obtain more realistic hydrodynamic values near the pumping mode, Huijsmans et al.(2001) applied 'lid' on the gap. The rigid-lid approach is, however, non-physical and may overly suppress the actual pumping mode.

In regard to the comparative study between simulation and experiment, Inoue and Islam (1999) conducted 2-body analysis based on linear wave theory in both frequency and time domain. Choi and Hong (2002) also studied the 2-body hydrodynamic interactions by frequency-domain approach and compared the numerical results with their experimental results. In the present study, we investigated the hydrodynamic interactions and