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The development of new type free-fall lifeboat using Fluid Structure Interaction analysis

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Abstract

Freefall lifeboats provide a safe alternative to conventional lifeboats for emergency evacuation from ships and offshore platforms. The international regulations require that a lifeboat for free-fall launching should be able to give protection against impact accelerations when it is launched with its full occupants and equipment from at least the maximum designed height. Since the height of offshore structure to the water surface is significantly high, during the water entry phase the acceleration response of the free-fall lifeboat might cause an injury to the occupants. The special hull form design should be applied to reduce the acceleration. The aim of the research is to develop a new type freefall lifeboat for the evacuation system on offshore platform. The new hull form design is proposed and investigated, especially on the acceleration response due to slamming load. The Fluid Structure Interaction (FSI) analysis with the penalty coupling method is used for estimating the acceleration response. The numerical results were compared with the requirements of the IMO regulations.

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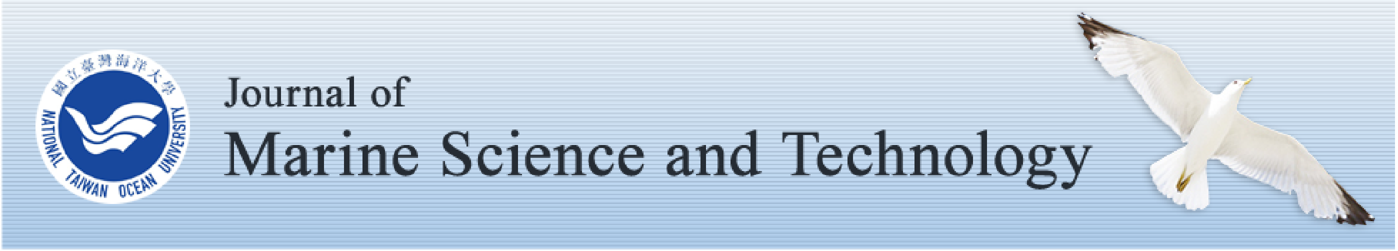

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Naoki Tojo, Kenji Minami, *et al.*
(https://jmstt.ntou.edu.tw/journal/vol19/iss3/9)

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Research Articles

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THE DEVELOPMENT OF NEW TYPE FREE-FALL LIFEBOAT USING FLUID STRUCTURE INTERACTION ANALYSIS

Ahmad Fauzan Zakki[1], Aulia Windyandari[2], and Dong Myung Bae[3]

Key words: acceleration response, fluid structure interaction analysis, occupants safety, freefall lifeboat.

ABSTRACT

Freefall lifeboats provide a safe alternative to conventional lifeboats for emergency evacuation from ships and offshore platforms. The international regulations require that a lifeboat for free-fall launching should be able to give protection against impact accelerations when it is launched with its full occupants and equipment from at least the maximum designed height.

Since the height of offshore structure to the water surface is significantly high, during the water entry phase the acceleration response of the free-fall lifeboat might cause an injury to the occupants. The special hull form design should be applied to reduce the acceleration. The aim of the research is to develop a new type freefall lifeboat for the evacuation system on offshore platform. The new hull form design is proposed and investigated, especially on the acceleration response due to slamming load. The Fluid Structure Interaction (FSI) analysis with the penalty coupling method is used for estimating the acceleration response. The numerical results were compared with the requirements of the IMO regulations.

I. INTRODUCTION

Marine evacuation systems are mandatory requirements to support activities on the ship and offshore platform. The development of marine evacuation system should consider the usability/functionality and habitability to give the long survival period under more severe environmental condition, (Taber et al., 2011). Formerly, the most common lifesaving equipment is the conventional lifeboat. However, many life threatening accidents have occurred with this type of lifeboats during launch into water. This risk has substantially reduced due to the use of free-fall lifeboats recently.

The freefall lifeboats have been designed to be fast and reliable evacuation system. Once the occupants have been gone onboard, the lifeboat is simply sliding from a skid before the free-fall. Some seconds after the water impact, the propulsion system can be started and the lifeboat can sail away from hazard location. Although the free-fall lifeboat has offered a safe alternative to conventional lifeboat, however the injury potential of the occupants was appeared because of acceleration response induced by the slamming load. Regulations for the protection against the impact acceleration were imposed by the International Maritime Organization (IMO) and national regulatory agencies.

Since the height of offshore structure to the water surface is significantly high, the acceleration response would become the main factor on the development of new type hull form of free-fall lifeboat. The particular hull form design should be applied to reduce acceleration response, such as: FF1200 from Schat Harding Company, and torpedo type from Noreq Company. The aim of this paper is to develop an alternative new type hull form of free-fall lifeboat for evacuation system on the offshore platform. The application of the deep V shaped (chine type) as the free-fall lifeboat hull form was investigated for the proposed design. The acceleration response of proposed design was evaluated by the numerical simulation using FSI analysis Technique with penalty coupling method of LS-DYNA code.

II. FSI ANALYSIS FOR ESTIMATION OF ACCELERATION RESPONSE OF FREE-FALL LIFEBOAT

The impact of the boat with the water was formulated on the mathematical equations by using theories of hydrodynamics, (Nelson et al., 1989; Boef W. J. C., 1992 a; Boef W. J. C., 1992 b; Arai et al., 1995). The water entry problem of the free-fall lifeboat could be treated as FSI problems, such as slamming and sloshing. These FSI problems could be conveniently simulated using Arbitrary Lagrangian Eulerian (ALE) formultion and Euler-Lagrange coupling algorithm. Volume of Fluid (VOF) that able to solve a broad range of nonlinear free surface problems is adopted for solving the formulations.

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HIGH-RESOLUTION SURFACE CIRCULATION OF THE BAY OF BENGAL DERIVED FROM SATELLITE OBSERVATION DATA

Mridula Kuttyattu Rayaroth[1], Benny Neettumkara Peter[2], and Mohd Razali Mahmud[1]

Key words: satellite altimetry, surface drifter, Bay of Bengal, surface circulation, Indian Ocean Dipole.

ABSTRACT

High-resolution surface circulation and its variability of the Bay of Bengal are derived by combining surface drifter and satellite observation data. The satellite altimetry data, satellite-tracked surface drifter data and ocean surface winds from satellite scatterometers during 1993-2012 are used. The estimated velocities show good agreement with in-situ acoustic Doppler current profiler observations. The estimated velocity components are significantly correlated with monthly mean velocity components from Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction buoy data. The mean circulation exhibits the strong western boundary current, zonal currents and weak eastern boundary flow. Large spatial and temporal variations are found in the western boundary current and intense mesoscale eddy activity in the western Bay of Bengal. Significant changes in surface circulation during positive and negative Indian Ocean Dipole (IOD) events are evident. During positive IOD, the eastward equatorial jet is reversed and the western boundary current is much weakened. Meanwhile, the western boundary current is the prominent flow during negative IOD events. High eddy kinetic energy is found during strong IOD events.

I. INTRODUCTION

The Bay of Bengal (BoB), the northeastern arm of the Indian Ocean, is a unique ocean with interrelated oceanographic, biological and sedimentary processes driven by monsoon winds. The semi-enclosed nature and the proximity to the equator make the BoB different from other oceans (Fig. 1). Systematic information on the BoB was first obtained from the studies (Duing, 1970; Wyrtki, 1971, 1973) conducted during the International Indian Ocean Expedition in 1960-1965.

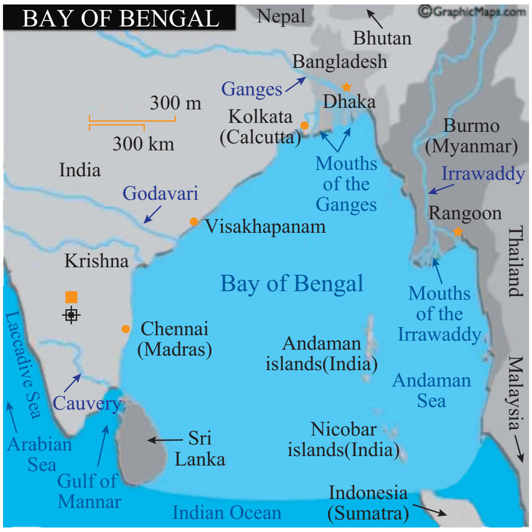

Fig. 1. Geographic location of Bay of Bengal (image taken from https://mygoldenbengal.wordpress.com).

A unique feature of the bay is the extreme variability of its physical properties. Sea surface temperature (SST) in the BoB has significant influence on the climate and monsoon precipitation over the surrounding land masses (Li et al., 2001; Shenoi et al., 2002; Shankar et al., 2007; Jiang and Li, 2011). The SST over BoB is much warmer than that over the Arabian Sea (Shenoi et al., 2002). Temperature in the offshore areas, however, is warm and markedly uniform in all seasons, decreasing somewhat towards the north.

Salinity distribution of BoB is highly heterogeneous with extremely fresh surface water in the northern part of the basin and saltier water at subsurface as well as towards the south. Several studies (e.g., Murty et al., 1992, 1996; Shetye et al.,

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INVESTIGATING MICROSTRUCTURES AND HIGH TEMPERATURE SUPERPLASTICITY BEHAVIOR OF MG-5(MASS%) SN ALLOY BY USING EQUAL CHANNEL ANGULAR EXTRUSION

Hao-Jan Tsai[1], Chin-Guo Kuo[2], Chuen-Guang Chao[1], and Tzeng-Feng Liu[1]

Key words: high temperature plasticity behaviour, Mg-5(mass%) Sn alloy, equal channel angular extrusion (ECAE), Mg_2Sn particles.

ABSTRACT

In this study, we investigated the microstructures and high temperature plasticity behaviour of an Mg-5(mass%) Sn alloy after equal channel angular extrusion (ECAE). These results show that the grain boundary of the as-cast Mg-5(mass%) Sn alloy contained continuous eutectic α-Mg + Mg_2Sn precipitates. After an ECAE process, the average grain size decreased from 147 μm to about 10 μm and the continuous eutectic α-Mg + Mg_2Sn particles were broken down, and those particles distributed uniformly. The maximum elongation was 550 % at high temperature 350°C with strain rate of 1×10^{-3} s^{-1}.

I. INTRODUCTION

Magnesium alloys are the lightest commercial structural alloys and have excellent specific strength and stiffness, and sounds better used in PC or portable information equipment (Kojima, 2001). Plasticity behavior has been proven to play a key role in the manufacturing of complicated parts in the industry. Fine structure plasticity of metals usually requires that the average grain size is distributed homogeneously below 10-15 μm without significant grain growth (Sherby, 1989; Nieh, 1997). High temperatures plasticity has found to exist in several magnesium alloys and their composites such as AZ31, AZ61, AZ91 and ZK60 (Bussiba, 2001; Hiroyuki, 2002; Tan, 2002; Hidetoshi, 2003; Wei, 2003; Yuichi, 2006). In order to increase plastic strain rate by reducing average grain size, several thermo-mechanical processes have been studied, such as extruding (Yuichi, 2006; Park, 2011; You, 2011), rolling (Tan, 2002; Wei, 2003) and equal channel angular extrusion (ECAE) (Hiroyuki, 2002; Yuichi, 2006).

Park et al. studied the extruded Mg-Sn based alloys (Park et al., 2011 and Park & You, 2011). These authors used the solution heat treatment (SHT) and indirect extrusion in a two-step process to produce ultrafine grains (1.5 μm). The results show maximum elongations achieving 670% and 900% at low temperature 200 °C with strain rate 1×10^{-4} s^{-1} due to the fine grain microstructure and the presence of small Mg_2Sn particles; You et al. studied the plasticity deformation mechanism of Mg-Sn based alloy at low temperatures (175°C and 200°C) (You et al., 2011). Therefore, we try to use ECAE process to reduce the size of grains and Mg_2Sn particles; then further evaluate the plasticity deformation mechanism of Mg-5(mass%) Sn alloy at high temperatures (250°C, 300°C and 350°C).

The Mg-5(mass%) Sn alloy was selected because earlier studies reported that the Mg-5(mass%) Sn alloy has good tensile properties and excellent creep resistance at high temperatures. Moreover, researchers investigated that the Mg_2Sn precipitates are very stable at high temperatures (Park, 2005; Chen, 2007; Liu, 2007; Kang, 2007; Wei, 2008; Wei, 2009; Tsai, 2012).

II. EXPERIMENTAL PROCEDURE

An alloy with a composition of Mg-5(mass%) Sn was prepared. Pure magnesium (99.95 mass%) and pure tin (99.98 mass%) were melted in a crucible under the protection of SF6 gas at 800°C. The melted mixture was stirred to ensure homogeneity. It was then held at 720°C for 30 minutes and finally cast into a steel mould that was preheated to 250°C. The cavity dimension of the mould was 300 mm × 70 mm × 60 mm. The ECAE was conducted by a die which is a block with two intersecting channels of identical cross-section with a 120° angled channel through the die via Bc processing route. Bc processing route means that the sample was removed from the die and then rotated by + 90° in the same direction between

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NUMERICAL SIMULATION STUDY OF HYDRODYNAMIC IMPACT OF SEA-CROSSING BRIDGE

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Key words: Quanzhou Bay Sea-Crossing Bridge, Lagrangian-Eulerian finite difference, triangle mesh, marine environmental impact.

ABSTRACT

This paper used the Sea-Crossing Bridge in Quanzhou Bay as an example to simulate its tidal flow field after construction by a semi-implicit Lagrangian-Eulerian finite difference method. Triangle or quadrilateral meshes were used to refine a mesh for the sea area close to the bridge in the model. Each bridge pier was treated as land. The minimum side length of the mesh was approximately 5 meters. The simulation results showed that slow flow areas were formed in front of bridge piers due to the influence of rising and falling tides; at the back of bridge piers, slow flow areas were also formed after rising and falling tides passed the piers. The tide race direction of rise and fall in the main bridge area was basically perpendicular to the bridge site line. The influence domain of upstream and downstream flow along the bridge site line could extend approximately 1 km away. The variation of annual siltation intensity was mainly located in the water area around the bridge piers. The annual siltation intensity of suspended sediment around the main bridge pier increased about 2-20 cm/year. The annual siltation intensities between piers decreased about 1-2 cm/year. The movement of tidal flow and the variation of sediment back-siltation rule would have certain impacts on the marine ecosystem, regional flood control, and navigation in Quanzhou Bay.

I. INTRODUCTION

In recent years, with the rapid development of marine economy, many sea-crossing bridges have been built in the coastal areas of China. After completion of sea-crossing bridge construction, the bridge piers submerged in the ocean resulted in the increase of flow resistance adjacent to the bridge and the decrease of the water-carrying section, which had certain impacts on the tidal flow field of the marine environment adjacent to the bridge site, and also influenced seabed erosion and siltation (Pang et al., 2008a; 2008b) and thus affected the marine environment.

The hydrodynamic impact of a sea-crossing bridge can be studied through a numerical simulation method. Due to the relatively small dimensions of bridge piers, approximately 3 to 30 meters, the generalization of the pier (Pang et al., 2008a) should be taken into special consideration when studying the numerical computation regarding hydrodynamic impact of bridge piers on marine or tidal river environments. Existing treatment methods (Tang and Li, 2001; Chen and Hu, 2003; Cao et al., 2006; Yuan and Xu, 2006; Zhang et al., 2007) mostly include mesh refinement within a certain extent adjacent to bridge piers, then carry out numerical simulation by the additive roughness method, the water-blocking area replacement method, and the additive resistance method, etc. These methods mostly simulate the hydrodynamic effect through increasing friction-resistance coefficient and decreasing water depth based on water-resistance extent; however, they could not characterize the local flow field adjacent to the bridge piers. Therefore, the computation based on these simulation methods differs from engineering actuality, which causes the computational results to have a higher rate of error.

This research used a semi-implicit Lagrangian-Eulerian finite difference method and triangle or quadrilateral meshes to accurately simulate the hydrodynamic environmental impact of sea-crossing bridge construction on a marine area. Each bridge pier was treated as land, with minimum mesh side length of about 5 m, to obtain the refined tidal flow field adjacent to the bridge piers. Based on the predication of hydrodynamic impact, this paper analyzed and assessed the marine environmental impact of sea-crossing bridge construction (Li et al., 2008).

II. PROJECT BACKGROUND

Quanzhou Bay is located off the middle of the south-eastern coast of Fujian Province; it is surrounded by Huian County on the north-eastern side, Quanzhou City on the north-western

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