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Ocean Engineering 31 (2004) 931–941

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# A study on experiment of human behavior for evacuation simulation

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Received 4 August 2003; accepted 5 December 2003

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## Abstract

Walking speed is a very important factor in evacuation analysis for human safety. To provide against emergencies such as abandonment of ship due to accident, the authority body required evacuation analysis for passenger ships. To develop a simulation tool for the evacuation analysis, human behavior data for evacuation situations are fundamentally necessary. In this paper, onboard experiments were carried out twice, once with ship motion and another without ship motion. They were performed assuming the situation where subjects are evacuating under instructions from the crew without panic. Not only individual movement but also group movement with and without motion based on inclination was covered.

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*Keywords:* Onboard experiment; Evacuation; Human safety; Ship design; Human behavior

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## 1. Introduction

There have been many accidents of passenger ships at sea and they have caused huge losses of human lives. The interim guidelines for evacuation analyses for new and existing passenger ships were developed by the Maritime Safety Committee (MSC) of the International Maritime Organization (IMO) and circulated as MSC/Circ. 1033 (IMO, 2002) for the purpose of unified implementation of the requirement of evacuation analysis which is required by regulation. The MSC considered whether the interim guidelines should be made mandatory for large passenger ships

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and, having noted that more data on application of the interim guidelines are needed to validate the methodologies and criteria contained in the above guidelines, agreed that this issue should be further considered by the committee.

In 1995, the 41 m long high speed twin hull passenger liner *St. Malo* (Lockey et al., 1997) was stranded off the shore of France and the passengers evacuated while the ship was listing. The total evacuation time of 308 passengers after the distress signal was recorded as 1 h and 17 min. It is more than nine times the total evacuation time recorded during evacuation drill in stationary conditions, which was 8 min. This is a good example showing that evacuation analyses that does not take account of motion, listing, and the psychological state of the passengers are meaningless in the real world.

In this paper, onboard experiments were carried out twice, once with ship motion and another without ship motion. They were performed assuming the situation where subjects are evacuating under instructions from the crew without panic. Not only individual movement but also group movement with and without motion based on inclination was covered. The results showed that a floor with motion decreases the walking speed by 10–20% and an inclined floor without motion also affected walking speed. The results from the experiments will be used to increase the accuracy of the evacuation simulation system, which is being developed.

## **2. Related works**

Human behavior study in evacuation situations provides important information to engineers, managers, operators and users. It is necessary to test if an appropriate safety system exists to cope with a possible critical situation in order to allocate resources including trained personnel. In addition, designing alarm systems announcing necessary information to passengers in critical situations without correct understanding of human behavior will decrease the overall efficiency of the evacuation system.

Past research reports that walking speed on a flat floor is between 0.98 and 1.39 m/s in case of Asians (Hwang et al., 1991; Fukuchi et al., 1998). Research in Japan (Ando et al., 1988) in busy train stations reports that people of about 20 years of age show the fastest moving speed. On the other hand, research from Europe and Australia reports the walking speed of adult males to be between 1.4 and 1.6 m/s.

To model human movement in an evacuation situation accurately, each evacuee is described as an object with a set of parameters including age, gender, and walking speed. The values of these parameters should be acquired from actual experiments for more realistic simulation. The characteristics and experiment results of major related research are summarized.

The National Maritime Research Institute of Japan experimented on an anchored ship from 1994 for 3 years (Katuhara et al., 1997, 1998). The subjects were 70–120 students of 20 years age. The subjects moved along a predefined evacuation path and the experiment was recorded using a video camera. The results of the experiment

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