Numerical simulation of falling behavior of an upright positioning crew at ship collision

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ABSTRACT

A crew in operation suffers danger of ship collision impact. The transient behavior of seated passengers has been studied. This paper describes a simple three dimensional human body model for a numerical simulation of an upright crew at ship collision. The human model consists from only 200 elements, which enable numerous simulations within a very short time. We carried out a series of numerical simulation to estimate the transient behavior of the upright crew, using 3 different operation conditions, the flat floor, the flat floor with a step and the flat floor with an operation panel, considering the effects of handrail in each case. The direction of the collision is considered too. The results show that the flat floor with a step generates large movement on the body of the upright crew. It also generates large head velocity according to the direction of the collision. We can not expect the effects of the handrail in case of ship collision considered here. The handrail may help us at the accident with very small impact. The existence of a small step on the flat floor may increase the amount of injuries.

KEY WORDS: ship; collision; impact; simulation; crew; head velocity; FEM

INTRODUCTION

Not a few accidents of ship collision against a quay or a ship or a floating wood, have been reported. Some numbers of passengers and crews are injured by the collision against a floor and a wall with these accidents. In April 2006, an accidental collision of a high speed hydrofoil boat with a velocity of about 80km/h (about 22knots) against a floating wood occurred in the southern sea of Japan. All of the passengers and crews injured by the accident. Even some seated passengers with equipped seat belts severely injured to brake their hipbones. The safety of passengers and crews at ship collision is very important especially in case that the ship goes very fast. But there were very limited numbers of research works in the area of the safety at a ship collision.

Shibue et al. focused on the behavior of seated passengers at ship collision. They have developed a simulation method to check the effects of the stiffness of seats and seatbelts on the behavior of the passengers using two dimensional FEM models based on the researches (Igarashi,M.et al,Shimamura,M.et al, and Maki,T. for examples) of automobile collisions.

On the other hand, there is a possibility that a working crew falls down with the accidental ship collision during his operation, and be injured. The falling behavior of an upright positioning crew during his operation, is deeply related to the pose of the crew and the arrangements of the operation facilities of the ship. There were very few studies concerning the effects of poses of the upright crew on the physical damage at accidental collision. A numerical simulation was carried out to see the movements of passengers of trains at the accidental collision. However, the relations between the poses of the passengers or the arrangements of the facilities and the injury of the passengers are not examined by the simulation.

So far as the accidental collision is difficult to avoid, and all of the crews are difficult to keep seated, it is necessary to evaluate the effects of collision between the human body and the equipments, such as a handrail and an operation panel, to keep the safety of the crew considering the human behavior at ship collision. The results should be included in the design of the ship arrangements and in the working regulation of the crew.

This study is to develop a simplified three dimensional human model for the numerical simulation to reproduce the falling down behavior of an upright positioning crew at ship collision. We use a simplified model for the estimation of the qualitative tendency of a human behavior within a short calculation time. The model has almost the same mass distribution with a human body, and has the joints which can rotate up to the limited angles under the certain amount of torque values.

The human model is made from 12 units. Each unit has two solid blocks at its ends, and beam elements connect two solid blocks. The solid blocks represent muscle and fat which work as shock absorbers. The beam elements represent bones which supports a human body. A series of numerical simulation are carried out using this model under the situation of the sudden stop of a ship caused by a ship collision. The parameters used in the series of numerical simulation are facing directions of crews, existence of a handrail and the arrangement of equipments. These parameters are used to examine their effects on the falling behavior of a crew. Based on the series of numerical simulation, the degrees of danger are evaluated for each parameter, which gives suggestions for the safer design of a ship.

3630