

Observation Study the Walking Speed and Distribution of Ship's Passengers as Basis for Passenger Evacuation Simulation

TRIKA Pitana^{1, a *}, KETUT Buda Artana^{2, b} and DIAN Prasetyawati^{3, c}
and Nurhadi Siswantoro^{4, d}

^{1,2,4}Institut Teknologi Sepuluh Nopember, Indonesia

³Universitas Muhammadiyah Surabaya, Indonesia

^atrika@its.ac.id, ^bketutbuda@its.ac.id, ^cdheyan@gmail.com, ^dnurhadisiswantoro@gmail.com

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Abstract. Several marine accidents was occurred in Indonesia. Passenger evacuation is considered as the last defence, which is used for eliminating the consequences of marine accidents. According to the convention of Safety of Life at Sea (SOLAS), the passenger evacuation simulation shall be conducted for reviewing the evacuation route on ships. The pasenger evacuation time is limited 60 minutes for roro passenger ships and for passenger ship having three main vertical zone is limited less than 80 minutes. It is hipotesed that the walking speed and passenger distribution is not represented the character of all nation in the world. Therefore, this research focus on the observation walking speed and distribution in ferry, in order to ensure that whether the guideline (M.Sc. 1238) could be represented in the condition in Indonesia's vessels or not. The results of research show that the diferences result of passenger evacuation simulation between Indonesia's and guideline's walking speed is much closed. On the contrary, the distribution of passenger on the ship in the guideline could not represent the real condition in Indonesia.

Introduction

Several marine accidents was occurred in Indonesia. Recently, there was an roro passenger ship's accident in Tanjung Perak, Surabaya, namely KM Wihan Sejahtera. At that time, the number of passengers was 170 person and had been be evacuated safely. From that point, the evacuation analysis is considered as very important aspect to be carried out in the first step of design of evacuation route. Passenger evacuation is the last defence for saving the life passengers.

The evacuation process is very closely related to the characteristics of the passengers on board. Evacuation time is affected by a passenger walking speed during the evacuation process. Each passenger has a different speed according to gender and age group of passengers. This resulted in not all of the passengers were able to move up to the assembly station during the evacuation process, causing casualties in the event of ship accident. In a study of passenger ship evacuation, evacuation modeling refers to the IMO standard MSC.1238. Guidelines for evacuation analysis for new and existing passenger ships [1] . IMO MSC. 1238 already provide standard speed running or walking speed passenger assumptions that can be used in reviewing the evacuation of passengers. Walking speed passenger is required input data for evacuation assessment.

In order to carry out passenger evacuation assessment, the IMO provides the guideline MSC Circ. 1238, explaining how to conduct simplified and Advanced Evacuation Analysis. However, the walking speed data, mentioned in guideline could not represent the real condition in Indonesia. From this point of view, the research is focusing on the observation of walking speed as well as the distribution of passengers on ship.

Therefore, this paper mainly is composed of 4 (four) sections. Firstly, the backgroud and literature review are presented to describe the originality of research. Secondly, by the observation of passenger on ship, it is pointed out that the different walking speed between the IMO's Guideline and observation are presented. Thirdly, the comparison evacuation simulation based on the IMO's Guideline and observation is perfomed. Lastly, the importance of the usage of observation data are shown rather than the the usage of IMO's Guideline.

Literature References

Characteristic of walking speed for Indonesia people might be different from walking speed of people in other countries. Several studies have been done to retrieve the data speed of people in each country. The pedestrian research had been conducted by Fruin since 1971. Fruin observed the 1000 pedestrians, without carrying any personal belonging. The study showed that the walking speed of male was faster than female[5]. The pedestrian research, which is related to walking speed of gender and age also had been carried out by Wilson and Grayson. Average walking speed of male and female are about 1,32 m/s and 1,27 m/s respectively [6]. Tanaboriboon and Guyano (1991) have observed the speed of pedestrians in the city of Bangkok with the object intersection, having signs of traffic.

The results showed that the speed of crossing male pedestrian was 1.31 m / s and a woman pedestrian was 1.23 m/s [2]. On the other observation walking speed, Tarawneh (2001) evaluated the pedestrian in Jordan and found that pedestrians aged 21-30 years is the fastest walkers, male speed (1.35 m / s) was significantly higher than the speed women (1.33 m / s). However, the pedestrian, have age 65 years is the slowest group [3]. Research walking speed in the US is done by Knoblauch et al. (1996), the study found an average crossing speed of 1.51 m / s for hikers young and 1.25 m/s for older pedestrians in the cities of East Florida [4]. Knoblauch found that walking speed of young pedestrian is about 1.25 m/s and old pedestrian is about 0.97 m / s. It is recommended that the walking speed for older pedestrian is about of 0.9 m /s. Armstrong et al (1996) was focusing on the research relating to disable walking speed. It was observed 116 females, who were 45-70 years old and had experience of hand fracture [7]. Several studies relating to pedestrian evacuation also had been conducted in Indonesia, which was conducted by firdausi et al, pradiya et al and arfi et al [8,9,10]. Therefore, it is shown the importance of this study. In addition, the study relating to walking speed and passenger distribution using agent based modeling has not been conducted by previous researcher.

Methodology

In order to solve the research, the scope of study is consisting of, first, identification of the problem and collecting data of walking speed through field observation; second, modeling the passenger evacuation and the last, making the conclusion. Problem identification was focusing the problems, which are faced during conducting a research, such as method of observation, measurement of walking speed and how to modelling the evacuation. Second step, the modeling passenger evacuation was conducted using Agent Based Model (ABM) simulation and last, the conclusion is showing the result of research.

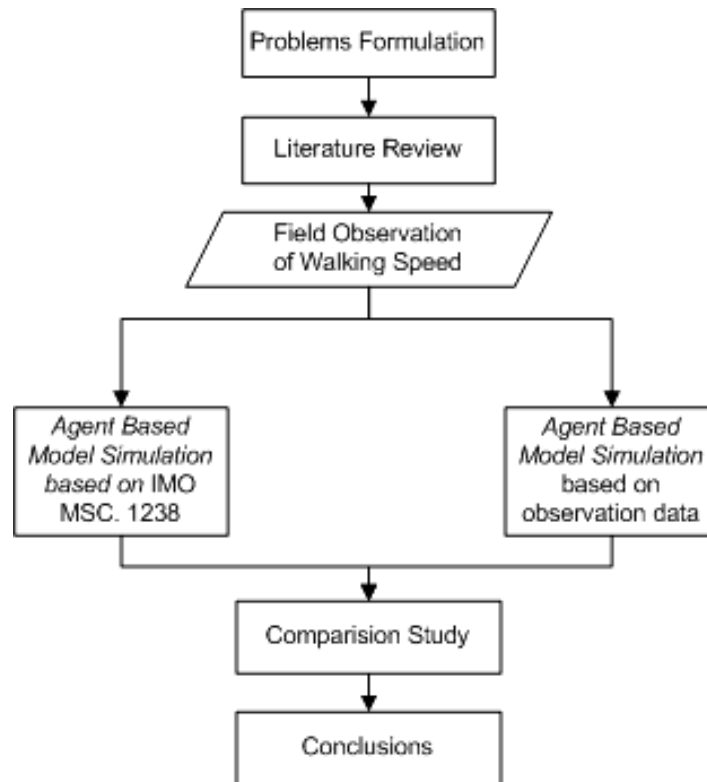


Fig. 1. Framework of Study

Several assumption shall be taken for conducting a simulation. The walking speed of passengers are assumed based on MSC.1/Circ.1238 and field observation on Ferry. The responses times of passengers follows lognormal distribution as described in MSC.1/Circ.1238.

Results

Field Observation of Walking Speed

Table 1 shows that the distribution of passenger on Ro-Ro Passenger is as follows: *female*<30 = 12%, *female* 30-50 = 21%, *female*>50 = 5%, *male*<30 = 19%, *male* 30-50 = 31%, *male* >50 = 12%. The distribution showing different with the guideline, described in MSC. 1238. It means that the assumption of distribution could not be used for evacuation simulation of Indonesia's case.

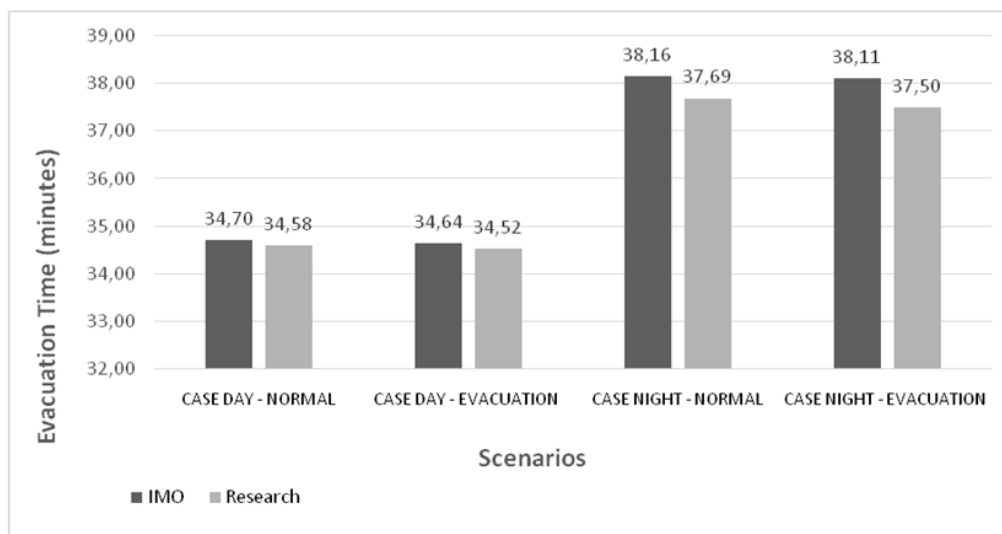
In addition, the walking speed are quite different with the guideline as shown in Table 2. The result shows that the different result is not so large, therefore, walking speed, based on guideline could represent the passenger condition in Indonesia.

Table 1. Observation Result of Passenger Distribution on Ro-Ro Pasengers

Category	Composition's Percentage	MSC.1/Circ. 1238 Percentage
Female <30 years old	12%	7%
Female 30-50 years old	21%	7%
Female > 50 years old	5%	16%
Male < 30 years old	19%	7%
Male 30-50 years old	31%	7%
Male >30 years old	12%	16%

Table 2. Result of Observation regarding to Walking speed

<i>Gender</i>	<i>Age</i>	<i>Sampling</i>	<i>V min</i>	<i>V average</i>	<i>Vmax</i>
Female	<30	36	0.74	1.19	1.70
Female	30-50	39	0.82	1.05	1.33
Female	>50	28	0.74	0.93	1.14
Male	<30	35	1.04	1.39	1.92
Male	30-50	76	0.86	1.21	1.50
Male	>50	41	0.76	1.08	1.48
Crew	male	18	0.80	1.26	1.92

**Fig. 2.** Summary of Evacuation Modeling

Simulation

The passenger evacuation simulation is carried out by using pathfinder, which is considered as agent based model. The scenarios of simulation consider the night and day scenario. The passenger simulation is carried out in Roro Passenger, which could be occupied 672 passengers and 48 crews.

In day scenario, It was found that majority staying in public space, such as passengers's deck, restaurant's deck and navigation's deck. This condition is basically similar to the population category, which is described on IMO's Guideline MSC. 1238. In addition, In night scenario, the passenger distribution is quite similar to the passenger distribution in day scenario.

Based on the result of simulation, it shows that the difference of total evacuation time is not different when the simulation use observed and IMO's data walking speed in both scenario as shown in Figs 3 and 4. It indicates that the usage of IMO's data walking speed is still relevant and could be used for estimation passenger evacuation time.

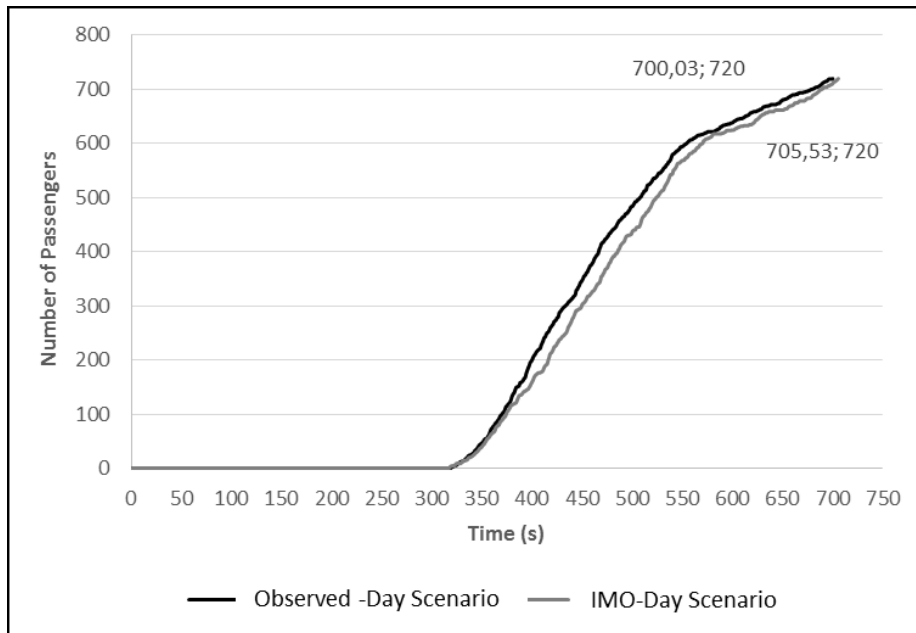


Fig. 3. Result of Comparison Simulation between Observed and IMO's data walking speed at Day Scenario

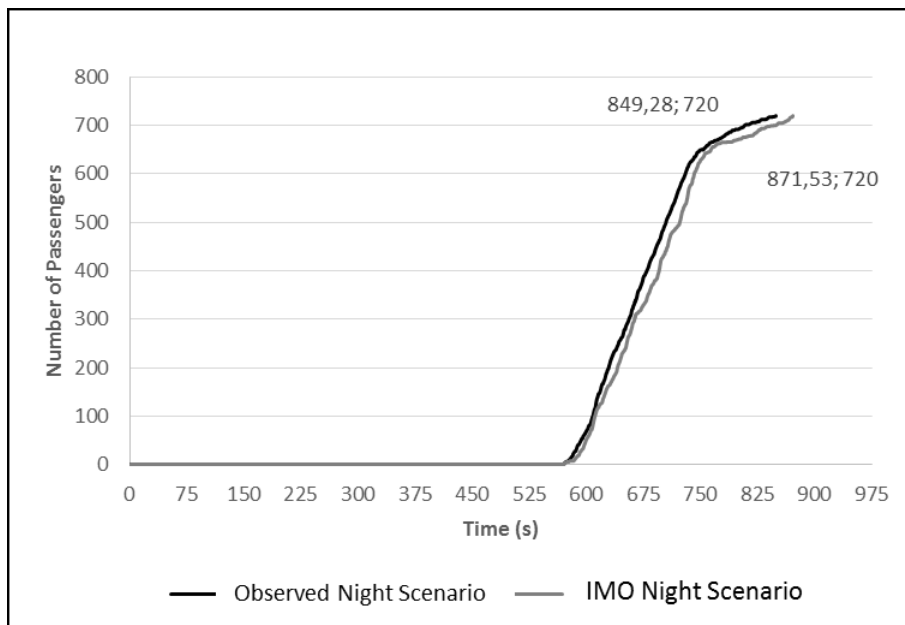


Fig. 4. Result of Comparison Simulation between Observed and IMO's data walking speed at Night Scenario

Summary

The result of research could be summarized as follows:

- The distribution of passenger based on MSC. 1238 is not applicable for the case on RoRo Passenger in Indonesia,
- Total time of evacuation with the data speed of research results is shorter than the used data IMO/MS. 1238.
- The differentiate in total evacuation time between data IMO and research is not too significant, it could mean that the data is relevant IMO if applied to the case of evacuation in Indonesia

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