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Analysis of Passenger Evacuation Time During Fire on KL Sultan Hasanuddin

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Abstract

The aim of this study is to determine the time required in the evacuation of the passengers KL. Sultan Hasanuddin when it experienced a fire based on IMO regulations. Data from the National Transportation Safety Committee (KNKT) shows that 221 shipping accidents were investigated during 2007-2023. The majority of accidents are classified as ships on fire (33 percent) with one of the biggest handling focuses on passenger ships and most of the accidents resulted in fatalities, so it is necessary to provide input and information regarding the evacuation of passengers and cadets regarding the process and time of evacuation when the ship experiences a fire. The type of research is quantitative research using pathfinder software simulation whose evacuation route is based on safety plan data for KL. Sultan Hasanuddin. From the simulation results and analysis obtained the time required in evacuating passengers KL. Sultan Hasanuddin when experiencing a fire based on the provisions of IMO MSC.1/Circ.1238 in night conditions is 25.44 minutes and in daytime conditions 24, 43 minutes, which is faster during the day due to the distribution of passengers on the deck which reduces the density on the evacuation route. The alternative evacuation route on the main deck is 24% faster than the evacuation route planned in the Safety Plan, thus providing an opportunity for passengers to evacuate faster and avoid fire smoke.

Keywords: Evacuation, KL. Sultan Hasanuddin, IMO, Pathfinder.

1. INTRODUCTION

The National Transportation Safety Committee (NTSC) data shows that 221 shipping accidents were investigated during 2007-2023. The majority of accidents were classified as ship fires (33 percent) with one of the biggest focuses on passenger ships and most of the accidents resulted in human losses [1]. From the existing accident cases, it is necessary to study more deeply related to shipping safety. The study can provide recommendations to several parties related to shipping safety. One of the shipping safety factors is the evacuation of the ship during an emergency. Passenger evacuation is an important factor in reducing the number of victims of ship accidents that occur [2]. Figure 1 shows that the KMP Mutiara Berkah I ferry fire occurred at the Indah Kiat Port dock. The ferry fire in Merak caused a number of people to be rushed to the hospital [3]. There were 159 passengers and crew on board, and all passengers were evacuated after the fire consumed the ship. Although no one died after all passengers were evacuated to the mainland, there were 5 passengers who were rushed to Krakatau Medika hospital due to shortness of breath.

From several statistical data presentations, it is very important to reduce the number of fatalities and injuries due to ship accidents that occur. Therefore, it is necessary to evaluate the evacuation handling of the crew and passengers during a ship accident or something undesirable. By reducing the evacuation time to a minimum, it will be possible to reduce the number of casualties and injuries if the ship has an accident [4]So it is necessary to evaluate and provide solutions for the evacuation process in the event of an accident. The analysis process, especially in the evacuation of passengers, still uses IMO (International Maritime Organization) standards related to walking speed data from both passengers and ship crew [2]. So far, the evacuation analysis used to evaluate the evacuation of passengers and crew has used the running speed data issued by IMO in IMO MSC.1/Circ.1238 [5], [6]. Although IMO is a world maritime organization that makes standards and rules regarding maritime on an international scale, therefore research is planned on

applying the IMO MSC.1 /Circ.1238 standard. with the object of research on passengers using ship transportation in Indonesia.

Figure 1. Kapal Feri KMP Mutiara Berkah I terbakar di Pelabuhan

Based on SOLAS rule II-2/28-3 which explains that passenger ships have an escape way must be evaluated with an evacuation analysis at the beginning of the ship design. The analysis is used to identify and eliminate congestion or accumulation of people during the evacuation process along the escape route. This analysis is used to demonstrate an escape arrangement that is flexible enough for the possibility that some passengers may not be able to reach the escape route, assembly station, embarkation station or lifeboat [7]. KL Sultan Hasanuddin is one of six units of 1200 GT (Gross Tonnage) cadet training vessels built by the Ministry of Transportation to support activities and improve the training capabilities of cadets of sailing schools or prospective Indonesian sailors [8]. The ship's capacity can accommodate 21 crew members, 4 VVIP passengers, 10 instructors, 100 cadets, and 100 passengers. In this study took a sample of the KL ship. Sultan Hasanuddin, which is expected to provide input and information regarding the evacuation of passengers and cadets regarding the process and time of evacuation when the ship has a fire.

2. METHODS

This type of research is quantitative research using simulation, which can provide information on how long it takes to evacuate KL passengers. Sultan Hasanuddin when experiencing a fire based on IMO regulations. This research activity was carried out in accordance with the theme of the Makassar Polytechnic of Shipping Science research road map on Sea Transportation, which is in line with the Focus Area of each Nautical Study Program in Maintaining the Safety and Security of Ship Crew and Passengers as well as the Operational Conditions of Life Saving Safety Systems, Fire Fighting and Others. This research was carried out on the KL ship. Sultan Hasanuddin owned by PIP Makassar which operates in South Sulawesi. The types of data collected in this study include primary data and secondary data. Primary data, namely data taken from direct measurements on the ship, such as the size of the evacuation gangway (path) on board and passenger walking speed data. Secondary data, namely data obtained through literature studies and KL ship data. Sultan Hasanuddin such as general plan drawings, ship Safety Plan, passenger statistical data, and walking speed that have been studied before. Data processing for simulation modeling will be carried out with software that helps the simulation process by modeling passengers on board with a fire scenario.

3. RESULTS AND DISCUSSION

3.1. Principal Dimension of Ship

Figure 2 shows KL Sultan Hasanuddin is one of six units of 1200 GT (Gross Tonnage) cadet training vessels built by the Ministry of Transportation to support activities and improve the training capabilities of cadets of

sailing schools or prospective Indonesian sailors. But currently KL. Sultan Hasanuddin operates for public passenger transportation on the islands and ports of South Sulawesi.

Figure 2. KL. Sultan Hasanuddin as Sample

The data on the main size of the ship and the capacity of KL. Sultan Hasanuddin is more clear as follows:

Ship Name	: KL. Sultan Hasanuddin
Tipe of Ship	: Training Ship 1200GT (Spesial Purpose)
Length (LOA)	: 63.00 Meter
Breadth Moulded	: 12.00 Meter
Depth Moulded	: 4.00 Meter
Draft Moulded	: 2.80 Meter
Crew	: 20 Person
VVIP	: 4 Person
Instruktur	: 10 Person
Cadet (Man)	: 80 Person
Cadet (Women)	: 20 Person
Passengers	: 100 Person
Total Power	: 2 x 759 Bkw
Gross Tonnage	: 1200 GT
Speed	: 12 Knot

The evacuation route or escaping route is obtained from the safety plan layout which displays the existing evacuation routes on the ship. The evacuation route will determine the direction of passengers to go to the assembly station or assembly point when a hazard occurs on the ship. Figure 3 shows an example of an emergency assembly point symbol or logo or assembly station is a place on an open deck (usually on the lifeboat deck) that is used to gather everyone during an emergency such as a ship leak, sinking ship, collision, platform collapse, fire, explosion, and others. On the evacuation route of KM. Sultan Hasanuddin assembly station is located on deck 3 (crew deck) and deck 4 (bridge deck).

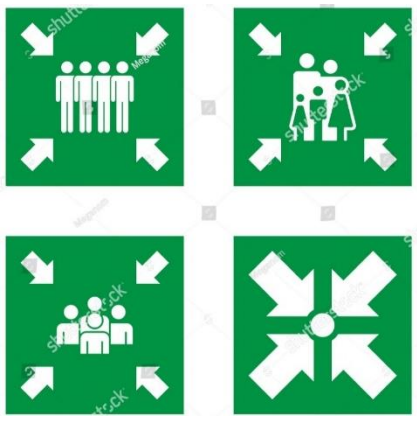

Figure 3. Symbol of assembly station

Figure 4. below is an overview of the evacuation route on board KL. Sultan Hasanuddin which already exists and which has been designed by the shipbuilder.

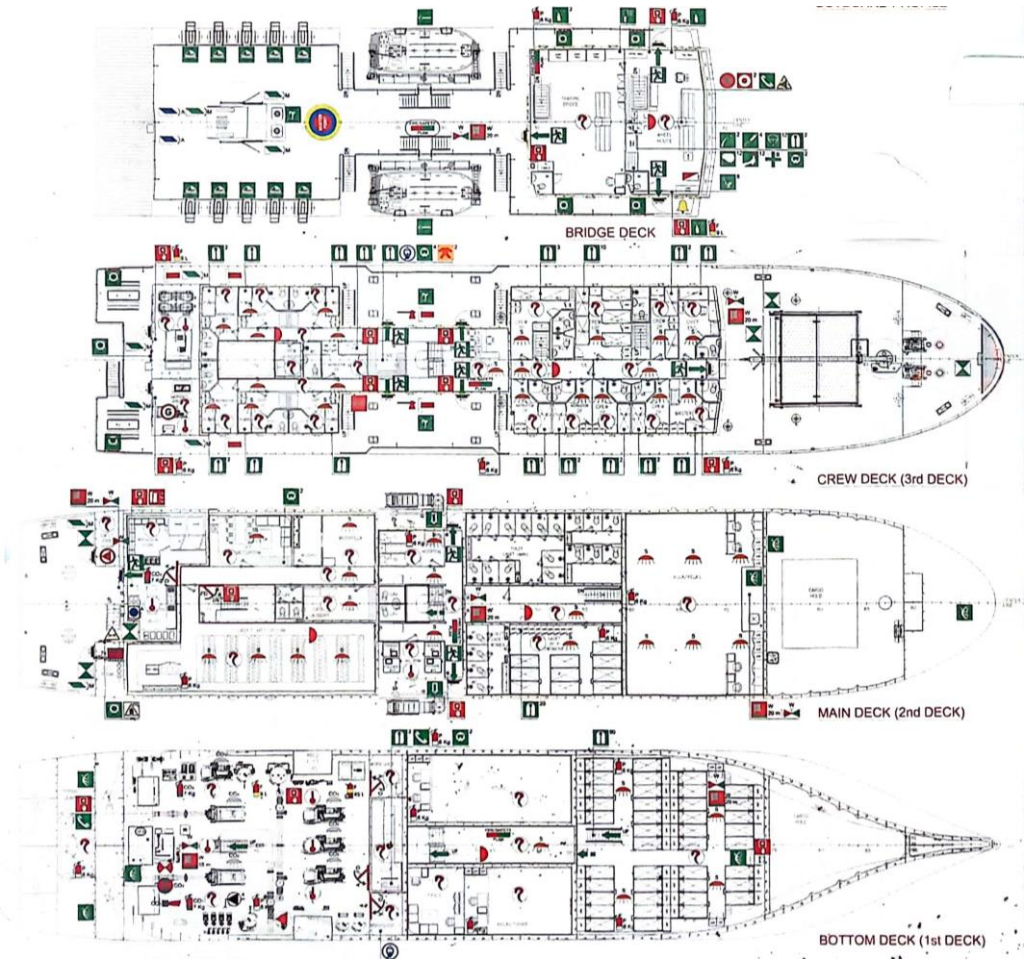

Figure 4. Evacuation Route of KL Sultan Hasanuddin Each Deck

3.2. Distribution Data of Passengers and Crews

The distribution of crew and passengers according to the initial specifications of the ship design is defined according to existing data on the ship. The data obtained in the form of distribution on each deck as well as day and night conditions. Specifications for the placement of passengers and crew are assumed to be centered on night conditions for passengers and crew. Passengers are centered in the rest area and its surroundings, while the crew is in the duty area of each crew member. Figures 5 and 6 below show the activities and distribution of passengers and crew on each deck.

Figure 5. Passenger Conditions on Deck at Night

Figure 6. Passenger Distribution Conditions on the Deck During the Day

In daytime conditions, the distribution of passenger and crew data on each deck, the distribution of crew follows the duty shift data according to the work on the ship, while the distribution of the number of passengers is modified from daytime conditions because it is the hour of passenger activity. Passengers are evenly distributed on each deck and room that is allowed to be accessed by passengers.

Table 1. Distribution Data of Passengers and Crews

Deck	Distribution of Crew		Total Passengers
	In Cabin	Random place	
Bottom Deck (1st Deck)	3	4	100
Main Deck (2nd Deck)	4	8	78
Crew Deck (3nd Deck)	4	-	4
Bridge Deck	-	5	0
Total	11	17	182
	28		

In Table 1, it is explained that the passenger distribution data at night focuses more on their respective rest areas. The data is obtained from the data specifications on the ship which will serve to facilitate evacuation modeling. From the data obtained in the previous sample, it can be seen that the characteristics of the population sample in Table 2. Table 2 above shows the presentation of passengers based on gender and age range and crew members obtained from the calculation of the percentage recapitulation of the number of passengers obtained during observation. From the results of the sampling data above, the passenger population of KM. Sultan Hasanuddin when the passenger load is overloaded is assumed to have the same composition as the composition of passengers when observations are made regarding the gender and age range of passengers.

Table 2. Characteristics of Passenger Sample Data

Passenger population composition	Number of passengers and ship crew (Person)	Presentation of passengers and ship crew (%)
Children (< 10 years old)	12	6,59
Adults (11-40 years old)	167	91,76
Older people (> 41 years old)	3	1,65
Captain	1	3,57
Chief Engineer	1	3,57
Deck Officer	3	10,71
Engineer Officer	3	10,71
Crew	20	71,43
Total	210	200,00

3.3. Evacuation Performance Standard

In IMO MSC.1/Circ.1238 formulates that the standard calculation of evacuation time with advanced method as follows [9]:

$$1{,}25\ \mathrm{T} + \frac{2}{3}\ (\mathrm{E} + \mathrm{L})\ \leq \mathrm{n} \tag{1}$$

$$(\mathrm{E} + \mathrm{L}) \leq 30\ \mathrm{Menit} \tag{2}$$

where: T = time to reach the evacuation process
E = Embarkation time
L = Deployment time
n = Maximum time in evacuation process

Performance standards incorporated with SOLAS regulation III/21.14 as follows:

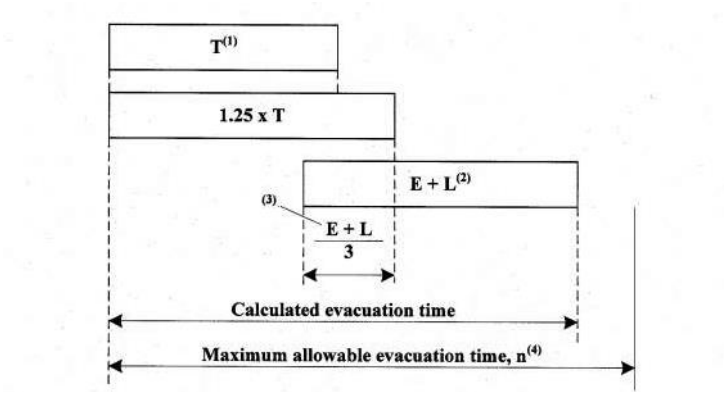

Figure 7. Calculation Performance standard IMO MSC.1/Circ.1238

Where:

1. Total evacuation simulation time
2. Maximum 30 minutes as per SOLAS regulation III/21.14 (in this case E+L is assumed to be equal to 30 minutes)
3. Overlap time
4. Time allowed for evacuation process, in this case n = 80 minutes, because KM. Sultan Hasanuddin has more than 3 MVZ (main vertical zone).

3.4. Case Simulation Results

In the simulation process with several Case variations, one fire point has been determined as the location of the fire in the Galley or kitchen on the Main Deck. In this simulation it is assumed that the fire smoke spread to the stern of the ship, so that it has not disturbed the running speed of passengers and crew. Furthermore, the distribution of each simulation condition and the results of the analysis are displayed in the graph. In the case of the first condition in the evacuation process at night, the distribution of passengers and crew can be seen in Figure 8 is a standard evacuation route that follows the Evacuation Route plan on the ship. Where the assembly point (assembly station) is on Crew deck (deck 3) and bridge deck (deck 4). In simulation condition 1, the ship at night is assumed that most passengers and crew are in the cabin to rest or sleep.

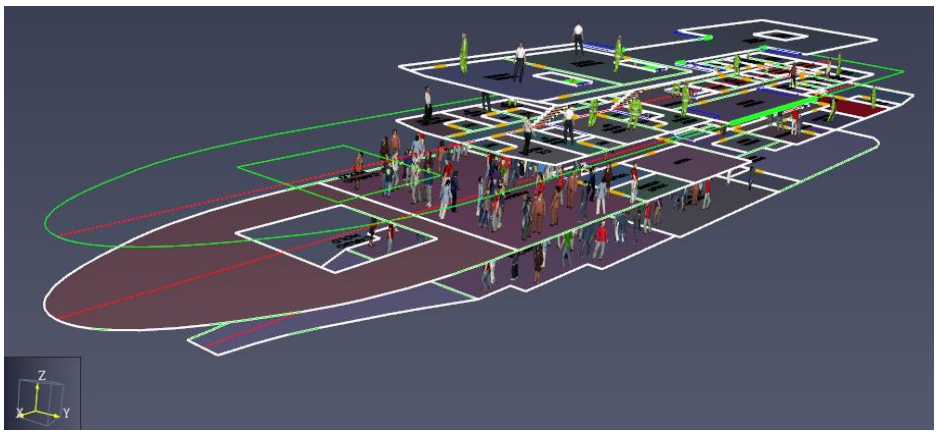

Figure 8. Passenger and Crew Distribution Case 1

Figure 9 displays a graph of the relationship between the number of passengers and crew who arrive at the assembly point and the travel time to the assembly point. The figure shows that the number of passengers and crew is 210 people can arrive at the Assembly Station point with a time of 276 seconds. The graph also shows the relationship between each passenger accommodation room on each deck and the evacuation time, where the longest evacuation time is 196 seconds in the Passenger Room on the Bottom Deck (1st deck).

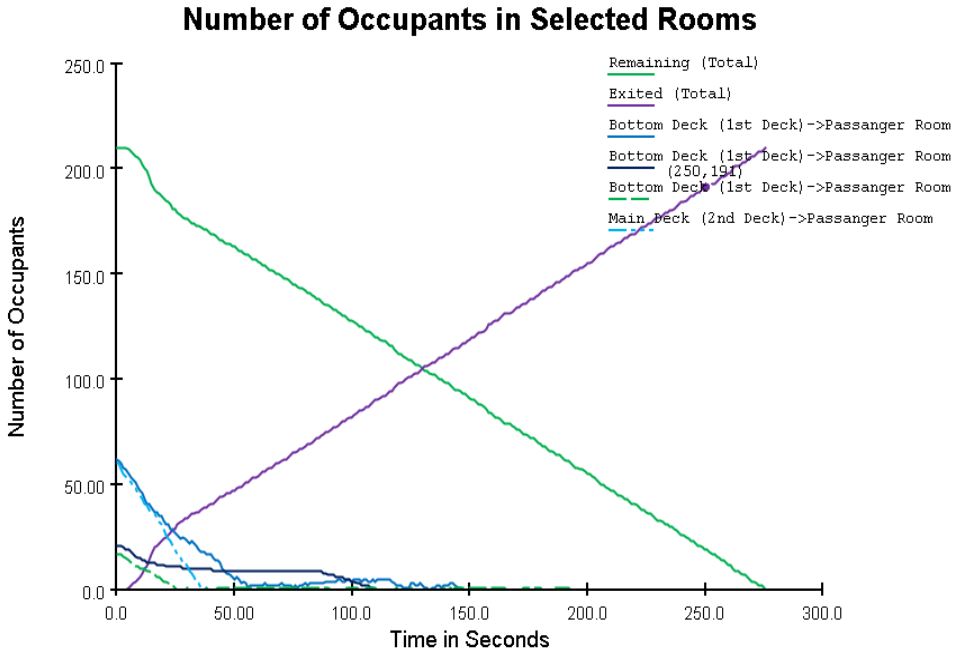

Figure 9. Simulation Results Traveling Time Case 1

In the case of the second condition in the evacuation process during daytime conditions, the distribution of passengers and crew can be seen in Figure 10 is a standard evacuation route that follows the Evacuation Route plan on the ship. Where the assembly point (assembly station) is on the Crew deck (deck 3) and bridge deck (deck 4). In simulation case condition 2, the ship during the day is assumed to have half the passengers in the resting cabin and the other half distributed on the ship's deck. Likewise, the crew and ship's crew are distributed at their respective work locations and some rest in the cabin.

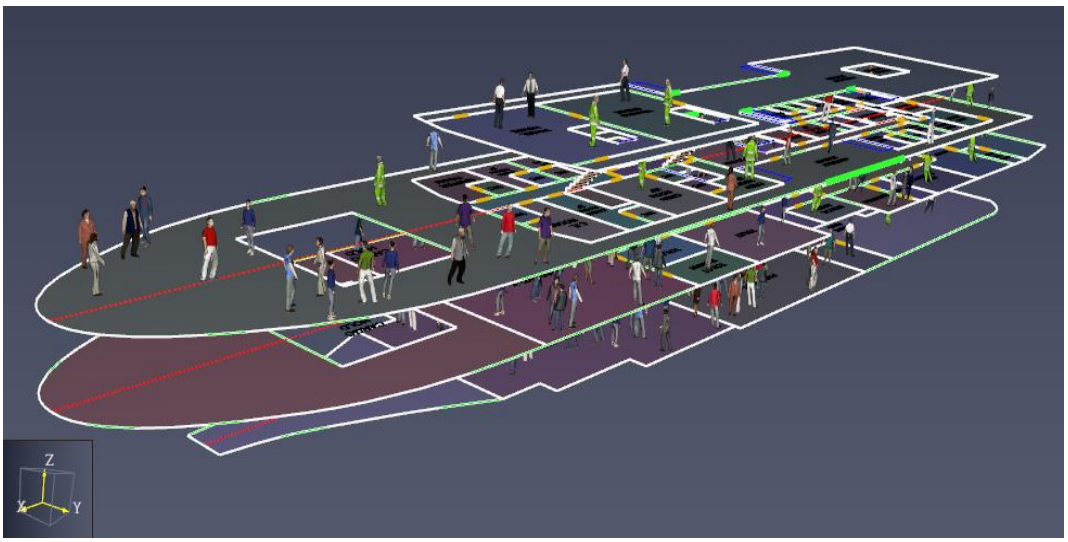

Figure 10. Passenger and Crew Distribution Case 2

Figure 11 displays a graph of the relationship between the number of passengers and crew who arrive at the assembly point and the travel time to the assembly point. The figure shows with the number of passengers and crew of 210 people can arrive at the Assembly Station point with a time of 234 seconds. The graph also shows the relationship between each passenger accommodation room on each deck and the evacuation time, where the longest evacuation time is 97 seconds in the Passenger Room on the Bottom Deck (1st deck) which is faster than Case 1.

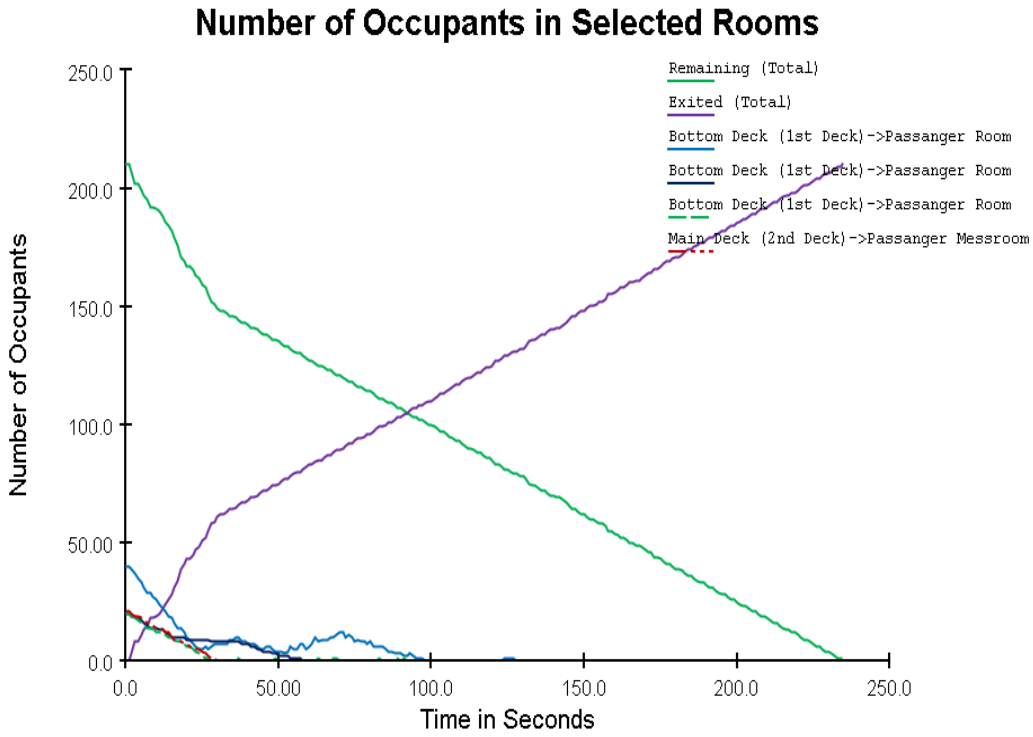

Figure 11. Simulation Results Traveling Time Case 2

In the case of the third condition in the evacuation process at night, the distribution of passengers is the same as in the first case with the addition of alternative routes. In simulation condition 3, the ship at night is assumed that most passengers and crew are in the cabin to rest or sleep. Where the assembly point (assembly station) is on the Crew deck (deck 3), bridge deck (deck 4) and alternatively on the Main Deck (deck 2) through the exit stairs area, so there are 3 assembly sections during the evacuation process as shown in Figure 12.

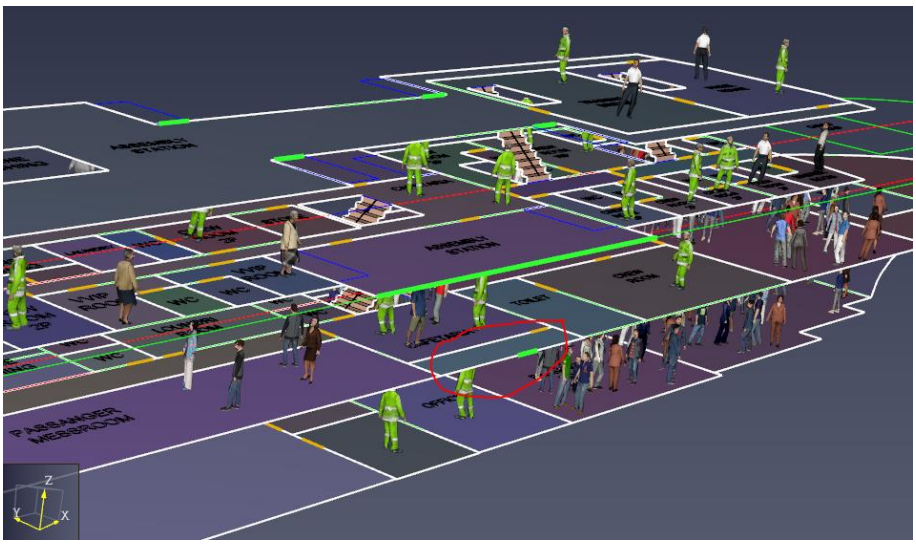

Figure 12. Distribution of additional exit alternatives on the Main Deck

Figure 13 displays a graph of the relationship between the number of passengers and crew who arrive at the assembly point and the travel time to the assembly point. The figure shows that the number of passengers and crew is 210 people can arrive at the Assembly Station point with a time of 141 seconds. The graph also shows the relationship between each passenger accommodation room on each deck and the evacuation time, where the longest evacuation time is 87 seconds in the Passenger Room on the Bottom Deck (1st deck) which is faster than the case 1 condition.

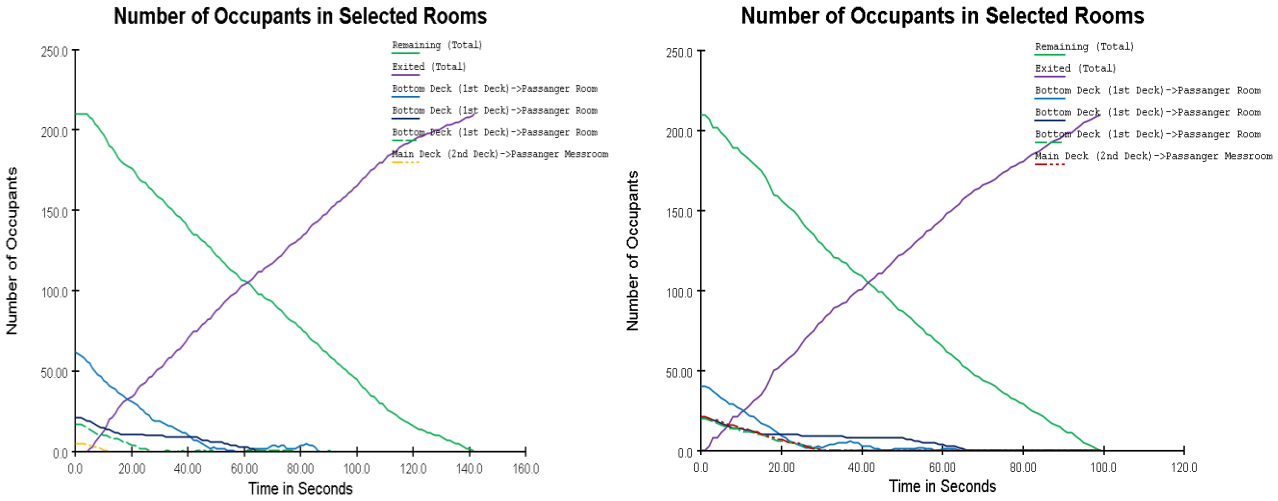

Figure 13. Simulation Results of Traveling Time Case 3 and 4

In the case of the fourth condition of the evacuation process during daytime conditions, the distribution of passengers is the same as in the second case with the addition of alternative routes. In simulation condition 4, the ship during the day is assumed to have half of the passengers in the cabin resting and the other half distributed on the ship's deck. Likewise, the crew and crew are distributed at their respective work locations and some rest in the cabin. Where the assembly point (assembly station) is on the Crew deck (deck 3), bridge deck (deck 4) and alternatively on the Main Deck (deck 2) through the exit stairs area, so that there are 3 assembly sections during the evacuation process as shown in Figure 13. Figure 13 displays a graph of the relationship between the number of passengers and crew who arrive at the assembly point and the travel time to the assembly point. The figure shows that with the number of passengers and crew of 210 people can arrive at the Assembly Station point with a time of 99 seconds. The graph also shows the relationship between each passenger accommodation room on each deck and the evacuation time, where the longest evacuation time is 66 seconds in the Passenger Room on the Bottom Deck (1st deck) which is faster than the case 2 conditions.

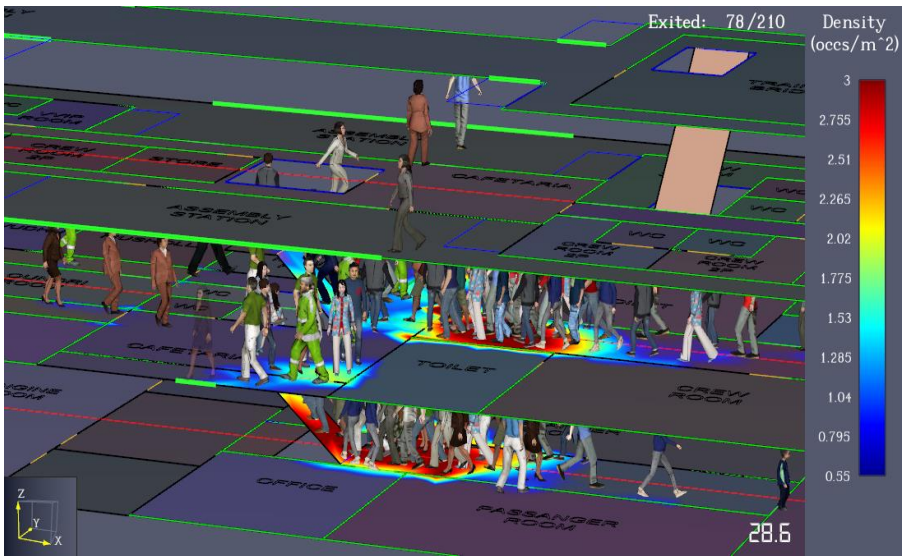

Figure 14. Passenger Density in the Evacuation Process

Figure 14 illustrates the condition of passenger density during the evacuation process, where the location of passenger accumulation when walking to the assembly station is in front of the half-landing stairs on the bottom deck (deck 1) and main deck (deck 2). The passenger density at that location reaches 3 p/m2 for each case condition. After obtaining each traveling time value, the next step is to enter the traveling time value that has been obtained into the performance standard. Then for each case, the time required is as shown in Figure 4.9. From the results of Figure 4.9, it can be identified that the daytime requires a relatively shorter time than the nighttime. In addition, the primary case also requires a relatively slower time than the secondary case with additional alternatives.

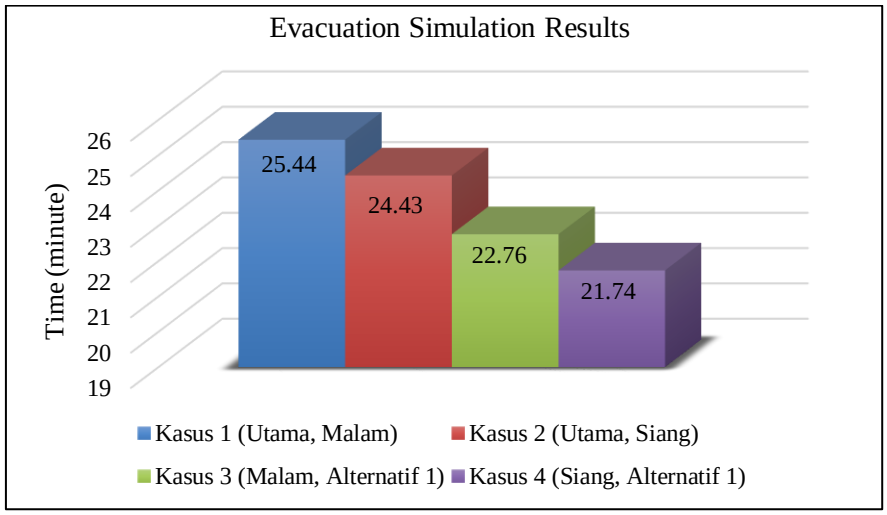

Figure 15. Comparison of Evacuation Time for Each Case

In the calculation of evacuation time, IMO limits the time as written in IMO MSC.1/Circ.1238 that for ships that have 3 MVZ (Main Vertical Zone) has an evacuation time limit of 80 minutes. From the data presented in Figure 15 all calculations in all four cases do not exceed 80 minutes.

4. CONCLUSION

The conclusions that can be drawn from the results of the analysis and discussion above are the time required to evacuate KMP passengers. Sultan Hasanuddin when experiencing a fire based on IMO provisions in night conditions is 25.44 minutes and in daytime conditions 24, 43 minutes, which is faster during the day due to the distribution of passengers on the deck which reduces the density on the evacuation route. Alternative

evacuation routes on the main deck are 24% faster than the evacuation route planned in the Safety Plan, thus providing passengers with a faster opportunity to evacuate and avoid fire smoke.

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REFERENCES

[1] Kompas, "KNKT : Sistem Keselamatan Kapal Roro Masih Bermasalah," Kompas.id. Accessed: Mar. 07, 2024. [Online]. Available: https://www.kompas.id/baca/ekonomi/2023/12/14/knkt-belum-ada-sistem-pemeriksaan-muatan-b3-di-truk

[2] Rudianto, "Permodelan Evakuasi Penumpang Saat Keadaan Darurat Pada Studi Kasus Kapal Penyebrangan Indonesia," Riset Sains dan Teknologi Kelautan, vol. 2, no. 1, pp. 79–85, Oct. 2019, doi: 10.62012/SENSISTEK.V2I1.13221.

[3] M. Iqbal, "Fakta-fakta Terkini Kebakaran Kapal Feri di Pelabuhan Merak," detikNews. Accessed: Mar. 17, 2024. [Online]. Available: https://news.detik.com/berita/d-6917219/fakta-fakta-terkini-kebakaran-kapal-feri-di-pelabuhan-merak

[4] R. T. Wijaya, "Analisa Evakuasi Penumpang Dan ABK Kapal PT. Pelni Dalam Kondisi List Dan Kebakaran," Thesis, Institut Teknologi Sepuluh Nopember Surabaya, Surabaya, 2016. Accessed: Mar. 17, 2024. [Online]. Available: https://repository.its.ac.id/75854/

[5] A. H. Muhammad and D. Paroka, "Analisis Lokasi Kritis Jalur Evakuasi Penumpang Kapal Penyeberangan Antar Pulau Dengan Metode Pergerakan Simultan | Prosiding Forum Studi Transportasi Antar Perguruan Tinggi," Prosiding Forum Studi Transportasi Antar Perguruan Tinggi, vol. 2, no. 2, pp. 999–1010, 2015, Accessed: Mar. 17, 2024. [Online]. Available: https://jurnal.unej.ac.id/index.php/PFSTPT/article/view/2923

[6] K. Priohutomo and B. R. Yuwana, "Analisa Waktu Evakuasi Dengan Metode Advance Pada Kapal Perintis 1200 GT," Kapal: Jurnal Ilmu Pengetahuan dan Teknologi Kelautan, vol. 14, no. 2, pp. 47–52, Aug. 2017, doi: 10.14710/KPL.V14I2.14626.

[7] G. A. Simatupang, "Pemodelan Simulasi Evakuasi Penumpang Menggunakan Salah Satu Desain Kapal Ferry Ro-Ro 500 GT," 2009.

[8] F. Syam, "Ini Spesifikasi Kapal Latihan Sultan Hasanuddin Milik PIP Makassar," Tribun-timur.com. Accessed: Mar. 17, 2024. [Online]. Available: https://makassar.tribunnews.com/2018/02/19/ini-spesifikasi-kapal-latihan-sultan-hasanuddin-milik-pip-makassar

[9] J. G. Perdana, I. P. Mulyatno, and Ari Wibawa Budi Santosa, "Analisa Evakuasi Pada Kapal KM. Kirana IX 9168 GT Menggunakan Metode Agent Based Modelling Simulation Dalam Kondisi Kebakaran," Jurnal Teknik Perkapalan, vol. 11, no. 2, pp. 93–103, Jun. 2023, doi: 10.2/JQUERY.MIN.JS.