JICE Journal Innovation of Civil Engineering

Vol. 5, No. 1, pp. 16-23, 2024
Submit: 22-03-2024 |
Accepted: 03-05-2024 |
Publish: 15-05-2024 |

COMPARATIVE STUDY OF EGRESS TIME ON BRAWIJAYA STADIUM AND GOR JAYABAYA KEDIRI

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ABSTRACT

Assesses egress times at Brawijaya Stadium and GOR (Sports Arena) Jayabaya, analyzing how architectural changes influence evacuation efficiency in emergency scenarios. By leveraging Pathfinder and Pyrosim simulations, the study identifies effective evacuation strategies, such as modifications to exits and circulation pathways, to optimize egress times. Prior research has largely overlooked the psychological effects of architectural features on evacuee behavior and discrepancies in evacuation times between simulations and actual emergencies. Addressing this gap, this study juxtaposes the evacuation dynamics in open (Brawijaya Stadium) and enclosed (GOR Jayabaya) sports venues under simulated conditions, aiming to enhance safety through structural and operational improvements. The findings demonstrate that architectural adjustments can substantially reduce evacuation times, with Brawijaya Stadium achieving an egress time of 6 minutes and 59 seconds, and GOR Jayabaya 6 minutes and 56 seconds, both well within the safety compliance benchmarks set by international standards. These modifications not only expedite egress but also align with safety protocols that advocate for evacuation times under eight minutes, thereby substantially enhancing emergency responsiveness in both facilities.

Keywords: *Egress Time; Evacuation Time; Evacuation Circulation*.

1. Introduction

Ease of accessibility of horizontal and vertical relationships in buildings must be applied to ensure safety and security for users. The purpose of accessibility systems and adequate evacuation circulation planning in sports buildings is to provide evacuation routes that are easily accessible to visitors and minimize crowding and accumulation of people at the exit. Adequate evacuation circulation planning needs to be done because many residents in stadium buildings and sports buildings cannot follow the predetermined evacuation route so the buildup at the exit endangers the safety of residents and affects the speed of evacuation time [1].

Evacuation regulations for stadiums and sports arenas in the UK require that the exit time from buildings with steel and concrete structures during evacuation to the assembly point should not exceed 8 minutes [2]. Stadiums and sports halls need to be compared in circulation planning because the two buildings have different characteristics in terms of audience capacity, and building shape. The stadium has a larger capacity and has an open building form, another factor for comparison is the distance to the evacuation route, the width of the exits, and the number of exits affect the evacuation time [3].

Sports buildings are a type of building that has a mass that tends to only move in place, in contrast to public buildings that have mass movements that never stop, therefore it is necessary to study the evacuation circulation system in soccer stadiums and sports buildings [4]. In recent years determining the exit time in closed and open-type buildings can be done using computer simulation

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using several consideration factors such as reference models and alternative models. Simulations are carried out to determine how long it takes to exit the building, and barriers to accessibility, and evaluate evacuation circulation.

The necessity for efficient evacuation strategies in sports facilities is paramount, particularly in urban areas like Kediri where Brawijaya Stadium and GOR Jayabaya are located. Existing research predominantly focuses on physical modifications to enhance egress efficiency; however, there is a lack of comprehensive studies examining the psychological responses of individuals during evacuations, which can significantly affect behavior and egress time. Moreover, most evacuation studies rely on simulated scenarios which may not accurately reflect real-life emergency responses due to varying panic levels and crowd dynamics. This research addresses these gaps by integrating psychological considerations and comparing simulated results with potential real-world applications to better prepare these facilities for emergencies.

2. Material and Method

This research was conducted at Gelanggang Olahraga Jayabaya which is a sports hall located at Jl GOR Jayabaya, Mojoroto, Kediri City, East Java, and Brawijaya Stadium which is a football stadium in Kediri City located at Jl Ahmad Yani, Banjaran, City District, Kediri City, East Java. The method used is the simulation experimental method. The experimental method is a method used to make a certain treatment on the object of research and then observe and measured how big the impact is [5]. In this study, a treatment was carried out on the two buildings by comparing the reference model with the alternative model. In the alternative model, modifications are made in several components, namely:

1. Entrance/exit
2. Exit stairs
3. Radial gangway

The purpose of the comparison between the original building modeling compared to the alternative model is to determine the level of effectiveness in building access during fire evacuation simulations. In the evacuation and fire simulation using two applications have their respective functions as follows.

1. Pathfinder
   Pathfinder is used to perform modeling on buildings that will be simulated, in addition, it is used to determine the evacuation time in the building and the effective evacuation circulation flow in the two buildings.
2. Pyrosim
   Pyrosim is used for modelling fires in both buildings which are then combined with Pathfinder modelling. From the combination of the two modeling applications, the differences in fire evacuation at the Brawijaya Stadium and GOR Jayabaya are analyzed. Pyrosim uses SFPE as the basic rule in fire simulation planning [6].

2.1. Alternatif Model

The alternative model is the result of modification of the reference model simulation and effective steps taken from the shortcomings of the simulation results produced by the reference model. In the alternative there are 3 modified accessibility sections, namely: exit, radial gangway, and stairs. Determination of 3 parts of building accessibility is based on the book Guide to Safety at Sports Grounds [7], PERMENPORA No. 7 of 2021 [8], and PERMENPORA No. 0445 of 2014 [9]. Each building has 8 modeling alternatives that will be sought for their effectiveness in simulating evacuation circulation.The following are alternative models for Brawijaya Stadium shown in Table 1 and GOR Jayabaya in Table 2.

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JICE Journal Innovation of Civil Engineering

Vol. 5, No. 1, pp. 16-23, 2024
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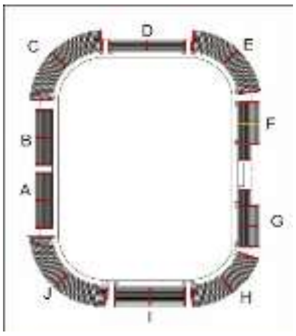
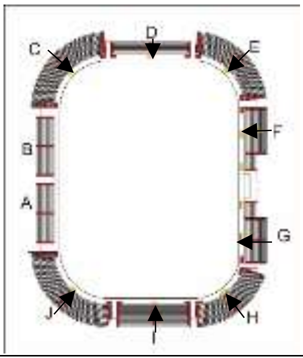
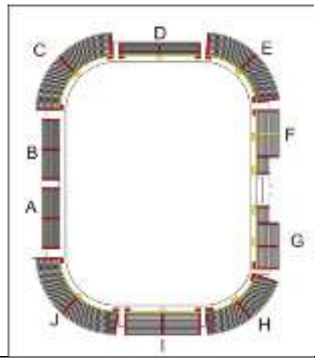
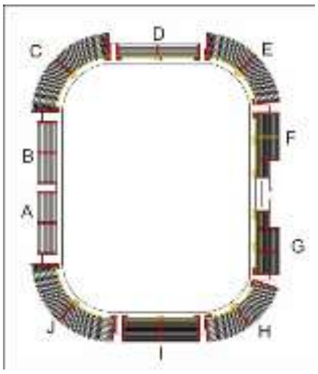
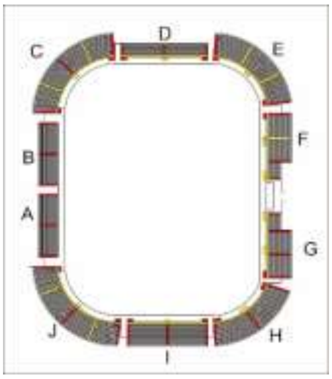
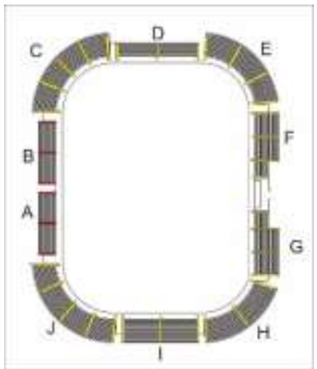
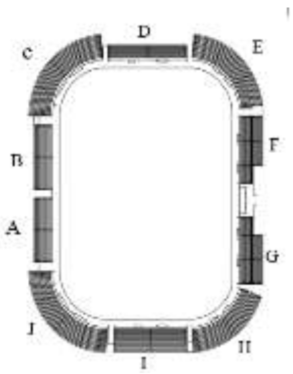
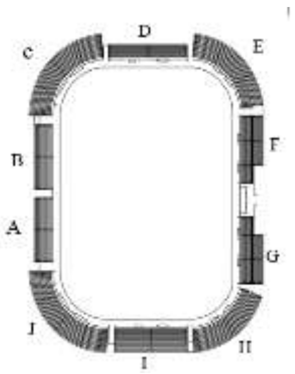
Table 1. Alternatif Model Brawijaya Stadium

Alternatif Model Brawijaya Stadium		
		
Alternatif Model 1: Addition of radial gangway for Sector F stands and increase the width of Radial gangway to 120 cm.	Alternatif Model 2: Increase the number of descending stairs in each grandstand sector	Alternatif Model 3: Widening of the road floor area marked in yellow on the stands in each sector to 150 cm.
Alternatif Model Stadion Brawijaya		
		
Alternatif Model 4: Increase the width of the main road floor area at the stadium to 500cm	Alternatif Model 5: Increase the number of radial gangways in sector C by 2 units, sector E by 2 units, and sector J by 2 units.	Alternatif Model 6: Using a continuous staircase from the radial gangway to the street level of the stadium

Alternatif Model Stadion Brawijaya	
	

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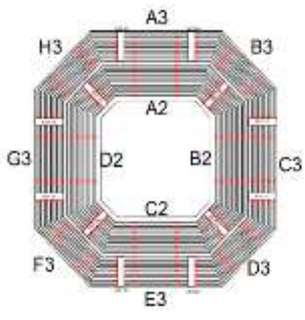
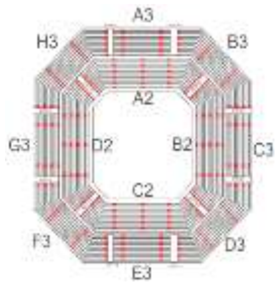
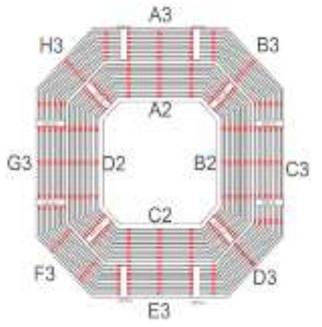
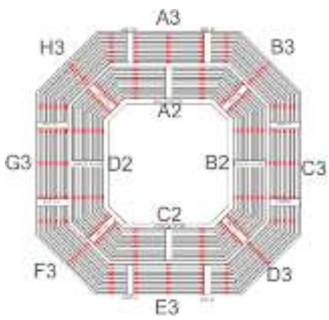
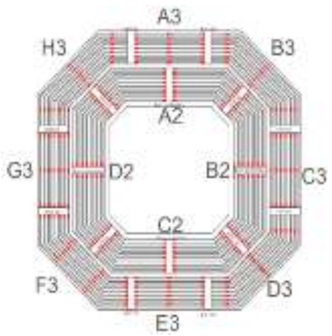
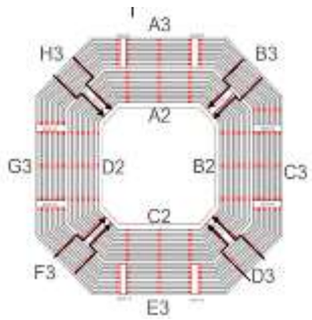
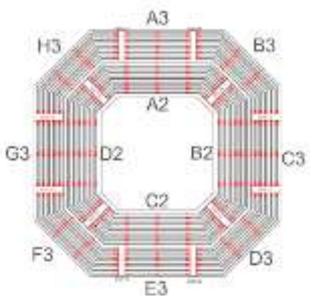
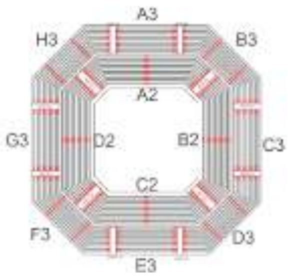
Alternatif Model 7: Changes in the staircase area down in the stands are replaced using a ramp with a slope of 5 degrees in sectors C, D, E, F, G, H, I, J.	Alternatif Model 8: Modifying the staircase descent, sectors C, E, H, J use a regular staircase descent and sectors D, F, G, I use a ramp with a 5-degree slope.

Table 2. Alternatif Model GOR Jayabaya

Alternatif Model GOR JAYABAYA		
		
Alternatif Model 1: Modification of the radial gangway on the 3rd floor stands of sectors B3, D3, F3, H3. Separation of circulation paths	Alternatif Model 2: Addition of radial gangways to the 2nd floor stands in Sectors A2, B2, C2, D2. Separation of circulation paths	Alternatif Model 3: Addition of radial gangway on the 3rd floor grandstand section in sectors A3,C3,E3,G3
Alternatif Model GOR JAYABAYA		
		
Alternatif Model 4: Addition of 2nd floor exit stands in each sector	Alternatif Model 5: Relocation of radial gangway in sectors A2, B2, C2, D2 next to the exit.	Alternatif Model 6: Creation of evacuation circulation paths, namely radial gangways in sectors H3, B3, D3, F3.

Alternatif Model GOR JAYABAYA	
	

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Submit: 22-03-2024 |
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Publish: 15-05-2024 |

Alternatif Model 7: Changes to the radial gangway with a size of 150 cm, Changes in the size of the 2nd floor exit to 280 cm	Alternatif Model 8: Modify the radial gangway to 150 cm and reduce the number of radial gangways on the 2nd floor to 3 in each sector.

3. Result and Discussion

In this study, there are two results obtained, namely the results of the evacuation time efficiency of the Brawijaya Stadium and GOR Jayabaya and the analysis of audience evacuation in fire disasters in open and closed buildings.

3.1 Fire Evacuation of Open and Enclosed Buildings

In this study, for the worst condition fire simulation at Brawijaya Stadium, 11 fire points were made and GOR Jayabaya had as many as 4 fire points on the 1st floor. The distribution of smoke in the building can be seen in Figure 1 below.

Figure 1. GOR and Stadium Fire Points

The results of the analysis at Brawijaya Stadium and GOR Jayabaya have different smoke distribution patterns. Brawijaya Stadium has a smoke distribution pattern that spreads quickly and tends to follow the direction of the prevailing winds because the obstacles in open buildings tend to be lower, just like the research conducted by Kozma [10]. While in GOR the smoke spreads vertically and spreads when it hits the roof of the building and will fill the room, this is like the research conducted by Gunawan on the simulation of evacuation circulation in the market in Samarinda city[11]. evacuation circulation in the two buildings also has differences. Brawijaya Stadium only consists of 1 floor while GOR Jayabaya has 3 floors. At GOR Jayabaya, the 3rd floor is the closest floor to the roof so it needs to be prioritized for evacuation, besides that the GOR has a longer evacuation circulation process compared to the Brawijaya Stadium because on the 3rd floor you must immediately exit the exit stands to the main stairs to go down to the 2nd floor and continue down to the 1st floor. The circulation flow at GOR Jayabaya is shown in Figure 2 below.

Figure 2. GOR Jayabaya evacuation circulation flow

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At the Brawijaya Stadium, the evacuation circulation is shorter than GOR Jayabaya, which is the audience going down the stands to the stairs down the stands which have a height of 1 meter, and continuing by walking towards the stadium exit. The following is Figure 3 of the Brawijaya Stadium audience circulation plan.

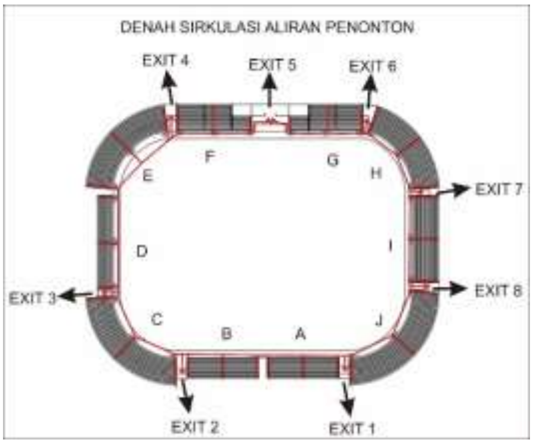

Figure 3. Evacuation circulation flow of Brawijaya Stadium

3.2 Time Efficiency of Brawijaya Stadium and GOR Jayabaya Evacuation

The analysis of evacuation time efficiency at Brawijaya Stadium and Jayabaya GOR using reference model conditions and alternative models. In the implementation of simulations using Pathfinder, the stadium capacity used is a normal capacity of 10,000 spectators and GOR of 7,500 spectators. The walking speed of residents during evacuation is 1.0 m/s. A reference model is the original condition of the existing building that will be seen in the length of time for evacuation. The alternative model is a modification to the existing building that will be compared with the reference model to determine the effective time for evacuation. There are 8 types of alternative models of the two buildings. The length of evacuation time generated from alternative models ranges from 6 minutes to 10 minutes the details of the length of evacuation time for each alternative model can be seen in the following detailed occupant flow Table 3.

Table 3. Types of alternative models to determine the effective time for evacuation

No	Brawijaya Stadium Evacuation Time	GOR Jayabaya Evacuation Time	Model Type
1	10 minute 31 second	8 minute 51 second	Reference Model
2	8 minute 48 second	8 minute 9 second	Alternatif Model 1
3	9 minute	7 minute 54 second	Alternatif Model 2
4	10 minute 33 second	7 minute 20 second	Alternatif Model 3
5	7 minute 11 second	6 minute 56 second	Alternatif Model 4
6	6 minute 59 second	8 minute	Alternatif Model 5
7	8 minute 10 second	9 minute 32 second	Alternatif Model 6
8	8 minute 58 second	7 minute 51 second	Alternatif Model 7
9	8 minute 20 second	8 minute	Alternatif Model 8

The results of alternative models at Brawijaya Stadium and GOR Jayabaya experienced a good acceleration of evacuation time in several alternative models. Some alternative models are made by adding radial gangways which are effective in reducing evacuation time. The effect of adding radial gangways increased the speed of evacuation time to 4 minutes 55 seconds from the evacuation trial time without modification which is 24 minutes [4]. At Brawijaya Stadium in alternative model 5, the effectiveness of evacuation time is 3 minutes 30 seconds faster, and at GOR Jayabaya in alternative model 3, it has increased time acceleration for 1 minute 30 seconds. The addition of the number of

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Vol. 5, No. 1, pp. 16-23, 2024
Submit: 22-03-2024 |
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exits and the increase in the width of the exit at the GOR has a considerable influence on the simulation results. The results of alternative models 4 and 7 are the results of modifications, namely the addition of exits and widening of exits carried out on the 2nd floor. The results of the addition of exits in alternative model 4 decreased the length of evacuation time by 1 minute 55 seconds. Alternative model 7, has decreased the length of evacuation time by 1 minute, this following research conducted by Liu, namely by increasing the width of exit access in the stands can reduce the length of evacuation time from 500 seconds to 200 seconds [2].

4. Conclusion

Differences in spectator evacuation during a fire in closed and open buildings. In the GOR Jayabaya building, the spread of smoke is different from the Brawijaya Stadium. The study reveals that appropriate design changes can significantly reduce evacuation times to under seven minutes, demonstrating compliance with international safety standards. However, the variability in evacuation efficiency between simulated and actual emergencies remains a critical area for future research. The spread of smoke at GOR Jayabaya tends to move vertically and spread down when it touches the roof of the building and there is no influence of wind gusts, so it is necessary to evacuate immediately for the floor stand area at the Brawijaya Stadium when a fire occurs smoke tends to follow the direction of the wind and spreads quickly depending on the current wind speed. So the evacuation must be carried out immediately to avoid visibility in the stands getting worse and the audience inhaling more smoke.

An alternative model that is effective and optimal for evacuation time during a fire is alternative model 5 at Brawijaya Stadium which has an evacuation time of 6 minutes 59 seconds and has fewer obstacles. Alternative model 4 at GOR Jayabaya was chosen because it has the most effective evacuation time of 6 minutes and 56 seconds. Both alternative models were selected based on the requirements of the Guide to Safety at Sports Ground book which requires that when an evacuation occurs the recommended time range is 2 minutes 30 seconds to 8 minutes. Further studies should explore the psychological impacts of architectural design on evacuee behavior and test the effectiveness of evacuation strategies in real-life emergency scenarios to validate and potentially refine simulation models.

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