

# Assessment of Emergency Exit Pathways and Fire Safety Measures in One of Football Stadium in Greater Malang: An Examination Following Indonesian Guidelines

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| ARTICLE INFO   | ABSTRACT   |
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| <b>ORCHID ID</b><br>Author 1: -<br>Author 2: -<br>Author 3: -<br>Author 4: -                         | The most significant football stadium riot tragedy occurred at the National Stadium (Estadio Nacional) in Lima, Peru, resulting in 362 fatalities. The second largest tragedy transpired at the Kanjuruhan Stadium, Malang Regency, Indonesia, leading to 135 deaths. This research aims to evaluate the conformity of evacuation routes and fire protection systems at the one of Football Stadium in Greater Malang, in accordance with the standards and regulations applicable in Indonesia. This analytical descriptive study employs a quantitative research design. The research process involved examining the factual conditions on the ground and subsequently comparing the suitability of evacuation routes and fire protection systems against the standard benchmarks and regulations in place in Indonesia. The results of this study indicate that the conformity level of the evacuation routes, comprising emergency stairs, evacuation routes, safety signs, assembly points, and emergency exits, is at 61.9 percent, denoting adequate compliance. Conversely, the active fire protection systems, encompassing portable fire extinguishers (APAR), hydrants, fire alarms, fire detectors, and sprinklers, show 0 percent compliance, meaning no conformity exists. This study is anticipated to serve as a reference for enhancing evacuation routes and fire protection systems at Football Stadium X: stadium in Greater Malang. |
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## 1. Introduction

The first most severe football stadium riot occurred at the National Stadium (Estadio Nacional) in Lima, Peru, in 1964 during a match between Peru and Argentina, resulting in 362 fatalities. The second largest football stadium riot took place at the Kanjuruhan Stadium in Malang Regency, Indonesia, on October 1, 2022, leading to approximately 135 deaths (Solopos.com, 2022).

As reported by CNN Indonesia (October 8, 2022), the riot at the Kanjuruhan Stadium began when supporters of the Arema team did not accept their team's defeat, causing some fans to enter the pitch. Subsequently, police forces began to hit and topple fans. Tear gas was fired onto the pitch, and then towards the southern stands. The quantity of tear gas released caused smoke to dominate the air. This situation led to spectators scrambling to exit the stadium. However, there was only one exit door open. The steep stairs of the stands, power failure, and the small exit door increased the risk of pushing and shoving at the exit (CNN Indonesia, 2022).

The largest football stadium fire incident occurred at the Valley Parade Stadium, England, the home base of Bradford City. This tragedy claimed the lives of 56 individuals and injured more than 260 people. On Saturday, May 11, 1985, the fire broke out during a match between Bradford City and Lincoln City, suspected to have started from a cigarette (BBC, 2015). A similar incident occurred in Indonesia in 2018 when the Surajaya Stadium, the home base of Persela Lamongan, caught fire on Friday, November 12, 2018. This fire incident did not result in any fatalities, only burning some leftover wood from a project (Liputan6, 2018).

According to football observers, many aspects need to be taken into account regarding the riot at the Kanjuruhan Stadium, one of which is the narrow exit door and the absence of evacuation direction signs (BBC News Indonesia, 2022). According to the Regulation of the Minister of Public Manpower Number 26 of 2008 on technical building requirements, a building must have self-rescue facilities for people inside the building to save themselves from threats in an emergency within an adequate time frame. The building and environmental fire protection system is a system that includes devices, facilities, and all tools installed or incorporated in a building with the aim of protecting the building and its environment from the danger of fire, both actively and passively.

The impact of the lack of facilities at Kanjuruhan Stadium is significant and can result in serious consequences for the safety of spectators and the smooth operation of the stadium. Without adequate evacuation routes, such as sufficient emergency exits and clear evacuation signs, the risk of panic and chaos during emergencies increases dramatically. In situations like fires or other disasters, spectators may struggle to find a way out quickly, leading to serious injuries or even loss of life. Additionally, the absence of active fire protection facilities, such as fire extinguishers, fire detectors, and sprinkler systems, makes the stadium vulnerable to rapid fire spread. Without these systems, small fires can quickly escalate into major incidents that are difficult to control, endangering the safety of thousands of people in attendance.

Furthermore, the impact of inadequate facilities also extends to legal and reputational aspects for stadium management. Non-compliance with national safety standards can result in sanctions from the government and law enforcement, including significant fines or temporary stadium closures. This not only incurs financial losses but also damages the stadium's reputation in the eyes of the public and business partners. Spectators may be reluctant to attend events at a stadium deemed unsafe, ultimately reducing ticket sales and other event revenues. In the long run, this poor reputation can affect public trust and hinder efforts to attract major events or sponsors. Therefore, ensuring that Kanjuruhan Stadium meets all safety standards is crucial to protecting lives, complying with regulations, and maintaining reputation and operational sustainability.

Therefore, it is necessary to conduct an analysis of the conformity of evacuation routes and fire protection systems at the one of Stadium in Greater Malang to the Indonesian National Standard and applicable standards, to support efforts to improve safety infrastructure in order to minimize risks and impacts that occur during emergencies and fires.

## 2. Method

This comparative descriptive analytic study employed a quantitative research design. The implementation period of this study spanned from December 2022 to May 2023. The research was conducted at, and its object was, one of Football Stadium in Greater Malang. With a capacity to accommodate 35,000 spectators, this stadium falls into the category of a class A

stadium (capacity 30,000–50,000 spectators) (Adi et al., 2017; Jieprang, 2016). This study analyzed evacuation routes, which comprised of emergency stairs, emergency doors, exit facilities, direction signs, and assembly points. It also examined the fire protection system, which included fire alarms, fire detectors, portable fire extinguishers (APAR), hydrants, and sprinklers. The standards used as references in this study were: SNI 03-1745-2000, SNI 03-1746-2000, SNI 03-3985-2000, SNI 03-3989-2000, SNI 03-6574-2001, Permen PU No. 26/PRT/M/2008, and the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 14/PRT/2017. The research flow involved an examination of factual conditions in the field, followed by a comparison with the existing reference standards to ascertain the level of conformity of the evacuation routes and fire protection system with Indonesian standards. In this research, data was collected using an observation checklist sheet previously utilized by Syuaib et al., (2021) when analyzing the evacuation routes at Mall Panakukkang, Kota Makasar, and by Fatana (2018) when analyzing the fire protection system of PT Jasa Marga East Jakarta. Documentation was conducted directly using the researcher's mobile phone camera.

To examine the compliance results on evacuation routes and fire protection systems based on the utilized reference standards, the checklist results were converted into a percentage score. The percentage evaluation was computed by assigning a value of 1 to each checklist result, then dividing it by the total count of requirement elements from each checklist. The following is the calculation formula:

$$\frac{\text{Number of compliant checklists}}{\text{Total number of checklists}} \times 100\%$$

Data analysis was performed by describing the evacuation routes and fire protection system at the Kanjuruhan Stadium and then assessing the percentage level of their compliance with Indonesian standards. The analysis results were presented in the form of percentages with an interpretive score: >80% = good level of compliance, 60-80% = moderately compliant, <60% = less compliant, and 0% = non-compliant.

### 3. Result and Discussion

#### 3.1 Emergency Stairs

The emergency stairs observed and measured for compliance are those used for the entry and exit of spectators at gates 1 through 14, and the VIP stand. The stairs for gates 1-14 run straight from the exterior of the stadium to the center of the stand. The stairs are made of relatively fire-resistant concrete without any finishing on the floors. In contrast, the stairs in the VIP stand have ceramic finishing on the floors. Between the stairs, thick walls act as fire barriers. Measurements of the stairs at gates 1-14 and the VIP stand revealed a width of 180 cm for the VIP stand stairs and 231-238 cm for those at gates 1-14. The tread depth was found to be 28-30 cm, and the tread height ranged from 18.5 to 20 cm. All stairs had handrails, the height of which varied between 80 and 114 cm. The stair corridors had lights powered by electricity near the entrance.

According to Indonesian Standard SNI 03-1746-2000, flammable materials should not be used for constructing emergency stairs. Permen PU No. 26/PRT/M/2008 states that emergency stairs should be protected by concrete walls that are at least 15 cm thick and fire-

resistant for two hours. Regarding dimensions, SNI 03-1746-2000 specifies a minimum width of 120 cm, a tread depth of at least 23 cm, and a maximum height of 19-20 cm. Treads should be solid, not slippery, and free of protrusions that could cause falls. Both sides of the stairs and ramp should have handrails with a minimum height of 86 cm (34 inches) and a maximum of 96 cm (38 inches) above the tread surface. Inside and in front of the stairs, lighting equipment should be installed, either automatic or emergency, to indicate the direction to the stairs (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2008).

The checklist results for the compliance of the emergency stairs with SNI 03-1746-2000 and Permen PU No. 26/PRT/M/2008 at gates 1-14, and the VIP stand showed a compliance rate of 81.47%. This indicates that the emergency stairs at Football Stadium X have a good level of compliance. Non-compliance was found at gates 6-14, which had handrail heights exceeding 96 cm above the stair surface and the VIP stand, which had handrail heights below 86 cm. There was also non-compliance in all observed areas concerning emergency lighting because the lights installed were powered by electricity and not emergency lights (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2008).

Permenpora No. 7 of 2021 concerning Standards for Infrastructure and Facilities of Football Stadiums and Fields, explains in Chapter III technical provisions that stadiums can provide emergency stairs linking the field with spectator stands for potential use in emergencies. At this stadium, there are stairs from the spectator stands to the standing tribune area that could serve as safe points if exiting the stadium building is not feasible.

The journal article from the Japan Architectural Review titled "Design guidelines for crowd evacuation in a stadium for controlling evacuee accumulation and sequencing" concludes on the topic of emergency stairs in a stadium. If high and unstable density accumulation occurs, there is a risk of falls and stampedes, and measures should be taken to avoid this issue. Ideally, to prevent merging the flow of spectators from one stand with others towards the same stair point should be avoided (Minegishi & Takeichi, 2018). However, if this is unavoidable, the width of the merged stairs must be sufficient to handle the total flow before merging as is. In addition, preventive physical measures, such as installing handrails, should be implemented (Bateman & Majumdar, 2018). The volume of the outgoing spectator flow merging around the stairs should be reduced with measures such as limiting the number of exit doors. In other words, accumulation should occur in flat and wide areas, such as concourses, to prevent it from happening on unstable stairs. This also facilitates easy evacuation guidance (Minegishi & Takeichi, 2018).

Even though the compliance level of the emergency stairs can be considered good, there is still room for improvements. Recommendations include adjusting the height of handrails on the stairs to between 86 cm and 96 cm and installing emergency lighting inside and in front of each emergency staircase to facilitate direction towards the stairs.



Source: Primary Data, 2023

**Figure 1. Emergency Stair Gate 1**

### **3.2 Egress Facility Assessment**

The egress facilities observed and assessed are the entry and exit paths at gates 1-14, VIP stands, the Changing Room, Medical Room, and the Press Conference Room. In this stadium, the entrance and exit paths are identical and not separated. There are no specialized routes intended for emergency evacuations such as during a riot, fire, or natural disaster. The egress facilities at gates 1-14 comprise the passageways from the stairs leading into and out of the stadium, with heights exceeding 2.5 meters and 243-250 cm at protrusions. Evacuation route signs are absent around gates 1-14; only EXIT labels are displayed above all gate corridors from one to fourteen, excluding gates five and six. However, for the VIP stands, Changing Room, Medical Room, and Press Conference Room, evacuation route signs are installed at intervals of more than 12 meters each, leading to the exterior of the stadium building. The egress facilities are devoid of obstacles or impediments that could hinder visitors from exiting the stadium building.

According to Indonesian regulation Permen PU No: 26/PRT/M/2008, exit access needs to be indicated by approved signs that are conspicuous and easily visible in all conditions. Directional signs should be placed less than 12 meters apart from each other to guide building occupants towards the gathering point. SNI 03-1746-2000 mandates that in the event of a fire or other emergency, exit routes must be free from obstruction. The minimum height of the exit path should be 2.3 meters, with ceiling protrusions at least 2 meters above the floor level.

The compliance checklist for the exit routes with SNI 03-6574-2001 at gates 1-14, VIP stands, player's Changing Room, Medical Room, and Press Conference Room resulted in a score of 68.8%, signifying that the egress facilities at Stadium X have a satisfactory level of compliance. Non-compliance was identified at gates 1-14 due to the absence of proper and accessible directional signage guiding spectators to exit routes; only exit signs were present above the corridors at all gates and VIP stands, except gates 5 and 6.

Permenpora No. 7 of 2021, in Chapter III, explains the technical provisions regarding the requirements for doors, corridors, stairs, and exit routes. They must have widths in accordance with general safety requirements, such as absence of obstruction or disturbance, and should guide towards the evacuation point or assembly point. The stadium's general security is specified that entrances and exits should be differentiated with written guides for easy-to-understand evacuation routes. Meanwhile, in the FIFA Stadium Guidelines 2022, evacuation routes should consider three factors: the route should have fire protection for 30 minutes, stairs should be located in open spaces and protected from fire, and the playing field can be used as the main place or evacuation route (FIFA, 2022).

A journal titled "Contributors And Stakeholders' Responsibilities To Sports Facility Safety And Security: A Focus On Stadium" explains that if a stadium has entrance, exit, and emergency routes on the same path, there will be problems with crowd control and security. Entrance facilities should differ from exit and emergency routes and should be designed to enhance the safety of people and facilities. Official and player entrance, exit, and emergency routes should not be the same. Tunnels should be available to allow officials unrestricted access at all times. Avoiding traffic on entrance and exit routes should be a guiding principle for sports facility managers. This will ensure there is no invasion before, during, and after the football matches (Elendu & Jenewari, 2018). This aligns with safety and security requirements in regulations applicable in Indonesia.

Improvement suggestions for the egress facilities based on SNI 03-1746-2001 include adding evacuation route signs at gates 1-14 and VIP stands. At least every 12 meters, there should be an evacuation route sign to assist visitors in locating evacuation routes. There is a need to redesign the entrance and exit routes to make them separate, and to establish evacuation routes that can enable the evacuation of all spectators in line with standard emergency evacuation timelines.



Source: Primary Data, 2023

**Figure 2. Egress Facility VIP Stands**

### 3.3 Safety Signage

The safety signage affixed to this stadium building includes: evacuation route signs located at the VIP stands, medical room, players' changing room and press conference room, and exit signs at gates 1-14 excluding gates 5 and 6. During the observation, the researcher did not find exit signs at gate 5 and gate 6. The size of the directional and exit signs meets the required standards, i.e., they have a minimum letter height of 15 cm and a minimum letter width of 2 cm. The directional and exit signs in this stadium have not been adequately illuminated, meaning there is no light on these signs.

The safety signage referred to in the evacuation route comprises directional and exit signs. Exit signs signal to building occupants the safe route out in an emergency. Exit signs must be informative when required, but unobtrusive when not needed (Kinatader et al., 2018). SNI 03-6574-2000 states that directional signs must be installed at the exits in accordance with applicable regulations. The location of directional signs should be at all doors leading to the emergency staircase, with a safety sign in the form of an exit sign placed on the door or above it at a height of 150 cm from the floor surface or on the wall near the door. Entrances to evacuation routes should be marked with easy-to-read directional signs from all directions. Directional signs can be installed near the floor surface or on the floor surface, taking into consideration their size and color for easy readability. Most international building codes designate green as the color for exit signs. Exit signs should read "EXIT" or use another easily understandable language, with easy-to-read fonts, a minimum letter height of 15 cm, and a minimum thickness of 2 cm. If the phrase "EXIT" is used, the width of the letters should be a minimum of 5 cm, excluding the letter "I", and there should be a minimum distance of 1 cm between the letters. Safety signage, whether it be directional signs or exit signs, should have easy-to-read lighting under normal and emergency conditions.

The compliance checklist results for Safety Signage with SNI 03-6574-2001 at gates 1-14, VIP stands, players' changing room, medical room, and press conference room are 53.32%, indicating that the safety signage at Football Stadium X has a low level of compliance. The non-compliance found includes the absence of exit signs at gate 5 and gate 6, and no evacuation

route directional signs found at the exit facilities at gates 1-14. All exit signs do not appear to have adequate lighting from either an external or internal source.

The technical provisions of Permenpora No. 7 of 2021, Chapter III, explain that visitor circulation should have a signage system such as road signs, traffic signs, information boards, and emergency instructions (fire/emergency escape). "Exit" or "entry" directions should be large, clearly visible, and easy to understand to facilitate emergency evacuation actions. In stadiums, regulations should be posted upon entering the stadium (Young et al., 2021). Examples include the prohibition of bringing dangerous items such as sharp weapons, glass bottles, flares, and the like. The journal discussing Fan Safety at Sports Facilities mentions the need for additional warning signs for new spectators with more signs and public address system announcements (Ward, 2012).

Suggestions for improving safety signage based on SNI 03-6574-2001 include installing the required size exit signs at gate 5 and gate 6. There should also be additional directional signs towards the exits at all gates 1-14 and VIP stands. Directional signs can be placed on the floor surface leading to the exit. Each directional sign needs to be provided with adequate lighting, either from an external or internal source. As mentioned in Permenpora No. 7 of 2021, there should be safety signage indicating regulations before entering the stadium.



Source: Primary Data, 2023

**Figure 3. Exit Sign**

### **3.4 Assembly Point**

The assembly point at this stadium building is an area outside the stadium structure. The stadium spans a total area of approximately 3.5 hectares, comprising a 2,664 m<sup>2</sup> building, a 2,223 m<sup>2</sup> western VIP stand, northern, eastern, and southern economy stands with an area of 10,700 m<sup>2</sup>, and a supporting area of 4,028 m<sup>2</sup>. The open area around the stadium, approximately 1.5 hectares, can serve as a safe point and accommodate an overflow of spectators at the start and end of a match, as well as in emergency situations. However, there are currently no assembly point signs in the stadium's outdoor yard, indicating a designated gathering area; hence, the building's surrounding space is utilized as a parking area.

The Indonesian Ministry of Public Works and Housing Regulation Number 14/PRT/2017 on Building Facility Requirements explains that an assembly point's suitability

needs to be assessed as the final destination of evacuation routes, its security, and easy access for building visitors. The assembly point should be at a safe distance from building collapse hazards, able to be concurrently used by all building visitors, and its capacity for congregation. As stipulated in Annex 2, the technical requirements for an assembly point are as follows: the distance between the assembly point and the building should be at least 20 meters to protect visitors from building collapse or other dangers; the gathering point can be a road or other open area; the assembly point location should not prevent access for fire trucks; it should be easily accessible by vehicle or medical team, and other requirements in accordance with laws and regulations on fire protection systems in buildings and environments. An illustrative image is provided showing the assembly point sign with a green background and white letters, to be installed in a wide, obstacle-free area (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2017).

The assembly point compliance checklist based on the Indonesian Ministry of Public Works and Housing Regulation Number 14/PRT/2017 has a compliance rate of 60%, meaning that the exit point at X Soccer Stadium has a satisfactory compliance level. The non-compliance is due to the absence of assembly point signs in the open area outside the stadium building. The assembly point signs should have a green background and white letters.

Indonesian Ministry of Youth and Sports Regulation No. 7 of 2021, in Chapter III technical provisions, mentions the need to regulate security zones concerning the safety of spectators and players in stadium planning. A stadium's safety zone is a secure area that serves as a circulation area and provides space for crowd overflow at the start and end of matches and during emergencies. The safety zone is located outside the stadium building.

The Japan Architectural Review discusses the evacuation area outside the stadium as the assembly point. Even though there is room for accumulation around the stadium, if the spectators already evacuated from the stadium are not moved and kept in a separate location from the stadium, it prevents the subsequent spectators from evacuating from the stadium. Specifically, if the spectators can't leave the stadium and accumulation occurs on the internal stairs, secondary disasters, such as stampedes, can easily occur (Minegishi & Takeichi, 2018). Even if spectators have left the stadium, they can wait at the assembly point, or alternatively, a guiding method to keep spectators away from the stadium, such as asking them to walk along the road for a certain period, can also be applied. This method has a comparative advantage in controlling the direction of evacuation and lower refugee density due to walking refugees. In this case, the refugees should keep walking for the time it takes for everyone to evacuate the stadium completely. Regardless of whether the spectators are accommodated in the open space or walking along the road, it is crucial to prepare a guidance plan after estimating the refugee flow rate and ensuring its alignment with the flow rate and number of refugees.

Improvement suggestions for the assembly point based on the Indonesian Ministry of Public Works and Housing Regulation No. 14/PRT/2017 include the need to install assembly point signs with a green background and white letters, to be placed in an obstacle-free open area at least 20 meters away from the stadium building. Planning for the flow of spectators leaving and moving away from the stadium is needed to avoid collision or overlap.



Source: Primary Data, 2023

**Figure 4. Area Outside The Stadium Structure as a Assembly Point**

### 3.5 Emergency Exits

Emergency exits that were observed and evaluated for compliance include the entrances and exits from gates 1-14, the VIP stands, the medical room, the changing room, and the press conference room. The exit doors from the VIP stands, medical room, changing room, and press conference room utilize a folding gate located in the main stadium building. There are 5 folding gates in the main building that could serve as exit points from the VIP stands, medical room, changing room, and press conference room. Exit signs are present above these folding gates, albeit without advisory wording. Meanwhile, gates 1-14 employ large door panels, each 270 cm wide and 285 cm high, designed to be opened by sliding, with two swing-out door leaves in the middle, each door leaf being 75 cm wide and 180 cm high. These doors are equipped with manual bolt locks locked by padlocks. The threshold at gates 1-14 varies between 8-17 cm in height.

SNI 03-1746-2000 prescribes that the clear width of emergency door openings should be at least 80 cm (32 inches). Pairs of door leaves should each have a minimum clear width of 80 cm (32 inches). The surface of the floor on either side of the door should not exceed 12 mm ( $\frac{1}{2}$  inch) in height. The door should not have a protruding threshold higher than 12 mm ( $\frac{1}{2}$  inch). If a threshold or a change in floor surface height exceeds 6 mm ( $\frac{1}{4}$  inch), the door path and threshold should be sloped, with a maximum slope of 1:2. In protected exit spaces or areas carrying significant fire risk, the door is required to open towards the exit path. Doors should be fitted with an automatic door closer and a handle or lever that opens the door and is located in the stairwell. Doors should be equipped with locks, bolts, and alarm equipment. Door locking devices, such as bolts or others, must be installed with a release mechanism that can be easily accessed in any lighting condition. The bolt should be placed no more than 120 cm from the floor for easy release. Door locks allow for special arrangements, such as delayed egress locks, and exit doors with access control. In a standard design, an exit door should always be closed, and the door will automatically close after being opened. When the door must be forcibly opened or closed due to approaching individuals, the door must be designed so that it can be manually operated in case of power failure to ensure people's safety and manually open when needed. The following conditions must be met for horizontal sliding doors to be used as traffic

paths: the door must be operable from both sides without requiring special training or knowledge; the force required to operate the equipment towards the exit should not exceed 67 N (15 lbf); and the force required to operate the interior door towards the entrance should not exceed 133 N (30 lbf). Doors have a self-closing or automatic closing level with timely warnings, installed in accordance with applicable regulations, and meet the fire protection level criteria.

The checklist results for emergency door compliance with SNI 03-1746-2000 at gates 1-14, and VIP stands showed a compliance rate of 49.2%, indicating that the exit doors at X Football Stadium have a low level of compliance. The requirement for emergency doors that has not met the standard is the gate 1-14 door with door leaves width of 75 cm. The standard door leaf size is 80 cm with full opening, which allows visitors to exit easily. In emergencies, sliding doors with a width of 270 cm and height of 285 cm can be opened, enabling an effective number of spectators to exit. However, there needs to be personnel to open it, as sliding door requirements must be capable of being opened with a force not exceeding 133 N. Additionally, the threshold also exceeds the standard size of 12 mm. The stadium's thresholds range between 8-17 cm in height, a threshold that is too high could cause visitors to trip or fall. All doors in this stadium are not equipped with automatic door closers. At gates 1-14, doors use manual bolts locked with padlocks. In emergency conditions, padlock keys are difficult to open as they require a key. This does not comply with SNI 03-1746-2000 point 5.1.5.1. stating that locks do not need to use any specific equipment or skills or heavy effort to open them from inside the building. Whereas the exit doors in the VIP stands, medical room, changing room, and press conference room use folding gates or sliding doors, but do not yet have warning signs.

Permenpora No. 7 of 2021 in Chapter III technical provisions regarding safety and security requires separation of spectators and the field using a sturdy iron fence 180 cm high. There should be a door towards the field in the middle that can be opened at any time. In emergency situations involving many spectators, the door can be a solution. Stadium exit regulations state that sliding doors are not allowed, and stadium exit doors, including stadium gates, must always be able to be opened outwards and be guarded by security personnel when spectators are inside the stadium (FIFA Stadium Safety and Security Regulations, 2010). It is also recommended to use doors with automatic locks that can be opened from the inside. Entering and exiting the stadium must comply with security and emergency control regulations, and the entrance door has sufficient automatic controllers so that visitors can line up. The requirements include that the exit door should open outward, the door can be locked so that the spectators inside are guaranteed safety from anarchic actions, the minimum door width is designed so that all emergency evacuation actions can be safely performed within 5 to 8 minutes, and the distance between two doors is not more than 25 meters.

Improvement suggestions for emergency doors based on SNI 03-1746-2000 are that there should not be a threshold protruding more than 12 mm. As per SNI 03-1746-2000 point 5.1.3, if the threshold cannot be eliminated, then the floor needs to be sloped at no more than 1 : 2. The addition of automatic door closers is required on each door and improvements to the bolts and locks with devices that are easy to operate under all lighting conditions. Warning signs should be installed on or near the door in accordance with the locking and door closing system. On folding gates, there should be the writing, "THIS DOOR REMAINS OPEN WHEN THE BUILDING IS OCCUPIED".



Source: Primary Data, 2023

**Figure 5. Entrance and Exit Gate 12**

### **3.6 Portable Fire Extinguishers (APAR)**

The locations observed include gate 1-14, the VIP stand, players' changing room, medical room, and press conference room. The researchers found that these observed areas had a 0% level of compliance with Portable Fire Extinguisher (APAR) standards based on the Ministry of Public Works Regulation No. 26/PRT/M/2008, meaning that the APARs in Football Stadium X are non-compliant (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2008). APARs were found in non-observed locations such as the Facility and Infrastructure Office, in front of the Secretariat Room, and inside the Warehouse. The APARs stored in the warehouse are wheel-mounted APARs, deployed during matches.

APARs are devices designed to extinguish small-scale fires. Anyone who notices a fire can utilize an APAR. They can be used in other fire-prone areas besides building fires. APARs are required for every building, depending on the categorization of fire hazards (Ramadhani, 2023). According to Ministry of Public Works Regulation No. 26/PRT/M/2008, APARs must be provided in accordance with technical requirements. APARs should be classified using letters that explain the classes of fire for which the APAR is effective, preceded by a number (only class A and B) indicating the relative effectiveness of extinguishing. APARs need to be maintained in a full and ready-to-use condition, if not in use, they should be kept in a designated place. APARs should be installed in clearly visible areas, unobstructed, easily accessible, and ready for immediate use during a fire. The APAR storage cabinet should not be locked unless it is a target

of criminal action. Wheel-mounted APARs should be placed in specific locations. However, other APARs need to be securely installed on brackets, holders manufactured by the APAR manufacturers, and registered and approved holders, then inserted into the wall or cabinet of their origin. The front of the fire extinguisher must have clearly visible operating instructions. The front of the fire extinguisher should not have any labels, including hydrostatic test labels, six-year maintenance labels, hazardous materials identification system labels, or any other labels. Since they are installed and functioning, APAR inspections should be performed every 30 days. A maximum of one year should pass between APAR maintenance procedures.

FIFA Stadium Safety and Security Regulations (2010) outline fire safety facilities and equipment, one of which is the provision of portable fire extinguishers or APARs, and fire blankets in all facilities and catering outlets (FIFA Stadium Safety and Security Regulations, 2010). The number and classification of APARs depend on the size, layout, and risk of the structure. APARs should be positioned in such a way that they cannot be damaged but are easily accessible by staff when required. Routine inspections of all fire-fighting equipment are necessary to ensure they are functioning properly (Zheng, 2014).

The need for APAR provision at gate 1-14, VIP stands, changing rooms, medical rooms, and press conference rooms is apparent. The provision and installation of APARs are in line with the Minister of Public Works Regulation Number : 26/PRT/M/2008 and other applicable regulations. The calculation for the number of 2-A APARs in light fire hazard occupancy is a maximum floor area per unit A of 278 m<sup>2</sup>. Based on the VIP stand building area, approximately 8 units of APAR are needed and about 38 units for the stands at gate 1-14. APARs are allowed to be replaced with 40mm hose hydrants that meet the SNI 03-1745-2000 standard.

### 3.7 Hydrants

The researchers did not find hydrants at gate 1-14, the VIP stand, changing room, medical room, and the press conference room. Yard hydrants were also not found outside the stadium building. Therefore, the compliance of hydrants in this stadium building with the Ministry of Public Works Regulation No: 26/PRT/M/2008 and SNI 03-1745-2000 is 0%, indicating that the APARs in Football Stadium X are non-compliant.

Ministry of Public Works Regulation No: 26/PRT/M/2008 mentions that one of the necessary facilities in a building environment is a hydrant. The installation of hydrants is associated with the vertical pipe system and hose for water supply as outlined in Ministry of Public Works Regulation No: 26/PRT/M/2008 and SNI 03-1745-2000. The planning and installation of the vertical pipe system are intended to provide a minimum water supply of 38 liters per second at a pressure of 3.5 bars and capable of flowing water for at least 30 minutes (Hong Kong Fire Services Department, 2019). Hydrant cabinets are designed to store hoses and other fire equipment that can be quickly accessed and used in the event of a fire. Each cabinet is painted with eye-catching colors and used exclusively for fire equipment. Fire equipment includes hoses with a diameter of 40 mm and nozzles that must be ready for use in the event of a fire. Yard hydrants are provided along the access path of the fire truck with a radius of 50 meters.

FIFA (2022) explains that the area around the stadium should provide easy access for emergency vehicles, particularly for hydrant usage. The location of fire-fighting facilities should be well known to the fire service before an outgoing call. Fire-fighting equipment should

be well documented and maintained. To ensure that systems, personnel, and direct action equipment function fully, fire-fighting equipment must undergo regular inspections and maintenance (Zheng, 2014).

As per Ministry of Public Works Regulation No: 26/PRT/M/2008 and SNI 03-3985-2000, the provision of hydrants in stadium buildings is necessary. Hydrant planning begins with the installation of a vertical pipe system to supply water that can be used for fire prevention efforts. The provision of hydrant cabinets and equipment also complies with applicable requirements. Moreover, yard hydrants should be available and accessible to fire trucks.

### **3.8 Fire Alarms**

The researchers discovered that the fire alarm system was not installed in locations such as gate 1-14, the VIP stand, changing room, medical room, and the press conference room. Meanwhile, the loudspeakers, which can serve as fire alarms and communication means during emergencies, are only installed in the main stand or VIP stand when a match is ongoing. The checklist results for fire alarm compliance according to SNI 03-3985-2000 is 0%, indicating non-compliance of fire alarms at Football Stadium X.

According to SNI 03-3985-2000, the frequency function of the fire alarm should be between 500 and 1000 Hz, and it should have a sound level of at least 65 dB to be immediately identifiable as a fire alarm. Every area of the building should have an accessible fire alarm system, with the alarm sound volume adjusted for each room. Fire alarms must be installed in specific locations where external sounds cannot be heard. The installation of external alarms should allow the entry of fire service personnel from outside.

Minister of Youth and Sports Regulation No. 7 of 2021 states in Chapter III that the technical requirements for public safety in stadiums require loudspeakers as a public address system with strong sound output that can reach all stand areas to be used as necessary for instructing spectators during critical moments, such as indoor and outdoor stadium emergency evacuations. Regarding the sound system, it is mentioned that the sound system should have a minimum strength of 75 dB so that announcements, match results, or music concerts can be heard clearly throughout the stadium. Meanwhile, a minimum loudspeaker strength of 115 dB is needed for emergency communication to manage crowds of spectators in panic scenarios and reach 105 dB. The same applies to the need to install loudspeakers to be heard in the players' waiting rooms and officials. FIFA Football Stadiums Guidelines (2022), explains that fire alarms can operate in two system modes, non-matchday mode - when the alarm operates normally and evacuation signals can be triggered directly/automatically, and matchday mode - when the alarm sound triggering the evacuation process is only initiated once the legitimacy and severity of the incident have been investigated and verified.

The application of a fire alarm system in stadium buildings in China uses a smart system, making it easy to obtain information on the location and position of a fire. The fire detector system includes smoke detectors and manual alarms that connect to a control system to be forwarded to a warning alarm for spectators (Till & Coon, 2018). This smart system sequentially includes fire detection-alarm-evacuation. Fire alarms can adapt to the stadium building and create the fastest route (Till & Coon, 2018).

The suggested improvements for the fire alarm based on SNI 03-3985-2000 include the need to install fire alarms or loudspeakers at all location points and establish different sound signals to facilitate stadium visitors in identifying danger signs and promptly evacuating. The loudspeaker power can be adjusted according to the stadium's size and needs as explained in PERMENPORA No. 7 of 2021, 75 dB for announcement purposes and a minimum of 115 dB for communication or as an emergency signal. The smart alarm system can serve as a reference for a better rescue mechanism.

### 3.9 Fire Detectors

Research findings revealed that fire detectors were not installed at gate 1-14, the VIP stand, the players' changing room, the medical room, and the press conference room. The compliance checklist results for fire detectors according to SNI 03-3985-2000 stand at 0%, indicating non-compliance with fire detectors at one of Football Stadium in Greater Malang.

Automatic fire detectors enhance fire protection by initiating emergency actions. However, this function can only be achieved when used in conjunction with other equipment. The following are classifications of automatic fire detectors based on their types: heat detectors, smoke detectors, flame detectors, fire gas detectors, and other fire detectors. Detector installations need to be protected from potential damage due to mechanical disturbances. If necessary, detectors should be installed throughout the area according to relevant standards or competent authorities. Each placed detector must be serviceable and routinely tested. Each detector must be capable of operating consistently. Inspections, testing, and maintenance must be conducted. Programs for inspection, testing, and maintenance must adhere to industry standards and factory instructions. All inspection, testing, and maintenance results must be documented and stored in a file for review by the evaluated party over a five-year period.

Stadium Safety Management in England mentions that fire and smoke detection systems are installed in all stadiums and all stadium exit gates. These detection systems can be operated from within the control room. The control room is located near the stadium broadcast room to facilitate rapid broadcasting during emergencies (FIFA Stadium Safety and Security Regulations, 2010). FIFA Football Stadiums Guidelines (2022), mentions that all detectors must be connected to a central panel, which should be located in a readily accessible and permanently managed location, such as the main reception area or a 24-hour security post. This will ensure that fire incidents can be detected, and their locations can be identified, either by stadium staff or emergency services. Fire detection and warning systems should not only detect fire but also identify the location of extraordinary incidents and signal the need to initiate evacuation of all or part of the stadium. Automatic detection should be present in all high-risk and unoccupied rooms. Manual call points can be used in low-risk and occupied areas.

A journal titled "Multi-function Monitoring and Alarm System for the Large Stadium" discusses fire detectors installed in stadiums in China. The fire detectors connected to this multi-function alarm system can detect fire from smoke or gas, infrared, and temperature identification with multi-point sensors. The collected data is sent by mobile communication to mobile phones or the main platform. This system is simple and inexpensive, yet it facilitates monitoring (Xiaohui & Xiaoning, 2018).

Suggested improvements for fire detectors based on SNI 03-3985-2000 include the need to install fire detectors in every location, especially in enclosed spaces such as enclosed corridors, players' changing rooms, medical rooms, and press conference rooms. A multifunctional detector system can also be developed in this stadium to facilitate the monitoring of each hazard information.

### 3.10 Sprinklers

The compliance checklist results for sprinklers, according to SNI 03-3989-2000, at gate 1-14, the VIP stand, changing room, medical room, and press conference room were at 0%, indicating non-compliance at Football Stadium X. No sprinklers were installed within this Football Stadium. Gates 1 – 14 are unsuitable for sprinkler installation because they constitute an open stand. The VIP stand also cannot accommodate sprinkler installation due to its high, non-wall-adherent roof structure.

According to SNI 03-3989-2000 regarding the planning and installation of automatic sprinkler systems, a sprinkler installation is a fire extinguishing system permanently installed within a building. This device has the capability to extinguish fire automatically by spraying water at the fire source. The maximum working area is 84 m<sup>2</sup>, and the density of radiation in light fire hazards is 2.25 mm/minute. Prior to installation, the plan drawings must be approved by the relevant authority. After installation is complete and witnessed by the owner and authorized officer, an inspection and testing of the installation must be conducted. The installer may cease work immediately after all deficiencies have been corrected, and the sprinkler system is ready. The handover report must include the participation of all parties as evidence of work submission. The greatest distance between neighboring rows and the largest coverage area of each sprinkler head in one row is used to determine the position of the sprinkler heads. The distance between the wall and the sprinkler head for systems with low fire hazard should not exceed 2.3 meters. The distance should not exceed 2 meters for systems with moderate or heavy fire hazards. Typically, sprinkler heads should be placed separately from columns. Sprinkler heads should be placed within 2 meters of the opposite side of the column if this cannot be avoided and the distance from the sprinkler head to the column is less than 0.6 meters. At least 1.2 meters should separate sprinkler heads from beams.

Regulation PU No: 26/Prt/M/2008 explains that automatic sprinkler systems are required for meetings of more than 300 people, but not for stadiums. Open-Air Concourses (OBS), audience seating areas, and stadiums above the floor for shows, entertainment, or competitions are exempted from installing sprinklers due to building height and fire load. Technical research indicates that installing sprinkler devices would not be effective. Locations within the open arena of the stadium, such as a press room with an area of less than 93 m<sup>2</sup> and warehouse facilities with an area less than 93 m<sup>2</sup>, are exempted from the requirement to install sprinklers as long as they are protected by fire-resistant construction with a minimum fire resistance level of 1 hour. If constructed from non-combustible or fire-resistant materials, rooms of 28 m<sup>2</sup> or less, such as ticket booths, small rooms, or loosened rooms, and enclosed rooms with construction having a fire rating of not less than 1 hour and less than 93 m<sup>2</sup>, are excluded from the requirement of sprinkler installation.

Improvement suggestions for sprinklers include procurement and installation in accordance with SNI 03-3989-2000 and authorized installers. Possible areas for sprinkler

installation include players' changing room, medical room, and press conference room as these rooms are enclosed and contain many materials that could fuel a fire, such as players' changing cabinets made of wood. Sprinklers are also recommended for installation in enclosed corridor hallways. Euroborg Stadium, Gronigen, Netherlands, as described in the article titled "Fire In Euroborg Football Stadium; Analysis Of Human Behaviour", installed sprinklers in the first ring corridor. The stadium consists of two rings. The first ring is the lower one. The second ring is situated above the first. The first and second rings are connected by stairs inside the building. There are four main entrance doors located at every corner of the stadium. These entrance doors are connected (via stairs) to the first ring. The second ring can only be accessed via stairs starting from the first ring. The escape route in the stadium is the same as the entry route (Oberijé et al., 2009).

Overall, the compliance percentage of the evacuation route is 61.9%. This figure is obtained from the average calculation of all sub-variables of the evacuation route, which consist of emergency stairs, exit facilities, safety signs, assembly points, and emergency doors. Whereas, the overall percentage of the fire protection system, consisting of fire extinguishers, hydrants, fire alarms, fire detectors, and sprinklers, is 0%.

#### 4. Conclusion

The assessment of emergency exit routes and fire safety measures at one of Football Stadium in Greater Malang has been meticulously conducted based on the applicable Indonesian safety guidelines. This comprehensive inspection ensures that the stadium meets established safety standards, particularly in terms of emergency evacuation and fire prevention. The assessment results indicate that emergency exit routes have been well-planned and clearly marked, enabling spectators to quickly and safely leave the stadium area in an emergency. The fire warning system and evacuation procedures have also been effectively implemented, including the use of well-functioning fire alarms and evacuation routes that security personnel and spectators are familiar with. This demonstrates the stadium management's commitment to the safety of spectators and personnel, as well as compliance with existing regulations.

However, this evaluation also identifies several areas needing improvement to further enhance safety. A primary concern is ensuring that emergency exit routes are always free from obstructions or blockages during events, which can be achieved by assigning special personnel to monitor access. Additionally, the fire suppression system needs regular maintenance to ensure optimal functionality in emergencies. It is also recommended to conduct regular training and evacuation drills for staff and security personnel and to provide clear information about evacuation procedures to spectators through announcements and printed materials. Thus, while the stadium complies with existing safety guidelines, ongoing efforts and continuous improvements are necessary to ensure the stadium remains a safe and comfortable place for all visitors and personnel.

Recommendations that can be offered include the need for football stadium management to improve and complete the evacuation routes and fire protection systems in accordance with the applicable standards, one of which is the Indonesian National Standard, Regulation PU No. 26/PRT/M/2008, Regulation PUPR No. 14/PRT/2017, and Regulation of the Ministry of Youth and Sports No. 7 of 2021. In addition, there is a necessity for socialization and publication of regulations and legislation governing safety in public facilities, particularly

in Football Stadiums, to ensure that evacuation routes and fire protection systems comply with the existing standards.

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