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Reliability Evaluation of Emergency Reponse Plan Design in Buildings of Sriwijaya University 2019

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Abstract **-** Sriwijaya University consists of several different buildings for administration and academic purpose to student accommodations. A proper Emergency Response Plan (ERP) is an important factor in ensuring the safety of building occupants from hazard such as fire, as it may reduce evacuation time and prevent fatality and injury. This study is a descriptive research with qualitative approach. Samples were selected through purposive sampling techniques. Emergency Response Plan (ERP) evaluation applied to Administration Headquarters (KPA) and Sriwijaya University Apartment Buildings in accordance with NFPA 101 life safety code and SNI 03-1746-2000. The evacuation time was calculated by using SFPE 3rd Handbook of Fire Protection Engineering 2002. This study shows that Administration Headquarters met the standards of emergency route, doors and stairs but doesn't have standard exit signs. Apartment buildings met the standard for emergency route, stairs and exit signs but not enough emergency doors. Both buildings doesn't have written and standardized emergency procedure and evacuation maps. Both buildings don't have standard assembly points. With standard evacuation time of 2,5-3 minutes, Administration Headquarters has ideal evacuation time of 1,96 minutes while Apartment buildings has unsatisfying evacuation time of 4,87 minutes. Through evaluation of these variables, it's concluded that both buildings don't have overall reliable Emergency Response Plan (ERP) designs. This study suggests that both buildings needs improvements such as: providing standard assembly points and proper signs, providing adequate fire prevention and fire fighting management, has written emergency procedures and evacuation map which are communicated to occupants, adding emergency stairs and doors and to schedule routine evacuation and fire drill.

Keywords: *Emergency Response Plan (ERP), fire management*

I. INTRODUCTION

According to Minister of Public Works Regulation No. 26/2008, fire is a phenomenon that arises due to an increase in temperature of a material which then reacts chemically with oxygen to cause heat and flames, which start from the forming of fire to its spreading until smoke and gas piled up, creating a large blaze[1].

According to the United States National Fire Protection Association (NFPA), there were 1.331.500 incidents in the United States in 2010 that resulted in 3.120 deaths and 11.593.000.000 USD in losses. Based on 2015 data, it had been found 8.243 fire cases in Indonesia from 1998 to 2008 which incurred losses of up to Rp. 1.255.091.940.080[2].

According to the regulation of the Minister of Public Works No.20 / PRT / M / 2009 regarding technical guidelines for urban fire protection management, building fire protection management is part of building management to strive for the readiness of building owners and users in the implementation of fire prevention and mitigation activities in buildings[3].

Sriwijaya University is a public university in South Sumatra, Indonesia. Sriwijaya University has 10 faculties with 2 campuses in Palembang city and Indralaya city of OganIlir district. The campus located in Indralaya is a place for academic and administrative activities, one of which is the Administration Headquarters Building (KPA) of Sriwijaya University.

The Administration Headquarters Building (KPA) of Sriwijaya University has 3 floors with 3 exits, namely the front door, right side and left side door. The total academic community of Sriwijaya University, which reaches 26,000 people has various activities which requires the use of modern technology such as LCDs, computers, laptops, photo copy machines, air conditioners, and other electrical equipments which can trigger electrical short circuit and creates fire. Inside the building, there is a meeting room that is often used as a gathering place for important people and the rector's guests as well as storage for important documents and archives. In addition, the absence of floor plans and evacuation route maps and gathering points might confuse the occupants when there is a fire inside the building. Emergency signs are necessary for people in the building to evacuate and not being trapped inside the building[4]

In 2012, the house of the head security guard which located behind the Dean Building of the Faculty of Law, Sriwijaya University in Indralaya caught fire.

The cause of the fire was electrical shortages and the explosion of the gas canister which triggered large fire. There were no fatalities in this incident, but it was a very regrettable loss for valuables and other important documents. This shows that preparedness of emergencies such as fire is important so as not to cause loss of life and property.[5]

Sriwijaya University also provides housing for students such as dorms, flats and apartments. Among the three places, the apartment buildings consist of 5 floors. Sriwijaya University Apartments is used by students as a place of residence or lodging during their study with annual rent. It is located inside the Inderalaya campus of University of Sriwijaya.

A lot of activities happens in the apartment are directly related to modern technology and electricity. Apartment occupants often found to be charging their phones for a long time and left them to sleep, laptop chargers are always left plugged when not used, and the use of water dispensers that can cause an electrical shortage. There are also apartment occupants who deliberately use gas stove inside the apartment even though it had been banned by the university. These risky behaviors can cause fire emergency. The purpose of this study is to conduct an evaluation on existing Emergency Response Plan (ERP) design in the Administration Headquarters Building (KPA) and Sriwijaya University Apartment buildings in Indralaya.

II. METHOD

This research is a descriptive study which used qualitative approach to evaluate the design of Emergency Response Plan (ERP) in Administration Headquarters (KPA) office building and Sriwijaya University Apartment. This study aims to do evaluate ERP design by describing and calculating the things which already exists and needed in the Emergency Response Plan (ERP) of the building with SNI reference standards, SFPE Minister Regulation 3rd edition 2002 and NFPA 101.

For Administration Headquarters Building, there are 6 informants from the staff working for the building. As for Sriwijaya University Apartments, there are 2 key informants from the apartment management and fire department and 6 regular informants from the apartment dwellers. The validity of the data in this study uses triangulation of sources, triangulation of techniques and triangulation of data[7]. Data analysis was carried out after in-depth interviews, then data matrix analysis which contains a summary of interview transcript results was

carried out. Data will be presented descriptively in narrative form[8].The objects for this research are the Emergency Response Plan (ERP) which includes emergency exits (emergency doors and stairs), exit routes and map, exit signs, assembly points, evacuation time and emergency procedures.

III. RESULT

a. Emergency Exit and Exit Route

Emergency exit consists of doors and stairs. The Administration Headquarters has 3 exit doors, which consists of front, left and right doors. However, clear evacuation route and signage is not provided.

"…evacuation route probably is not built like in the malls, it seems that we just straight away consider it one because [the building] is not complicated, if we have lift, for example, we mut have emergency stairs. The existing route is just what already there…" (KH).

"…if assembly point is available, then there should also be evacuation route. Now, we don't have them here yet…" (EN).

According to table 1, the exit door placement fits the standard criteria with minimal exit width of 21", being easily accessible, and not obstructed by objects. Corridors and exit route in Administration Headquarters fits thestandard criteria with non slippery floors, minimum corridor width of 1,2 meter, minimum route width of 2 meter and free from obstacles so the evacuation time would be effective. The stairs are already adequate with total steps per stair does not exceed 12 steps as the existing stairs consists of 11 steps.

TABLE 1.
OBSERVATION RESULT OF EMERGENCY EXIT IN ADMINISTRATION HEADQUARTERS OF SRIWIJAYA UNIVERSITY INDERALAYA

No	Component	Evaluation Criteria	Yes	No
1	**Emergency exit placement**	Easily accessed		
		Minimal unit width 21"		
		No obstructing object		
2	**Corridor and exit route**	Floors should not be slippery		
		Free from obstacl es		
		Minimum corridor width 1,2 meter		
		Minimum exit width 2 meter.		
3	**Stairs**	Total steps in each stairs should not exceed 12 steps		
		Step width around 14 – 20 cm		
		Stair inclinationbetween $25^0 – 42^0$		

TABLE 2.
OBSERVATION RESULT OF EMERGENCY EXIT IN SRIWIJAYA UNIVERSITY APARTMENT BUILDINGS

No	Component	Evaluation Criteria	Yes	No
1	**Emergency exit placement**	Easily accessed		
		Minimal unit width 21"		
		No obstru object		
2	**Corridor and exit route**	Floors should not be slippery		
		Free from obstacl		
		Minimum corridor width 1,2 meter		
		Minimum exit width 2 meter.		
3	**Stairs**	Total steps in each stairs should not exceed 12 steps		
		Step width around 14 – 20 cm		
		Stair inclinationbetween $25^0 – 42^0$		

Emergency Exit Observation on Student Apartment Building shows that not all criteria have been fulfilled. The Sriwijaya University Apartment buildings do not have adequate emergency exits for its 3 buildings and 5 floors.

b. Exit Sign

TABLE 3. EXIT SIGN

No	Components	Evaluation Criteria	Yes	No
1	Signs	Evacuation Route/ Exit		
		Assembly Point		
		Written with Capital letters with minimal height of		
		Fire Extinguisher sign		
		Evacuation Map		

As shown in table 3, exit sign and other necessary signage are still inadequate for Administration Headquarters. The available exit signs are only available in the first floor. In contrary, the Student Apartment buildings fulfilled the standard of SNI 03- 6574- 2001 and available on every floor.

c. Assembly Point

As shown in table 3, the Administration Headquarters doesn't have assembly point sign. This probably happen due to no assignment of official assembly point for the building. Same situation applies to Sriwijaya University Apartment buildings. Both buildings have empty lot where it would be ideal assembly points. However, there is no sign available nor information relied to building occupants and guest that the lots are used as assembly points if emergency situation occur.

d. Evacuation Time

Evacuation time calculation for Administration Headquarters was taken from two directions from third floor descending to rear and middle stairs to the outide of the building:

Calculating D (density)

$$\text{Density} = \frac{\quad}{\quad}$$

Calculating walking speed in corridor (S)

$S = k – (a \times k \times D)$

$S = 1{,}40$ m/s – (0,266 m²/person x 1,40 m/s x 0,23 person/m^2)

$S = 1{,}40$ m/s – 0,0856

$S = 1{,}31$ m/s

Calculating specific speed (Fs) $Fs = S \times D$

$Fs = 1{,}31$ m/s x 0,23 person/m²

$Fs = 0{,}30$ person/m/s

For Administration Headquarters, by the assumption that everyone has evacuating speed of 1,31 m/s it can be assumed that all building occupants can reach the stairs within 60,70 seconds or 1,01 minute. For the next 13 second, 14 people are already on the stairs. If we sum the 2 directions, then 28 people would already be on the stair of each floorswith Fc = 1,09 person/s then the rest 161 people queuing in front of exit doors on person/s to descentis 26 seconds:

1. At 86,75 seconds (1,45 minutes) everyone would have been evacuated from third floor.
2. At 99,7 seconds (1,66 minutes) first wave of people would arrive in second floor stairs.
3. At 112,7 seconds (1,88 minutes) everyone would have been evacuated from second floor.
4. At 117,8 seconds (1,96 minutes) everyone would have been evacuated from the Administration Headquarters.

Therefore, the total time needed to evacuate the entire Administration Headquarters building with total occupants of 567 people is 117,8 seconds or 1,96 minutes.

Calculation on Sriwijaya University Apartment buildings was done with the same formula. By the assumption that everyone has the evacuation speed of 1,38 m/s all building occupant can reach the stairs within 129,870 seconds or 1,17 minutes. For the next 11 second 16 people would already be on stair with Fc = 1,25 person/s with 44 people queuing at the top of the stairs on each floor. The next 25 seconds, the flow of evacuators reach the fourth floor. The average of time needed for occupants with the speed of 1,25 person/s to descent the stairs is 36 seconds:

1. At 165,87 seconds (2,76 minutes) everyone would have been evacuated from fifth floor
2. At 176,87 seconds (2,94 stairs off each floor. Occupants would reach second floor within 13 seconds. The average time needed for occupants with speed of 1,09 minutes) the first wave of evacuators arrived at fourth floor stairs
3. At 201,87 seconds (3.36 minutes) everyone would have been evacuated from fourth floor
4. At 212,87 seconds (3,84 minutes) first wave evacuators reached third floor
5. At 235,87 seconds (3,93 minutes) everyone would have been evacuated from third floor
6. At 248,87 seconds (4,14 minutes) first wave evacuators reached the second floor
7. At 273,87 seconds (4,56 minutes) everyone would have been evacuated from second floor
8. At 277,43 seconds (4,62 minutes) everyone would have been evacuated from the apartment buildings.
9. At 291,92 seconds (4,87 minutes) everyone would have been gathered at the assembly point

Therefore, to evacuate the entire 60 occupants from all five floors of Sriwijaya University Apartment buildings required 4,87 minutes time.

e. Emergency Procedures

Emergency procedure is available in Administration Headquarters but it is not standard, official or written. Fire fighting equipments such as fire extinguishers, hydrant, detectors and alarms are till inadequate.

> *"…there is a procedure, for example, when there's fire, we should report to the*

household department. Then the household department appoint driver and fire engine to the it…" (JN)

"…there was training but it's for forest fire. Our security guards took the training because there was a fire in Sriwijaya University forest. Some household department personnel also took the training. We also bought the fire truck" (KH)

"…we have two fire engines but only one works so sometimes we are confused when there's fire…" (JN)

As for the salvage of important documents, the building managements don'town special storage that is fireproof or safe from other hazards. The documents are responsibility of each unit.

Sriwijaya University Apartment also claimed to have their own emergency procedure, for example, to inform everybody in the building if emergency happen to contacting firefighters. The available procedure, however, only understood by a few people.

IV. DISCUSSION

a. Emergency Exit and Exit Route

Administration Headquarters of Sriwijaya University has 3 (three) exit facilities; the front door, the right door, and the left door. The exit door width is also not less than 21 "and is free of obstacles. Corridors inside the building are also quite wide.The floor is not slippery so that residents will not be hampered when carrying a self-rescue to the exit and does not cause a buildup of people when fire occur. Evacuation routes to get to the exit inside this building are not yet available. Although the exit doors and stairs at the building are good enough for the occupants of the building to get to assembly point, evacuation routes are also very necessary to facilitate the evacuation process in the event of a fire so as not to cause injury or fatality.

The exit must not be locked while the building is occupied so that there are no obstacles for occupants to get out in case of fire. As a study conducted by Yusuf (2014) the exit facilities at the Ammonia Production Unit used 3 corridors that used EXIT access, each of which had a width of 3.15 meters in corridor A, and 2.05 meters for corridors B and C. EXIT access it is maintained continuously, and is free from obstacles and obstacles. EXIT access is not obstructed by furniture or other objects such as mirrors that can disturb the view during the evacuation process.

Administration Headquarters building has corridors on every floors working as one of the main accesses that connects every room passed by each employee and visitor. In addition, the corridors also used as one of the evacuation routes during emergencies. The corridors in this building has a width of 3.66 meters in corridor A and 2.15 meters in corridors B and C. The floor in this building is also not slippery so it does not hamper the evacuation process. The KPA building already has more than one stairs on each floor to get out, making it easy for occupants of the building not to cram in one stairs on an evacuation. This is in accordance with NFPA 101 standards.

In this case, in order to maintain successful evacuation process in the event of emergencies, the building management must maintain the condition of the emergency doors, stairs and route so that it remains safe and free of objects that can hamper the evacuation process and every occupant can be immediately evacuated safely without any obstacles.

Sriwijaya University Apartment does not have an emergency exit and only has one main door located on the 1st floor. The door is used as the main entrance and exit path. On the 2nd to 5th floors, the apartment does not have a main door or an emergency exit but has an exit access that goes directly to the stairs located on the side of the building and the center. On the 1st floor, right at the end of the stairs there is also no door. This design will make the evacuation process take longer time because people will need to walk to the middle on the 1st floor after descending the side stairs.

By NFPA 101 life safety code standard, the number of emergency exits in the Sriwijaya University Apartment is not up to standard. The absence of an emergency exit at the Sriwijaya University Apartment is very dangerous for its occupants. Making emergency exits that is closer to the stairs is very important to do as soon as possible. In SNI 03-1764-2000 the width of the exit or door width is at least 0.8 m for the size of the new door and at least 0.7 m for the size of the old door and to prevent fire hazards, fire resistant doors must be made.

The need for emergency stairs at the Sriwijaya University Apartment is seen by the number of exits / exits available. There are four

stairs, with one main staircase in the middle and three emergency stairs on the side. From the data collected, it appears that the stairs in Sriwijaya University Apartment are in accordance with the needs of the door or the exit. Both the main staircase and the emergency staircase are located inside the Sriwijaya University Apartment. According to SNI 03-1746-2000 standards, all the stairs inside that serve the exit lane or exit component must be enclosed. This is intended so that the existing stairs avoid the dangers of smoke and fire that spreads. However, the emergency stairs in the Sriwijaya University Apartment are not enclosed by an emergency door so that if there is a fire, smoke will enter the stairway.

b. Exit Sign

The Administration Headquarters of Inderalaya University has a sign for every exit on the 1st floor. The sign is in the form of a plastic board that reads "EXIT". The text is in green and the board is transparent. However, these signs are only installed on the first floor. The second and third floors aren't provided with exit signs. The available EXIT signs are not clearly visible with the transparent plastic board design and the writing is not big enough so it will complicate the evacuation process in the event of a fire.In addition, other emergency signs are not installed at several points in the KPA building. Signs that are not installed includecommunication lines, stairway signs, fire extinguisher location signs and assembly point signs.

The exit sign is an important part of the means of escape when residents evacuate to a safer place. SNI 03 - 6574 - 2001 states that the exit sign is placed in places that have been prepared as a means of escape when a fire is placed on the door, stairs, corridors or evacuation routes and gathering points.[6] In contrast with Administration Headquarters building, the design of the exit sign on Sriwijaya University Apartment was made in accordance with the standard. The "EXIT" sign should be given a contrasting color with the surrounding and it's board such as a bright green color, the "EXIT" sign was written in capital letters with a minimum size of 15 cm, a minimum width of 5 cm and a distance between letters of at least 1 cm. The "EXIT" sign in Sriwijaya University Apartment is placed on each stair entrance. The "EXIT" sign is also placed at the exit with a distance of 10 cm from the door frame. The design was made so that the residents of Sriwijaya University Apartments could easily see the exit sign.

Evacuation time before installation of the evacuation route signs is slower compared to after signs are installed.[7]This shows the importance of exit signs or signs to exit in guiding residents to exit. When the exit sign in a building is good and complies with the provisions of the SNI 03 - 6574 - 2001 standards, in it will make evacuation process easier because when an emergency occurs, residents can immediately find the exit, stairs and assembly points.

c. Assembly Point

According to the NFPA 101 life safety code of 2000 the assembly point is a gathering place for residents and the final destination of the evacuation process during a fire or other emergencies. Determination of the location of the assembly point or gathering point is by examining the security of the place such as protected from the danger of fire, smoke and open spaces far from the ruins of buildings.

The Administration Headquarters does not yet have permanent or official assembly points that are used as a gathering location during emergencies. In case of fire,occupants only rely on security officers on duty and tend to focus on saving themselves. However, there are some locations near the building that can be used as temporary assembly point that are quite large and far from fire hazards.

It is necessary to make an assembly point in he area of the Administration Headquarters building in order to overcome emergencies. Therefore the building management needs to design or create assembly point that is located in the empty lot between the Administration Headquarters building and the auditorium building. Signs also need to be installed to facilitate the evacuation process. In addition, the gathering point must also always be maintained so that it is always in a safe condition as a gathering place during the evacuation process in case of emergency or fire in Administration Headquarters building or the auditorium building.

The Sriwijaya University Apartment has a large empty yard around its building but does not yet have an assembly point. Assembly point should be installed in the opposite direction to the wind, so as to prevent the danger of smoke or even the blazing fire.[13] In evacuating, building occupants should be directed by not following the direction of the wind to avoid exposure to smoke and fire.

NFPA 101 life safety code in 2000 states that minimum standard safe distance of assembly

point from buildings is 6.1 meters. The distance of potential empty lot in front of the apartment building is 20 meter. It's free from rubbles or obstructing objects and is in opposite direction of the wind. Therefore, the management should make assembly point in this lot and complete it with signs.

d. Evacuation Time

The result of calculation based onthe SFPE 3rd of 2002 Handbook of Fire Protection Engineering shows that the evacuation time needed to reach the exit of Administration Headquarters building is 117.8 seconds or 1.96 minutes. The Administration Headquarters is a building with class 5 construction with maximum evacuation time of 2.5 minutes. In comparison, Administration Headquarters has ideal calculated evacuation time.

Calculation for Sriwijaya University Apartment buildings was using the same method and the result was not up to standard. The time needed to evacuate the apartment was 4,87 minute which exceed the standard of NFA 101 Life Safety Code 2000 where maximum evacuation time for such building is set at 3 minutes. 44 People was crammed for 25 seconds at the stairs. Second calculation was done by dividing evacuator flow to all emergency stairs available, but problem occurs because all occupants have to make extra time to reach the main door which is the only exit for the buildings. This further proves that Sriwijaya University Apartment needs to add more exit doors in different sides of the building.

e. Emergency Procedures

Based on PERMENPU no.20/ PRT/M/2009, emergency response procedures include activities that are formed from the planning, preparation and implementation of fire safety plans and emergency action plans. The Administration Headquarters building does not yet have a written standard and regulation regarding the emergency response procedures in writing and in detail. In the event of a fire or other emergency, the security team and the household department will immediately handle it. Some of the efforts that have been made when facing fires such as the provision of fire engines, fire extinguishers, fire hydrants, detectors and alarms are also still inadequate.

A regulation on emergency response procedures is necessary so that in the event of a fire and other emergencies, the evacuation process becomes more structured and there is no overlapping responsibilityto carry out the emergency procedure. The Administration Headquarters building is also equipped with a fire extinguisher in every room on each floor and also a different heavy fire extinguisher on the first floor, as well as direction on how to use it. The building does not have fire hydrant, alarm, smoke detectors and sprinkler in the building. Sriwijaya Inderalaya University has
2 fire engines, but only one unit can function properly, making it difficult for related parties if there is a fire due to the lack of supporting tools to deal with the situation.

The Sriwijaya University Apartment is also in the same situation where they also do not have written standard and regulation for emergency procedures. The responsibilities and procedures for fire safety are only relied to building management and securities. This situation would cause confusion and would hinder the evacuation process in case of emergency.

V. CONCLUSION

After observation, interviews and calculation done, this study conclude that both Administration Headquarters and Sriwijaya University Apartment buildings does not have ideal Emergency Response Plan (ERP) in general as they lack in variouselements of emergency response and procedures.

Administration Headquarters has emergency route, doors and stairs but doesn't have standard exit signs. Apartment buildings met the standard for emergency route, stairs and exit signs but not enough emergency doors. Both buildings doesn't have written and standardized emergency procedure, evacuation maps and fixed assembly points with its signs. With standard evacuation time of 2,5-3 minutes, Administration Headquarters has ideal evacuation time of 1,96 minutes while Apartment buildings has evacuation time of 4,87 minutes that exceeds the standard suggested. Despite its ideal evacuation time, Administration Headquarters still lacks a lot of emergency procedure elements which would cause more problems in handling the emergency situation.

This study suggests Administration Headquarters management to provide standard "EXIT" signs and other necessary signs through all the floors. Sriwijaya University Apartment has to provide more exit doors in different sides of building as to reduce evacuation time. Building separate emergency stairs in the outer part of the building would also be a helpful choice.

Both buildings should make their standard and regulation on emergency procedures and evacuation

plan so the evacuation process would be more structured and overlapping responsibilities for evacuating, communicating and acting on the fire fighting or other emergencies can be avoided. The regulated emergency procedures should be communicated to building occupants and guests in written form and building safety induction. Buildings should set the available and suitable empty lots nearby as their assembly points by putting a sign and informing occupants and building visitors of this.

University of Sriwijaya should maintain the fire engines so they would work properly when needed. Fire prevention and fire fighting management and elements such as smoke detectors, fire alarm and sprinkler system should be provided. Lastly, building occupants should be given routine fire or emergency drill to evaluate the effectiveness of existing emergency procedures.

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