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Functionality of Building Design Related to Means of Escape (MoE) in Student Housing at Public Universities, as Required By-Law and Other Fire Codes

Mohd Zailan Sulieman[1,*], Fahrizal Zulkarnain[2]

[1] Building Surveying Department, School of Housing, Building and Planning, Universiti Sains Malaysia, 11800, Penang
[2] Faculty of Civil Engineering, University of Muhammadiyah Sumatera Utara, Medan, Indonesia

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ABSTRACT

One of the most serious problems facing student housing at public universities is fire hazards. The fire risk is significantly increased by some works that may be performed in the facilities and laboratories. The primary concern with any fire is to save lives. In the worst case, they lose consciousness, making them vulnerable to mistakes. The building should be designed to help the occupants in this situation. The passive fire protection system in the building should be always accessible and work well because it is permanent and is usually used frequently until the occupants are familiar with it. Occupants should be able to use the Means of Escape (MoE) design elements in the building to escape the fire even if the active fire protection system is not working or the fire department arrives too late at the scene. Therefore, this research was conducted to determine the functionality of Means of Escape (MoE) in building design and their effectiveness in allowing all occupants of student housing in public universities to escape during evacuation. The functionality of Means of Escape (MoE) in building design and their effectiveness for student housing in public universities is of great importance because they can reduce fire accidents, property damage, and loss of life. The methods used were observation, review of legal requirements and other fire safety-related rules and regulations. In addition, the research was also based on pilot testing of the questionnaire. In the case of compliance and design consideration, performance is evaluated by examining whether the elements meet the requirements of the regulations, while in the case of occupant findings, performance is evaluated based on the difficulty and complexity of the complaints and their solutions. In conclusion, the authorities and public universities need to work together to implement an adequate fire safety system in student housing in public universities.

1. Introduction

Malaysia has 20 public universities and 443 private higher education institutions with a total of over 1 million students and several thousand staff, faculty, and visitors [8]. Each of these institutions is committed to ensuring the safety and general welfare of the people on their campuses and

* *Corresponding author.*
E-mail address: mzailan@usm.my

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providing appropriate policies, procedures, and strategies to maintain a safe campus. As with many other critical areas on administrators' agendas, a campus fire safety plan requires the support of building and implementing a thorough and systematic process to create a quality plan to prepare for and respond to campus emergencies. However, saving lives is the primary concern in managing fire incidents in buildings. This requires that firefighters be able to rescue building occupants or that occupants themselves be able to escape if they are trapped in the building. To avoid fatalities, both parties must clearly and effectively plan access to the building and escape routes to safer locations outside the building.

This happened in a fire at Madrasah Darul Quran Ittifaqiyah, an Islamic school in Kuala Lumpur. The fire broke out on the second floor of the school and spread to the entire building, trapping the occupants and preventing them from being rescued or escaping. Firefighters had difficulty getting into the building due to metal grills attached to all the windows. Since the dormitory has only one exit door and every window has metal bars, some residents managed to escape by forcibly breaking the window bars or through a water pipe, while the remaining 23 residents died on the scene [21]. Although the case was caused by the sabotage activities of insiders, the main problem is the change and weakness of the Means of Escape (MoE) elements in the building, which limits the mobility of both occupants and firefighters. Since escape routes are designed to allow occupants to escape from a burning building, it is important that they can move along the safest routes within the building, and this also applies to the work of firefighters, who need the fastest and safest access to rescue trapped occupants.

Sometimes the existing elements are expected to perform well, but building inspectors mandate changes to the building, so the building's performance degrades. Therefore, the former Prime Minister of Malaysia, Dato' Sri Najib Razak, emphasizes that all hostel buildings, especially Islamic schools such as Tahfiz and Madrasah, must comply with the Malaysian Fire and Rescue Department Malaysia (BOMBA) fire safety regulations [22]. Many mishaps can happen during the evacuation, but effective Means of Escape (MoE) such as exits (openings), escape routes, evacuation, travel distance, exit doors, fire-fighting escape stairs, exit capacity, assembly point, vehicular access, and fire safety awareness [18] can help to assist building occupants even if they cannot receive outside assistance during a fire. Special attention should be paid to buildings with a high population, as these buildings may be exposed to more severe accidents that result in a high number of fire deaths. Therefore, this research was conducted to determine the functionality of Means of Escape (MoE) in high-rise student housing at public university design and their effectiveness in evacuating all building occupants.

1.1 Concerns in Fire Cases for High-Rise Student Housing at Public Universities

Since the main idea of Means of Escape (MoE) is to literally provide a clear and safe path for evacuation, occupant awareness of the intended means of escape in the building has a great impact on the success rate of occupants safely escaping during evacuation. In other words: If occupants are unaware of the existence of the means of escape and are unable to use the elements provided in the building, they are likely to be at risk of becoming trapped and panicking. The main objective of the design criteria for building escape routes (MoE) should be to ensure the safety of human life, the protection of property, and the continuity of operation or function. This paper evaluates the functionality of building design as it relates to building means of escape (MoE) in student housing at public universities, as required by legislation and other fire codes. Compliance with design criteria for escape routes (MoE) in student housing at public universities, as required by -law and other relevant fire codes, is of great importance because it can reduce fire accidents, property damage, and loss of life.

Similarly, there was a fire in a building at the Faculty of Economics and Administration, the University of Malaya on 27 August 2019, which caused a room fire due to a short circuit. This is not the first time this has happened at the University of Malaya, on June 29, 2001, the Tunku Chancellor's Hall building caught fire and destroyed almost 90% of the entire building and due to the same factor [14]. Apart from that, the fire incident at the men's dormitory block of Universiti Islam Antarabangsa Malaysia (IIUM) in section 16, Petaling Jaya on 26 June 2014, and four rooms at the Universiti Utara Malaysia (UUM) student hostel block in Sintok were damaged in a fire incident on the third floor of the building 20 July 2021 also shocked the public and involved fire safety issues at public universities. To avoid all these accidents, a proper fire safety plan needs to be prepared. Public universities, themselves have a lot of flammable equipment that can start a fire in just a second. All the equipment must be taken care of and managed well to decrease the possibility of an accident occurring. Since it is proven that the high number of fire occurrence in high-rise student housing in public universities recorded pretty much received huge impact to fire safety issues, therefore Restu (M01 & M02), Saujana (M03 & M04) and Tekun (M05 & M06) hostels in Universiti Sains Malaysia are chosen as the site study as it consists of 10 – 9 storeys buildings with an average of 3,000 – 5,000 of living occupants.

Therefore, this incident is deemed as a wake-up call for us to be aware that in any building, the applicable regulations must be followed, especially in terms of escape routes and other fire-related guidelines, to avoid this situation. When implementing egress elements in building design, the rules and specifications of fire codes must be followed. There are four (4) primary codes and standards used in Malaysia in the design phase for fire safety. They are the Uniform Building Code 1984 (UBBL, 1984), the National Fire Protection Act 101 (NFPA 101), the Fire Services Act 1988 (Act 341) and the Malaysia Standard (MS). Based on these codes and standards, ten (10) major criteria for Means of Escape (MoE) have been established: Exits, Escape Route, Evacuation, Travel distance, Exit Doors, Fire Escape Stairs, Exit Capacity, Assembly Point, Vehicular Access, and Fire Safety Awareness [12]. This list of criteria is used to assist designers in designing fire protection buildings for student housing in public universities to ensure that the building is safe for occupants. Compliance with the design criteria of Means of Escape (MoE) in student housing at public universities is based on the regulations listed as shown in Table 1.

As mentioned earlier, a Means of Escape (MoE) plays an important role in student housing at public universities by preventing business interruptions, lowering property insurance premiums, increasing public confidence, and thus increasing an organization's profitability. A Means of Escape (MoE) is a set of measures designed to reduce the destruction caused by fire. Means of escape include measures designed to prevent the ignition of an uncontrolled fire and those designed to limit the development and impact of a fire once it has started. Means of escape include those measures designed during the construction of a building or implemented in existing buildings, as well as those measures taught to the building's occupants. If a fire accident occurs due to negligence in means of escape, it will have a negative impact on the competence of public universities compared to private universities. In conclusion, the authorities and public university management need to cooperate in complying with the design criteria for means of escape (MoE) in student housing at public universities. If these buildings were completed with the ideal design criteria for escape routes (MoE) in student housing at public universities, the impact of fires could be reduced, and more people could survive in these fires.

Means of Escape (MoE) can be defined as structural means that allow people to move from any location in a building or structure to a safe location without the need for outside assistance. It is important that occupants of a building be able to reach a safe location uninjured in the event of a fire, and a safe location is usually associated with an area outside the building that is distant from the threatened space [19]. Moreover, the functionality of the Means of Escape (MoE) design in the building can be determined based on its compliance with the by-laws and its occupants' experience in using it and every element in Means of Escape (MoE) will determine how well can the overall design assists occupants during the evacuation process. Having one failure such as an unclear evacuation route and absence of evacuation plans on every storey may cause occupants to have difficulties of escaping as they might be unable to find the designated exits. In collateral of implementing Means of Escape (MoE) elements into building design, it is crucial for the design to follow the rules and specifications guidelines required in the fire safety standards – for which in Malaysia, the Uniform Building By-Laws, National Fire Protection Act, Malaysian Standards and such become significant references for relevant authorities to design a building with satisfactory performance in providing efficient Means of Escape (MoE) elements for the occupants [18].

Table 1
Statutory requirements for means of Escape (MoE) design criteria Compliance with MoE design criteria of MoE in student housing at public universities

1.0	**Exits (Openings)**	
1.1	Accessibility of exits.	UBBL166/2
1.2	Availability of 2 separate exits in every storey.	UBBL166/1, UBBL167/1
1.3	Ability of exits to provide a direct exit to final exit, a protected staircase leading to final exit, or an external route leading to final exit.	UBBL174/2
1.4	Location of exits no closer than 4.5 m apart.	UBBL167/1, UBBL174/1
1.5	There must be at least two exits spaced apart on each floor or fire compartment of a building.	NFPA101/20.2.4.2
2.0	**Escape routes (Egress/corridor)**	
2.1	The escape route is free of obstructions and is not used for storage.	-
2.2	The escape route remains the same width along its entire length of travel.	UBBL169
2.3	Where the communicating space includes an open stairway, the opening created between floors shall be at least 50 percent larger than the footprint of the stairway and all landings.	NFPA101/8.6.6(C)
2.4	The egress capacity shall be sufficient to allow all occupants of all levels within the communicating space to exit the communicating space simultaneously by considering the communicating space as a single floor area when determining the required egress capacity.	NFPA101/8.6.6(8)
2.5	Each occupant of the communicating space has access to at least one exit without having to (i) traverse another floor within the communicating space and (ii) having to enter the communicating space.	NFPA101/8.6.6(9&10)
2.6	The clear width of a corridor/passage required for exit access shall not be less than 1120 mm.	NFPA101/21.2.3.3
2.7	A dead- end corridor is permitted if (i) the dead-end corridor is not longer than 15 m if there is a monitored automatic sprinkler system, or (ii) the dead-end corridor is not longer than 6100 mm if there is no sprinkler system.	NFPA101/20.2.5.2
3.0	**Evacuation**	
3.1	Availability of evacuation plan.	-
3.2	Successful rate of occupants evacuates during fire drill.	-
4.0	**Travel distance**	
4.1	Travel distance to all exits must not more than 45m.	UBBL165, UBBL166/2

4.2	Maximum travel distance of 15m is permitted if there's availability of sprinkler system when the travel distance to any exits exceed 46m.	NFPA101/21.2.6.2.2
4.3	Travel distance for place of assembly from any point to reach an exit not exceed 45m.	UBBL188
4.4	Compliance of the travel distance to the maximum distance calculated in accordance with provision in the Seventh Schedule.	UBBL165
5.0	**Exit door**	
5.1	Determination whether all exit doors are openable from the inside without the use of a key or any special knowledge or effort.	UBBL173/1
5.2	Determination whether all exit doors able to close automatically when released and all door devices including magnetic door holders able to release the doors upon power failure or actuation of the fire alarm.	UBBL173/2
5.3	Determination whether all doors used by the public as exit door from any part of the place of assembly or leading to the open air only open in the direction of exit.	UBBL186/1
5.4	Determination whether all exit doors and doors through which the public pass on the way to the open air are without lock, bolts or other fastenings while the public are in the building.	UBBL186/2
5.5	Doors in stair enclosure are held open by an automatic release device.	NFPA101/20.2.2.3
6.0	**Exit capacity**	
6.1	Calculation of storey exit width.	UBBL176
6.2	Calculation of occupancy load and capacity of exit.	UBBL175
7.0	**Fire-fighting staircase**	
7.1	Availability of mean of egress via at least 2 separate staircases.	UBBL168/1, UBBL229/1
7.2	Compliance of the width of staircase to the width calculated in accordance with provision in the Seventh Schedule.	UBBL168/2
7.3	Availability of protected lobby to serve staircase.	UBBL197/1
7.4	Determination whether the enclosed staircase come with ventilation at each floor or landing level by either permanent openings or openable windows to the open air having a free area of not less than $1m^2$/floor.	UBBL198/1
7.5	Determination whether the enclosed staircase below ground level equipped with suitable means to prevent the ingress of smoke.	UBBL201
7.6	Determination whether the staircase provided has direct access to fire-fighting lobby.	UBBL229/4
7.7	Computation of number of staircase and staircase width.	UBBL177
8.0	**Place of assembly**	
8.1	Determination whether the exit for place of assembly is located, separated or protected to avoid any undue danger to the occupants of the place of assembly from fire originating in the other occupancy smoke therefrom.	UBBL178
8.2	Identification of the classification of places of assembly.	UBBL179, UBBL183
8.3	Street floor exits shall be sufficient for the occupant load of the street floor plus the required capacity of the open stairs and ramps discharging through the street floor.	NFPA101/20.2.3.2
9.0	**Vehicular access considerations**	
9.1	Significance of design consideration for vehicular access.	GTFPM2006 4.2.2
9.2	6m access must be provided if building has volume >112,000m^3	GTFPM2006 4.2.2
9.3	If it is an island building, the road for fire access should be 12m wide	GTFPM2006 4.2.2
9.4	The building must have accessible 6m back lane	GTFPM2006 4.2.2

2. Methodology

The research methodology is important so that the research conducted has the most appropriate and effective method to answer the research problem. Therefore, the methodology of the study includes the design, the surveys of the study or topic, the study procedures, the data collection procedures, and the data analysis procedures. For the purpose of this study, this research focuses on Desasiswa Restu, Saujana, and Tekun, (RST) the prominent buildings that house students of Universiti Sains Malaysia (USM), main campus. There are two cafeteria buildings - Tekun cafeteria and Restu and Saujana combined cafeteria. There are a total of 6 dormitory blocks, each of which Desasiswa has two buildings that house both genders separately as shown in Table 2.

Table 2
The student accommodation details

Student Housing	Block	Storeys
Desasiswa Restu	M01 and M02	10
Desasiswa Saujana	M03 and M04	10
Desasiswa Tekun	M05 and M06	10

In conducting the study, a mixed method was used to achieve the objectives. In this study, the research methodology begins with investigating the research problem by applying specific procedures or techniques used to identify, select, process, and analyze data information to understand the problem, which allows the entire case study to be critically evaluated for validity and reliability. The researcher decided to use a survey because it was the most appropriate to answer the questions and the purpose of the study. In other words, only a portion of the population is studied, and it is expected that the results can be generalized to the entire population [17]. Similarly [13] defines the survey as a study of public opinion or individual characteristics through the use of questionnaires and sampling methods. This study uses the exploratory design method, which begins with a qualitative approach and is followed by a quantitative approach. The researcher begins with a structured interview with the experts, followed by a quantitative approach using a checklist and observation method to review the elements of Means of Escape (MoE) in student housing at public universities.

The interview technique was used to collect the primary data. In interviews, the interviewer asks questions, and the respondent answers these questions. However, for this research, a structured interview was used to collect data because it is consistent with the purpose and objectives of this research. The structured interview approach is similar to the standard questionnaire survey method. For example, the structured method is similar to an observational study with checklists, where the observer, rather than the respondent, complete the questionnaire and the questions are generally closed-ended. The researcher designed an interview schedule as one of the data collection tools for this study. The Ministry of Higher Education (MOHE) including the management of public universities, the Student Housing Management (USM), the Public Works Department (PWD), the Fire and Rescue Department of Malaysia (FRDM), NIOSH, professional architects, professional engineers, and maintenance experts were interviewed.

For the large sample, the minimum number of respondents to be appointed should not be less than 100. The sample size must be based on previous commonalities. Experienced researchers consider a sample of about 100 respondents as the minimum sample size requirement for a large population [20]. According to Hair, the minimum sample size should not be less than 100 respondents to meet the minimum requirement for data analysis [6]. The interview questions aimed to elicit relevant information about Means of Escape (MoE) in student housing at public universities. The questions addressed the methodology and materials used for Means of Escape (MoE), perceived problems in learning Means of Escape (MoE), and possible strategies that could be used to improve Means of Escape (MoE) in student housing at public universities. For the purposes of this study, the interview was divided into four sections and the details of each section are described as shown in Table 3.

Table 3
The sections in the research interview

Section	Topic
A	Respondent's Background
B	The Scenario of Means of Escape (MoE) at the student housing at public universities.
C	The critical questions about the aspects of escape routes in student housing at public universities.
D	The measures to improve the prioritization of escape routes in student housing at public universities.

Data are entered and analyzed using the Statistical Package for Social Science (SPSS). It is one of the most popular statistical packages that can perform highly complex data manipulation and analysis with simple instructions. It is designed for both interactive and non-interactive (batch) applications. Descriptive statistics are used to summarize the socio-demographic characteristics of the subjects. Numerical data are presented as mean (SD) or median (IQR) based on their normality distribution. Categorical data are presented as frequencies (percentages). Data collected in the field were analyzed. The statistically weighted mean was used to answer the research questions. The response options in the instrument are weighted as shown in Table 4.

Table 4
Method of Data Analysis Source

Strongly Agree (SA)	Agree (A)	Neither Agree nor Disagree (NAD)	Disagree (D)	Strongly Disagree (SD)
5 points	4 points	3 points	2 points	1 point

The acceptance point for the items was 2.50 and any mean below 2.50 was considered rejected, not disseminated, and an unpopular view

A total of 100 questionnaires were sent to respondents. This number represents 100% of the participants who responded to the survey. Table 5 shows the distribution of participants according to their position in the organizations. Regarding the position of the participants in the organization, professional architects and engineers represented most respondents with 30 people (30%), followed by professional maintenance experts and senior managers with 20 people (20%) and engineers with 11 people (11%). Overall, the study received feedback from all respondents in the target group.

Table 5
Position of respondents

Position of Respondent	Frequency	Percent (%)	Cumulative Percent (%)
Admin Assistant	1	1.0	1.0
Administration	7	7.0	8.0
Assistant Facility Manager	1	1.0	9.0
Asst. Fire Superintendent	4	4.0	13.0
Universities management	5	5.0	18.0
Deputy Fire Superintendent	2	2.0	20.0
Engineer (PWD)	11	11.0	31.0
Facility Engineer (PWD)	5	5.0	36.0
Facility Head of Engineering (PWD)	3	3.0	39.0
Facility Manager	1	1.0	40.0
Fire Superintendent	2	2.0	42.0
Professional Architects	15	15.0	57.0
Professional Engineers	15	15.0	72.0
Professional Maintenance experts	10	10.0	82.0
Senior Asst. Fire Superintendent	1	1.0	83.0
Senior Executive (PWD)	10	10.0	93.0
Technical Executive	7	7.0	100.0
Total	100	100.0	

3. Evaluation of Means of Escape (MoE) Design Criteria in Student Housing at Public Universities

Based on the results and findings of the analysis, the implementation of Means of Escape (MoE) must be considered in the design of buildings to ensure that the success rate of safely escaped occupants can be achieved during the evacuation process. At the same time, it is important that all elements of the means of escape (MoE) function well in the event of a fire. In addition, the functionality of the building's escape routes can be determined based on code compliance and occupant experience in using the escape routes, and each element of the escape routes determines how well the overall design supports occupants during evacuation. A single flaw, such as an unclear evacuation route or the lack of evacuation plans on each floor, can make it difficult for occupants to leave the building because they cannot find the designated exits. When implementing Means of Escape (MoE) elements in building design, it is critical that the design follows the rules and specification guidelines prescribed in fire codes. In Malaysia, the Uniform Building By-Laws, the National Fire Protection Act, the Malaysian Standards, and the like are important references for authorities having jurisdiction to design buildings with satisfactory performance in providing efficient Means of Escape (MoE) elements for occupants [18].

The following are the elements of means of escape (MoE) that have been analyzed and relate to the regulatory requirements for the design criteria for means of Escape (MoE). Compliance with the design criteria for MoE in student housing at public universities is based on the regulatory requirements listed below.

a. Exits (Openings)

Any access to an exterior area outside of the Desasiswa Restu, Saujana, and Tekun (RST) buildings can be considered an opening. In this context, an opening applies to any open structure on the building wall. This opening, intended to serve as an exit, must be accessible at all times and provide direct egress to the final exit (or) to a protected stairway leading to the final exit (or) to an external path leading to the final exit. RST buildings shall have at least two separate exits on each floor, not less than 4.5 m apart. Each RST residence hall has a total of 8 exits, 4 of which are main exits located in the central part of the building, while another 4 alternative exits serve as final exits for each stairwell as shown in Figure 1 and Table 6. The minimum distance between all exits is 10 m (> 4.5 m) and they are widely spaced on each side of the building to allow residents to escape through the nearest exit. These exits allow residents direct access to the open spaces of the surrounding parameters at all times, as they are constructed as openings in the wall structure.

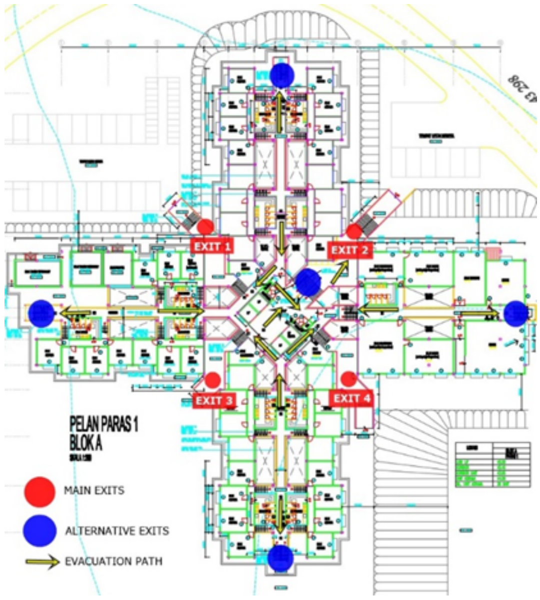

Fig. 1. Shows floor plan Desasiswa Restu (M01) has 9 total exits with a 10m minimum exit distance

Table 6
Shows exit access at Desasiswa Restu (M01) has 9 total exits with a 10m minimum exit distance

Exit	Access to
Exit 1	M01 parking space
Exit 2	M01 motorcycle parking space
Exit 3	M01 parking space, from Desasiswa Restu café entrance
Exit 4	Roadside of M03 entrance
Alternative exits	Connecting all floor levels to First floor level & Open spaces

The exits (openings) for the Desasiswa Restu, Saujana, and Tekun (RST) buildings meet the specified requirements. The number, width, and location of exits are as expected and adequate to assist occupants in evacuation. If a fire occurs and occupants are not familiar with exits that are infrequently used, it may disrupt traffic flow as there may be exits that are too full to be used at the same time during evacuation, slowing the process.

b. Escape routes (Egress/corridor)

The occupants of the Desasiswa Restu, Saujana and Tekun (RST) buildings meet the specified requirements. The number, width, and location of exits meet expectations and are adequate to assist residents in evacuation. If a fire occurs and occupants are unfamiliar with exits that are infrequently used, this can disrupt traffic flow as there may be exits that are too crowded to be used at the same time during evacuation, slowing the process. In RST buildings, corridors or passageways can be used as escape routes as long as they are clear of obstructions and are not used for storage. The escape route must have a constant clear width of at least 1120 mm to allow occupants to move comfortably during evacuation as shown in Figure 2. This will also ensure that at least two occupants can safely escape in accordance with the required escape capacity of each floor. Each occupant within the interconnecting space must have access to at least one exit (i) without having to traverse another floor within the interconnecting space, and (ii) without having to enter the interconnecting space. There is only one limited pathway, which consists of a 3-4 m dead-end corridor without a sprinkler system, located in the basement and rarely used by occupants. The internal corridor or passageway is designed the same for the RST residence hall. The corridor for each floor is a constant 1600 mm wide, but the internal corridor located along the hostel room has a critical width of 1200 mm. This could cause inconvenience in the event of an evacuation, as it is a closed pathway that could cause claustrophobic feelings among residents in the event of a power outage.

Escape routes for the Desasiswa Restu, Saujana and Tekun (RST) buildings meet the above requirements. The capacity of the escape routes is sufficient to accommodate the optimum number of occupants passing through them during evacuation, and in most cases the escape routes provide occupants with a clear and direct path to the nearest exits. Further research needs to be conducted to determine if occupants find the condition of the internal corridor/passageway in hostel rooms stuffy or claustrophobic when they use it. This will help identify potential problems that may occur if residents panic during evacuation, especially if power outages occur.

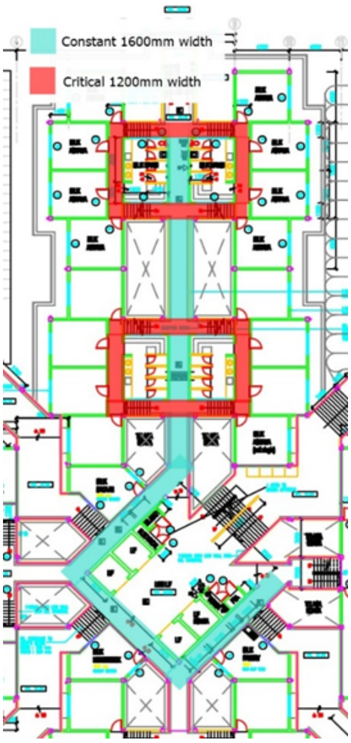

Fig. 2. Shows floor plan Desasiswa Restu (M02) corridor width diagram. The distance travel to reach nearby exits are all in walkable distance of approx. 15.2m. However, the maximum distance would be 30m. (<45m) (UBBL165, 166/2).

c. Evacuation

An evacuation plan must be prepared for each floor and escape routes must be clearly visible to occupants. However, the evacuation plan is not available. Data on the evacuation rate of occupants during the fire drill is obtained from the University's Occupational Health and Safety Department. During the inspection, it was noted that there is no evacuation plan for each floor posted on the notice board. However, the plan can be obtained from the residence hall office, which is located in the cafeteria of each residence hall. It appears that only the office staff has access to the plan. Residents are briefed on escape routes during fire drills. Evacuation requirements are inadequate in terms of availability of evacuation plans, and some of the rates of residents escaping during fire drills are considered unsatisfactory as shown in Table 7. Residents' opinions about knowledge of the evacuation route in the RST buildings should be further investigated to determine if the route is clear and direct enough for residents to use without the aid of an evacuation plan. Residents' opinions about the low percentage of safely escaped residents in the fire drill need to be collected, as there could be more reasons for factors other than just residents.

Table 7
Shows the evacuation requirements

3.0	Evacuation		M01	M02	M03	M04	M05	M06
3.1	Availability of evacuation plan at every storey.	-	×	×	×	×	×	×
3.2	Successful rate of occupants evacuates during fire drill.	-	✓	✓	✓	✓	✓	✓

d. Travel distance

The escape routes provided in the Desasiswa Restu, Saujana and Tekun (RST) allow a maximum distance of 45 m to all exits and to the assembly point from any point as shown in Table 8. The corridor/walkway is not equipped with a sprinkler system. The distance from the RST buildings to the designated assembly points exceeds 45 m. Compliance with the maximum distance is calculated in accordance with the provisions of the Seventh Schedule. Most routes to all exits are strategically located within the residence halls so as not to exceed 45 m. However, residents must travel a long distance to reach the designated assembly point.

Table 8
The travel distance to the available exits in Desasiswa RST buildings

Student Housing	Walkable distance to any nearby exits (m)	Maximum travel distance to exits (m)
M01	15.2	30.4
M02	15.2	28.8
M03	15.4	31.5
M04	15.2	29.7
M05	15.0	32.6
M06	15.2	32.0

M03 – The travel distance by using the short path is 650m which exceeds the required distance

Fig. 3. Shows view travel distance at Desasiswa Saujana (M03)

The layout/location of the exits is strategically located within the building, as the exits are no more than 45 m apart. However, the distance between the RST buildings and the designated assembly points is more than 45 m. The longest distance is the path to USM parade ground, which the residents have to travel 650 m. Further research needs to be conducted to find out if residents are able to walk to the assembly point as shown in Figure 3.

e. Exit door

Exit doors can be opened from the inside without the need for a key or special knowledge or effort. They must close automatically when released, and all door devices, including magnetic door stops, must be capable of opening the doors in the event of a power failure or fire alarm activation. Stairwell doors shall be held open by an automatic release device. All doors serving the public as exit doors from any part of the assembly area or leading to the outdoors shall open only in the direction of egress. Locks, latches, or other closures shall be disabled on all exit doors and doors through which the public passes on their way outdoors or to an outdoor area when persons are still inside the building. The exit door in this context is primarily the door to the resident's room. Each room is occupied by two people and there are four rooms with a bathroom in a cabin. Each resident has a key for the door, so the door can be opened manually with the key. The RST buildings are open plan so there is no exit door that the public must enter to escape the buildings. The door to residents' rooms may be manually accessed and may not be automatically released when the fire alarm sounds because there is no magnetic door holder installed. This may result in the occupants being trapped in their room and the door becoming stuck. Investigation is needed to determine what they can do next to escape the trapped room.

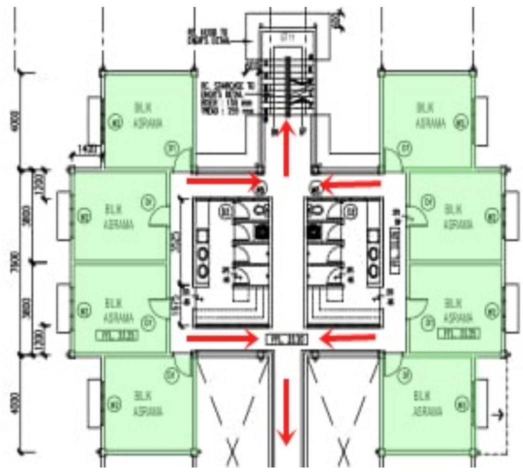

Fig. 4. Shows floor plan of the interior corridor of the resident's room at Desasiswa Saujana (M04)

The occupancy density and capacity of exits for each building are listed below (UBBL175). Exits for places of assembly are located, separated, or protected to prevent unreasonable hazards to occupants of places of assembly from fire emanating from, or smoke from, other occupancies (UBBL178) are also included. Floor exit width calculations for Desasiswa Saujana M04 (RST) buildings are provided, and occupancy load and exit capacity are determined as shown in Figure 4.

1. *Occupancy Load*

Type of meeting place: Class A (> 1000pax), concentrated use meeting room with fixed seating (accommodation).
Required space: 20 gross
Approx. No. of Present Occupant: 838pax
Occupancy load:
Floor Area for M04 / No. of occupant
= 12105.4m² / 838pax
= 14.45 gross of occupancy load/m² (<20gross)
The distribution for occupancy density according to each level is as shown in Table 9:

Table 9
Shows the occupancy load (pax) at Desasiswa Saujana (M04)

Floor	Area (m²)	Occupancy Load (pax)
Level 1	1721.87	119
Level 2	1689.29	117
Level 3-4	1869.82	129
Level 5-6	1869.82	129
Level 7-8	1642.77	114
Level 9	1415.72	115
Level 10	1415.72	115

The dormitory has 2 people/room, while the house Felo has 4 people/room.

The initial capacity for each building is able to handle the building's occupancy load if all stairwells are used equally. The stairways highlighted in red are the stairways most frequently used by occupants, and further research on occupant behaviour regarding their preference to choose the provided stairways for escape.

g. Fire-fighting staircase

Each enclosed stairway has ventilation on each floor or landing, either through permanent openings or through openable windows to the outdoors with a clear area of at least 1 square metre per floor. Occupants can escape via at least two separate stairways, and the stairway has direct access to a protected area for firefighting. Enclosed stairwell located below the first floor and equipped with appropriate means to prevent smoke penetration. The number of stairways and their widths are calculated to determine if they comply with the provisions of the Seventh Schedule. To determine the number and width of stairways sufficient to evacuate an optimum number of occupants at one time during evacuation, this can be theoretically demonstrated by showing compliance of the number and width of stairways on site with the provisions of the Seventh Schedule. Even though the initial capacity, based on the occupancy density of the buildings, does not match the required initial capacity of the Seventh Schedule (UBBL168/2), it is still assumed that a high success rate of safe escape of occupants will be achieved by using all available stairwells, which is explained by the experience of past fire drills. However, it is noticeable that Desasiswa Saujana M04 has poor results. Therefore, this problem is included in this report in the context of fire safety deficiencies of the building.

Table 12
Shows the percentage of saved occupants during fire drill training (%)

Student Housing	Percentage of Saved Occupants during Fire Drill Training (%)		
	Semester	2016	2017
Restu M01	1	61.29	56.03
	2	72.43	66.00
Restu M02	1	81.33	81.33
	2	88.73	77.26
Saujana M03	1	82.12	78.13
	2	84.00	83.25
Saujana M04	1	35.20	35.20
	2	37.33	55.01
Tekun M05	1	32.45	31.76
	2	61.20	34.0
Tekun M06	1	75.71	75.72
	2	62.92	67.57

As can be seen from the Table 12 on the compliance of the existing stairwell width with the requirements of the Seventh Schedule, it should be noted that the stairwells must accommodate more occupants than the prescribed number. For example, 490 occupants should be able to escape via Stairway 8, but Stairway 8 can only accommodate 161 occupants per use, and if this number is exceeded, it could be too crowded and slow down evacuation. However, there are other stairwells that can be used, and if these stairwells are used in an even distribution of occupants, the number and width of the stairwells are considered sufficient to save an optimal number of occupants at one time during evacuation. Further research needs to be conducted to ensure how residents would react in a crowded situation and to determine which of these stairways are familiar and used by them.

h. Place of assembly

Open spaces generally used as places of assembly shall be strategically located, separated, or protected and shall be at least 45 m from the building so as not to endanger the occupants of the place of assembly by fire smoke from the other spaces. Street level exits are adequate for street level occupants and the required capacity of open stairways running the entire street level are adequate if the load is evenly distributed. The assigned assembly spaces for all RST buildings meet the above requirements as shown in Table 13. Further investigation should be conducted to determine if building occupants are aware of the assigned assembly locations, as some occupants may not be aware that USM Recreation Park and Malaysian Institute of Pharmaceuticals and Nutraceuticals (IPharm) are assembly locations for M01, M02, M03, and M04, respectively.

Table 13
Place of assembly

8.0	Place of assembly		M01	M02	M03	M04	M05	M06
8.1	Determination whether the exit for place of assembly is located, separated or protected to avoid any undue danger to the occupants of the place of assembly from fire originating in the other occupancy smoke therefrom.	UBBL178	✓	✓	✓	✓	✓	✓
8.2	Identification of the classification of places of assembly.	UBBL179, UBBL183	✓	✓	✓	✓	✓	✓
8.3	Street floor exits shall be sufficient for the occupant load of the street floor plus the required capacity of the open stairs and ramps discharging through the street floor.	NFPA101/ 20.2.3.2	✓	✓	✓	✓	✓	✓

i. Vehicular access considerations

The Desasiswa Restu, Saujana and Tekun (RST) buildings are considered island buildings that are constructed as a single, separate building and have a volume greater than 112,000m³ as shown in Figure 5. Since Tekun M05 has a volume of approximately 520,523.5m³ (> 112,000m³), a 6m access must be provided. Tekun M05 does not have an accessible 6m back lane.The road marked 'X' can be considered as a fire access with a width of 7m (main entrance Tekun M05). However, the requirements for island buildings with this volume should be 12m wide. Since there is no rear lane, two fire access roads must be provided for better coverage. However, only one access is provided. There is another parking lot for Tekun M05 that can be used as an access because it is 7300mm wide, but there is no hydrant there.

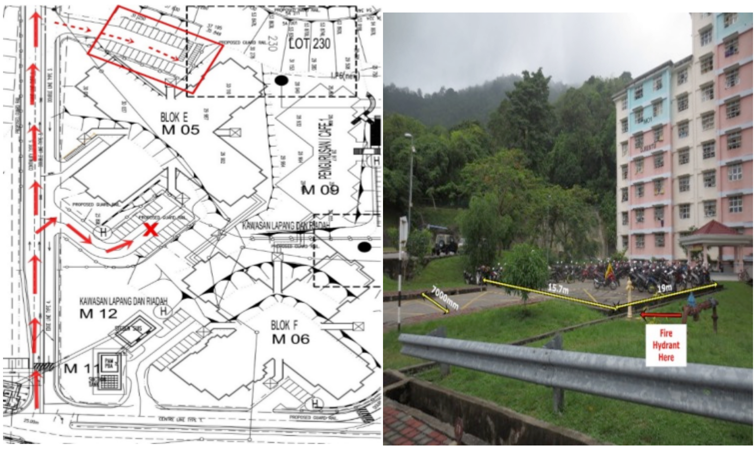

Fig. 5. Shows site plan and view at Desasiswa Tekun (M05)

The design considers vehicle access and does not impede the escape route of building occupants during evacuation. However, it is anticipated that certain features, such as the lack of a 6-metre back lane and only one fire department access road, may not fully support fire suppression for the Desasiswa Restu, Saujana, and Tekun (RST) buildings as shown in Table 14.

Table 14
Fire access road in Desasiswa Restu, Saujana and Tekun (RST) buildings with their solutions

Student housing	Weakness	Solution
Restu M01	Absence of 6m back lane	Two fire access roads with fire hydrant are provided
Restu M02	Absence of 6m back lane	Two fire access roads with fire hydrant are provided
Saujana M03	• Absence of 6m back lane. • Only one fire access road with fire hydrant is provided.	Another road with large parking area is available and suitable to be use as fire access road by providing it with fire hydrant
Saujana M04	• Absence of 6m back lane. • Only one fire access road with fire hydrant is provided.	The firefighting process might not be able to reach the rear side of the building as the fire hydrant is only provided on the front side of the building. Fire fighting process might need to be done inside of the building for the rear side.
Tekun M05	• Absence of 6m back lane. • Only one fire access road with fire hydrant is provided.	Another road with large parking area is available and suitable to be use as fire access road by providing it with fire hydrant
Tekun M06	Absence of 6m back lane	Two fire access roads with fire hydrant are provided

The existing Means of Escape (MoE) in the existing buildings mostly meet the requirements of the statute. However, there are issues with these elements that need to be further investigated based on the findings and experiences of the occupants as they frequently use the RST buildings.

4. Conclusion and Recommendations

The overall performance of existing Means of Escape (MoE) elements in student housing public universities @ the Desasiswa Restu, Saujana, and Tekun (RST) buildings can be determined based on compliance findings and resident insights as shown in Table 15. In terms of compliance and design, performance is evaluated by assessing whether the elements meet code requirements, while in terms of resident findings, performance is evaluated based on the difficulty and complexity of complaints and their solutions. The condition of the escape routes (Means of Escape (MoE) in student housing public universities @ Desasiswa Restu, Saujana and Tekun (RST) and the identification of their problems is an important element. This problem should be solved as soon as possible before these problems lead to a serious disaster. Most Means of Escape (MoE) meet the requirements of the By-Law's requirements. Those where certain requirements of the statute have not yet been met are evacuation, travel distance, exit door, fire escape stairs, and consideration of vehicular access. The existing Means of Escape (MoE) in the existing buildings largely meet the requirements of the Act. However, there are issues arising from these elements that need to be further investigated based on the findings and experiences of the residents as they frequently use the student housing public universities @ Desasiswa Restu, Saujana and Tekun (RST) buildings. In addition, the functionality of Means of Escape (MoE) design in a building can be determined based on the compliance and experience of the occupants in using the escape routes, and each element of the escape routes determines how well the overall design assists the occupants in evacuation. A single mistake, such as an unclear evacuation route or lack of evacuation plans on each floor, can result in residents having difficulty escaping because they cannot find the designated exits. The importance of following the guidelines provided is illustrated by the recent fire in Surat, India, where a major fire broke out in a tutoring centre, killing 15 students, as reported in [16]. Finally, the other Means of Escape (MoE) for the student housing public universities @ Desasiswa Restu, Saujana, and Tekun (RST) buildings are also of good functional quality and capable of assisting residents in evacuation.

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