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VIRTUAL GO GREEN: CONFERENCE AND PUBLICATION "Rethinking Built Environment: Towards a Sustainable Future"

> Organiser: Research, Industrial Linkages, Community & Alumni Network (PJIM&A)

Co-organiser: Department of Built Environment Studies & Technology (JABT), Faculty of Architecture, Planning & Surveying (FSPU)

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Fire Safety for Residential College in Higher Education: A Literature Review

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Abstract

A residential college is a building that functions as students' accommodation. Other than providing an attractive environment that is conducive for learning, it is expected to have functionalities that comply with building standards including the safety features. Fire poses a significant risk to residential college buildings. When a fire occurs, it may cause injuries and deaths as well as losses to university management and occupants. The aim of this paper is to review the literature on issues related to fire safety in a residential college. The objective of this paper is to find the gap on critical factors of fire occurrences in a residential college. This paper uses content analysis methodology to critically review 29 papers. The thematic analysis is adopted by categorising the critical factors into the theme. Results show the four main critical factors which are human, high fire load, design configuration, and facility conditions. The findings suggest that over occupancy and poor means of escape route designs lead to overcrowding and chaos during fire evacuations. The article recommends identifying design criteria of escape routes in residential college buildings for fire-safe buildings.

Keywords: Means of Escape; Fire Safety; Residential College

1.0 Introduction

Universities and other higher education institutions play a vital role in developing a country's human capital and workforce. Human capital, funding, and infrastructure are considered the three key resources that these organisations rely on to function properly (Simpeh & Adisa, 2021). University facilities help to create a conducive environment and to promote positive teaching and learning experiences for students and staff members (Simpeh & Akinlolu, 2021). A residential college is one of the essential facilities provided by a university. It is expected to provide an attractive environment that is conducive for learning, promoting unity, developing students and maintaining vibrant student culture (Hassanain, 2008; Simpeh & Akinlolu, 2021). Sanni-Anibire and Hassanain (2015) suggest that a residential college is crucial in helping students to attain intellectual competence and personal character, leading to fulfilling students' living experiences. Other than that, a residential college must have functionalities that comply with building standards including safety features. A residential college is categorised as high-risk living accommodation (Sanni-Anibire & Hassanain, 2015; Mahmoud et al., 2017; Simpeh & Adisa, 2021). Kofi et al. (2016) claimed that a fire incident in a residential college may jeopardise students' future and leave lifelong scars.

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Table 1.1 file cases for residential category										
No	Type of Building	Year								
		2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Squatter	50	69	60	106	195	159	147	127	101
2	Residential	2918	2994	2172	3235	1205	1319	1263	1300	1327
3	Hotels	32	40	27	49	42	41	41	32	45
4	Hostels	44	40	37	56	29	24	14	23	23

Table 1. Fire cases for residential category

(Source : Portal Rasmi Kementerian Perumahan dan Kerajaan Tempatan, 2020)

According to the annual statistical report on the occurrence of fire cases in residential buildings published by the Fire and Rescue Department of Malaysia (FRDM), there were 23 fire cases in residential colleges in 2018, as shown in Table 1 (Portal Rasmi Kementerian Perumahan dan Kerajaan Tempatan, 2020). Even though this number seems low, the average number of occupants per residential college is high. A fire incident in a residential college can lead to a major destruction. The fire incident in a male students residential college at Universiti Utara Malaysia is a good example (Zulkiffli, 2021). Almost 80% of the residential college was destroyed. In 2014, a fire incident occurred in an International Islamic University of Malaysia male dormitory which caused serious damage to the building (Tamboo, 2014). Fortunately, 800 students who were residing in the dormitory were able to escape. In another fire incident in a residential college at Kolej Universiti Islam Melaka in 2014, three rooms in the residential college were destroyed (Bernama, 2014). Although no casualties or injuries were reported, there were losses to be borne by the university management and occupants. The fire incidents in residential colleges harm occupants, university institutions, surrounding communities, and nations. They also cause significant losses to university management and infrastructure.

Finally, this paper aims to reveal the critical factor of fire occurrences in residential colleges by reviewing previous literature. The objective of this paper is to determine the gap on fire safety in residential colleges. Therefore, this paper provides a review of the literature on issues related to fire safety in a residential college.

2.0 Fire in General

The fire triangle provides a good illustration of the causes of fire. Fire is caused by the presence of three elements; fuel, air, and heat. If any of these elements is absent, a fire will not start (National Fire Protection Association, 2004). Fuel must be combined with oxygen to ignite a fire. Wood, paper products, clothing, fibre materials, and plastic are examples of flammable materials which are highly volatile.



(Source: National Fire Protection Association, 2004)

Figure 1. Fire Triangle

The second element is heat. According to the National Fire Protection Association (2004), heat is required to initiate the reaction between fuel and oxygen. According to Mohd Shariff (2010), when

flammable materials absorb heat, they burn to produce gas. Oxygen, often present in the air, is the third element. Air is a colourless, odourless, and tasteless gas (Mohd Shariff, 2010). Oxygen must be enough to start a fire.

When oxygen and flammable materials react, the burning process begins. Heat raises the temperature of the materials, allowing oxygen to enter the reaction (Tabin, 2004). Agyekum et al. (2016) suggest that fires can be started in three ways: (i) misusing appliances, (ii) purposeful ignition, (iii) equipment failure. When a fire starts, the combustion process releases heat energy which keeps the reaction going.

2.1 Classification of Fire

There are four classifications of fire according to MS1182: Classification of Fire. These include Class A (Solid Material-Organic), Class B (Liquids or liquefiable solid), Class C (Gas), and Class D (Metal). According to the National Fire Protection Association (2004), fire classifications are important to distinguish the agents needed in fire extinguishers. A fire may belong to more than one class of fire.

	Classification of Fire	Methods of Extinguishing
CLASS A	 Ordinary combustibles Carpets and curtains are examples of solid and biological materials that can catch fire, such as wood, paper, cotton, cardboard, and soft furnishings. Only the creation of glowing members causes a fire. 	• This type of fire is abundant and adept at absorbing significant amounts of heat, it can be put out using water.
CLASS B	 Flammable liquids and combustible liquids. The materials that can flow while burning. Gasoline, kerosene, oils, paints, and liquefiable solids like candles and fats are among them. 	 To prevent the generation of vapours, a coating of foam is added to the surface of the fuel. Extinguishing the fire with dry chemicals such as carbon dioxide, dry powder, vaporising liquids, and water spray.
CLASS C	 Energised electrical. Although electricity cannot burn, it can give the energy needed to start a fire. When the power is switched off, the fire may fall into one of two classes: Class A or Class B. 	 Carbon dioxide, dry chemical agents, and halogenated agent extinguishers for special electrical equipment are prevalent. Water can conduct electricity, making it dangerous for use.
CLASS D	 Combustible materials. Sodium, potassium, lithium, titanium, magnesium, and zirconium are members of this group. It is difficult to put out. 	 Use a heat-absorbing substance that reacts with the burning material to put out the fire. Another approach is to use clean, dry sand. Water should not be used to put out a fire because it can create a chemical reaction, resulting in the release of explosive hydrogen gas.
CLASS K	 Cooking materials and media. Cooking oil, fat, grease, and vegetable or animal oil are examples. It is common in commercial kitchens and challenging to put out since it holds a lot of heat, allowing the chemical reaction to restart. 	• Use a wet chemical fire extinguisher to put out the fire.

	Table 2	Classification	of Fire
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2.2 Fire Safety – Passive and Active

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A building structure should incorporate fire safety features for protection against fire (Foong, 1994). The primary goal of the fire prevention system is to restrict the spread of smoke and fire while allowing occupants to evacuate safely. Fire protection is required to avoid or decrease damage to the building structure and adjacent structures and the failure of emergency services. Table 3 shows that fire safety can be divided into two measures; active fire protection and passive fire protection.

Table 3. Types of Fire Protection System				
Active Fire Protection	Passive Fire Protection			
Fire hydrant Means of Escape				
Fire Extinguisher and Fire Hose Reel System Compartmentation				
Riser				
Sprinkler System				
Fire detection and Alarm System				
(Source: Abu Bakar, 2006)				

Passive fire protection can save lives and prevent building and infrastructure destruction. Passive fire protection is built into the structure of a building to ensure that it can withstand fire for the duration of its life cycle. Passive fire protection includes compartmentalisation and structural fire protection, provision of access for fire-fighters, safe and effective means of escape. Passive fire protection does not have to be operated manually by people as it is incorporated in the building structure and design. Kim et al. (2013) concluded that passive fire protection is a type of fire protection that provides adequate protection to a building, ensures reasonable time for escape, and avoids building structure collapse during a fire incident.

On the other hand, active fire protection is a system that needs to be operated by individuals or automatic systems to control a fire. Active fire protection systems such as water sprinklers and spray are widely used in residential colleges, especially high-rise buildings. Hassanain et al., (2018) suggested that automatic sprinklers are the most effective form of active fire protection. A fire protection system has to extinguish and control the fire or provide exposure protection to prevent potential domino effects (Jones, 2009).

3.0 Methodology

This paper adopts content analysis to review 29 papers which focus on fire occurrences in residential colleges. This paper includes fire safety in residential colleges and excludes in other than residential colleges. All papers reviewed were categorised into several themes. The thematic analysis is used as data analysis for this study to theme the critical factors. Four critical factors have been identified to cause fire occurrences in residential colleges.

4.0 Issues Associated With Fire Protection in Residential Colleges

A residential college provides students with a room for studying, sleeping and relaxing. Simpeh and Adisa (2021) recognise that residential colleges are one of the important support services required to provide high-quality tertiary education so a residential college must be safe and secured. However, previous studies classified residential colleges as a high-risk facility in a higher education institution (Sulaiman et al., 2012; Ebenehi et al., 2018; Hassanain et al., 2018; Zakaria et al., 2019; Simpeh & Akinlolu, 2021; Asigri et al., 2021). There are four main critical factors which are human, high fire load, design configuration and facility conditions.

4.1 Critical Factor – Human Factor

The first factor is human. A residential college houses many occupants who can be exposed to fire in one location (Sanni-anibire & Mohammad, 2015; Hassanain et al., 2018; Zakaria et al., 2019). When a fire occurs, the large number of students crammed into a high-rise building often poses a challenge to residential college building management for fire evacuation. The passive attitude of the occupants and

management also lead to difficulties in fire safety (Ebenehi et al., 2018; Osunsanmi et al., 2019). Sanni-Anibire and Hassanain (2015) suggested that primary causes of fatal fires and casualties in residential colleges are smoking, intentional activities, electrical issues, illegal cooking in the room, candles, and heating. These cases prove human ignorance as well as a lack of concern and awareness of fire safety. Incidents of fire alarm pranks by students also contribute to fire casualties which cause students to ignore the real alarm and become slow in responding to emergencies. When the students only have a short period to save themselves; the occupants should either extinguish the fire or evacuate. It can be concluded that human is one of the critical factors that need to be considered to ensure a fire safe residential college.

4.2 Critical Factor – High Fire Load

The second factor is the high fire load. A residential college often contains a large number of combustible materials that can ignite and result in severe fires (Hassanain et al., 2018; Zakaria et al., 2019; Asigri et al., 2021; Simpeh & Akinlolu, 2021). Stollard et al. (2014) define fire load as the amount of fuel in a room or building that can burn, release heat, and feed fire growth. Hassanain et al. (2018) and Zakaria et al. (2019) suggest that a fuel's nature, amount, and arrangement play important roles in fire incidents. Students' rooms contain a large number of fire loads, such as furniture, books, papers, plastic displays, curtains, carpets, and mattresses. These materials can ignite a fire and cause fire growth. Therefore, a residential college needs to consider these materials which can cause high fire load and increase the probability of fire.

4.3 Critical Factor – Design Configuration

The third factor is design configuration. Most residential colleges in higher education institutions are high-rise buildings. High-rise buildings can provide accommodation to a large number of students in residential colleges. Several researchers found that majority of the students who stay in residential colleges are assigned rooms on the upper floors of high-rise buildings (Sanni-anibire & Mohammad, 2015; Samad et al., 2017; Hassanain et al., 2018; Temidayo et al., 2019; Zakaria et al., 2019; Asigri et al., 2021). In a fire incident, overcrowding, panic, and chaos among occupants at exit routes with limited means of escape prevent efficient evacuation. To support the growing number of students in residential colleges, several residential college building managements make changes to building layouts. Without proper considerations, these changes can lead to technical obstacles to means of escape. Lo (1998) argues that changes in design configuration often do not fulfil building standards requirement. According to Lo (1998), although most residential colleges were built according to building codes and fire safety regulations, the prescriptive building standards have been updated over the time and new building standards have been introduced. As such, there is a need to raise safety levels by prescribing and monitoring updated standards efficiently and proactively. It can be concluded that the design configuration also plays an important role especially in terms of fire safety in residential colleges.

4.4 Critical Factor – Facility Conditions

The fourth factor is facility conditions. Sanni-Anibire and Hassanain (2015), Agyekum et al. (2016), and Simpeh and Akinlolu (2021) find that difficulties during fire evacuation are often caused by the lack of maintenance of fire safety features such as means of escape. Poor housekeeping and maintenance of escape routes can lead to problems during evacuation. For example, faulty and obstructed exit doors as well as waste bin littering can result in bottlenecks during evacuation (Sanni-Anibire & Hassanain, 2015). Furthermore, Kofi et al. (2016) suggested that storing combustible materials along the escape routes can prevent efficient evacuation. Several colleges have installed burglar bars on the windows and doors of residential colleges without proper consideration of fire safety standards. In conclusion, the facility condition is also one of the critical factors to be considered for a fire safe residential college.

Based on the discussion, there are four factors in the critical review; (i) human factor, (ii) high fire load, (iii) design configuration and (iv) facility condition. The four factors are the critical factors for fire protection in residential colleges. Besides, it is also found that over-occupancy and poor means of escape route designs lead to overcrowding and chaos during an evacuation.

5.0 Conclusion

There are four critical factors being identified based on the critical review; (i) human factor, (ii) high fire load, (iii) design configuration and (iv) facility condition. Over-occupancy and poor means of escape route designs lead to overcrowding and chaos in a fire. Therefore, the residential college building management should ensure that adequate measures are taken for fire safety of occupants by providing both passive and active fire protection measures. This paper only discusses the literature on issues related to fire safety in residential colleges. Further study is needed to identify the design criteria of escape routes in residential colleges for fire safe buildings. It is important to ensure that fire safety measures are always effectively maintained.

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Setuju.

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