FIRE RISK ASSESSMENT OF OLD LOW-COST RESIDENTIAL APARTMENT BUILDING; A PERSPECTIVES REVIEW

[1]Nur Amalina Hanapi, Jakathisvaran, [1] Nasrul Arif Ahmad Mahmud

[1] Department of Architecture,
The Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn,
86400 Parit Raja, Johor Darul Takzim

*Correspondence e-mail: amalina@uthm.edu.my

ABSTRACT

This study is to analyse the fire risk assessment for the old low cost high residential building in Malaysia. This research is conducted through reviewing the methods of study, scoping fire risk important aspects, and analysing the information in order to mitigate a way to do fire risk assessments in old low-cost residential apartment in Malaysia supported by the Uniform Building By-Law (UBBL 1984). As an outcome, this paper will be outlining future expectation of elements to be conducted on improving fire safety in old low-cost high rise residential building and updating its characteristics by imparting more efficient fire risk assessment method for a better safety of fire protection in old low-cost high rise residential building in Malaysia.

Keywords: *high rise, residential, fire safety.*

INTRODUCTION

The growing number of the population requires more homes for people worldwide and high-rise residential building is optional because it requires less area of land and provides a lot of facilities and homes for people. This means the number of demands for high rise residential buildings is rising year by year and the human population goes higher as well as demand raises. The increment of the demand for high rise residential have been a subsequent effect of the land cost and multiple facilities provided in the building such as gymnasium, swimming, etc. (Report, 1978). Codes and guidelines and regulations have been created by the Malaysia government which is known as Uniform Building By-Law 1984 (UBBL 1984) as a regulation to ensure limited damages and referred structural factor requirement in fire safety. However, codes and guidelines generally do not provide all information for future improvement or development for the building's fire fighting system (He, 2013). The fire department in Malaysia had imposed stern measures and practices to fire safety rules and regulations for high rise residential buildings in for public safety. Every fire strategy and fire parameter do require maintenance and replacement of old fire-fighting equipment such as fire extinguishers. This process is also known as fire safety maintenance. As years go by, the quality of the fire protection system in the building may decrease and the well being of the building may weaken that it may affect the fire-resistant ability (Suryoputro, Buana, Sari, & Rahmillah, 2018).

FIRE RISK RANKING

The relationship between fire science and fire safety will contribute to the fire risk ranking. This aspect of fire ranking is described in Table 1. Fire risk ranking reduces the cost of paper and energy compared to full detailed risk assessment that are much more complex and requires more information (Frantzich, 1998). According to Gretener Methods, the concept of fire risk ranking is meant to predict the probability of fire ignition that results in fire hazards and also the degree of fire. For this method, fire hazard means that a potential hazard is divided by protective measures which include 5 standard fire measures, special fire safety measure and fire resistance of the building (Frantzich, 1998). This fire ranking method is simple, but it needs a narrowed down information from a hierarchy table that describes the policy, objective, strategy, and components. The fire risk calculation involves the measure accumulation sum of total multiplication of parameters and weight of parameters. From this study, a complete list of parameters is needed for valuation for assigning the value to parameters between range of 1 to 5; indicating from the least to the most frequent fire scenarios that provide operational definition of parameters and elicit subjective value systematically. This fire risk ranking requires mathematical operations on the values to produce an assessment of the hazard's risk. The parameters need to be constant in characteristic and parameters which seems to be the variable factor that will affect fire risk assessment scale (Frantzich, 1998). The parameter must be interactive in this case study because active fire protection also was involved in this study. The reading does not necessarily need to be exactly accurate, but this fire risk ranking method is produced in a short period of time to state the range of fire risk rank it holds. The validated result will be stated in terms of more than expected value or less than expected value of fire risk ranking.

FIRE SCIENCE	FIRE SAFETY
• Study of all aspects of fire. • Study fire behaviour to fire investigation.	• To reduce the destruction caused by fire by practice. • To prevent ignition of an uncontrolled fire. • Those that are used to limit the development and effects of fire after it starts.

Table 1 : Fire science and fire safety facts

FIRE RISK ASSESSMENT METHOD

There are some methods of fire risk ranking found in several countries that had been utilised and had given rational results of building fire protection rating.

a) ***Rapid Fire Risk Assessment***. Gillet created Rapid Fire Risk Assessment in 1994 which was discovered to be extremely helpful and later some parts of it have been further developed into a new model. For example, the technique for joining the start sources and combustible materials has been utilized. Users use the table to choose appropriate boxes and assign proper score where 2 results will be obtained and both of the results will be combined (Suryoputro et al., 2018). This is exceptionally short-sighted; as there is scarcely any data or precise information that could be obtained to acquire a fast evaluation of the fire

danger of a structure utilization. It works through the different highlights of a structure, in which, positions them as high, medium or low as indicated by their relative impact on the wellbeing of a structure. Even though this is basic, it can still distinguish perils and their related dangers (Suryoputro et al., 2018). This model is said to be utilized viably by certain experts and made a decision about solid by peer audit. The strategies utilized are not precise. It does not cover the number and kind of tenants, or the included fuel stacks. There is also no clarification of the strategies utilized in building up the tables in the model or the support of the scores appointed to them. (Suryoputro et al., 2018)

b) ***Analytical Hierarchy Method (AHP).*** This method is used to identify the fire hazards and consequently the fire risks in high rise residential buildings. The data is collected from observation. The observation of an assessor is usually recorded and graded based on a 1 to 10 scale. AHP is a multi-criteria decision making and it is used as an alternative supportive fire risk ranking to produce analyst data from calculation through Microsoft excel (Ibrahim et al., 2011). The table shows the fire safety components found in high rise residential building based on UBBL 1984. Set of weightages for each criterion and its respective attributes will be fixed according from top priority to least priority in sub of main fire safety during fire accident using analytical hierarchy method. This table can be further adjusted to add more information according to features of fire safety that can be found in high rise building and building characteristics based on literature review (Ibrahim et al., 2011). In this method, 4 main factors are combined into one to obtain a total safety score as shown in the following table.

GOAL OF STUDY **To Evaluate Fire Risk In High Rise Residential Building**			
Criteria			
Passive Protection System	Active Protection System	Fire Management	Building Characteristic
Attributes			
• Compartmentation • Egress/Evacuation Route • Corridor Width • Number of Exit • Maximum Travel Distance • Exit Signages • Site Accessibility	• Detection and Alarm System • Automatic Suppression System • Fire Hydrant • Portable Fire Extinguisher • Emergency Lighting • Hose Reel and Standpipe • Communications	• Housekeeping and Maintenance • Management Fire Safety Plan • Security • Staff Training • Fire Officer/Marshall • Emergency Response • External Exposure to Fire	• Building Contents • Building Fabric/ Material • Architectural Features • Building Status • Historical significance

Table 2 : Analytical hierarchy method (AHP) for fire risk assessment

Rank	Criteria	Criteria score
1	Passive Protection System	
2	Active Protection System	
3	Building Characteristic	
4	Fire Management	
Total Fire Safety Score		

Table 3 : Fire risk assessment criteria

Table 3 is a checklist that consists of 4 or more criteria such as passive protection system, active protection system, fire management, building characteristics, etc. Each criterion has its own separated element such as corridor width. This table uses self-observation for its data input and self-predicted grades in relation to the understanding of the rules and regulations in UBBL 1984 and other requirements. (Ibrahim et al., 2011)

CHARACTERISTICS OF HIGH-RISE RESIDENTIAL BUILDING

There are several advantages in a steel structured property for high-rise building construction. Thin structural elements made of steel allows more design freedom for building elevations, including openings which could be filled with glass, non-load-bearing brick wall etc.; as can be seen in many buildings of the early 20th century. Along the years, technological advancement has allowed heavy load bearing brick walls to be replaced with lighter and more flexible non-load bearing brick walls, thus allowing newer features such as huge curved glasses. This is evidence of the tremendous improvements in construction technology and it is not surprising that high rise buildings can now be constructed to seven times the height of high-rise buildings in the early of 20th century. With the development of high–rise building technology, new materials and systems have come together such as glass facades, glass walls, and the system of enveloping the building's structures and others. (Amaral et al., 2013)

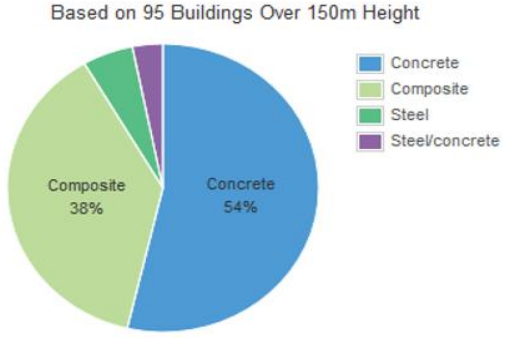

Diagram 1 : Example of structural material in Shanghai rises

In Asia countries such as China, there have structures of high rise buildings that are dominantly made of concrete (54 percent) and composite structures (38 percent). High–rise buildings is constantly growing around the world and building upwards has been deemed to be a necessity for humanity and fast becoming an accepted living style. Vertical cities, also called the sky cities, in their simplest definition refer to high–rise buildings and skyscrapers with stunning attractive living style by many people (Amaral et al., 2013).

Since years have gone by, the value of protection for the citizens has evolved with the technical advancement of materials, which has also contributed to the growth of *structural architecture*, with core hybrid structures capable of moving lateral loads. High rise building still requires the safety and sustainability in order to give and to receive positive sociological aspect to their inhabitants (Amaral et al., 2013). There are 3 categories which are distinguished by the type of high-rise buildings and their characteristics:

a) ***The first category.*** High-rise buildings with exterior walls made of bricks or stones; with columns and beams built out of iron and steel, and was largely unprotected. The floors were made of timber, and the elevators were unclosed. Many of these buildings have been demolished due to the lack of the steel and iron safety requirements that made them a danger to use. (Amaral et al., 2013)

b) ***The second category****.* High – rises are frame structures in which the building's foundation is made of steel. The steel columns and beams are protected by casting them in concrete which distinguishes them from the first category. This provides a higher degree of security to the structural system. These high–rise structures uses non-combustible materials and greatly reduces the possibility of collapsing in case of any impact actions on the structure, or in case of fire. (Amaral et al., 2013)

c) ***The third category****.* High-rise buildings that were built after the World War II. Steel-framed structures, reinforced concrete construction, and steel-framed concrete structures or composite structures are present in the case of structures. In order to support and introduce new safety rates for high-rise uses, various regulations have provided a normative. (Amaral et al., 2013)

FIRE STUDY MODEL

a) ***Fire safety management.*** Fire safety management is a step to reduce fire accidents. The fire safety of a building is determined under fire safety codes, regulations, and standards according to fire fighter department to achieve good satisfaction in fire safety level which known as acceptable level. There are no buildings that can be said to be 100% safe with no fire accident risks. Complete safety is impossible particularly for residential buildings. A building fire safety can be can divided into two which are ‘very safe’ and ‘low fire risk’. A building fire safety involves occupants, building contents and its structure.

b) ***Fire risk identification.*** Fire risk identification is the initial step to analyse the starting point of any fire accidents that may occur and how critical it could be

and what are the causes and impact to occupants, materials, and building. Risk identification is a common factor that enhances fire risk that include potential sources of flammable substances that can cause serious damage to human life and building structure such as misuse of defects in and defective wiring to electrical appliances or equipment, prefabricated buildings or temporary structures built from untreated timber or lined with hardboard or other anti-fire-resisting boarding and these most rapidly happening in construction sites. Presence or absence of fire protection also measures a factor in risk identification such as Fire detection systems, sprinklers, smoke ventilation systems, fire doors, fire extinguishers. Another approach is to look for specific points that influence the risk of fire for some types of buildings such as ignitable materials and from a low-energy smouldering source, such as, latex foam, finely powdered rubber number of occupants in a building and their position number of young, elderly, and disabled persons. These examples are samples of hazards. A property (residential building) divided into different parts because different parts have its own risk factors. Example, a house has main hall, rooms, bathrooms, kitchen, storeroom, lifts, main board room etc. These parts will be identified its risk factor and fire surveyor, or any fire safety officers will be conducting a physical inspection to value the building safety.

c) ***Qualitative risk assessment***. Qualitative risk assessment is the next step carried out to lower risks that analyses based on fire risk identification. The main aim is to assess the probability of fire accidents which may happen over a certain period of time that may cause fatality or property damage. The fire risk assessment is categorized into worksheets with different factors such as causes of combustion, flammable objects, building design, exhaust devices, active fire control systems, fire prevention measures and others. The worksheet consists of fire precaution regulation for buildings and the response will be ‘yes’ or ‘no’. This provides valuation of buildings, whether it falls in low, normal, or high fire risk; differently for each purpose i.e. life risk or property damage. This assessment is more suitable for average size buildings with low fire risk that may have a clear and straightforward procedure; however, for large and complex buildings, a specialist's advice will be needed. The scores would also depend on whether life safety or property damage, or both, were being considered. The scores may be on a scale ranging from zero to ten, to 20 or to 100 depending on the accuracy with which the risk is required to be assessed.

d) ***Risk reduction.*** After carrying out fire risk assessment, possible actions will be taken according to short term and long-term measures. After actions were taken, a routine is carried out for each period for inspections, defects or faults observed and remedial work that were carried out. For residential buildings, the building’s head or fire department may perform fire drills to improve awareness of fire emergencies and how to avoid certain situations, such as informing the fire brigade, fighting the fire with first aid, using water buckets or sand, or fire extinguishers, and supporting the fire brigade. After all these actions were taken, re-evaluation for risks will be done to optimise risk reduction level.

PERCENTAGE OF FIRE ACCIDENT HAPPENED IN RESIDENTIAL BUILDINGS

Fire accidents does not occur frequently in real life, but it could happen a few times in a year or once every few years. The fire occurrence can be estimated through Poisson method and the number of fire occurrences in time interval can be calculated by a Poisson distribution (Yuan-Shang Lin, 2005). With that assumption, it was found that fire accidents happened quite frequently on residential buildings as compared to others, as analysed by Yuan-Shang Lin in 2005. The researcher stated that for 17 years' period, residential buildings and its occupancy showed high percentage of fire occurrences compared to industrial, commercial and other buildings.

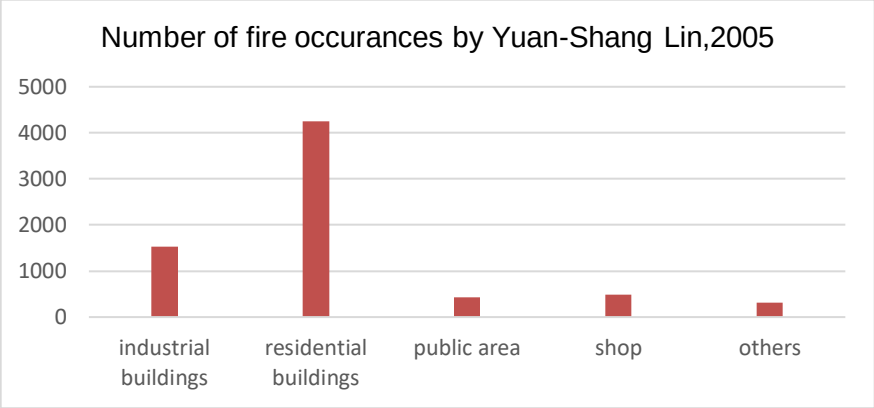

Diagram 2 : Number of fire accident by Yuan-Shang Lin

THEORY SAFE EGRESS TIME OF THE FIRE SAFETY REQUIREMENT

Required safe egress time (RSET) is time needed for the entire occupants to escape the building during a fire accident based on human behaviour factor. Available safe egress time (ASET) is egress components that had been installed or built for the occupants to be escaped in estimated time. RSET is a mixture of time when fire incidents begin to occur, warning detector time for building occupants, warning time for occupants and recognition of fire accidents, and finally time for occupants to escape the building. Many fire accidents cause fatalities due to unavoidable human behaviour (Margrethe Kobes, Ira Helsloot, Bauke de Vries, Jos G. Post, 2010) and if the ASET is less than RSET, it will cause even greater damage to the victims. (G.Q. Chua, T. Chenb, Z.H. Sunb, J.H. Suna, 2007). If the active fire safety system in the residential building is centralized, fire incidents can be minimized. This is due to the presence of firefighting equipment and water sprinkler will be active as the smoke detector system sends information to the sprinkler system which will minimize RSET by prolonging the escape time needed by the occupants to escape from the building.

METHODOLOGY

The type of result analysis been used is known as scoping review is mainly concern of preliminary assessment of many research paper and synthesis knowledge to obtain key concepts, type of proves and missing puzzle in the research which related civil engineering

field that this paper is carried on. This research is flexible, but the scope of review is comprehensive and does not manipulate the original information. With this method, the advantages and benefits proposed by many researchers in regards to fire risk assessment is explained and some basic studies of fire safety designs are also explained for future researcher to have an understanding about fire safety and existing methods of fire risk assessment. This research paper is unique because the literature review, results and discussed in relation to each other. The information gained from researchers had been simplified in tables and simple graphs so that future researchers will have a clear and better understanding on fire protection systems for high rise residential building.

DISCUSSION

1. FIRE MANAGEMENT SYSTEM ASSESSMENT: BASED ON SEVERITY SEGREGATION.

Levelling for each fire scenario, fire systems have been used to encounter the situation and the fire systems assumed by the researcher are AFA, sprinkler system and smoke extraction. From the probability of event tree analysis, the researcher discovered the level of severity with a proposed formula of fire risk level which equals to fire frequency level that multiples with fire consequence level or by using method of fire frequency-consequence matrix. The applied method will have to be pre-studied based on the fire scenario of a room or a department, and compare it with a fire dynamic stimulator FDS software to detect the probable system failure and how effective is the fire system of the building; subsequently evaluating a condition for evacuation. In this fire risk assessment, the main importance goes to life safety that is affected by thermal effects, toxicity, and visibility. These factors will rise or drop safety evacuation time (ASET) that can be predicted by fire modelling through judgement of thermal effects, toxicity, and visibility. The relationship between thermal effects and available safety evacuation time shall be synthesized as the thermal effect raises, the available safety evacuation time reduced. The thermal effect raises as the heat released by fire accident increases and accumulates rapidly. For human body temperature, 36 degrees Celsius is the optimum temperature and anything above this may cause difficulty in breathing and could harm living things' health condition. As toxicity in air increases, the available time for safety evacuation decreases. The relationship between the visibility of human eyes and available safety evacuation time are also interrelated; where the visibility of human eyes increases, the available safety evacuation time also increases which depends on the view ability and human age variants.

2. BUILDING CHARACTERISTICS: TOWARDS FIRE RISK ASSESSMENT RELATIONSHIP.

Liu Xiuyu, Zhang Hao, Zhu Qingming described in the article entitled *'Factor Analysis of High-rise Building Fire Reasons and Fire Protection Measures'* that the building characteristics are considered as the key elements for the degree of fire protection. This is due to three main factors, which are ability to spread fire easily, the level of difficulty for evacuation and difficulty to put out fire. High rise residential buildings, which normally encompasses five floors and above, will consist of beams, columns, structural steel frames, floors, compartment floor and party walls. Whilst, inside the building, fittings and furnishing, furniture and equipment brought by occupants are mostly consumables, flammable, and hazardous materials as the occupants themselves. These internal factors

can cause the fire to spread more quickly during fire incidents which can contribute to weakening of the system and causing collapse. Therefore, the Uniform Building By-Law contains a few design restrictions that was developed to prevent the building from becoming weak and reduce fire spreading in case of fire. The characteristics and typology of buildings like home office and commercial residential do also play a major role that contibutes to this cause as the neighbouring context or macro planning of the building is basely on commercial sites and compared to residential apartment in suburban area.

3. PASSIVE FIRE PROTECTION SYSTEM: FIRE RISK ASSESSMENT OF HERITAGE BUILDING.

Heritage buildings are often old and needs more attention if it is 5 floors or more than 30m in building height. High-rise residential construction will be older as years go by and there will be valuable benefit points in this paper that can be found for high-rise residential fire protection system development. According to M. N. Ibrahima, K. Abdul-Hamida, M.S. Ibrahima, A. Mohd-Dina, R. M. Yunusb, M. R. Yahyac, the better and more effective the fire safety is, the more it will reduce any risk of fire. However, fire risk cannot be avoided completely. The method proposed is not very complicated and simple. These researchers used a panel of experts from various backgrounds for their interview session to answer queries in regards to the analysis and weightage works before further conducting surveys on selected buildings to find the fire index of the buildings. The researcher gave questionnaires to the maintainance department, insurance department, fire consultant and fire and rescue department of Malaysia. These researchers used AHP method to do the analysis and weightage works. Passive fire protection system, active fire protection, fire management and building characteristic were being inculcated as the system’s main factors to evaluate fire risk of the building. The researchers used the score system of criteria (scale from 1 to 10) and these researchers rated the four key factors from rank 1 to 4 according to the value of preserving the building's fire protection and finally the overall fire safety score is obtained by including all the criteria score factors. As for observation of fire system in the building, these researchers add an observation portion and assessment grade to evaluate through observation. The researchers had proposed attributes score and final score for criteria calculations. For each criterion, these researchers find weightage, total attributes score by all attributes score for each criteria and total attributes scores will be multipled with the criteria weightage to find the final score for each criterion and sum up all the final scores of all criterias to produce a total fire safety score using expertchoice2000 or can also be done manually according to AHP method using the matrix system.

4. ACTIVE FIRE PROTECTION SYSTEM.

According to Ar Chong Lee Siong, the Uniform Building By-Law is a prescriptive building code which sets a pre-determined prescription between a range of safety factors and provide rules and regulations on the application of the code. Active systems are needed to prolong the necessary safe egress period, including smoke and alarm detection, and to send information through wire or wireless communication and smoke control systems to avoid building smoke accumulation and to provide portable fire extinguishers. In shorter words, active fire protection is using equipment invented solely to fight a fire (Chandrakantan Subramaniam, 2004). Active fire protection is aimed to reduce the spread of smoke and to extinguish fire in a building with the help of manual or automatic fire detection system that includes fire extinguishers (APAR), hydrant box, fire alarms, sprinklers, and fire detectors (L.T.Wong; H.W.Chong; W.K.Chow).

a) ***Fire extinguisher.*** This is a portable fire extinguisher and it is used to extinguish fire at an early stage of a fire accident. There are four types of portable extinguishers for use against the appropriate class of fires. The list below is summarized to the type of fire classes and its usage. (Chandrakantan Subramaniam,2004)

a) water supply
b) pumps
c) installation main control valves
d) alarm gong
e) piping arrays
f) sprinklers heads, common types of sprinkler systems: -

i. wet pipe system.

Wet pipe system is a system that is applied mostly in 2 seasons of weather because the temperature of the building must be above 70-degree celcius in temperature. It can be installed easily, and the water will be sprayed when activated (L.T.Wong;H.W.Chong;W.K.Chow).

ii. dry pipe system

Dry pipe system is usually applied in cold weather countries and not usually in Malaysia (L.T.Wong; H.W.Chong; W.K.Chow).

iii. pre-action system

This system consists of the sprinkler system and detection system. This system will not cause the water to be sprayed if mechanical failure happened because the detection system is the one that sends information to pre-action valve then to sprinkler system during a fire accident. This system is normally applied in libraries or computer laboraratories where it can stop any sudden water discharge (L.T.Wong; H.W.Chong; W.K.Chow).

iv. deluge system

This system will be installed in places that contains flammable contents and have less anti fire resistance equipments where fire could spread faster. The detectors of fire will be protected in safe places and it will pull out fire immediately (L.T.Wong;H.W.Chong;W.K.Chow).

v. drencher system

This system is used to protect the inner and outer parts of a building (Fong et al., 2001). This system will prevent spreading of fire in a building and it is installed at staircases to avoid fire from spreading into staircases during evacuation (L.T.Wong; H.W.Chong; W.K.Chow).

b) ***Fire Hose Reel.*** Hose reel system is a firefighting tool for occupants to use in fighting a fire during the early stage. It consists of hose reel pump, fire water storage tank, hose reels, pipe work and valves. Water is stored in storage tanks and used during occurrence of fire and it contains no chemical but uses grey water. (Chandrakantan Subramaniam,2004)

c) ***Smoke alarms.*** Fire alarm systems are designed to provide warnings of the outbreak of fire and allow appropriate firefighting action to be taken before the situation gets out of control. Smoke alarms are usually placed at estimated

areas where fire accidents could happen such as the cylinder room and can send response to the sprinkler system instantly. However, some smoke detectors are not able to provide the details on the fire accident such as frequency of fire accident, location, exact temperature of fire and etc. (Chun-Chi Peng, Kuei-Shu Hsu, Ming-Guo Her, Yen-Chia Peng, Jinn-Feng Jiang, Yi-Jie Chen, 2014).

d) ***Evacuation.*** Evacuation process of a building is assisted by egress components and its characteristics. The characteristics involved are the change of occupant demographics, occupant behaviors and advances in technologies which are associated to the number of floors in a building. Stairs are the main component of egress together with alternative components such as evacuation elevator, sky-bridges, and others. (Enrico Rochi and Daniel Nilsson,2013)

e) ***Stairs.*** This method had been applied since a long time ago to transport a human from one floor to another floor and as evacuation tool during fire accident. The size of a staircase will be designed according to the live load (occupants) to ensure it has enough strength to carry and to transfer most of the occupants out of the building during fire accident within a certain period of time. There are some human factors that may delay the evacuating time such as gender and age. There will be merging streams which means occupants will keep on increasing at each point of the staircases that will further increase the total evacuation time (Enrico Rochi and Daniel Nilsson,2013).

f) ***Evacuation elevators.*** Elevators were not an element of egress component due to the electrical wires that can be easily damaged in a fire accident, and can therefore be fatal. If only stairs are the egress component in a building, the injuries and fatality rate may be high due to the longer evacuation time. After *emergency elevators* have been introduced, disabled people and senior citizens who are weak in strengths can escape faster in a fire accident, resulting in a lower number of fire victims. With having emergency elevators and staircases, the total evacuation time will be reduced; however only if prior maintenance routines of the lift is carried out (Enrico Rochi and Daniel Nilsson,2013). The reason behind why elevators have not been a factor of egress component is due to the sudden cut of electrical supply that could result in the victims being trapped in the elevators during fire. Within moments fire smokes can infiltrate the lift and create a piston effect. Emergency lifts have its own emergency power supply and contains active fire protection system in the lift itself to prevent the lift from burning or collapse (Enrico Rochi and Daniel Nilsson,2013).

g) ***Sky bridges.*** The sky-bridge concept is not entirely new. The first sky-bridge was the Ponte dei Sospiri, designed by the architect Antonio Contin in Venice in the beginning of the 17th century' (Wood et al. 2005). The sky bridge can only be applied in high rise buildings that has at least 2 towers to be attached together. Sky bridges cannot provide vertical evacuation, but it will provide

horizontal evacuation at the same level, transferring victims from one tower to another. This egress component can be an advantage to reduce vertical excavation and it adds an option for an escape point. For twin towers, the escape time might be longer due to the transporting of victims from high ground to the lower ground. The sky bridge will add to the ease of evacuation and therefore the number of fire accident victims will be lower (Enrico Rochi and Daniel Nilsson, 2013).

h) ***Refuge floors.*** Refuge floor is specific floor that have large space to hold occupants in a building that will prolong the much needed time for fire victims to escape (Enrico Rochi and Daniel Nilsson,2013). The advantages of a refuge floor are: -

i. provides an assembly point for victims to escape (Williamson and Demirbilek, 2010)
ii. presence of emergency lift and stairs will reduce the amount of fire smokes (Williamson and Demirbilek, 2010)
iii. act as a protection place for disabled people and senior citizens (Williamson and Demirbilek, 2010)
iv. it will easier for emergency fire squad to command and direct occupants to escape routes (Wood, 2007).
v. it acts as the fire fighters place to fight fire accident in a building (Wood, 2007).

CONCLUSION

This research is a review of fire protections in high rise residential buildings in accordance to the Uniform Building Based Law 1984. The main issue that this paper has found is that the numbers of high-rise residential buildings are raising due to the drastically increased number of population of human and land value. This research paper studied in general on the fire safety models and fire risk assessment methods. Building safety is the number one priority for human being. The method used for reviewing this paper is the scoping method which analyses and discusses the knowledge of fire safety on high rise buildings and relates them to high rise residential buildings in particular. This was done by combining inputs from many articles and journals to make a review paper on fire safety in high rise residential building with aid of the UBBL 1984. In the discussion part, a fine study of fire safety models such as active fire protection and its importance with its requirement and importance of it had been explained briefly. This also includes other elements of fire safety in high rise buildings with explanation of fire nature and building characteristics. The objectives of this paper had been achieved successfully.

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