International Journal on Emerging Technologies **12**(1): 241-246(2021)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Assessment of Fire Safety Management of High Rise Buildings in Lahore, Pakistan

Mudassar Jehanzeb[1], Usman Ilyas[2] and Prof. Sajid Rashid Ahmad[3]
[1]M. Phil Student, College of Earth and Environmental Sciences,
University of the Punjab, Lahore, Pakistan.
[2]Assistant Professor, Department of Civil Engineering,
University of Management & Technology, Lahore, Pakistan.
[3]Professor, College of Earth and Environmental Sciences,
University of the Punjab, Lahore, Pakistan.

(Corresponding author: Usman Ilyas)
(Received 30 November 2020, Revised 25 January 2021, Accepted 27 February 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The high-rise building phenomenon provide an advantage of better human living environment and urban functions; however, it does come with cons. Fire outbreak is one of the biggest threats in high-rise buildings. In Pakistan it can be said that evaluation of fire outbreaks and prevention is insignificant in case of high-rise buildings. This study was therefore conducted to assess the fire safety awareness and evaluate the current safety measures available in high-rise buildings of Pakistan. The study was based on quantitative questionnaire related to fire safety among the occupants in two high-rise buildings in Lahore, Pakistan. One of the building was A and second was B. From the analysis of survey, it was concluded that building (B) has better fire safety measures as compared to building (A). The one sample t-test analysis, however showed that overall occupants of both building thinks that their buildings have good defense system of fire and speedy action is taken in case of fire outbreak. This study also reveals that the most common causes of fire incidents in high-rise buildings are electrical faulty equipment and negligence of building occupants. This could be avoided by properly fitting of good quality electrical cables, installation of fire balls in electrical distribution boards, and educating occupants of high-rise buildings on fire outbreak response. A careful observance of fire safety measures as specified in building codes of Pakistan must be considered in the design of high-rise buildings to avoid any unwanted situation in future.

Keywords: High rise buildings, Fire safety measures, Fire hazards, Strategies for fire safety, Framework for fire design, Fire load density

I. INTRODUCTION

Fire safety is one of the most significant concerns due to its vital role for the survival of human beings and protection of properties. With the development of urban economy, high-rise buildings and super high-rise buildings become more because of high population density and land price [1]. In the U.S., the National Fire Protection Association estimated a skyscraper as being taller than 75 feet (23meters) or around 7 stories [2]. In China, according to Technical Specification for Concrete structures of Tall Buildings, an elevated structure is a private formation of 10 floors or further or about 28 meters in stature, and other business structures exceeding 24 meters, compressing super elevated structures (business structures in any event 100 meters tall) [3]. Over the years, fire disaster has been a troubling issue mostly in emerging countries. It can be devastating to human society if not controllable. Urban areas around the world are more vulnerable to fire hazards because large populations are engaged in commercial, industrial and other activities

Many people become seriously injured or die due to fire accidents each year. Regarding the general statistics of fire accidents, the World Health Organization (WHO) reported deaths of more than 300,000 people annually by fire-induced burns. Unfortunately, disturbing statistics are that 95 percent or more of these deaths happen in low-income and middle-income countries [4]. According to the recent report published in Bureau of Labor statistics in 2019, fire and explosion were responsible for 115 workplace deaths in 2018 and 123 deaths in 2017, which is slightly higher than the 88 fatalities recorded in 2016 showing a recent increase in fire accidents [5]. Unfortunately, reliable statistics of fire hazard are not available in Pakistan. Therefore, it is under reported and needs to be addressed.

In recent times, there has been a high Concern towards fire safety issues in high-rise buildings due to several fire incidents that have occurred. The incident that occurred at the World Trade Center (WTC) in September 2001 has led to the demand for the provision of a certain acceptable level of safety in high-rise buildings. This was the most fatal high-rise building fire incident that has occurred in history. The event left not less than 2977 deaths aside from the property loss [6]. Another unfortunate fire incident at Lahore Development Authority Plaza, Lahore in 2013 took 23 lives due to short-circuiting or an overheated flood light [7]. The catastrophic fire at Hafeez Centre, Lahore in Oct 2020 has proved yet again that all concerned departments of the city district government such as the Lahore

Development Authority, MCL and LCB are 'helpless' in ensuring compliance of building bylaws and safety codes. Although no loss of life has been reported in that incident, but hundreds of shops and offices are said to have been gutted and merchandise destroyed. It took the firefighters well over 36 hours to douse the flames. The increase in the rate of fire outbreak incidents is a clear indication that it needs to be prevented as technology improves [8].

Fire hazard is one of the factors present in a building that can cause ignition, aggravate the severity of fire and prevent operations of escape or firefighting. Cooking is proposed to be the main source of fire in both residential and commercial buildings, based on statistics available [9].

In Pakistan, buildings are confronted with a diverse issue particularly in sky-high structure that are characterized extended travel distance for the escape and means of entrance that present ultimatums to fire safety. High rise buildings are now evolving in the direction of modernization, maximization and multi functions making it harder to prevent and evacuate fires from outside as compared to fires that takes place in ordinary buildings. Consequently, it leads to major economic losses and serious injuries for staff, tenants and customers. There are basically three risk factors in fire incidences which combine as threats to elevated structures.

1. Concentration Inhabitants of building, this will impact emergency escape in the event of a fire if it is high and increase the risk for damages and harms.
2. Building structure capable of helping to spread and transfer smoke.
3. Elevated structure layout and figure with open stairways, escalator, HVAC system and electrical wiring also act as source of smoke at the time of fire [10].

A research by Soh analyzes four keyways to improve the protection of high-rise buildings in an efficient way. These include the followings:

1. Provision of fluorescent exit signs at each story of building.
2. Layout and design format for building.
3. Escapes routes and assembly point where workers congregate once they have evacuated the building.
4. Regionalization and installation of fire defense systems.
5. Emerging fire prevention strategies and building preparation includes having a pre-knowledge of fire sources.

A number of casualties evacuated from any incident of a fire outbreak in high-rise buildings due to lack of attention given to the safety measures for occupants, in the construction of such buildings by architects or engineers. Therefore, the need for a fire defense plan in high-rise buildings is necessary. This study will provide the basis for more awareness in facilitating an increasing role of building design professionals in fire safety measures in Pakistan. This study will also help the local Government and fire management in evaluating existing fire protection programs so that effective fire prevention strategies for high-rise buildings can be strengthened. It will assist owners of high-rise buildings to pay attention to the core issues of occupants' life protection, so they can consider the needs of tenants to fulfill the required prerequisites.

II. MATERIALS AND METHODS

This study is quantitative questionnaire based on fire safety measures, awareness fire safety mechanism and causes of fire occurrence in two high-rise buildings of Lahore, Pakistan

A. Base of the Research

The analysis of fire defense mechanism and dynamics was conducted in two sky-high buildings in Lahore city to achieve objectives of this research. The study was based on quantitative questionnaire related to fire safety among the staff and tenants in two high-rise buildings in Lahore, Pakistan. The questionnaire was filled by concerned staff and tenants and it determined their understanding and awareness of fire defense mechanism in sky-high buildings and the suitability of procedures that could be taken to enhance protection and defense. The questionnaire comprised of two different parts. The first part specifies the description and demographic data of the respondent, while the second part attempted to know about the awareness of respondents, fire protection mechanism and their execution in elevated buildings. The designed statements are shown in table 1. The survey questionnaires were distributed among the staff and tenants of both sky-high rise buildings. Random sampling technique was used.

Table 1: Designed statements related to fire safety.

Unit	Description
1	**Fire safety mechanism awareness**
1.1	Understanding fire safety procedures
1.2	Requirement of fire safety procedures in elevated building
1.3	Aim of the requirement to fire safety in elevated building
2	**Fire safety mechanism in the building**
2.1	Emergency exit stairs provided
2.2	Illuminated exit signs installed in the building
2.3	Provision of illuminated exit signs
2.4	Fire defense system in the building
2.5	Conducting scheduled regular fire evacuation drill
2.6	Building has evacuation map and signs at each floor
3	**Feedback to fire occurrence**
3.1	Fire safety mechanism at the time of fire occurrence
3.2	Working of fire services

B. Characteristics of Building A

1) Safety Measures in Building (A):

The fire defense system in the building include:

1. 85 fire extinguishers were placed throughout the building.
2. Fire hose reel and hydrant system was mounted on all levels of the building.
3. Fire alarm system was installed in the building.

2) Benefits of building (A) in case of fire:

1. Local fire authorities cannot approach the building promptly.
2. The building has large vents that can be used as a source of ventilation to mitigate fire happenings.
3. The parking lots are well established so that the tenants and the customers can safely evacuate the premises, not having much trouble in the event of fire occurrence.
4. Over 50% of the building materials used was non combustive components.

3) Insufficiency of fire safety in building (A):

1. The doors were not fire resistant allowing the smoke to spread into the building.
2. The emergency escape stairs at the end of the building were not adequately large and wide to carry workers and customers in the event of fire occurrence.
3. There was no emergency action plan within the building for the customers and the staff in event of a fire occurrence.
4. The staff and customers could be puzzled during emergency escape because there was no emergency lighting in the escape stairs.
5. Emergency exit signs were lacking.

C. Characteristics of Building B:

1) Safety Measures in Building (B):

The fire defense system noticed in the building includes:

1. Fire alarm and tracking process was in working condition and this alarm system is the product of US Company Fake Alarm System.
2. Fire extinguishers were placed at each floor of the building inside the cabinets. Total numbers of fire extinguishers are 650 in the building.
3. There were well-defined emergency exit signs for emergency exit on each floor in case of fire occurrence. Total emergency exit stairs are 22 inside the building.
4. Hose reel and hydrant system was mounted on all levels of the building to allow water to be pumped from the fire main.
5. There were smoke dampers at every floor and every zone of the building which prevent the spread of smoke from the space of fire origination to other areas in the same building.

2) Benefits of building (B) in case of fire:

1. Local fire authorities can approach the building promptly because it is situated on main road.
2. Wall envelope of the building consists of bricks that make it hard for fire to travel due to superb quality of fire shield.
3. Escape routes and emergency exit stairs were properly defined in all zones of the floors.
4. Emergency exit stairs inside the structure had ordinary lighting and emergency lightings were also installed.
5. Fire sprinkler system was installed inside the ceiling of buildings at all zones of every floor.
6. The fire alarm and tracking system in the building was in working condition, as the alarm generates, the exact location was shown on the display of control panel.

3) Insufficiency of fire safety in building (B):

1. Fire safety department team working in building (B) was not enough according to the size and covered area of the building.

D. Sample Size Population

Respondents of this study belong to two sky-high buildings of Lahore Pakistan. Sample size for this research was 150.

E. Survey

In order to conduct survey, building (A) and building (B), Lahore were visited during office hours i.e., 9AM to 5PM. Questionnaire was distributed through email and personal visits. Respondents were asked to fill the questionnaire in their convenient time. All of them responded positively that enables us to collect data confidently from two high-rise buildings

III. RESULTS AND DISCUSSION

A. Descriptive Statistics of building (A) and building (B)

The data being analyzed have been incorporated in statistical package for the Social Science (SPSS) [11]. A plain, frequency and T-test based descriptive analysis was used to report the results of data.

A total of 115 respondents participated in this study from both building (A) and building (B) is shown in graph. The frequency and percentage of respondents of building (A) was 55 and 47.8 respectively, whereas the frequency and percentage of respondent of building (B) was 60 and 52.2 respectively, as shown in Fig. 1.

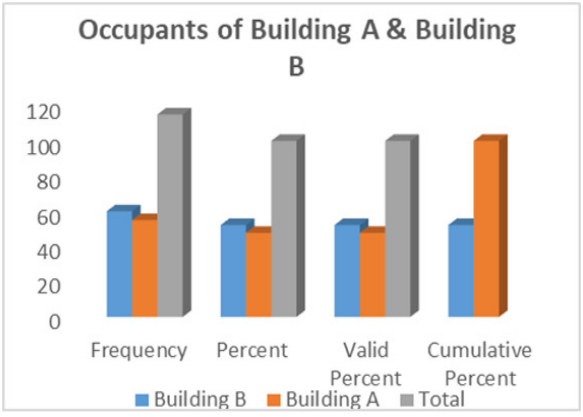

Fig. 1. Descriptive Statistics of Building A & B.

B. One Sample T-test of Building A

One-sample t-test mean for building (A) shown in table 2 and figure 2 is performed to assess if the sampled respondents agreed with the variables surveyed in the elevated buildings report study.

For mark points (1.1–1.3), Null hypothesis (Ho) that there is no level of knowledge in respondents on fire safety in elevated building and alternative theory (Ha) is that fire safety awareness was present among the respondents in the building. For the mark points (2.1–2.6), Null hypothesis (Ho) is that the occupants of the building disagree with any fire safety mechanism in the building whereas the alternative hypothesis (Ha) is that the occupants agree with the presence of fire safety mechanism in the building. And finally, for mark point (3.1) and (3.2), Null hypothesis (Ho) is that no prompt response to fire occurrence and the alternative hypothesis (Ha) is that quick response to fire occurrence was present.

Hence the level of significance (p-value) is ≥ 0.05 (i.e., the result is not significant) and the null hypothesis Ho is accepted. If the p-value is < 0.05, the alternative hypothesis (Ha) will be accepted.

Table 2: T-test result of Building (A).

Item	Test Value = 0				
	(t)	(df)	Sig. (2-tailed)	Mean Diff.	SD
1.1	21.39	54	0.000	1.236	0.43
1.2	15.92	54	0.000	1.218	0.57
1.3	22.14	54	0.000	3.273	1.1
2.1	17.98	54	0.000	1.309	0.54
2.2	32.42	54	0.000	1.836	0.42
2.3	20.13	54	0.000	2.436	0.9
2.4	15.09	54	0.000	2.473	1.22
2.5	35.67	54	0.000	1.945	0.41
2.6	39.42	54	0.000	2.036	0.38
3.1	54.54	54	0.000	1.927	0.26
3.2	24.01	54	0.000	2.018	0.62

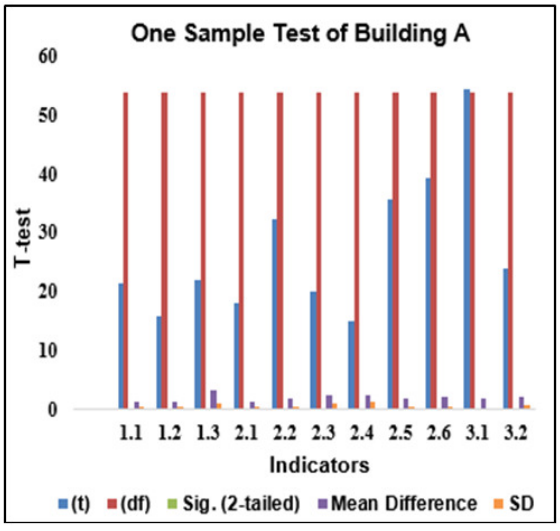

Fig. 2. Graphical representation of Building A.

It can be inferred from the above findings / tables that the three-null hypothesis (Ho) were dropped while the alternative hypothesis (Ha) was accepted.

So, we can say that

1. In building (A), good information and awareness about fire safety procedure was present.
2. Average fire protection measures were available.
3. In the event of any fire occurrence, there was relatively inadequate response.

C. One Sample T-test of Building B

One-sample t-test mean for building (A) shown in table 3 and figure 3 is performed to assess if the sampled respondents agreed with the variables surveyed in the elevated buildings report study. For mark points (1.1–1.3), Null hypothesis (Ho) that there is no level of knowledge in respondents on fire safety in elevated building and alternative theory (Ha) is that fire safety awareness was present among the respondents in the building. For the mark points (2.1–2.6), Null hypothesis (Ho) is that the occupants of the building disagree with any fire safety mechanism in the building whereas the alternative hypothesis (Ha) is that the occupants agree with the presence of fire safety mechanism in the building.

Table 3: T-test result of Building (A).

Item	Test Value = 0				
	(t)	(df)	Sig. (2-tailed)	Mean Diff.	SD
1.1	28.16	59	0.000	1.1	0.3
1.2	24.06	59	0.000	1.1	0.35
1.3	17.74	59	0.000	2.683	1.17
2.1	49.68	59	0.000	2.85	0.44
2.2	21.35	59	0.000	1.1	0.4
2.3	23.74	59	0.000	2.55	0.83
2.4	17.27	59	0.000	1.967	0.88
2.5	17.02	59	0.000	1.2	0.55
2.6	20.39	59	0.000	1.133	0.43
3.1	25.24	59	0.000	2.883	0.89
3.2	15.01	59	0.000	1.533	0.79

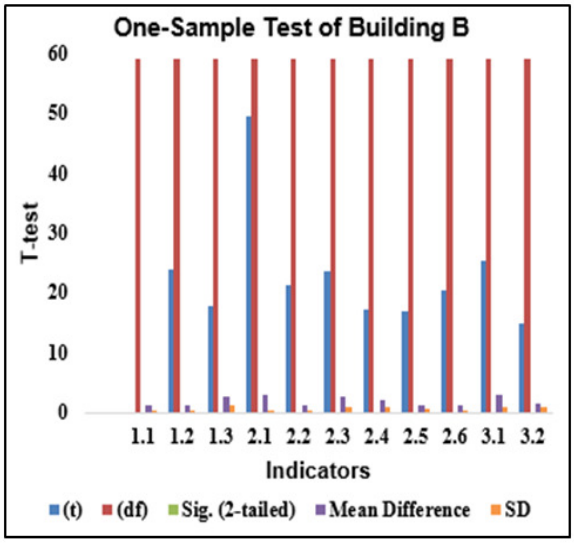

Fig. 3. Graphical representation of Building B.

And finally, for mark point (3.1) and (3.2), Null hypothesis (Ho) is that no prompt response to fire occurrence and the alternative hypothesis (Ha) is that quick response to fire occurrence was present.
Hence the level of significance (p-value) is ≥ 0.05 (i.e., the result is not significant) and the null hypothesis Ho is accepted. If the p-value is < 0.05, the alternative hypothesis (Ha) will be accepted.
It can be inferred from the above findings / tables that the three-null hypothesis (Ho) were dropped while the alternative hypothesis (Ha) was accepted. So, we can say that

1. Sufficient awareness on fire safety procedures in building (B) was present.
2. Defense system for fire protection was working in building (B)
3. Prompt response in case of any fire occurrence.

D. Comparison of Building (A) and Building (B)

1. Fire Safety Awareness:

Building (A)	Building (B)
Approximately 76% of the participants confirmed that they have information regarding fire safety measures.	About 90% of the participants confirmed that they have information regarding fire safety measures.

2. Fire Safety Mechanism:

Building (A)	Building (B)
72% of the respondents accepted that the emergency exit stairs are not vast enough to fit the huge number of people in the event of a fire occurrence.	88.3% of the respondents accepted that the emergency exit stairs installed in their buildings vast enough to fit excess people in the event of fire occurrence.
80% of the respondents acknowledged that emergency signs are not installed in the building.	92.6% of the respondents agreed with the presence of Illuminated exit signs were provided in this building.
83.6% of respondents agreed that they did not perform any fire and safety training or emergency evacuation drills in the building.	93% of respondents agreed that they performed fire evacuation drills.
85.5 % of respondents said that there were no evacuation maps or signs posted in the building.	90 % of respondents said that evacuation maps and signs were posted at each floor.

3. Feedback of Fire Outbreak:

Building (A)	Building (B)
18.2% of the respondents considered the local fire emergency authority as operational.	18.2% of the respondents stated that local fire authorities were active.
40% of the respondents recognized that most fire accidents were due to electrical flaws.	45% of the respondents acknowledged that most fire accidents were due to electrical flaws.
22.5 % acknowledged that many fire accidents were due to both electrical faulty equipment and negligence of building occupants.	24 % acknowledged that many fire accidents were due to both electrical faulty equipment and negligence of building occupants.

The above findings show that respondents from building (B) had more awareness as compared to building (A). It has been seen in literature that people who had been exposed to fire safety awareness would respond more accurately to a fire: that is, they would make more rational and appropriate decisions at the time of emergency and danger. This agrees with NFPA [12] report that workers who were trained for fire safety management managed the situation better by proper change attitude and behavior in a fire situation by instructing others to evacuate by following proper evacuation procedures. This change will lead to the best chance of a safe and methodical evacuation being conducted during emergencies [13].
The findings of this study related to fire safety mechanism show that wider staircase accommodates more people, but it will add additional construction cost. Therefore building (B) was better than building (A). Literature also validates above findings that wider staircase helps a greater number of people to escape with in no time and hence prevent losses [14]. As far as illuminated exit signs were concerned. Illuminated exit sign in high rise buildings as safety measures could immensely contribute to assisting building user to locate escape routes during the fire incident. Therefore building (B) was better than building (A). Literature also shows that illuminated exit signs will help user to exit the building in case of any fire incident [14].
The findings of this research related to feedback of fire outbreak. It was stated that fire fighting services were not very active in near vicinity and most of the fire occurrence was due to electrical short circuiting and carelessness of the building occupants. Literature also shows that above findings was correct that most of the fire occurrence was due to faulty equipment and negligence of building users [14].

IV. LIMITATIONS OF THE STUDY

1. The main challenge faced during the study was the sample size due to limited staff from which data can be collected.
2. Because of this the sample size was less and this study could have been improved with more diverse sample.

V. CONCLUSION

A number of casualties evacuated from any incident of a fire outbreak in high-rise buildings occur due to lack of attention given to the safety measures for occupants, in the construction of such buildings by architects or engineers. In order to improve this situation, an evaluation of fire safety measures in high-rise buildings system is paramount.
From the results of our study it can be concluded that building (B) occupants have advanced degree of understanding on fire protection mechanism as compared to building (A). Also, the fire safety procedures and mechanism enforced in building (B) are superior to building (A). The lack of fire safety measures in building (A) can be attributed to poor management commitment towards fire safety.

REFERENCES

[1]. Islam, M. Monowarul and Adri, N. (2008). Fire Hazard Management of Dhaka City: Addressing Issues Relating to Institutional Capacity and Public Perception, Jahangirnagar Planning Review, *6*: 57-67, Jahangirnagar University, ISSN 1728-4198

[2]. National Fire Protection Association (NFPA), High-Rise Building Fires, 2016, http://www.nfpa.org/News-and-Research/Fire-statistics-and-reports/Fire statistics/Fires-by-property type/High-Rise-Building-Fires.

[3]. Ministry of Housing and Urban-Rural Development (MOHURD) of the People's Republic of China, Technical Specification for Concrete structures of Tall Building, 2010, http://www. soujianzhu.cn/Norm/jgzy230.htm.

[4]. Shokouhi, M., Nasiriani, K., Cheraghi, Z., Ardalan, A., Khankeh, H., Fallahzadeh, H. (2019). Preventive measures for fire-related injuries and their risk factors in residential buildings: A systematic review. *J. Inj. Violence Res*. 2019, 11, 1–14. [Google Scholar]

[5]. Bureau of Labor Statistics National Census of Fatal Occupational Injuries in 2018—2019. Available online: https://www.bls.gov/news.release/pdf/cfoi.pdf

[6]. Arhens, M. (2016). High-rise building fire. National Fire Protection Association (NFPA) Research.

[7]. Newspaper Article, Published in The Express Tribune, May 13th, 2013.

[8]. Newspaper Article, Published in Dawn, October 20th, 2020.

[9]. USFA (2016). "Residential and nonresidential building fire and fire loss estimates by property use and cause (2003-2016)", U.S. Fire Administration, available at: www.usfa.fema.gov/data/statistics/order_download_data.html(accessed 30 June 2019)

[10]. US Fire Administration (2002). High rise fires, topical fire research series, *2*, National Fire

[11]. IBM Corp. Released (2015). IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. *Emerging Technologies*, *10*(1): 47–53.

[12]. NFPA. Selection from U.S. fires in selected occupancies. Offices. NFPA, Quincy, Massachusetts, 2006.

[13]. A. Lewis & W. Dailey. Fire Risk Management in the Workplace (2nd ed.). London: Fire Protection Association, UK, 2000.

[14]. Nimlyat, S.P., Audu, U.A., Ola-Adisa, O.E. and Gwatau, D. (2017). "An evaluation of fire safety measures in high-rise buildings in Nigeria", *Sustainable Cities and Society, 35*, pp. 774-785.

How to cite this article: Jehanzeb, M., Ilyas, U., Ahmad. S. R., (2021). Assessment of Fire Safety Management in High Rise Buildings in Lahore. *International Journal of Emerging Technologies*, **12**(1): 241–246.