VULNERABILITY AND USER AWARENESS LEVEL ASSESSMENT OF FIRE RISKS OF HIGH-RISE BUILDINGS IN DHAKA CITY: A STUDY OF MOHAKHALI COMMERCIAL AREA

By

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ID: 18168001

Master in Disaster Management

Postgraduate Programs in Disaster Management (PPDM)

Department of Architecture

Brac University

March 2022

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A thesis submitted to the Department of Architecture in partial fulfillment of the requirements for the degree of Master in Disaster Management

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Declaration

It is hereby declared that

1. The thesis submitted is my own original work while completing Master in Disaster Management degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I have acknowledged all main sources of help.

Student's Full Name & Signature:

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Approval

The thesis titled "Vulnerability and User Awareness Level Assessment of Fire Risks of High-Rise Buildings in Dhaka City: A Study of Mohakhali Commercial Area" submitted by Dewan Nurul Huda, Student Id: 18168001 of Summer 2018 been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master in Disaster Management on March 22, 2022.

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Ethics Statement

The whole study was conducted with an ethical competence and integrity in terms of conscious decision making and responsibly acting considering of legal standards as well as social, economic and ecological consequences.

While conducting field survey, at first and foremost, consent was taken from each authority to survey their buildings and facilities. During the survey and meetings FSCD personnel were with data collection team. All the actions such as taking photographs, talking with officials, respondents were conducted with permission. The field survey was conducted with Beneficence- Do not harm manner. Wherever any intellectual property is used for the purpose of this study, they are given proper credits with proper citation. The whole research is conducted with full objectivity starting from determining the research questions to research findings. The overall research design, data analysis and representation are carried out regardless any bias and inclination.

Abstract

Dhaka City grew in a spontaneous and unplanned way. A huge population with weak services and facilities further increases its vulnerability. Government offices have very inadequate control over the growth trend. In recent times, a number of the high-rise building is growing day by day covering commercial, residential, industrial, and even hospital buildings. Fire is the most occurring urban disaster and can cause huge loss of life and property in a very short time especially in high-rise buildings. Again Dhaka is also vulnerable to seismic risks. Immediately after an earthquake, fire will break out all over the city. Primary and secondary data were used in the study. Primary data were collected from individual building users and building authorities. The data were collected by questionnaire survey, key informant interview, and field observation.

The finding of the study showed that most of the dwellers and owners do not have a basic awareness and fire management knowledge & practice. Respondents can identify few potential sources of fire, claimed that they know what to do in time of the fire, how to extinguish a fire, etc. But most of the respondents also said that they do not know how to operate a fire extinguisher, they didn't participate in any fire drill ever or receive any fire or rescue training, etc. Mostly these buildings have mixed land use. They spent a very small amount on fire preparedness. None of the buildings has a fire safety plan; very few building has fire emergency exit signage.

Almost no building authorities practice any fire or evacuation drills. No building has the required size of the water reservoir, the specified capacity of pumps, and firefighting pump house according to law. Most of the buildings have a fire riser system in their buildings, but not all risers were in good condition. Very few buildings have automatic detection systems but no building has a sprinkler system. All the buildings have some form of portable fire extinguisher but they were not enough. It is also common that building owners, developers, office, industry owners even common people do not want to abide by the laws, comply with the regulations. FSCD is mainly responsible for fire incident management services in Bangladesh. But several agencies are also involved in the overall process. RAJUK, City Corporation, DDM has important roles to play in fire hazard management. Again there is a huge lack of coordination between these departments. They have lacking in their technical, financial, HR and field-level monitoring capacities. An integrated initiative needs to be taken including planning, implementing, regulating, service giving line agencies.

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List of Acronyms

AFD	Armed Forces Division
BBS	Bangladesh Bureau of Statistics
BNBC	Bangladesh National Building Code
DDM	Disaster Management Department
DGHS	Director General Health Service
DMA	Dhaka Metropolitan Area
DESA	Dhaka Electric Supply Authority
DPDC	Dhaka Power Distribution Company
DESCO	Dhaka Electric Supply Company
FCS	Fire Command System
FSCD	Fire Service and Civil Defense
GIS	Geographic Information System
HRR	Heat Release Rate
IDMC	Internal Displacement Monitoring Centre
IFSTA	International Fire Service Training Association
KII	Key Informant Interview
MoDMR	Ministry of Disaster Management and Relief
NHA	National Housing Authority
NGO	Non-Governmental Organization
NFPA	National Fire Protection Association
PDB	Power Development Board
RAJUK	Rajdhani Unnayan Kartripakkha
RMG	Ready Made Garments
UDD	Urban Development Directorate
UNISDR	United Nations Office for Disaster Risk Reduction

Chapter 1
Statement of the problem

1.1. Introduction

Bangladesh is one of the most disaster-prone countries in the world (IDMC, 2018). Its terrestrial setting is the biggest contributing factor for the proneness to disasters (Shahed, 2009). It is estimated that about 775,303 people died in the coastal areas of Bangladesh within the last 222 years (1775–1997) time, only due to cyclones and associated storm surges (Akhand, 2003). Dhaka is serving as a megacity with over 18 million people and also serving the role of the national capital for 163 million Bangladeshis. Among the cities of Bangladesh, Dhaka city's dominance is not only in terms of population but also in terms of economy, trade, commerce, service, and administrative facilities. But with the pace of rapid urbanization, the utility facilities of Dhaka city are not developed yet. As a result, the citizens usually have to live with varieties of risk factors.

Fire hazard is one of the most frequent hazards that caused huge economic loss as well as the tragedy of human death in a frequent manner. High-rise buildings both commercial and residential structures are very common in this densely populated city. In Bangladesh fire service reported that fire incidences from 2004, 2005, and 2006 were 7140, 7135, and 9642 respectively; whereas within Dhaka City, the incidences were respectively 803, 984, and 1161 in each year (Wahed, 2018). In 2006, the country's 12% fire accidents occurred in Dhaka city which was 13.79% and 11.2 % in the years of 2005 and 2004 respectively (M. Islam & Adri, 2008). Along with death and injury, the destruction of property in Dhaka city was estimated to be more than Tk. 6 crore on an average due to fire accidents every year (M. Islam & Adri, 2008). However, this figure has been increased many folds at present. Fire can cause widespread damage within no time and is one of the most feared blights of modern civilization. Fire is such a hazard that cannot be fully eradicated but vulnerability and risk can be minimized by improved prevention and preparedness measures and well-planned mitigation strategies and that must be developed based on complete assessment based on its spatial, temporal, and causal pattern (J. B. Alam & Baroi, 2004).

1.2. Background

According to the annual report of FSCD, the human and financial loss due to fire accidents in Dhaka City both were very high compared to the other cities, it was Tk. 166 crore in 2018 and Tk. 91 crore in 2017 and Tk. 129 crore in 2017 (FSCD, 2018a). The annual human and monetary loss due to fire accidents is very high in Dhaka City compared with the other urban centers as Dhaka city has a high population density and is involved in the highest attention of economic activities.

Ready-Made Garments (RMG) industries are another sector where fire incidents are very common. Almost all of these factories are situated primarily in Dhaka and Chittagong city, with Dhaka holding over 70% of the total (Muhammad, 2011). The sector is also the largest employer in the country with around 3.6 million people directly working in these factories (Mahamud, 2014). At least 1,841 garment workers have been killed in different types of accidents including fire and building collapse in the RMG industry in the last 12 years, according to the Bangladesh Institute of Labour Studies (Fardaus Mobarok, 2014).

Fire safety in large cities like Dhaka, Chittagong is not highly emphasized from an institutional and planning perspective in Bangladesh. Usually, after any large scale fire devastation, the issue of fire safety issues is highly discussed among experts, legislator, newspapers, and local people but with the progress of time, the fire issues are ultimately fading away from people's memory. As a result, the responsible people, offices, the government showed a reluctant attitude in taking further steps for strengthening firefighting capacities. At present, the authority of this metropolitan city has no contingency plan and sufficient preparation to avoid large-scale fire destruction. Furthermore, the responsible city authorities are not properly equipped with adequately trained manpower, machinery to combat fire hazards, particularly for high-rise buildings. Few studies have been done addressing the high-rise building fire safety in Bangladesh.

The skyline of Dhaka city has evolved spontaneously and has changed beyond recognition, and the change is taking place fast over the past decade. Two storied to four-storied buildings have transformed to high-rise apartment and office buildings, almost all over the commercial part of the city. As high-rise commercial buildings contain large occupant loads and complex evacuation systems, they are more

vulnerable to severe casualties and loss of properties (Sifat-e-noor, 2014). In recent past fire incidents in Basundhara City shopping mall killed 7 people (The Daily Star, 2009), BSEC Bhaban fire killed 4 people (The Daily Star, 2015), Nimtoli fire killed 123 people (The Daily Star, 2019a), Chowk Bazaar fire killed 80 people (The Guardian, 2019) and FR Tower fire killed 26 people (Dhaka Tribune, 2019b), etc. showed the violent nature of fire. So assessing the fire safety of commercial high-rise buildings of Dhaka city will be useful for government authorities and policymakers.

Nowadays high-rise building construction is going on in different parts of the city but most of them are without the provision of adequate fire safety and emergency exit. The trend of commercial and residential fire incidents in Dhaka City is increasing alarmingly along with the other fire. According to a study, 302 residential and 306 commercial fire accidents against only 129 industrial fires were reported in 2007 in Dhaka City (M. Islam & Adri, 2008). Some devastating high-rise fire accidents in recent times also exposed the weak capacity of FSCD for firefighting and fire management of high-rise buildings.

1.3. Objectives of the Study

Fire vulnerability assessment of high-rise buildings in Dhaka City is the prime concern of this research. Lake of knowledge on fire hazards and inadequate safety preparedness contributes to the overall vulnerability. The results of this dissertation will look into both physical and social aspects of fire risks in high-rise buildings and it will contribute towards finding out some key obstacles and a better fire management system. The key objectives of the study are the following:

- To know the awareness level of the occupants/ users of the buildings regarding fire risks.
- To assess the fire hazard vulnerability of the selected buildings.
- To find out problems and give recommendations for better fire management.

1.4. Rationale of the Study

Several research works and studies have been carried out for Dhaka city on the fire hazard modeling (Haque, Md, 2001), fire hazard categorization and risk assessment (J. B. Alam & Baroi, 2004), earthquake and vulnerability assessment of fire hazard (Rahman et al., 2015), identification of fire risk index (Jahan et al., n.d.) and so on.

But no comprehensive research has yet been done on the knowledge level assessment of fire and fire vulnerability of high-rise buildings.

The probability of loss and damage in high-rise buildings is very high due to their height and population density. As our country has the technology to fight fire in the highest range of 30m, prevention is the key for buildings to minimize the risk of severity (Sifat-e-noor, 2014). The present condition of existing building structures needs to be known in order to take mitigation measures. Also, the conditions of the building will help the owner and authority to find out weak points that need to address.

So fire risk assessment for high-rise buildings has high importance. The results and findings of the study will help the legislator and policymaker to formulate regulations and policies considering the present trend of construction of high-rise buildings in regards to fire prevention and mitigation. The detailed examination of the capacity of an existing high-rise building concerning building code will be assessed. The policymaker will be able to identify necessary steps to overcome the lackings of the fire-fighting arrangement and to ensure fire safety more professionally and efficiently.

1.5. Scope of the Study

The study offers a varied scope of knowledge improvement on fire hazard management on the individual level. It will also give a clear picture of the fire hazard vulnerability of high-rise buildings in Dhaka city. It will also give a socio-economic scenario that has contributed to the fire hazard vulnerability. The study assesses the physical and structural vulnerability of the buildings in regards to the prevailing building code. Though the study area selection focuses on a specific small part of Dhaka City, the assessment criteria can be used for all high-rise buildings in the whole Dhaka as well as other cities to analyze the overall fire hazard vulnerability situation. Thus the research offers a wide scope and opportunity for fire disaster management in Dhaka City by recognizing vulnerable areas and buildings to focus respective disastrous incident management planning and decision making.

1.6. Limitations of the Study

This study comprised a limited time for the interview of the targeted respondents. The following problems were encountered during the study period.

- This study does not cover a large area because of the limitation of time and resources.
- This study considers a limited number of vulnerability indicators which can be a basis for further study.
- The users and managers of these buildings have never experienced any fire incident.
- After the FR Tower fire incident on 28th March 2019, most of the building authorities did not want to give the researcher any information regarding fire preparedness. It is becoming a very sensitive issue to them. Even some top management personnel and owner forbid their staff to share any information.
- After the incident, they started to invest in fire preparedness. They bought light equipment like a fire extinguisher, fire alarm, exit sign, etc.
- It was very hard to determine the physical strengths of the doors, walls, etc in the physical survey as we do use any equipment to test the fire-rated doors, walls, riser, sprinkler, etc.

1.7. Operational Definition

Awareness: It is the state or capability to observe, feel, or be conscious of events, matters, sensory patterns, or objects. More commonly, it is the state or quality of being aware of something.

Fire: Fire originates from a chemical reaction between oxygen and some type of fuel (wood or gasoline, for example). Fire is the rapid oxidation of a material in the exothermic chemical process of combustion that results in releasing heat, light, and various reaction products.

Fire Extinguisher: It is an active fire defense device which is used to extinguish or control small fires, frequently in critical and emergency situations.

Firefighting Elevator: An elevator or lift within the firefighting channel with a double power supply connection and is capable of being controlled by the fire service personnel. The operation of the firefighter elevator is controlled by a switch (usually

located at the particular place or ground floor level) that initiates the elevator controls for firefighter use.

Fire Sprinkler: It is a system or device that releases water when the smoke of a fire has been sensed when a predetermined temperature has been exceeded. It is found that when a building is properly protected by a correctly designed and functional fire sprinklers system, over 99% of fires incidents were controlled by fire sprinklers system alone.

Fire Insurance: It is one kind of insurance scheme. It is property assurance that covers damage and losses caused by fire incidents. The fire insurance helps the property owner to cover the cost of replacement, repair, or reconstruction of property, above the limit set by the property insurance policy.

High Rise Building: According to Dhaka Mohanagar Building (Construction Development, Protection, and Removal) Rule 2008, any building which is more than 10-storey or above 33 meters high is called a high-rise building.

Knowledge: Knowledge is a familiarity, awareness, or understanding of something, for example, facts, information, descriptions, or skills, which is acquired through experience or education by perceiving, discovering, or learning (Merriam-Webster, 2019).

Fire Safety Plan: A strategy which provides tenant information to control of fire-related hazards, maintenance of fire defense systems, and evacuation measures for their infrastructure and buildings.

Fire Protection Systems: A defense mechanism that is used to deter the initiation or extinguish the fire incidents. The fire protection system includes fire alarm, sprinkler systems, portable fire extinguishers, fire dampers, hose stations, smoke control equipment, emergency lights, exit signs, fire doors, and voice communication systems.

1.8. Organization of the Thesis

Chapter one consist of all introductory view of Bangladesh overall disaster vulnerability and fire hazard vulnerability of Dhaka city, study objectives, rationale, scope, limitations of the study, operational definitions and organization of the thesis.

Chapter two is the methodology that consist detail approach of the study to fulfill the objectives of the study efficiently including objective wise indicators, study area selection, sampling technique, data collection and analysis methods.

Chapter three consists of two parts. First part consists of the review of fire incidents in Bangladesh, in Dhaka city, loss and damage related information. Second part consists of relevant concepts related to fire, vulnerability, insurance, etc. This chapter also reviews fire related regulatory frameworks in Bangladesh.

Chapter four narrates the study area with number of high-rise buildings, building height, plot size, construction year, floor area, occupants work experience, building occupancy, respondents education level, sex ratio and fire zones category.

Chapter five consist the main findings of the study which firstly focus on occupants awareness and knowledge level on fire risks like identifying potential sources, actions in time of the fire, knowledge on fire extinguishing etc. This chapter also analyzed the building fire vulnerabilities like buildings water supply system, water pump capacities, fire safety plan, expense on fire preparedness, detection system, fire alarm, riser, sprinkler system, fire escape, fire command station etc.

Chapter six consists of the key observations on the problems and needs. It also provides some important suggestions and way forward for reducing fire vulnerability and better fire management for the buildings.

Chapter seven narrates the conclusion highlighting the growth of Dhaka city, trend of high-rise building construction with the rising trend of fire incidents. Individual, community, developer, government all have to work together for safer cities.

Chapter 2
Methodology

2.1. Introduction

First, it is necessary to develop the various concept related to different issues of the study which was achieved by communicating with the resource persons and studying different journals, books, reports, which focus on the issue, related to the research topic, the concept of different aspects of the research are developed.

2.2. Problem Identification

Fire vulnerability of high-rise buildings in Dhaka City is a major problem in Dhaka city. Lake of knowledge on fire hazards and inadequate safety preparedness contributes to the overall vulnerability. Sometimes building construction and installation of safety measures are not always in accordance with the building code. The level of awareness of users and building authorities' also an important reason for fire vulnerability.

2.3. Formulation of the Objectives

After conceptualization and selection of the title, the problem of the study has been clearly defined. The study will assess individual knowledge level and physical, the economic vulnerability of the building user and authorities.

2.4. Selection of the Study Area

Mohakhali area is one of the important commercial areas in Dhaka City. Several fire incidents took place in this area namely DGHS warehouse, delta life insurance, Korail slum, Shat tala slum, etc. The criteria which help to find out the appropriate study area are given below:

- The study area has many commercial, official, educational institutes.
- The area has several high-rise buildings.
- A number of fire incidents took place.

2.5. Reconnaissance Survey

In order to get a view of the nature of the study area, a reconnaissance survey was conducted. It helped in preparing a perfect questionnaire for the study and to finalize the sample size.

2.6. Selection of Parameters and Sub-parameters

There are some parameters were selected to conduct the study. For this study, the following parameters were selected:

Table 1: Objective wise parameters

Objective	Parameters
■ To know the awareness level of the occupants/users of the buildings regarding fire risks.	Concept on fire hazard (definition, type, composition, source)
	Response (emergency response)
	Trainings/drill (fire and rescue)
	Evacuation (plan, route, assembly point)
	Preparedness
	Emergency number (fire service, police)
	Knowledge on law, rules, regulations
	Do' and Don'ts

Objective	Parameters
■ To assess the fire hazard vulnerability of the selected buildings.	**Physical vulnerability** (building type, construction material, building surroundings, inside materials, floor area ratio (FAR), water reservoir, electrical aspects, accessibility, land use the number of stored etc.)
	Economic vulnerability Maintenance cost, preparedness cost, loss and damage, income, employment, etc.)
	Social vulnerability (population density, male-female ratio, population age, People with Disability, People with Illiteracy

2.7. Awareness and Awareness Level

This concept is used to measure their position on the topic. The term awareness is the condition or capability to perceive, feel, or be cognizant of events, sensory patterns, or objects. In this level of perception, sense data can be established by an observer

without essentially implying thought. In biological literature, awareness is defined as a person's or an animal being's perception and cognitive response to a condition or event more generally; it is the condition or quality of being conscious of something. (Definitions, 2018).

2.8. Knowledge Level Proficiency Scale

According to the NIH (National Institute of Health), the knowledge level proficiency scale is a tool or an instrument that is used to measure an individual's ability to prove competency on the task or job. The scale shows a wide range of ability levels and categorizes them into five stages; from "Fundamental Awareness" to "Expert". This scale serves as the guide to understanding the knowledge level of the respondents.

0- Not Applicable Level

1 - Fundamental Awareness Level (basic knowledge)

2 - Novice Level (limited experience)

3 - Intermediate Level (practical application)

4 - Advanced Level (applied theory)

5 - Expert Level (recognized authority)

Table 2: Knowledge level proficiency scale

Level	Description
Not Applicable Level	Individuals are not obligated to apply or prove this competency. This competency does not apply to an individual's position.
1 - Fundamental Awareness Level (basic knowledge)	Individuals have a general knowledge or an understanding of basic methods and ideas.
2 - Novice Level (limited experience)	Individuals have the level of experience gained in tentative scenarios. Individuals are expected to need help when performing this skill. He can understand and can converse on the concepts, terminology, values, and topics related to this competency.
3 - Intermediate Level (practical application)	Individuals can complete the assigned tasks at this competency level as requested. Help from a skilled person may be required from time to time, but individuals can generally perform the skill self-sufficiently.
4 - Advanced Level (applied theory)	Individuals can perform the activities without support. They are definitely recognized by official institutions. Individuals are capable of training others in the application of this ability.

Level	Description
5 - Expert Level (recognized authority)	Individuals are recognized as an expert in this competency. They can deliver guidance, troubleshoot problems, and answer questions associated to this area of knowledge and the arena where the skill is applied.

Source: (NIH, 2009).

2.9. Study Methods

For this study a mix of probability and non-probability sampling techniques were used. For building number selection purposive sampling method was used. For building case selection, a systematic sampling method was followed. Again for knowledge level assessment, random sampling method was used. The study also used observation method to see the condition of different fire frightening systems. The study also used observation method to see the condition of water pumps, overhead water tank, staircase, riser system, sprinkler system, smoke & heat detection system, fire elevator, generator, substation etc.

2.10. Sample Size Determination

For this study a mix of probability and non-probability sampling techniques were used. For building number selection purposive sampling method was used. There were 25 high-rise buildings in the Mohakhali commercial area having a height of more than 11 stories. 10 buildings were taken as a sample size using purposive sampling method. This sample size represented 40% of the total high-rise buildings. The advantages of this method is that, in this type of sampling, researcher purposively select the sample size for constituting a sample on the basis that the number they selected will be representative of the whole. The judgments of the researcher play an important role in this sampling design.

Again for knowledge level assessment, random sampling method was used. Ranging from 4 to 17 respondents were selected from each building (based on land use type), a total of 110 respondents were selected randomly for the individual survey. The advantage of this method is that every item of the population has an equal chance of inclusion in the sample. The sample has same composition and characteristics as the population. This is the reason why random sampling is considered as the best technique of selecting a representative sample.

Table 3: Building wise sample size

Sl. NO	Building Name	Land use				Total
		Official	Commercial	Educational	Medical	
1	Ambon Complex	9	4	0	0	13
2	Opex Tower	13	0	0	0	13
3	Rupayan Centre	5	9	0	0	14
4	Civil Engineer's Bhabon	12	0	0	0	12
5	Haque Tower	5	0	0	5	10
6	Aqua Tower	5	0	5	0	10
7	J.R Casero	7	3	7	0	17
8	Siddique Tower	0	0	4	0	4
9	Medona Tower	5	0	0	0	5
10	High Tower	12	0	0	0	12
Total						110

2.11. Sample Case Selection

For building case selection, a systematic sampling method was followed. The first building was selected randomly and thereafter every 3rd of the high-rise buildings were selected. The advantage is that, in most instances, it is the most practical way of sampling. An element of randomness is introduced into this kind of sampling by using random numbers to pick up the unit with which to start. Other sampling method like random or stratified were not used due to small population size and same type of building characteristics.

2.12. Questionnaire Preparation

For collecting primary data, three semi-structured questionnaires were prepared for the study. For this study, both a questionnaire survey and Key informant (KII) were done. Information and data were collected from both primary and secondary sources. Primary data has been collected from a field survey from the individual respondents. Secondary data and information have been collected from published books, literature, internet sources, government offices like the Bangladesh Bureau of Statistics (BBS), Disaster Management Department (DDM), and Bangladesh Fire Service, Civil Defense, and other national and international organizations.

2.13. Data Collection

To achieve the objectives of the study, data and information were collected from both primary and secondary sources.

Primary data collection: Primary data has been collected from a field survey from the individual building users and building authorities.

Secondary data collection: Secondary data and information have been collected from available books, literature, websites, Bangladesh Bureau of Statistics (BBS), Disaster Management Department, and Fire Service & Civil Defense.

2.14. Data Interpretation and Analysis

In this stage of research, assembled and processed data have been analyzed using SPSS and Microsoft Excel. Researchers used frequency tables, cross tabulation for data analysis. Different type's charts, figures and tables are created based on analyzed output using Microsoft Excel and Microsoft Word.

2.15. Preparation of Draft and Final Report

After the completion of the analysis of the study findings, a draft report has been prepared. After reviewing the draft report, the necessary correction has been made. Then the final report of the study has been formed under the guidelines of the supervisor and finally submitted to the supervisor.

Chapter 3

Literature Review towards a Conceptual Framework

Some relevant literature has been reviewed, to realize the depth and magnitude of the problem. The review of literature helped to select the parameters to evaluate the problem and assist to formulate the guidelines or recommendations to improve the existing condition as well as structure of the study. Several studies related with disaster-induced displacement have been undertaken by the researchers. Some of them are discussed below.

3.1.1 Fire Incidents in Bangladesh

Fire occurrence is a common incidence in Bangladesh. There is a growing inclination of happening fire incidents in Bangladesh with a higher occurrence rate, especially in Dhaka city. Fire breaks out in slums, squatters, garment & clothing factories, and small manufacturing and engineering-based industries are regular incidents during the summer season. The number of occurrence of fire events has amplified more than three times in Bangladesh since 1997; in the year 2018, the daily average is 53 fire incidents (Dhaka Tribune, 2019a).

Fire hazards cause the loss and damage of many lives and valuable properties in Dhaka city as well as other metropolitan cities of the country (J. B. Alam & Baroi, 2004). According to a survey conducted by the Fire Service and Civil Defense in 2017, a combined total of 360 factories and stores of chemicals were found to operate in the areas but residents of Old Dhaka say that the number could be close to 1,000 (The Daily Star, 2019a). But according to the law, all chemical factories and warehouses must acquire a license from the fire service and civil defense department, as prescribed in the Fire Prevention and Control Act, 2003 (GoB, 2003, Jahan et al.,2016).

At present, around 54 percent of the world's population lives in urban areas which are forecasted to rise to about 66 percent by 2050 (Tienan, 2005). The urbanization process is also heavily happening in Bangladesh, especially in and around Dhaka city, which rate is very high (Tishi, 2015). The urban population growth rate in Bangladesh in the last decade was 3.73% (BBS, 2011). Statistically, Dhaka is one of the most populated cities in the world (Dhaka Population, 2019). It is accommodating a huge

number of inhabitants and is one of the most densely populated cities in the world, with a density of 23,234 people/sqkm within an entire area of 300 sqkm (BBS, 2017). A devastating fire broke out in Tajreen Fashion Limited on 24 November that killed a total of 111 workers and around 300 workers were injured in this incident (Razzaq & Hasan, 2013).

Table 4: Fire related loss in Bangladesh (2006-2018)

Year	Total Fire Incident	Property Damage in Crore Taka (Approx.)	Saved Property in Crore Taka (Approx.)	Wound	Death
2009	12,182	305.89	1,042.60	1,087	118
2010	14,682	325.65	1,344.80	719	63
2011	15,815	293.49	1,033.30	1,385	365
2012	17,504	482.39	2,868.80	759	210
2013	17,912	779.71	1,809.50	1,385	161
2014	17,830	359.32	1,427.90	210	70
2015	17,488	856.95	1,831.30	216	68
2016	16,858	240.43	1,157.04	247	52
2017	18,105	257.24	1,348.19	269	45
2018	19,642	385.77	1,862.09	664	130
2019	24,074	330.41	1,422.92	586	185
2020	21,073	246.66	1,426.00	317	154
2021	21,601	218.32	1,149.52	570	219
Total	234,766	5,082	19,724	8,414	1,840

Source: FSCD Annual Report 2018 (FSCD, 2018b).

This speedy urbanization process is putting a burden on Dhaka city's inadequate land area with the already existing delicate environment and inadequate urban services (AKM uz Zaman et al., 2010). This fast urban growth significantly increases the fire susceptibility of the urban population and economic hubs. Fire occurrences are very common in Dhaka city, and the high population density makes the situation worse. As Dhaka is the center of all economic and commercial activities, and as such the center of maximum investment, Dhaka faces enormous economic losses and fatalities due to these increasing number of fire incidents.

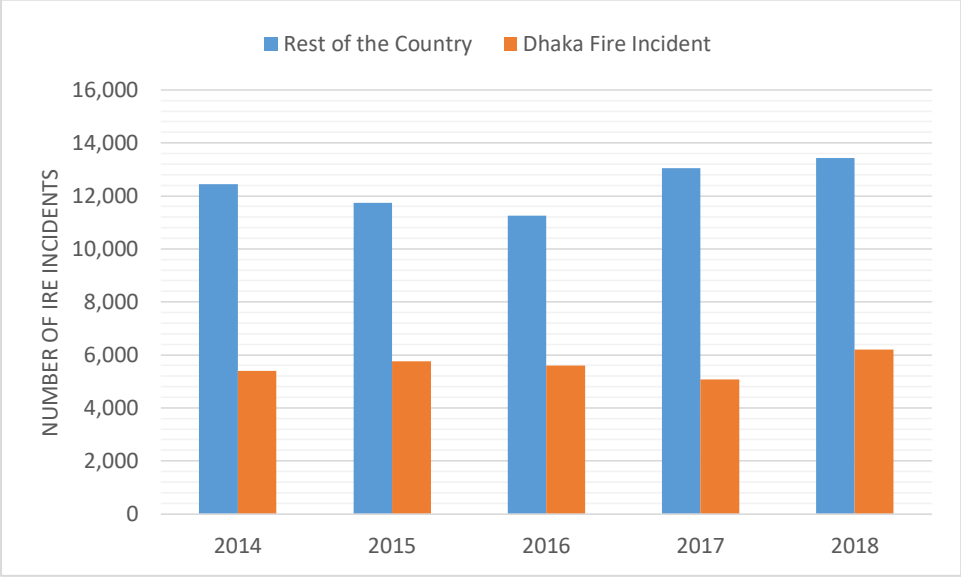
In BFSCD nearly 9000 people are working and they have a strong management team Islam & Hossain, (2018). Also, they are several volunteers throughout the country. Again these volunteers' fleet is also mostly inactive. Despite this manpower, the fire mitigation measures in Dhaka city are not adequate at all. This fire vulnerability condition is very common in entire Dhaka city but in slums and semi-structured buildings, this scenario is worse.

Table 5: Fire related loss in Greater Dhaka districts

Year	No. of fire incidents	Estimated Loss & Damage (in crore/ Tk)
2010	2,669	147
2011	2,422	96
2012	2,794	240
2013	2,891	407
2014	5,392	178
2015	5,752	670
2016	5,595	129
2017	5,066	91
2018	6,208	166
Total	38,789	2,124

Source: FSCD annual report 2018.

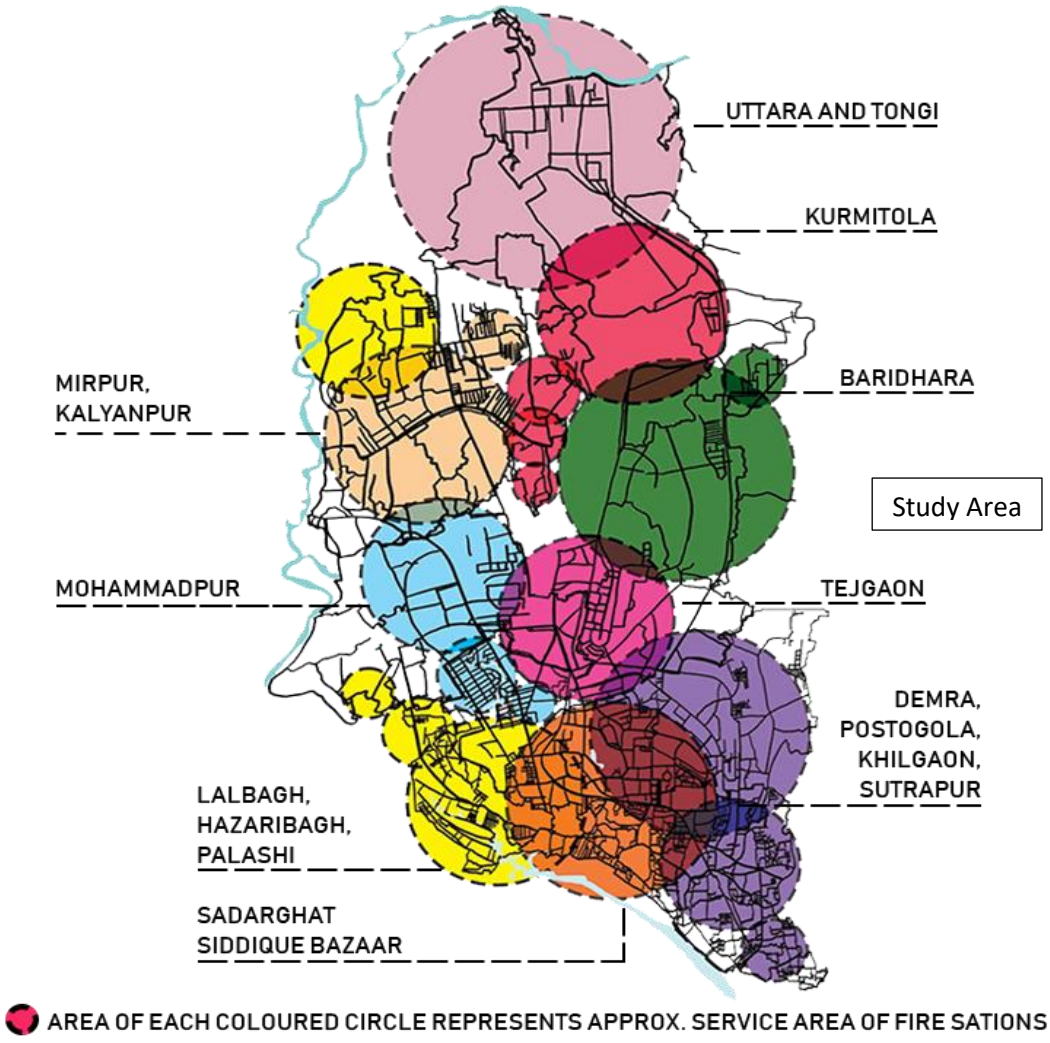
Figure 1: Share of Dhaka division incidents with the rest of the country



Source: FSCD annual report 2018.

3.1.2 Fire Stations in Dhaka Metropolitan Area (DMA)

There are 16 fire stations located within Dhaka city to serve the huge population. And among these stations, Tejgaon Fire Station is responsible to serve the study area Mohakhali.



Map 1: Fire stations service area of Dhaka metropolitan area.

3.2 FSCD Inspection, Fire Drills, and Training Information

FSCD also regularly done inspection visits to different buildings and industrial sites. They provide fire management, search and rescue training. Regularly organize fire drills at different government, private and industrial installations.

Table 6: FSCD inspection, fire drills, and training information

Year	Building inspected	Provided training	Trained personnel	Fire drill	High-rise building visit
2015	455	333	13,056	360	189
2016	532	476	19,358	543	400
2017	454	454	18,312	844	834
2018	537	624	29,329	673	1,375
Total	1,978	1,887	80,055	2,420	2,798

Source: FSCD Annual report 2015 to 2018.

3.3 Concepts Related to Fire

3.3.2 Fire

Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products (NWCG, 2009). Typically, fire comes from a chemical reaction between oxygen in the atmosphere and some sort of fuel like wood or gasoline, for example (Harris, 2019).

3.3.3 Stages of a Fire

Different fire-related literatures identified the fire initiation process in different stages. But most of the researchers recognized the standards of the International Fire Service Training Association (IFSTA). According to IFSTA, there are 4 stages or phases of a fire (Josh, 2010). These stages are

A. Incipient,
B. Growth,
C. Fully developed, and
D. Decay.

The following is a brief overview of each stage.

Incipient – This primary stage starts when heat, oxygen and a fuel source combine and have a chemical reaction and that results in a fire. This stage is also known as "ignition" and is typically characterized by a very small fire. This stage has the greatest chance for suppression or escape.

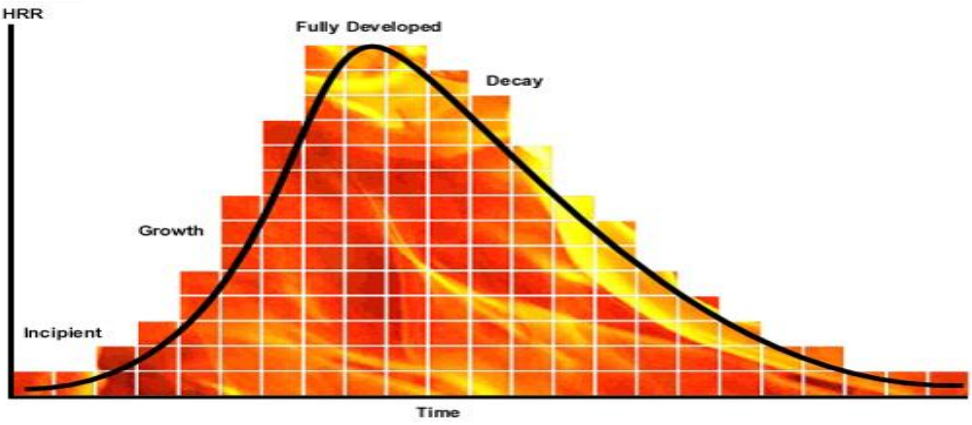
Growth – The growth stage is where the element of the structures and oxygen are used as fuel for the fire. Several factors are affecting this stage including where the

fire started, combustibles elements, ceiling height, air availability, etc. In this stage deadly "flashover" can occur; potentially trapping, injuring, or killing firefighters.

Fully Developed – When the growth stage has reached its extreme and all combustible materials have been ignited, then the fire is considered *fully developed*. This is the hottest phase of a fire incident and the most dangerous for anybody who is trapped inside.

Decay – Usually it is the lengthiest stage of a fire incident and the *decay stage* is characterized by a substantial reduction in oxygen or fuel, putting an end to the fire.

Figure 2: Heat Release Rate (HRR) and Fire Development



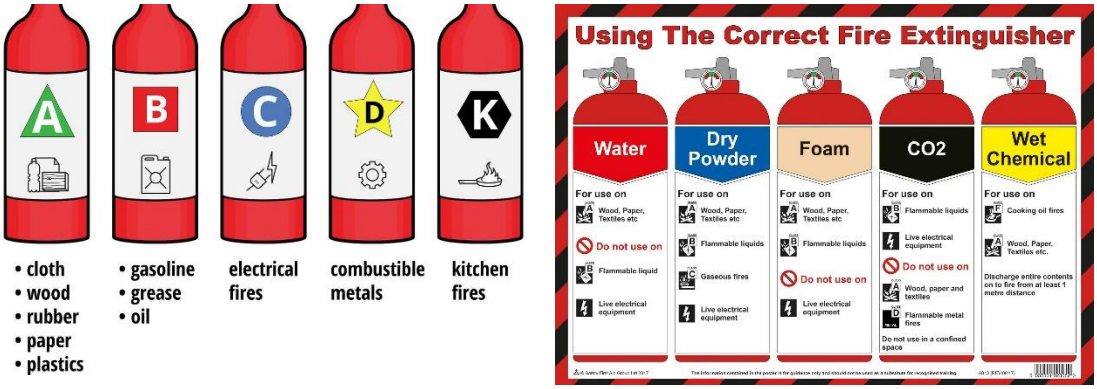
3.3.4 General classification of fire

Fire is classified by fuel type. There are five (5) classes of fire

- Class A - Ordinary Combustibles
- Class B - Flammable Liquids & gases
- Class C - Electrical
- Class D - Combustible Metals
- Class-K - Animal Fat or Vegetable Oil

- **Class A:** This type of fire involves common combustibles materials like paper, fiberglass, wood, and many other items commonly found.
- **Class B:** This type of fire involves flammable and combustible liquids and gases like gasoline, diesel fuel, and propane.
- **Class C:** This type of fire involves energized 120-volt Ac electrical equipment, including wiring, circuit breakers, fuses boxes, machinery, and appliances.

- **Class D:** This type of fire involves combustible metals like sodium, magnesium, potassium, uranium, sodium-Potassium alloy, and powdered aluminum.
- **Class K:** This type of fire involves restaurant grease.



Picture 1: Class-wise fire extinguishing system.

3.4 Defining Knowledge

Knowledge is a familiarity, consciousness, or understanding of somewhat, for example, information, facts, skills, or descriptions, which is acquired through education, experience, or by perceiving, learning, or discovering (Merriam-Webster, 2019). Knowledge can be referred to as a practical or theoretical understanding of a subject. It can be implicit (as with expertise or practical skill) or explicit (as with the theoretical understanding of a topic); it can be more or less formal, methodical or systematic (Oxford, 2019).

3.5 Firefighting Elevator

a) An elevator or lift within the firefighting channel with a double power supply connection and is capable of being controlled by the fire service personnel. The operation of the firefighter elevator is controlled by a switch (usually located at the particular place or ground floor level) that initiates the elevator controls for firefighter use.

b) The fire elevator shall be adjacent and reachable to an exit stairway and that can be approached by a fire-fighting lobby at each level. The fire elevator shaft shall be nonstop throughout the building and can serve every level.

c) The fire elevator shall be equipped with an operational feature that would allow firemen to cancel first or earlier calls that had been unintentionally made to the fire elevator during an emergency.
d) An elevator mainly planned for the transport of people or goods shall not be designated as a fire elevator.
e) The fire elevator shall be located in such a way that every level is accessible to fire-fighters using the fire elevator.

3.6 The Concept of Vulnerability

The word vulnerability usually means susceptibility to certain issues or hazards. According to UNDRR, former UNISDR disaster-related terminology (UNISDR, 2009), the features that are determined by physical, economic, social, and environmental aspects or processes that raise the susceptibility of an individual, a community, systems, or assets to the impacts or effects of hazards. Vulnerability is the incapacity to resist a hazard or to respond when a disaster has happened. For example, people who live in the low-lying area are more vulnerable to floods than people who live in the higher area. Vulnerability depends on numerous factors, such as geographic condition, people's state of health, age and, local environmental condition, sanitary settings, as well as on the quality and state of local buildings and their location concerning any hazards.

There are Four (4) Main Types of Vulnerability:

1. **Physical Vulnerability:** This type of vulnerability may be determined by aspects such as structural or physical condition, house, unregulated land use, population density, inaccessibility, settlement remoteness, the site, terrain, land undulation, materials, and design used for critical infrastructure (UNISDR). Example: house made of wood is less likely to collapse in an earthquake but are more vulnerable to fire.

2. Social Vulnerability: This type of vulnerability refers to the inability of people, communities, organizations, societies, or groups to withstand adverse impacts of hazards due to features inherent in social interactions, institutions, and systems of cultural values. It includes aspects related to levels of literacy and education, access to basic human rights, the existence of peace and security, social equity, systems of good governance, customs, and ideological beliefs, positive traditional values, and overall collective organizational systems (UNISDR).

Example: When any disaster occurs like flooding, certain citizens, such as the elderly, children, and differently-able people may be unable to protect or evacuate themselves.

3. **Economic Vulnerability:** This type of vulnerability depends on the individual's economic condition. The degree of vulnerability is highly dependent upon the financial status of individuals, communities, societies, and nations The poor, marginalized people are usually more vulnerable to disasters because they are in lack of the essential resources to build strong houses and to take other measures to protect themselves from the adverse impact of disasters. Example: Poorer families may live in bamboo-made houses or outside of embankment because they cannot afford to live in safer or more expensive places.

4. **Environmental Vulnerability:** This type of vulnerability refers to natural resource degradation and resource depletion, exhaustion are the key characteristic of environmental vulnerability. Example: Agricultural lands are sensitive to the increasing level of salinity from seawater, and pollution from the use of pesticides, agricultural chemicals, etc.

3.7 Firefighting Shaft

A firefighting shaft is a safe area. It provides the fire extinguishing and rescue service with an area from which firefighting operations will be taken. It links all necessary levels of a building, providing at least 2 hours of fire resistance to protect fire crews and are connected to fresh air. Several structural arrangements are available to be used in the construction of high-rise buildings.

3.8 Floor Area Ratio (FAR)

It is the ratio between the total amount of usable floor area of a building and the total area of the plot on which the building has been constructed. It can be easily explained with an example. FAR of 1.0 refers that the developer is allowed to construct the equal of a one-story building over the whole plot or a 2-story over half the plot. FAR of 2.0 refers to the developer is allowed to construct the equal of a two-story building over the whore plot or a 4-story over half the plot. (Dom Nozzi, 2010).

3.9 Definition of High-Rise Building

- According to **BNBC 2006**, building more than 20 meters high from grade shall be considered high-rise buildings.
- According to **BNBC 2020**, any building that is more than 10-storey or 33 meters high from reference datum. Buildings appurtenances like machine rooms, overhead water tanks, communication towers, etc. will not be measured in determining the height.
- According to **Dhaka Mohanagar Building (Construction Development, Protection, and Removal) Rule 2008,** any building which is more than 10-storey or above 33 meters high. Buildings appurtenances like rooftop stair room, overhead water tank, elevator machine room will not be considered in determining the height.
- According to **Fire Protection & Prevention law-2003,** any building which is more than 7-story is considered as a high rise building.

3.10 Regulatory Framework

Several legal documents have been reviewed related to fire prevention, mitigation, and management. They are as follows:

- Fire Protection & Prevention law-2003
- Fire Protection & Prevention Rule 2014
- Bangladesh National Building Code 2006
- Dhaka Mohanagar Building (Construction Development, Protection, and Removal) Rule 2008.
- Building Construction Rule 1996
- Bangladesh National Building Code 2020

3.10.2 Fire Protection & Prevention Rule 2014

Under this rule-following provision has been given for fire prevention and mitigation. They are in brief as follows;

Basement and Ground Floor:

- There should be a minimum 1,00,000 gallon capacity underground water reservoir with a fire service inlet facility at the basement. For fire extinguishing purposes 2/3 of its capacity should be preserved.
- For the riser and automatic sprinkler system, an overhead tank with 40,000-gallon capacity needs to be constructed at the roof. For fire extinguishing purposes, 50% of its capacity should be preserved.
- Water pressure at the main pipe of the wet riser should not be more than 20 millibars. The water pump meter head should be according to the building height and floor area.
- If the building is more than 14 floors, then there should be a relay pump and intermediate reservoir for every 26-meter height.
- Water pressure at the main pipe of the riser and sprinkler system should not be under 6/7 millibar.
- Floor area more than 300 sq meters in high-rise building departmental supermarket under F1 category and F3 category, minimum capacity of underground reservoir 1,50,000 gallon and overate tank capacity 50,000~ gallon.

Stair and Alternative Stair:

- The alternative staircase should not be extended up to the basement.
- The width of a stair is 1.5 meters of F1 category buildings and the width of a stair is 2 meters of F3 category buildings.
- If the building height is more than 14 floors, then the alternative stair doors should be a minimum of 1hour fire-rated auto enclose type, and the stair wall should be 2hour fire rated.
- There should be 1 stair from the ground floor to the basement.
- The stair landing area in the basement should be heated and smoke-free. The safety wall should be a minimum 2 hours fire-rated auto enclose type and the stair wall should be 2hour fire rated.
- If the travel distance to the basement is more than 20 meters then an additional staircase should be constructed.
- The width of the main road is 9 meters. The height of the main entrance gait should be a minimum of 5 meters.

Wet Raiser:

- 1 wet raiser is for 600 sq meters floor area and another wet riser point for additional floor areas. There should be 100 feet hose pipe connected to the riser.

3.10.3 Dhaka Mohanagar Building (Construction Development, Protection, and Removal) Rule 2008

- Each building should have a marked emergency exit for fire incidents.
- There is a separate annexure in the rule for fire prevention but no mention of a high rise building fire.
- The elevator can be used as a fire exit.

3.10.4 Building Construction Rule 1996

- Special provisions for seven or above seven-storied buildings
- The building should use BNBC 1993 code or FSCD fire protection and prevention rule
- There are no specific rules or provisions for fire hazard prevention and management in high-rise buildings.

3.10.5 Bangladesh National Building Code 2006

BNBC 2006 also described several codes related to fire prevention. Few important provisions are discussed below;

Refuse Area:

- It is a location in a building intended to hold residents during a fire incident or other types of emergency, when evacuation may not be possible or safe. Residents will wait there until rescued by firefighters All buildings shall include the provision of a refuge area on the external walls as cantilever projection or any other appropriate means.
- Refuge area of a building shall not be less than 15 sqm at the heights mentioned below
    - One refuge area on the floor immediately above 20 m.
    - One refuge area on the floor immediately above 26 m and then one refuge area per five-floor above 26 m.

Fire Safety Plan

A Fire Safety Plan shall be developed for each building and/or premises which must have the approval of the local fire services and civil defense authority regarding its adequacy and appropriateness.

The building management/owner/tenant shall distribute the approved plan to all the occupants of the building including the employees of all the offices and stakeholders using the building.

Individual occupant/s, single or in a group, as owner, tenant, a single corporate body or company, private or public residing in the building shall be subject to the provisions of a fire safety plan. All the occupants and variously employed persons in a building and/or premises shall actively participate and cooperate in carrying out the provisions of the Fire Safety Plan. Any change in the fire safety plan shall require the prior approval of the fire services and civil defense authority.

Fire Prevention and Protection Program

A plan for periodic formal inspections of each floor area, including exit facilities, fire extinguishers, and housekeeping shall be developed. A copy of such a plan is to be submitted to the local fire authority. Provision shall be made for the monthly testing of communication and alarm systems.

Detailed Building Information shall be maintained on a form which shall include the following information; Building address, name, address, and telephone number of the owner (corporate body or individual) and the person in charge of the building.

It should also have the certificate of occupancy, height, area, construction class, number, type and location of fire stairs, number, type, and location of horizontal exits or other refuge areas. Locations of fire alarm-floor-wise and central. Interior fire alarms, or alarms to central stations.

Size and location of the stand pipe system, size, and location of risers, gravity or pressure tank, fire pump, location of Siamese connections, and the name and qualifications of the person or persons in charge of the facilities,

Sprinkler system, primary and secondary water supply system, fire pump, and the area or areas being protected along with the name and qualification of the person or persons in charge, etc.

Fire Command Station

- A fire command station shall be provided on the ground floor and maintained by the owner of the building. A floor plan of the entire building showing particularly Means of Escape, staircases, elevators, and escalators, and detailed locations of firefighting equipment, first aid book, and other pertinent information regarding the services and equipment of the building shalt be maintained at the station.
- A fire alarm on each floor shall be electronically connected to the fire command station. A two-way communication system between each floor and the fire command station on the lobby of the entrance floor shall be provided.
- The crew of the fire command station, the number of which shall depend on the size of the building & the hazards, the occupant load and the fire load, and who shall be identifiable by attire or colour tag/band may comprise of Fire Safety Director, Deputy Fire Safety Director, fire Warden and Deputy Fire Warden.

3.11 Some Recent High-Rise Building Fire Incidents in Dhaka

High-rise building fire incidents are one of the most technical fire suppression challenges posed to modern firefighting departments and require a high degree of association and cooperation among participating units to be successfully controlled and extinguished the fire. The first notable high-rise building fire occurred at San Francisco, USA after the 1906 San Francisco earthquake.

Bashundhara City Fire

Picture 2: 19 Story building Bashundhara City fire, Dhaka.

Bashundhara City is a 19-floor building complex covering a total area of 1,91,200 sqft containing an 8-floor podium comprising retail spaces, cinemas, theme parks, swimming pool fitness clubs, and a food court with a 19-level Corporate Office of the Bashundhara Group. A fire broke out On 13 March 2009, at the top floors of the Bashundhara City complex. The blaze started around 1:30 pm, after Friday prayers, on one of the top floors. Most of the offices were empty, as Friday is the first day of the weekend in Bangladesh.

A security guard died as he jumped off the top of the building to escape the fire. Seventeen others were injured. Later on the same day, reports stated the death of three more people – found in an elevator by a group of Fire Fighters. Fifty people were injured – most of them treated for smoke inhalation. The fire took 10 hours to be brought under control due to the summer winds. A three-member committee to review the incident proclaimed the damage was caused because of the lack of fire-protection equipment during the time of the incident.

On 21 August 2016, a fire breaks out again in Block-C of the Bashundhara City shopping complex. Fire breaks out on level 6, 29 firefighting units partially douse flames, 11 rescued from the rooftop, 2 injured.

FR Tower Fire

Picture 3: 22-storey building FR Tower fire at Dhaka city.

The fire broke out on the eighth floor of the 22-storey building called FR Tower at the commercial Banani area of Dhaka city on 28th March 2019 around 1:00 pm local time. It caused 26 deaths and more than 70 others were injured. The fire was brought under control around 4:45 pm. A total of 21 firefighting units brought the blaze down and rescue the people trapped inside the building. Later, Army, Navy, and Air forces; police, and Rapid Action Battalion (RAB) joined the operation. Helicopters were seen spraying water on the building and firefighters were bringing people out the window panes in groups, using ladders. Authorities say that FR Tower violated the building code and that it had unusable firefighting equipment.

3.12 RAJUK Report on High-Rise Building Fire Vulnerability Situation

After the FR Tower fire incident, RAJUK has started a survey on fire preparedness of high-rise buildings. From April 01 to April 15, 2019, 24 RAJUK teams completed a detailed inspection and examination of hundreds of 11-storey buildings and above. Key findings are;

- About 63 percent of the 1,818 buildings in the capital, 10 stories or higher have lacked the fire safety measures (The Daily Star, 2019c).
- Around 44 government high-rise buildings have failed to show any designs approved by the city developer.
- Only around 293 buildings were constructed without any deviation from their approved designs out of 1,818 buildings.
- Out of the total surveyed buildings, only around 1,136 have RAJUK-approved designs while 207 high rise buildings have taken approval either from City Corporation or from National Housing Authority (NHA).
- Around 431 high-rise building owners could not able to show any approved designs from RAJUK.
- Out of the total buildings having RAJUK-approved designs, the RAJUK survey report found that around 277 buildings have done vertical deviations and 674 buildings have done a setback and other deviations.
- Among the NHA and city corporation-approved buildings, 32 buildings have done vertical deviations, 64 buildings have done a setback and other deviations.
- Around 478 high-rise buildings could not able to show any approved design by none of the authorities.
- The survey report also highlighted the high-rise building's firefighting system, emergency exit, occupancy, and structural deviation.
- 566 building without emergency exit (The Independent, 2019).

3.13 Prime Minister Directives

PM Sheikh Hasina issued a set of directives for high-rise buildings fire management at a cabinet meeting on 1st April 2019 (Dhaka Tribune, 2019c; The Daily Star, 2019b). They are as follows in brief;

- Concerned authorities should regularly inspect the fire safety arrangements of the high-rise buildings and other establishments.
- Fire Service and Civil Defense which is responsible for issuing fire safety clearance certificate for construction of any building to make ensure that the building is viable for construction by inspecting the place.
- Making arrangements for fire drills by the building owner every three months to make people more aware of fire safety.
- Equipment and techniques need to be installed and followed to control smoke during fire incidents.
- People should maintain the building code strictly while constructing any building and create water reservoirs and preserve the lakes.
- FSCD has only 3 turntable ladders in the country, PM asked to increase the number.
- Architects should design the buildings keeping in mind the environment, ensure the fire exit and keep it open all time.
- Presently several offices and industries have installed and used electronic doors that usually do not work during electricity failure. This type of door needs to be workable manually when there will be no electricity.
- Make sure the pre-arrangement of tarpaulin and rope at the high-rise building so that it could be used during the fire incident as the emergency exit.
- Authorities should keep veranda in each school and hospital and asked the interior designers to arrange so that those verandas remain open all time.
- Make provision for more than one emergency exit, at least two, for each high-rise building.

Chapter 4
Study Area

4.1 Introduction

The hazard-prone areas were based on different broad land use categories like a planned residential area, mixed residential area, commercial area, institutional area, slum area, and industrial area based on the previous pattern of fire incidents (Haque, Md, 2001). The unplanned and uncontrolled construction of high-rise buildings, paved roads, and markets are emerging as risk factors for the urban dwellers in Dhaka city (M.Maksudur Rahman, 2017). For the detailed investigation, Mohakhali areas were selected. In a study, it was found that Tejgaon, Ramona, and Postogola are found to be the most hazardous zone with above thirty fire incidences per year (J. Alam & Baroi, 2004).

Out of 25 high-rise buildings 10 buildings were selected based on different characteristics. Detail characteristics of these areas and buildings include land use categories, structure type of building, building height, occupancy, and road width of the areas, have been studied.

4.2 Location

Mohakhali is a commercial area of Dhaka city. Many important offices and institutions are situated here. Mohakhali is located at 23° 46′ 46.2″ N and 90° 24′ 16.56″ E. It had 22,138 households and a total area of 1.73 km². Mohakhali area is bounded by Banani on the north, Tejgaon on the south, Gulshan on the east, and Tejgaon on the west.

4.3 Population

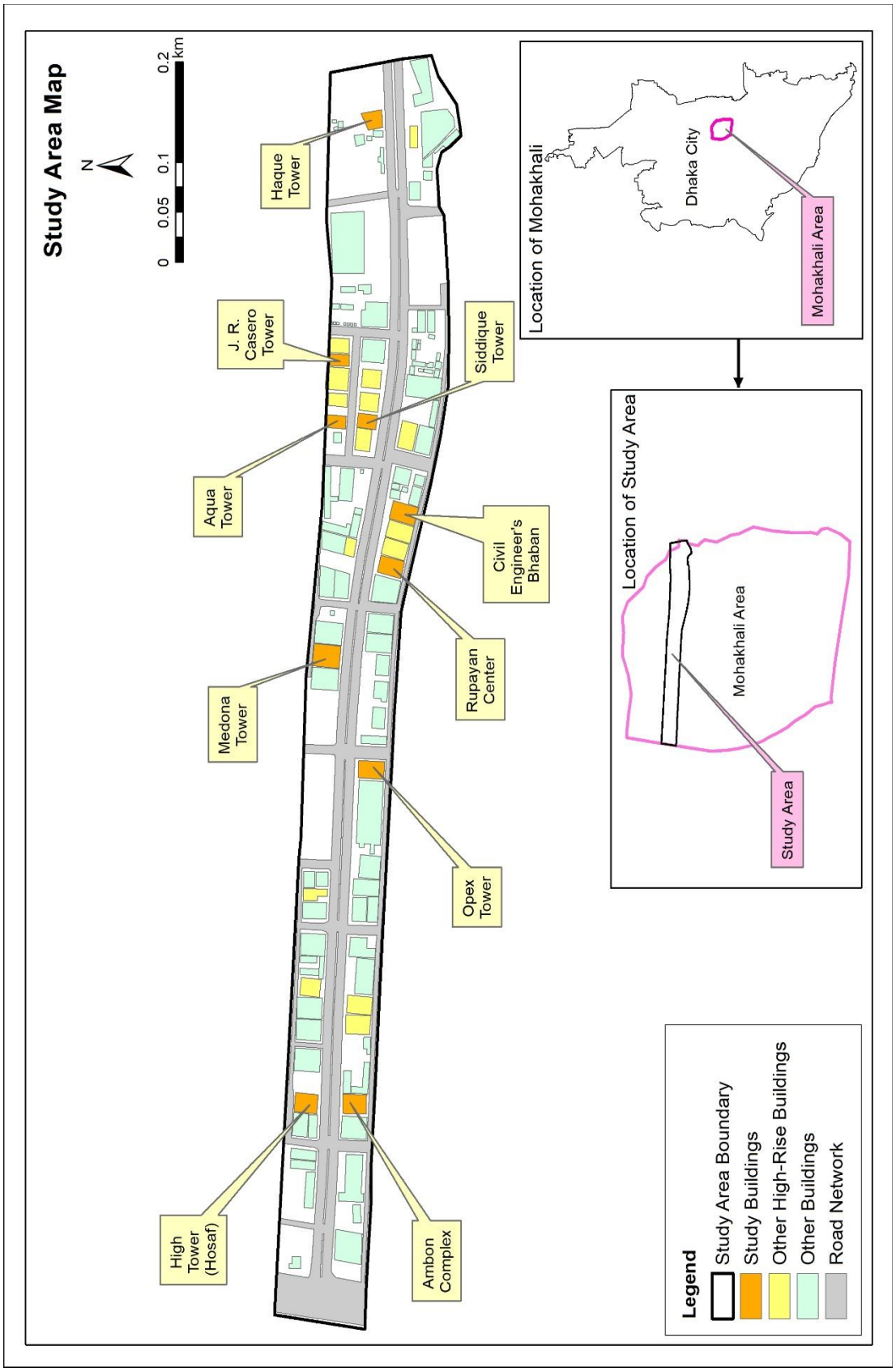
Dhaka is the most populated city in Bangladesh, and it is also one of the most populated cities in the world. The Greater Dhaka Area has a population of over 18 million as of 2016, while the city itself has a population estimated at 8.5 million. Dhaka city is also one of the most densely populated areas in the world, with a density of 23,234 people per square kilometer. The total population of Mohakali (ward 20) is 93,143 (BBS 2011). Among them, men 48,378, and women 44,765.

4.4 Educational and Community Institutions

There are 4 primary schools, 2 high schools, 3 colleges, 7 technical institutions, 12 madrasas, and 3 universities situated in this area. There are 32 mosques and 3 temples, 11 water pumps, 2 waste dumping centers, and 2 filling stations situated in this ward.

4.5 Number of Buildings

The study mainly considers buildings from both sides of the Bir Uttam AK Khandokar road from the Amtoli area to Gulshan lake. There were about 84 buildings



Map 2: Study area map

4.6 Building Height and Plot Size

The highest building of the study area is Rupayan Centre having 22 storied height and the lowest building is High Tower having 13 storied.

Table 7: Storied and plot area of the buildings

Sl. NO	Building Name	Number of Storied	Plot area (Katha)
1	Ambon Complex	16	8
2	Opex Tower	18	8
3	Rupayan Centre	22	8
4	Civil Engineer's Bhaban	21	8
5	Haque Tower	14	4
6	Aqua Tower	15	5
7	J.R Casero	15	5
8	Siddique Tower	12	5
9	Medona Tower	16	9
10	High Tower	13	8

Source: Field survey, 2019.

4.7 Construction Year of the Buildings

70% of buildings were constructed before 2000. The oldest buildings were Ambon Complex and J R Casero. Opex Tower was comparatively new only 15 years old structure.

Table 8: Age of the buildings

Building name	Construction year	Building Age (Years)
Ambon Complex	1991	28
Opex Tower	2004	15
Rupayan Centre	2002	17
Civil Engineers Bhaban	1998	21
Haque Tower	2001	18
Aqua Tower	1992	27
J R Casero	1991	28
Siddique Tower	1998	21
Medona Tower	1994	25
High Tower (Hosaf)	1999	20

Source: Field survey, 2019.

4.8 Building Floor Area

Table 9: Building wise floor area

Building name	Number of Storied	Plot area (Katha)	Per floor area (sqft)	Total floor area (sqft)
Ambon Complex	16	8	5500	93,500
Opex Tower	18	8	4300	92,000
Rupayan Centre	22	8	5500	105,000
Civil Engineers Bhaban	21	8	4088	81,776
Haque Tower	14	4	2500	37,500
Aqua Tower	15	5	3154	51,000
J R Casero	15	5	3200	51,200
Siddique Tower	12	5	3400	44,200
Medona Tower	16	9	6400	110,160
High Tower (Hosaf)	13	8	5500	77,000

Source: Field survey, 2019.

4.9 Occupants Work Experience

Most of the occupants were comparatively new in these buildings. 65% of occupants' respondents that they were working less than 5 years in these buildings. 13% occupants' were working here from 6-10 years, 10% occupants' were working here from 10-15 years. Only about 2% were working for more than 26 years in these buildings.

Table 10: Occupants work Experience

Years	Cumulative Percent
Less than 5	65.5
6-10	79.1
11-15	89.1
16-20	97.3
21-25	98.2
26+	100.0
Total	100.0

Source: Field survey, 2019.

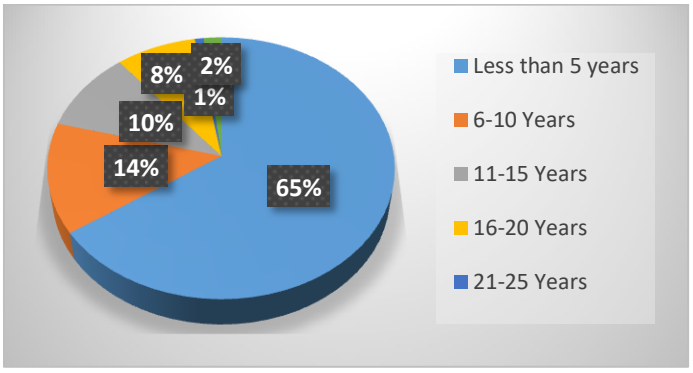


Figure 3: Work Experience in percentage

4.10 Building Occupancy and Sex Ratio

The total number of occupants of these buildings was about 6238 people. Among them, men were 85% and women were 15%.

Table 11: Building occupancy 24 hours

Building name	Building occupancy, person (9am-5pm)	Building occupancy, person (6pm-1am)	Total	Occupancy Ratio
Ambon Complex	700	20	720	35:1
Opex Tower	450	15	465	30:1
Rupayan Centre	800	20	820	40:1
Civil Engineers Bhaban	750	50	800	15:1
Haque Tower	600	8	608	75:1
Aqua Tower	500	10	510	50:1
J R Casero	730	10	740	73:1
Siddique Tower	600	15	615	40:1
Medona Tower	250	10	260	25:1
High Tower (Hosaf)	650	50	700	13:1
Total	6030	208	6238	29:1

Source: Field survey, 2019.

4.11 Respondents Education Level

About 34% of the respondent has education level below SSC, they were mainly security guards and office assistant, etc. about 31% respondents have masters level education, 25% has graduate-level education. About 11% have education between SSC-HSC.

Table 12: Respondents education level

Level of Education	Cumulative Percent
Below SSC	33.6
SSC-HSC	44.5
Graduation/Bachelor	69.1
Post-Graduation/Masters	100.0
Total	100.0

Source: Field survey, 2019.

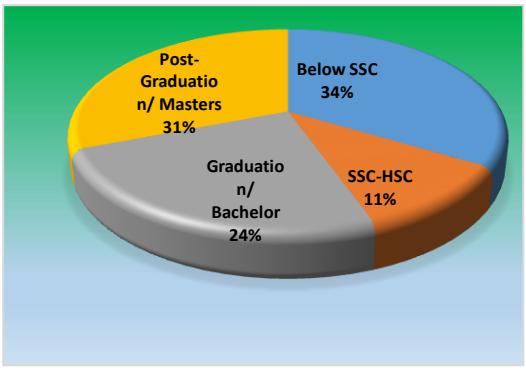


Figure 4: Education level

4.12 Fire Zones

According to BNBC 2006, the planning and development authority of the city, township, municipality, or region where this code is intended to be implemented shall divide the area under their jurisdiction into distinct fire zones. The basis of this zoning shall be the fire hazard inherent in the buildings and the degree of safety desired for the occupancy accommodated therein. The number of zones in an area shall depend on its size and the strategies undertaken for its development.

Fire Zone 1

Table 13: The following occupancy groups shall comprise this zone

Category	Landuse	Category	Landuse
Occupancy A	Residential	**Occupancy F**	Mercantile
Occupancy B	Educational	**Occupancy H**	Livestock Storage Building
Occupancy C	Institutional for Care	**Occupancy l**	Assembly
Occupancy D	Health Care	**Occupancy K**	K1 and K2
Occupancy E	Offices	**Occupancy M**	Miscellaneous Buildings

Source: BNBC 2006.

Fire Zone 2

Table 14: The following occupancy groups shall comprise this zone

Category	Landuse
Occupancy G :	Industrial Buildings
Occupancy H :	Storage Buildings
Occupancy K :	K3 Parking

Source: BNBC 2006.

Fire Zone 3

The only occupancy falling in this zone shall be Occupancy J, Hazardous Buildings.

The study area of this research fell on the F category mercantile.

Chapter 5
Survey Findings and Analysis

5.1 Introduction

In this chapter, the findings of the study are presented with analysis.

Objectives 1: Knowledge level assessment

5.1.2 Process of Fire Ignition

99% responded said that they do not know how a fire starts or ignites. Three things are required in proper combination before ignition and combustion can take place--- **Heat, Oxygen,** and **Fuel**. There must be **Fuel** to burn. There must be **Air** to supply oxygen. There must be **Heat** (ignition temperature) to start and continue the combustion process.

Fire is a chemical reaction (combustion) in which energy in the form of heat is produced. Fire begins with ignition. The match is a common ignition device. Friction creates sufficient heat to ignite the phosphorus at the end of the match. Combustion occurs and the match flames.

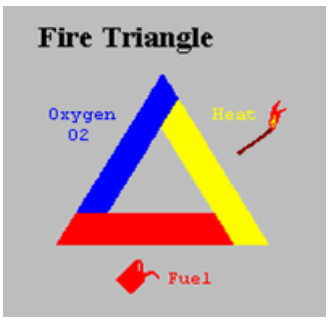


Figure 5: Combustion process

5.1.3 Potential Sources of Fire

100% responded identified few potential sources of fire. About 50% of respondents identified electric short circuits as the main cause of the fire, 24% said the gas explosion, and 15% said throwing burning cigarettes & matchsticks to vulnerable places like fuel pumps, kitchens, store, chemical industries, etc.

Table 15: Potential sources of fire

Sources of fire	Responses
	Percent
Gas explosion	24.1%
Electric short circuit	49.5%
Burning cigarette & match stick	14.6%
AC system	2.4%
Faulty electric appliance	0.5%
Cooking stove	2.4%
Chemical reaction	0.9%
Mosquito coil	2.4%
Machine	1.4%
Leaked wire	0.9%
Unawareness	0.9%
Total	100.0%

Source: Field survey, 2019.

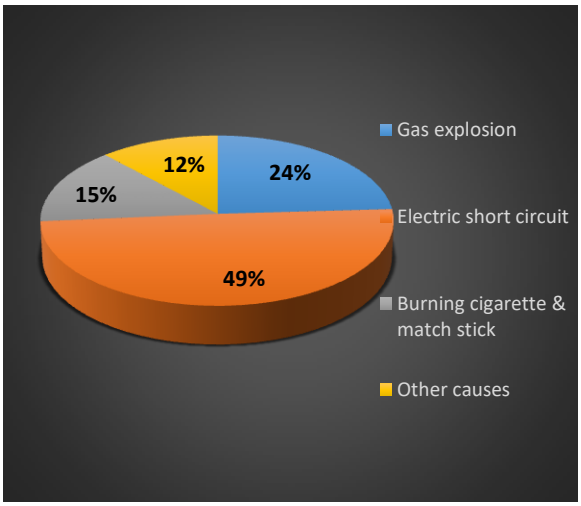


Figure 6: Main causes of fire in percentage

5.1.4 Activities in Time of the Fire

In repose to the question, do you know what to do in time of the fire, about 95% responded said that they know what they will do in time of fire situation. Only 5% said they do not know anything what to do at that time. About 24% responded said that they will leave the place immediately, 23% said that they will use fire extinguishers. About 22% of people said that they will only shout.

Table 16: Activities during a fire

Activities in time of fire	Responses	
	Frequency	Percent
Only shout	30	22.1%
Leave house immediately	33	24.3%
Switch off electricity line	12	8.8%
Switch off gas line	3	2.2%
Collect important documents first then go out	6	4.4%
Call fire service	8	5.9%
Use fire extinguisher	32	23.5%
Continue my duty	1	0.7%
Roof	3	2.2%
Fire Alarm	4	2.9%
Calling committee	1	0.7%
Depend on extent of fire	2	1.5%
Lock cutting	1	0.7%
Total	136	100.0%

Source: Field survey, 2019.

5.1.5 Emergency Exit in Time of the Fire

About 99% responded said that they will use the staircase in time of the fire, only 1% responded said that they will use the elevator as a fire exit as the building is a high-rise, they may not be able to come down quickly and safely through the stair.

5.1.6 Knowledge of Fire Extinguishing

About 81% responded said that they know how to extinguish the fire, 19% said they do not how to stop a fire. Among the known people, 50% said they will use fire extinguishers, 25% will use water and 15% will use sand to extinguish the fire. Some responded also said they will use a wet cloth, hose pipe water and called the building authority to respond to the fire incident.

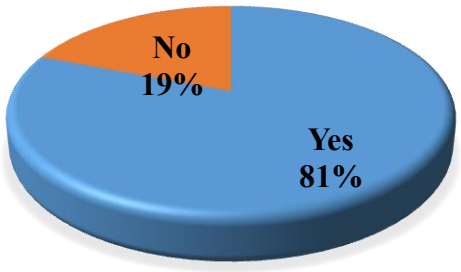


Figure 7: Knowledge of fire extinguisher

Table 17: Responses on how to extinguish a fire

Ways to extinguish a fire	Responses	
	Frequency	Percent
Use fire extinguisher	59	50.4%
Use water	29	24.8%
Use sand	17	14.5%
Use wet cloth	7	6.0%
Switch off the main electricity supply line	1	0.9%
Hosepipe	3	2.6%
Call building authority/ committee	1	0.9%
Total	117	100.0%

Source: Field survey, 2019.

5.1.7 Actions if You Caught By Fire

82% responded said that they know what to do if they were caught by fire. 18% have no idea what to do then. About 60% responded said that they will roll on the ground, about 24% said that they will tear off/ undress themselves. About 14% said that they will throw water on them and only 1% said that they will cover themselves with a wet cloth.

Table 18: Actions if your dress caught by fire

Actions	Responses	
	N	Percent
Rolling on the ground	57	60.6%
Undress	23	24.5%
Water throwing	13	13.8%
Wet Cloth	1	1.1%
Total	94	100.0%

Source: Field survey, 2019

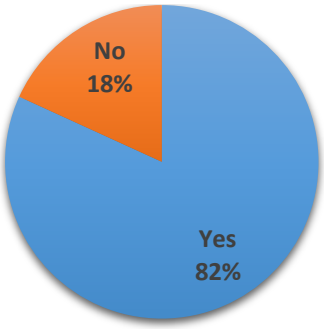
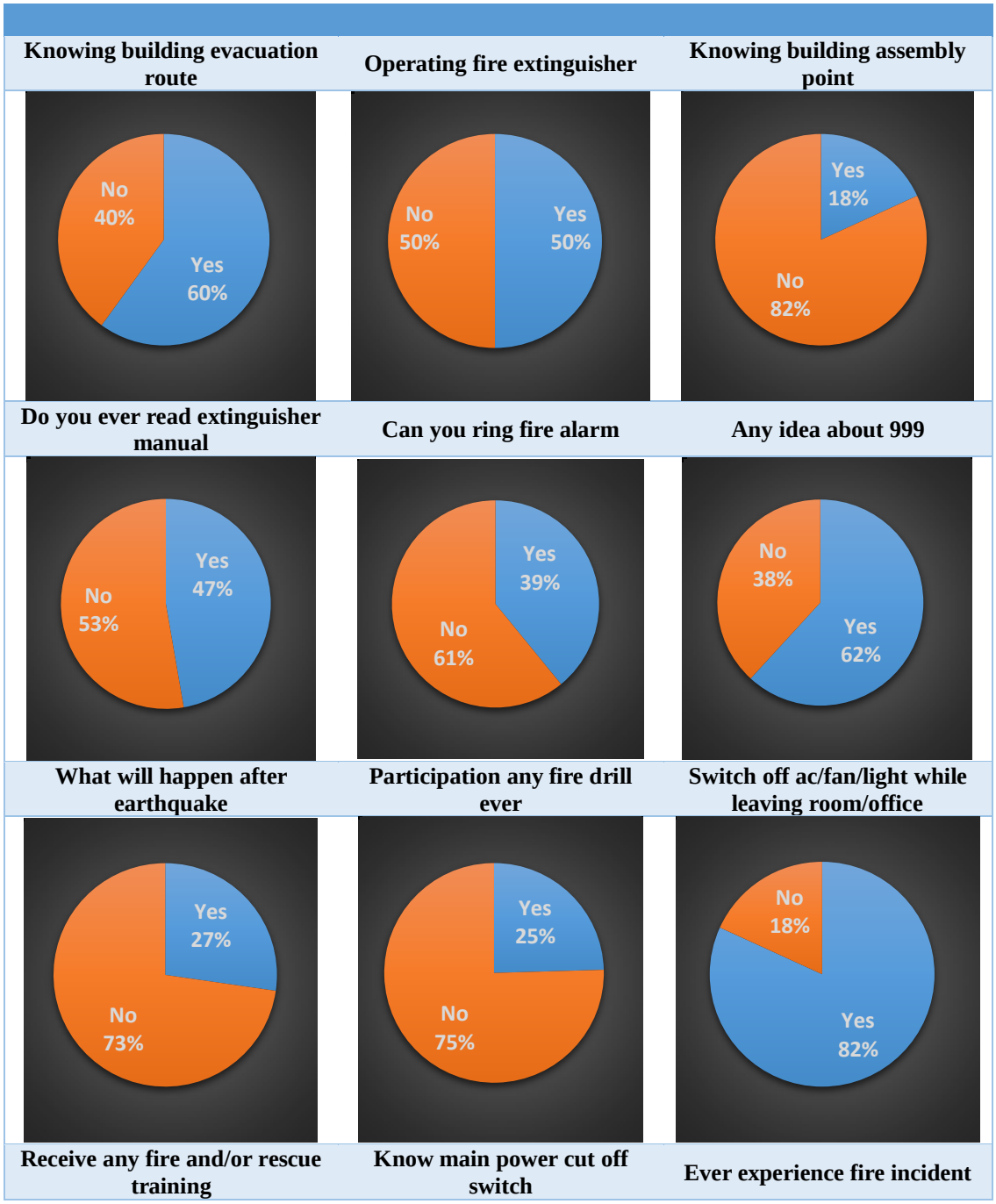


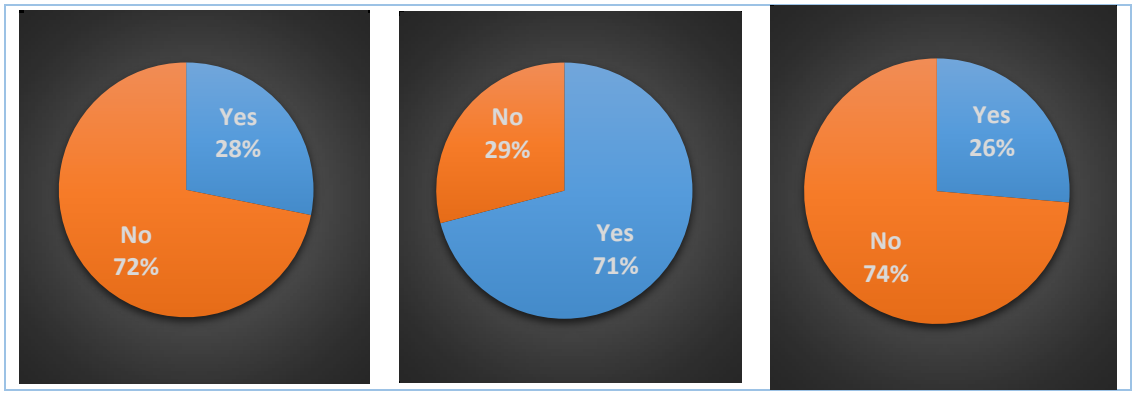
Figure 8: People know actions if caught by fire

5.1.8 Knowledge of Exit Route, Emergency Number (Yes/No Answers)

There were some questions with yes/no answers to assess the individual respondent's knowledge level. The questions includes like do you know fire service number; do you receive any fire-related trainings or do you know the building assembly point or emergency exit route etc.

Figure 9: Yes/no answers on knowledge-based questions





Source: Field survey, 2019

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Picture 4: Many claimed that they can use a fire extinguisher but in reality, they can't operate. FCSD officials teach them how to use it.

5.1.9 Ranking Knowledge Level

Around 11% of respondents have no clear idea about the conceptual understanding and/or actionable knowledge on the event of a fire. 40% respondents have basic knowledge and about 41% has limited experience on the fire event. So around 51% of respondents do not have any useful knowledge to fight a fire.

Table 19: Knowledge level ranking

Ranking	Cumulative Percent
No Idea	10.9
Fundamental Awareness (Basic Knowledge)	50.9
Novice (Limited Experience)	91.8
Intermediate (Practical Application)	100.0
Total	100.0

Source: Field survey, 2019.

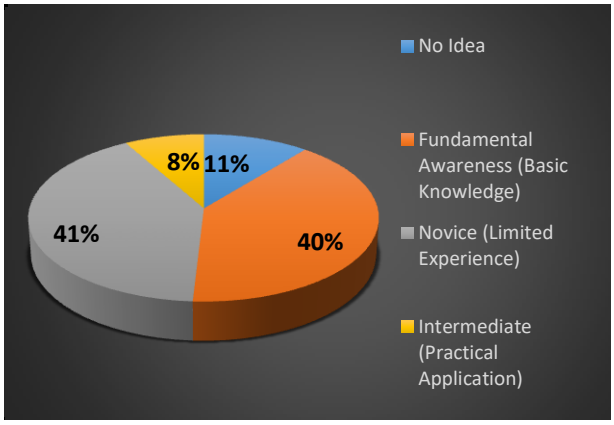


Figure 10: Knowledge level

5.1.10 Building Wise Knowledge Level

The table showed that respondents having no idea on fire mainly work on Ambon Complex and Haque Tower. Respondents having basic knowledge equally distribute to all buildings. No idea on fire mainly works on Ambon Complex and Haque Tower. Respondents having limited knowledge on fire mainly work on Civil Engineers Bhaban and High Tower. Respondents working on Medona Tower and Siddique Tower have Intermediate or practical knowledge of fire events.

Table 20: Building wise knowledge level

Building name	Ranking				Total
	No Idea	Fundamental Awareness (Basic Knowledge)	Novice (Limited Experience)	Intermediate (Practical Application)	
Ambon Complex	30.8%	23.1%	30.8%	15.4%	100%
Opex Tower	7.7%	46.2%	23.1%	23.1%	100%
Rupayan Centre	0.0%	57.1%	42.9%	0.0%	100%
Civil Engineers Bhaban	0.0%	16.7%	75.0%	8.3%	100%
Haque Tower	0.0%	60.0%	40.0%	0.0%	100%
Aqua Tower	30.0%	60.0%	10.0%	0.0%	100%
J R Casero	11.8%	41.2%	47.1%	0.0%	100%
Siddique Tower	0.0%	50.0%	25.0%	25.0%	100%
Medona Tower	0.0%	40.0%	20.0%	40.0%	100%
High Tower (Hosaf)	16.7%	16.7%	66.7%	0.0%	100%
Total	10.9%	40.0%	40.9%	8.2%	100%

Source: Field survey, 2019.

5.1.11 Responded Education-wise Knowledge

The table reveals that respondents having education below SSC and HSC have no idea on fire-related issues. Respondents having an education at graduate and master level have theoretical knowledge but very limited experience. But some respondent's practical experience on fire-related issues, they were mainly security guards having trained on fire mitigation.

Table 21: Responded education-wise knowledge level

Responded education	Ranking				Total
	No Idea	Fundamental Awareness (Basic Knowledge)	Novice (Limited Experience)	Intermediate (Practical Application)	
Below SSC	16.2%	35.1%	32.4%	16.2%	100%
SSC-HSC	16.7%	50.0%	33.3%	0.0%	100%
Graduation/Bachelor	7.4%	33.3%	51.9%	7.4%	100%
Post Graduation/ Masters	5.9%	47.1%	44.1%	2.9%	100%
Total	10.9%	40.0%	40.9%	8.2%	100%

Source: Field survey, 2019.

Picture 5: Interview with Security guard Mst Yasmin at Brac university of Siddique Tower building.

Picture 6: Interview with Tahmina Yasmin, Financial Accounts Officer of Standard group at Civil Engineers Bhaban

5.2 Objectives 2: Building Fire Vulnerability

5.2.10 Building Construction

Fire vulnerability or damage depends on the quantity of inflammable material, which is a major contributor to the intensity of the fire. The contributory factors were

building typologies, construction material, and location proximity with potential fire sources. These buildings were mainly mercantile or commercial mixed-used high-rise buildings. Rigid frame structure construction technology has been used. They were mainly RCC structures. There were some small restaurants beside those buildings which can be potential sources for fire.

5.2.11 Building Use

Mostly these buildings have mixed land use which constitutes 70%, single landuse has 30% buildings. Among the mixed-use buildings, 61% for office, 30% for educational, 5% for medical, and 4% used for commercial purposes.

Table 22: Landuse of the buildings

Building name	Use 1		Use 2		Use 3		Total
	Type	%	Type	%	Type	%	
Ambon Complex	Official	94	Commercial	6	.	0	100
Opex Tower	Official	100	.	0	.	0	100
Rupayan Centre	Official	80	Commercial	20	.	0	100
Civil Engineers Bhaban	Official	100	.	0	.	0	100
Haque Tower	Official	70	Medical	30	.	0	100
Aqua Tower	Official	47	Educational	53	.	0	100
J R Casero	Official	33	Educational	67	.	0	100
Siddique Tower	Official	25	Educational	75	.	0	100
Medona Tower	Official	100	.	0	.	0	100
High Tower (Hosaf)	Official	78	Medical	7	Educational	15	100

Source: Field survey, 2019.

5.2.12 Roof use

In those high-rise buildings average 42% of roof space is occupied and 58% is free or empty. Roof space is occupied by the mobile tower, solar panel, illegally constructed floors which were used as kitchen room, guards, staff living space, dining room, etc.

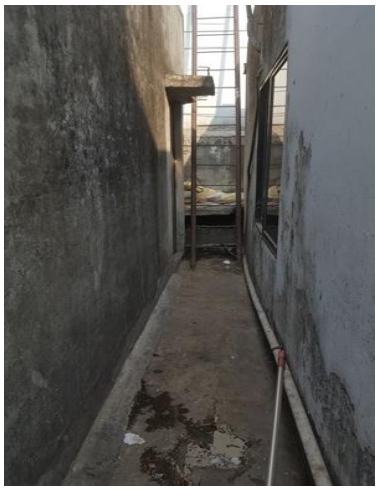
Table 23: Building wise roof floor use

Building name	Roof occupied (%)	Roof empty (%)
Ambon Complex	20	80
Opex Tower	100	0
Rupayan Centre	20	80
Civil Engineers Bhaban	0	100
Haque Tower	60	40
Aqua Tower	100	0
J R Casero	20	80
Siddique Tower	100	0
Medona Tower	0	100
High Tower (Hosaf)	0	100
Average	42	58

Source: Field survey, 2019.

Few buildings like Haque, Aqua Tower, Siddique Tower constructed one and even two floors on the top of the roof. These are completely illegal.

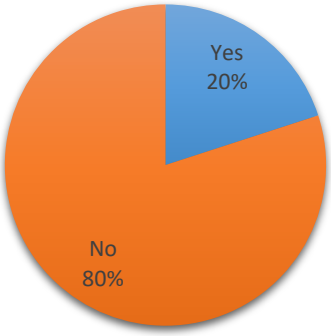
Picture 7: Aqua Tower built 2 floors at the roof used for guards, staff living space, kitchen room, dining room, toilet, etc.



Picture 8: Roof of Siddique Tower is about completely occupied 2 rooms.

5.2.13 Restaurants in the Building

Figure 11: Restaurants in the buildings



Eating and drinking establishments are one of the important sources of fire in a building. According to National Fire Protection Association (NFPA), there were an estimated 7,410 fires reported to U.S. fire departments related to eating and drinking establishments each year and these fires caused average annual losses of 3 civilian deaths, 110 civilian injuries, and $165 million in direct property damage each year (Campbell, 2017). In the studied buildings, 80% have no restaurants, only 20% have restaurants in their building complex. But 40% of buildings have gas burners used at an individual level.

Table 24: Details of two restaurants

Building	Burner	Gas cylinder	Freezer	Oven	Cooking appliances (blender, juicer, etc)
J R Casero	2	2	2	2	3
Siddique Tower	2	2	3	2	5

Source: Field survey, 2019.

There was one fast-food restaurant on the first floor in the J R Casero building. It is about 3600 sqft restaurant having the facility to serve about 70 people at a time. There was 2 gas burner with 2 cylinders. There also several ovens, refrigerators, and cooking appliances in the kitchen. It is a rented privately managed restaurant. Again in the Siddique tower, there was a cafeteria managed by the university authority. It is also a 3600 sqft cafeteria having the facility to serve about 70/80 students. Its kitchen has 2 gas burners, 2 cylinders, 3 ovens, 2 refrigerators, and other cooking appliances in the kitchen. They are operated commercially.

5.2.14 Budget Expense on Building Maintenance

About 90% of authorities said that they spend money on building repair and maintenance. In the last year, they have spent about BDT 40,25,000/- maintenance.

5.2.15 Budget Expense on Fire Preparedness

Among the 90% of buildings that spent money for repair and maintenance, 70% of them spent budget for fire preparedness. 30% didn't spend on fire preparedness. It needs to be mentioned here that after the fire incident at FR Tower on dated 27 April, building authorities started to spend on fire preparedness. Only the Civil Engineers Bhaban authority has spent about 10 lac taka only for fire preparedness. The fire-rated doors, smoke mask, water drum, high capacity buster pump, jokey pump, heavy fire extinguisher, etc.

Table 25: Budget expense on building repair & maintenance and fire preparedness

Building name	Expenditure on repair & maintenance	Expenditure on fire preparedness
Ambon Complex	700,000	300,000
Opex Tower	50,000	50,000
Rupayan Centre	700,000	100,000
Civil Engineers Bhaban	1,500,000	1,000,000
Haque Tower	100,000	50,000
Aqua Tower	300,000	0
Siddique Tower	50,000	0
Medona Tower	100,000	100,000
High Tower (Hosaf)	525,000	50,000
Total	4,025,000	1,650,000

Source: Field survey, 2019.

5.2.16 Fire Insurance

Fire insurance is property insurance that covers damage and losses caused by fire. The insurance helps to cover the cost of replacement, repair, or reconstruction of property and the cost limit is set by the property insurance policy. In the study area, 70% of buildings have no fire insurance, only 30 % have fire insurance. For example, Civil Engineers Bhaban has fire insurance from Standard Group Insurance Company They were mainly first-party insurance and the insurance company is a sister concern of the mother company done with Standard Group, another company of the building owner.

5.2.17 Building Fire Safety Plan

According to BNBC 2006, every high-rise building should have a fire safety plan and this plan should be endorsed by FSCD. None of the buildings has a fire safety plan of such kind. Only 10% building has fire emergency plan exit plan.

5.2.18 The Importance is given to Fire Hazards by Building Authorities

The researcher has discussed with each building authority about their fire preparedness situation in April 2019. It is notable that even after the FR Tower fire incident on 28th March 2019, most of the authorities, (80%) said that they do not give fire hazards high priority. They consider it as a medium priority. It was even not in their priority list before the FR Tower event. 10% of authorities said fire preparedness is their top priority.

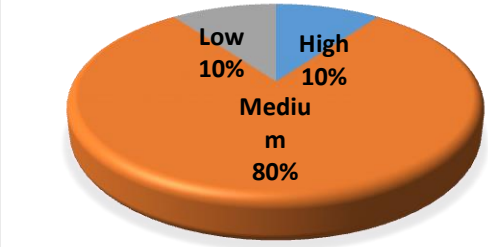


Figure 12: Priority on fire hazard by Authorities

5.2.19 Fire/ Evacuation Drill

Almost 80% of buildings do not practice any fire or evacuation drills, only 20% of building authorities arranged fire-related evacuation drills. They are usually done once a year. But according to BNBC 2006, they should do 2 drills in a year and 1 drill every 6 months.

Table 26: Fire drill frequency according to BNBC 2006

Occupancy	Frequency
Industry Having occupancy more than 150	Monthly
Industry Having occupancy less than 150	Quarterly
Mercantile occupancy more than 150	Quarterly
Mercantile occupancy less than 150	Half-yearly
School, college, Universities	Half-yearly
High-rise building	Half-yearly
Tall building	Quarterly

Source: BNBC 2006.

5.2.20 Information on Building Water Supply System

All the building has an underground water reservoir. But according to the Fire Protection & Prevention Rule 2014, there should be a minimum 1,00,000 gallon capacity underground water reservoir with a fire service inlet facility at the basement. The Overhead tank should be a minimum 40,000-gallon capacity. For fire extinguishing, purpose 2/3 of its capacity should be preserved. No building has the required size of water reservoir according to law.

Table 27: Water storing capacity of underground water reservoir

Building name	Storing capacity of underground water reservoir	Water storing capacity of overhead tank
Ambon Complex	25,000	37,000
Opex Tower	67,000	37,000
Rupayan Centre	22,000	44,000
Civil Engineers Bhaban	10,000	20,000
Haque Tower	21,000	7,000
Aqua Tower	1,100	1,100
J R Casero	10,000	9,000
Siddique Tower	10,000	3,300
Medona Tower	35,000	30,000
High Tower (Hosaf)	9,000	9,000

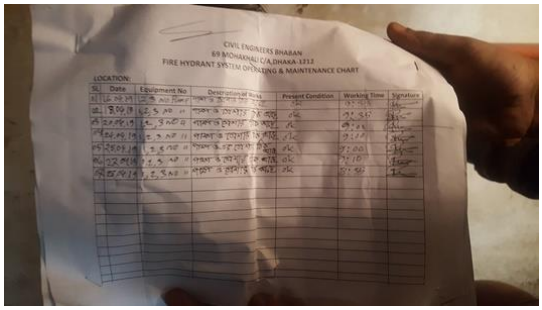
Source: Field survey, 2019.

5.2.21 Relay Pump and Intermediate Reservoir

According to BNBC 2006, every high-rise building should have a relay pump and intermediate reservoir after the 14th floor or every 26 meter height. In the study area, 10% of buildings namely Civil Engineers Bhaban have a relay pump. But no building has an intermediate reservoir after the 14th floor. 10% building has a driveway at the basement which is extended up to the reservoir tank. According to Fire Protection & Prevention Rule 2014, there should be a firefighting pump house at each rise building with a specified capacity of pumps. But only Civil Engineers Bhaban has that kind of pump house.

Picture 9: Heavy-duty pump

Picture 10: Water pressure gauge



Picture 11: Regularly documented pressure reading

Picture 12: Main fire pump control

Picture 13: Jockey Pump control

Picture 14: Buster pump control

Picture 15: Normal water pump at High tower building

Picture 16: Normal water pump at Aqua tower

5.2.22 Information on Staircase/ Alternative Staircase

- 10% of buildings namely Civil Engineers Bhaban has a firefighting floor plan.
- 40% of buildings have fire exit signs.
- 10% buildings namely Civil Engineers Bhaban has lighted exit sign through the green light.
- 100% building has a backup system for the staircase lighting. Backup through alternative power supply through a generator. But it was found that 20% of buildings do not have light at the 2nd staircase.
- 70% building has two separate staircases, 30% building has one staircase.
- According to BNBC 2006, a high-rise building should have stairs having a width 1.5 meters. 100% of building in the study area didn't meet this criterion. The level of violation ranges from 10-30%, but the average is about 20%.

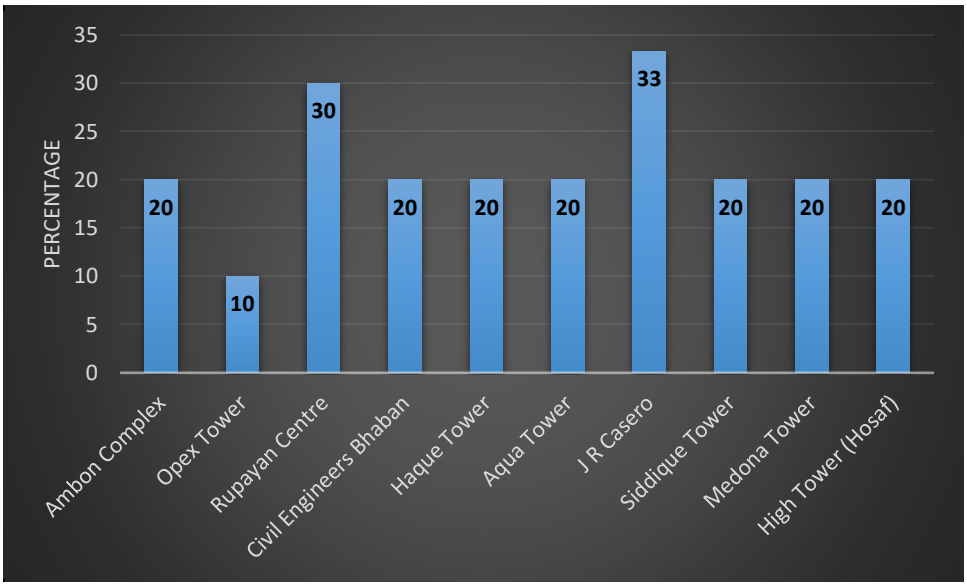


Figure 13: Level of violation of the main staircase of the building

Again 30% of buildings do not have any emergency fire escape staircase. Among the 70% buildings that have emergency fire escape staircase, 100% building has violated this provision. The level of violation ranges from 20-70%, but the average is about 38%. Rupayan building claimed that they have fire exit stair but it is not a conventional one. It is one kind of spiral steel ladder, very narrow. There is no light. The staircase is so frightening that if a normal person tries to come down with this, he will be fainted or feel sick.

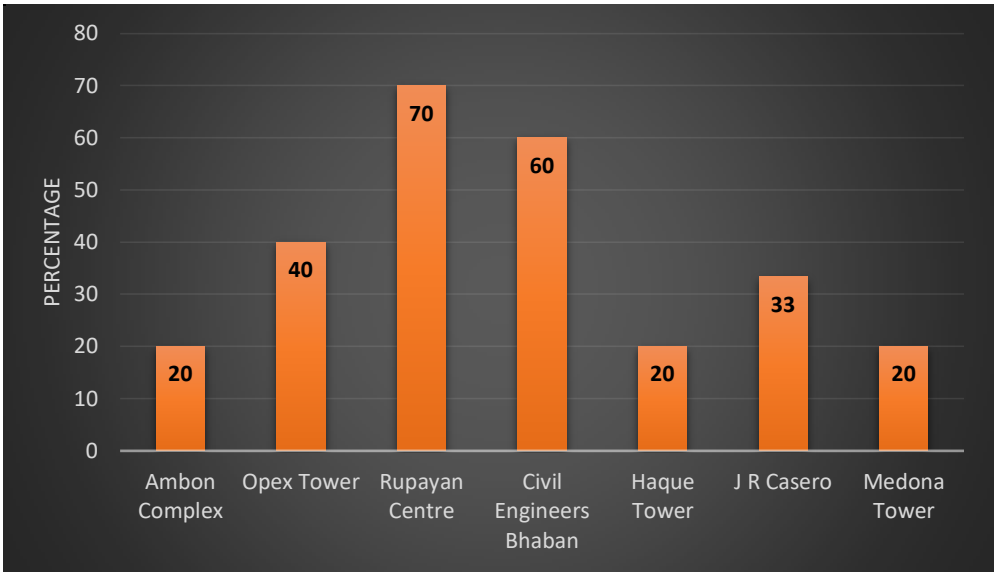


Figure 14: Level of violation of the fire escape stairs of the building

It is found that the stair landing area and lobby of 80% is not free from heat and smoke.

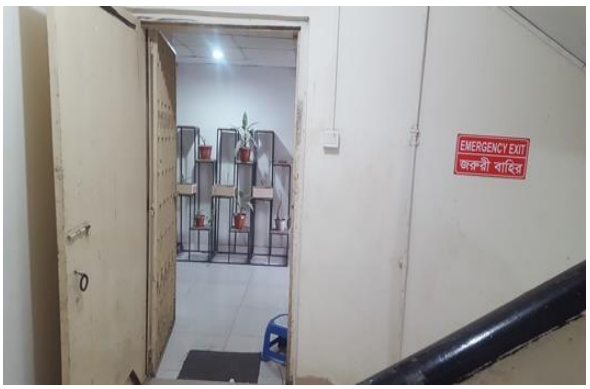
Picture 17: No light at fire escape stairs at JR Casero

Picture 18: Fire escape at Rupayan Centre

5.2.23 Doors of the Stairs

Only 10% of buildings namely Civil Engineers Bhaban have a fire-rated auto enclose system. These doors are at least 1 hour rated. They also claimed that the sidewalls of their building are also at least 2 hours rated. Rupayan used a steel door in the fire exit stair but it is not fire rated. Most of the doors of the building were wooden doors. There is no light at the stair of JR Caseros. There is no safety lobby in those buildings. It is found that stairs of 10% of buildings were blocked. They were blocked by big packages and used as storage space. Fire exit stair of 20% building is directly open outside of the building, 80% buildings fire exit opens at the lobby.

Picture 19: Wooden door at JR Casero



Picture 20: Wooden door at Ambon Complex

Picture 21: Steel door at Ruapayan Centre

Picture 22: Fire rated doors at Civil Engineers Bhaban

5.2.24 Fire Escape Open Directly Outside

According to Fire Protection & Prevention Rule 2014, the fire emergency escape stair should directly open outside of the building behind the street. 30% building has fire escape stairs directly open outside of the building.

Picture 23: Ambon fire escape directly open outside

Picture 24: Medona Tower fire escape directly open outside

5.2.25 Riser and Sprinkler

In the study area, 80% building has riser system in their buildings. Again among the 80% buildings, 50% buildings riser system has connected with overhead water tank. But not all risers were in good condition. No building in the study area has a sprinkler system.

Picture 25: Riser location was inside the room

Picture 26: Materials were stored at the riser location

Picture 27: Riser at Civil Engineers Building

Picture 28: Riser at Haque Tower

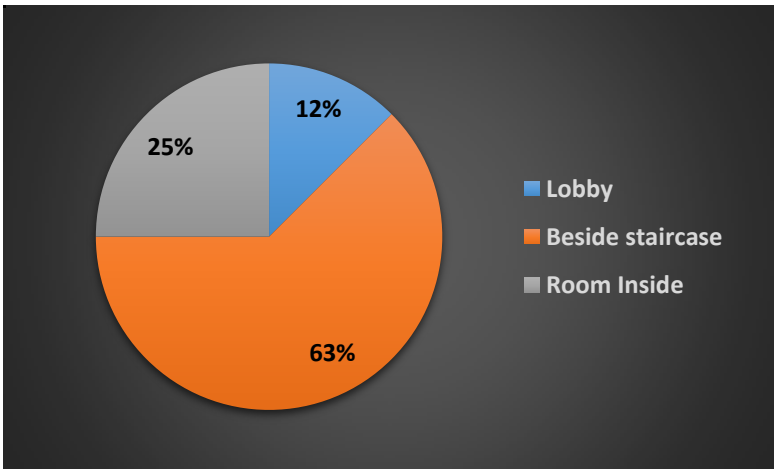


Figure 15: Location of risers inside the buildings

5.2.26 Water Pump

According to Fire Protection & Prevention Rule 2014, high-rise buildings should have a firefighting pump house. The pump house should have at least a minimum 1 main pump with 500 GPM capacity, 1 standby pump (diesel operated), and 1 jockey pump connected with the main standpipe. All pumps should be connected with an alternative power supply. An automated jockey pump should be installed (electric and battery operated). Only Civil Engineers Building has a firefighting pump house with all the required facilities.

- All the main pump has generator connection
- Only 20% building has standby pump.
- 10% building has jockey pump and buster pump.

5.2.27 Information on the Fire Alarm System

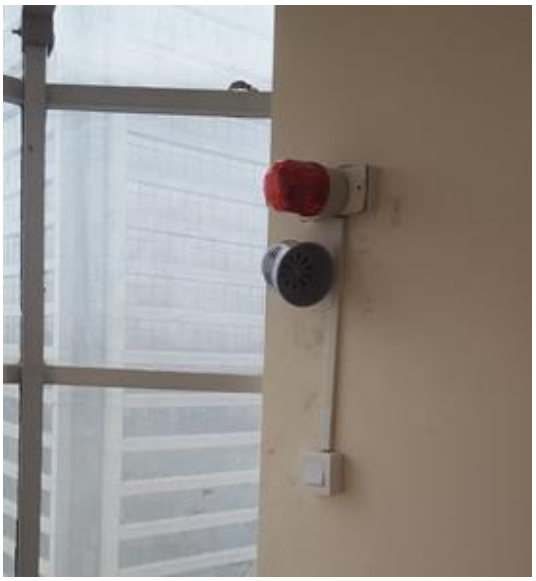
In the study area, 50% of buildings have a fire alarm system. Again among the 50% buildings, not all buildings have fire alarms at the mentioned place specified by the BNBC 2006. Opex Tower, Civil Engineers Bhaban, and Haque Tower have a fire alarm system at all the specified places except the elevator. Siddique Tower has a fire alarm at the Brac university used floors only. High Tower has a fire alarm in the lobby only.

Table 28: Fire alarm system of different buildings

Building name	Basement	Each floor	Staircase	Elevator	Lobby	Store
Opex Tower	Yes	Yes	Yes	No	Yes	Yes
Civil Engineers Bhaban	Yes	Yes	Yes	No	Yes	Yes
Haque Tower	Yes	Yes	Yes	No	Yes	Yes
Siddique Tower	No	Yes (7 floors)	No	No	No	No
High Tower (Hosaf)	No	No	No	No	Yes	No

Source: Field survey, 2019.

Only Civil Engineers Bhaban has a public announcement (PA) system and fire command center. The PA system is connected with the command center.



Picture 29: Fire alarm at Haque Tower

Picture 30: Fire alarm at High Tower

5.2.28 Information on Smoke and Heat Detection System

In the study area, 20% of buildings have automatic detection systems. They were mainly used multi detectors that can detect both smoke and heat. Civil Engineers Bhanban has 200 multi detectors and Siddique tower has 2 multi detectors. According to Dhaka Mohanagar Building Rule 2008, there should be smoke and heat at the laundry, kitchen, generator room, and transformer room. But no building met those requirements.

Picture 31: Multidetector system at Civil Engineers Bhaban

All the buildings have individual small ac and floor-wise central ac systems. But there was no fire or smoke dumper. Fire dampers are passive fire protection products used in heating, ventilation, and air conditioning (HVAC) ducts to prevent the spread of fire inside the ductwork through fire-resistance-rated walls and floors. Smoke dampers are similar to fire dampers in fire-resistance rating, and also prevent the spread of smoke inside the ducts.

5.2.29 Information on Emergency Lighting

Most of the buildings 90% have backup/ emergency lighting systems in all the important places. These lights were connected with dual power sources. According to the building authority, they have installed enough lights. No buildings but only Civil Engineers Bhaban has strobe light. Again only Civil Engineers Bhaban has a light exit sign.

Table 29: Status of emergency light at the important places in the buildings

Building name	Pump house	Generator room	Sub station	Fire elevator	Lobby	Staircase
Ambon Complex	Yes	Yes	Yes	No	Yes	Yes
Opex Tower	Yes	Yes	Yes	No	Yes	Yes
Rupayan Centre	Yes	Yes	Yes	No	Yes	Yes
Civil Engineers Bhaban	Yes	Yes	Yes	No	Yes	Yes
Haque Tower	Yes	Yes	Yes	No	Yes	Yes
Aqua Tower	Yes	Yes	Yes	No	Yes	Yes
J R Casero	Yes	Yes	Yes	No	Yes	Yes
Siddique Tower	No	Yes	Yes	No	Yes	Yes
Medona Tower	No	Yes	Yes	No	No	Yes
High Tower (Hosaf)	Yes	Yes	Yes	No	Yes	Yes

Source: Field survey, 2019.

5.2.30 Information on Fire Elevator and Refuse Area

According to Fire Prevention and Protection Rule 2014, if the buildings have 2 elevators then one elevator should be designed and maintained as a fire elevator. If the building has 4 or more elevators then at least 2 elevators should be designed and maintained as fire elevators. But no building in the study area has or use as a fire elevator.

Table 30: Building wise elevator number

Building name	Number of elevators	Passenger Capacity			
		Elevator1	Elevator2	Elevator3	Elevator4
Ambon Complex	2	9	9		
Opex Tower	2	15	15		
Rupayan Centre	3	11	11	11	
Civil Engineers Bhaban	4	12	12	12	12
Haque Tower	2	10	10		
Aqua Tower	2	10	10		
J R Casero	2	10	10		
Siddique Tower	2	6	6		
Medona Tower	2	15	15		
High Tower (Hosaf)	2	10	10		

Source: Field survey, 2019.

Again According to BNBC 2006, there should be a 15sqm refuse area for immediately above 26 m and then one refuge area per five floors above 26 m. but in the study area, no building has a refuse area.

5.2.31 Information on Portable Fire Extinguisher

All the buildings have some form of portable fire extinguisher. But few buildings like Medona Tower, High Tower do not enough fire extinguishers. No buildings have Nitrogen gas suppression systems that are used for fire at computer room, lab, server room, etc. Civil Engineers Bhaban has other items also like a gas mask, helmets, gloves, gumboots, rope, wire cutter, etc. During the field survey, no fire extinguisher was found hanged at High Tower. They just bought and kept them at the store. This same for Aqua Tower also, they just bought items like fire blankets, the exit sign, warning light, etc.

Table 31: Building wise portable fire extinguisher

Building name	Fire extinguisher at each floor	Total fire extinguisher CO2	Total fire extinguisher chemical	Total fire extinguisher chemical
Ambon Complex	3	19	8	27
Opex Tower	4	22	22	44
Rupayan Centre	10	23	207	230
Civil Engineers Bhaban	6	84	40	124
Haque Tower	1	12	10	22
Aqua Tower	3	24	24	48
J R Casero	4	18	36	54
Siddique Tower	5	35	30	65
Medona Tower	1	10	17	27
High Tower (Hosaf)	0	6	0	6
Total	37	253	394	647

Source: Field survey, 2019.

Picture 32: Newly bought fire extinguishers were kept at the store at High tower.

Picture 33: It has expired almost 7 years ago found at Aqua Tower.

Picture 34: Newly bought fire was kept at store at Aqua tower.

Picture 35: Water and sand at Civil Engineers Bhaban

5.2.32 Information on Fire Command Station (FCS)

According to BNBC 2006, every high-rise building should have a Fire Command Station. The station should have all the facilities like the FCA should be on the ground floor, firefighting plan should be hanging on the wall. There should be a repeater control panel/display board, PA system, indicator monitor, key storage, etc. Only the Civil Engineers Bhaban has the FCS with all the facilities. The building also has a lightning protection mast and aviation light mast.

5.2.33 Information on Building Management Committee

- 10% of the building has a fire incident history
- 20% of the building has separate Fire management and evacuation committee
- No building has done Fire Risk Assessments
- 40% of the building has trained staff on fire management
- 292 staff trained on firefighting, first aid, and rescue
- 20% building practice fire extinguish drill once in a year
- 10% has an assembly point
- 70% of the building has and preserves register books

Table 32: Trained staff on firefighting, first aid and rescue activities

Building name	Number
Civil Engineers Bhaban	160
Haque Tower	2
Aqua Tower	30
High Tower (Hosaf)	100
Total	292

Source: Field survey, 2019.

5.2.34 Vulnerability of Offices in the Buildings

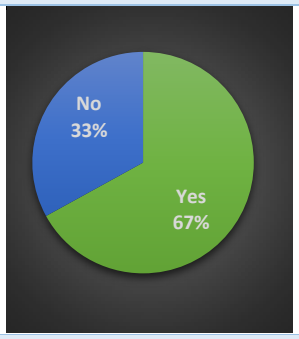
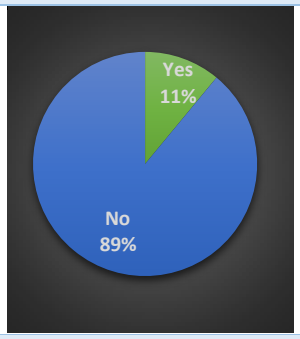
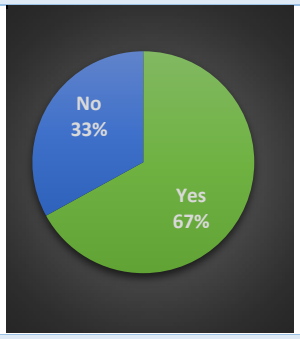
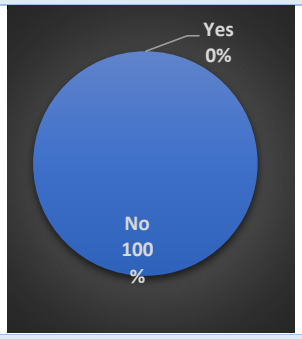
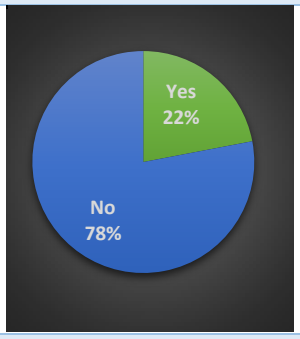
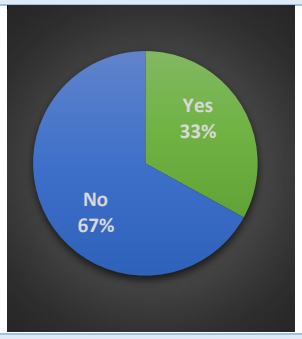
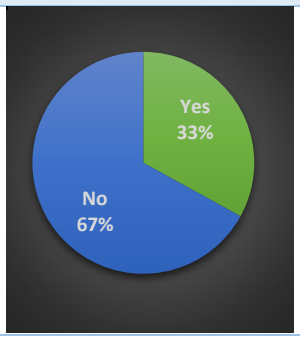
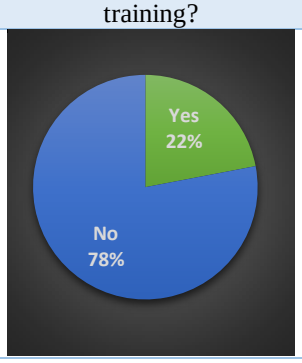
The study area in Mohakhali is mainly a commercial area. There were several offices and shops were in those buildings. Some of them were rented and some of them have their own space inside the buildings. Fire incidents in these offices can put the whole building at risk. This study also inspected some offices and shops to assess their vulnerability to fire risks. The researcher briefly described their vulnerability mainly with yes/no answers.

Table 33: Surveyed offices in those buildings

Building name	Office name
Aqua Tower	Micro Trade
J R Casero	Why not Restaurant
J R Casero	Banglalink Warehouse
Rupayan Centre	Rupayan Group
Ambon Complex	Six Season Food & Beverages Ltd.
Ambon Complex	Nitol Motors
Aqua Tower	Emami Bangladesh Ltd.
Haque Tower	LifeCare
Opex Tower	Opex Group

Source: Field survey, 2019.

Figure 16: Yes/no answers on fire vulnerability

How frequently office owners examine the electric wire	Do you ever do Fire Risk Assessments of your office/shop?
	
Have you any firefighting systems in your office?	Do you have an emergency evacuation plan?
	
Is there any fire-trained staff?	Do you practice evacuation drills?
	
Is the emergency number displayed?	Do you think security guards should have fire training?
	

5.2.35 Summary from Key Informant Interviews

Fire Service and Civil Defense

Faisalur Rahman
Senior Station officer (Station In-charge).
Fire Service and Civil Defense
Tejgaon Station Dhaka

Picture 36: KII with FSCD personnel

Fire service officials are involved in fire inspection on regular basis. Usually, a team of 3 people consists of 2 firemen, and station officers regularly visit different offices, sites, and industries. They have a predefined format to do the inspection. They identify the potential fire sources, their available equipment, vulnerability, capacity, and recommended preparedness measures with the required equipment. According to him, they again visit those offices after few months to monitor the implementation of their recommendation. But there is a gap between the first and second visits. The first visit they made on the request of the respected offices and the second visit made on their own. They do not visit all the offices, only the important offices. FSCD usually gives 2 clearance certificates for high-rise, one on the building design approval time and the other one after completion of construction.

Building developer or owner submits firefighting floor plan to FSCD authority with their building design. FSCD reviews that plan according to the Fire Prevention & Protection Rule 2014. Then FSCD issued a building construction clearance certificate with 6 conditions. Main conditions include no alteration can be made this approved floor plan, construction should be complete within 36 months, need to inform FSCD within 15 days after the beginning of construction.

The building developer or owner needs to collect the building occupancy certificate within 15 days after completion of construction. Then FSCD issued a building construction clearance certificate with 8 conditions. Main conditions include building

firefighting equipment are always ready to use, within one month constitute firefighting & rescue committee no alteration can be made this approved floor plan, construction should be complete within 36 months, need to inform FSCD within 15 days after the beginning of construction.

FSCD consider eight storied building and above as high-rise building. This is mainly for fire hazard management aspects whereas RAJUK considers 10 storied buildings as high-rise buildings. He also emphasized the coordination between RAJUK and FSCD. According to him, the good intention of the owner or developer is enough for firefighting management.

According to him, for managing high-rise building fires, we need to implement BNBC strictly. If we can follow BNBC it is more than enough for fire hazard management. High-rise buildings should have a detection system, public announce system, alarm system, advanced firefighting equipment, riser system, firefighting pump, two staircase, fire elevator, fire-rated doors, refuse area, etc. Firefighting facilities should be in-build in the building design. They suggest a portable fire station. He thinks a new fire station is needed between Tejgaon and Baridhara fire station.

The main problems fire service faces are owner, developers do not take the approval of the Building Fire Safety Plan, do not follow FSCD regulations, few and poor quality equipment. FSCD also suffers from a lack and manpower and equipment. Sometimes traffic jams and crowed cause delays to reach and extinguish the fire.

Picture 37: Makid Ehsan, Authorized Officer, Rajdhani Unnayan Kartripakkha, Zone -4/1, 4/2, Mohakhai, Dhaka.

Rajdhani Unnayan Kartripakkha (RAJUK)

RAJUK exercises development control function as per provisions by the East Bengal Building construction Act, 1952 and its subsequent amendments and the rules & by-laws. Every construction/erection/excavation within the jurisdiction of RAJUK requires

permission/approval from the Authorized Officer or Building Construction Committee appointed under the provision of the Town Improvement Act, 1953. At present, Eight Building Construction Committees in force in which the Authorized Officers have been working as member-secretary of the committee.

RAJUK officer identified that there is a huge lack of coordination between FSCD and RAJUK. This coordination is very important. RAJUK actually deals with the building design aspects. They do not give much importance to the fire-related structural design features. They only check two things; firstly, before approval of a building plan, they make sure that the owner has a firefighting floor plan clearance certificate from FSCD. Secondly, RAJUK checked the staircases of the buildings especially high-rise buildings.

RAJUK approved building permission and design in accordance with Dhaka Mahanagar Building Construction Act' 2008, Town Improvement Act' 1953, Land Development Rule' 2004, and Building Construction Act'1996

RAJUK also issues occupancy certificates for buildings. But people didn't bother to take occupancy certificates. But in recent times, few owners, developers take occupancy certificates. A professional person or firm will inspect and recommended for occupancy certificate. Several documents RAJUK checked in time of issuing the occupancy certificate like completion report, as-built architectural drawing, structural design, and building service design. The professional person architect and civil engineers will be responsible for these designs.

At the time of building inspection, RAJUK usually inspects the structural aspect, setback, the violation from the approved design. They just see the condition of fire preparedness but did not give much importance as FSCD is responsible for that. RAJUK only inspects the staircase and/or alternation staircase.

He recommended that there should be more coordination between FSCD, RAJUK, and building owner, more coordination between RAJUK and professional bodies (architecture, engineers and planner), strict implementation of BNBC, increase human resources at RAJUK. The building owner should more aware of fire preparedness.

Abu Sayed Mohammad Hashim
Director General (Additional Secretary)
Department of Disaster Management

Picture 38: KII with DG, DDM.

Department of Disaster Management (DDM) under the Ministry of Disaster Management and Relief is responsible to execute the directions, recommendations by the government in connection with disaster management as well as the national disaster management principles and planning.

For fire hazard management, DDM procured several firefighting types of equipment suitable for extinguishing high rise building fire and handed them over to FSCD and City Corporation, army. DDM handed over 3 turntable ladders to FSCD which can reach 22 storied buildings.

In Bangladesh, we do not have a hydrant which is very important for firefighting capacity building. DDM already started to work with Dhaka and Chittagong WASA to install hydrant. Hopefully, within a short time, we will see the roadside hydrant. DDM was also taken the initiative to procure firefighting balls, jumping kits, rope, and advanced machinery required for firefighting and management especially for high-rise buildings.

He also emphasized planned urban development and well equip authorities, then high-rise building fire not will be a problem for Bangladesh. The building or office decoration materials should be fire-rated and people, engineers, architects, owners should be aware of these materials. DDM has taken initiative to aware them.

DDM already trained a number of people working at the hospital, market high-rise buildings through our National Disaster Management Training Institute. This is a continuous process. DDM and FSCD people conduct these types of training for effective fire incident management as well as overall disaster management.

UDD and RAJUK will implement and monitor the building-related rules, regulations, codes, etc. But when disaster strikes, then DDM will be the coordination and responsible authority for disaster management, and other authorities like FSCD, Law enforcing agencies AFD, NGOs will coordinate with us. It is according to the law.

In connection to the FR tower fire accident, he pointed out that they didn't follow the setback rule, so space between buildings, no assembly point, no option for gas through, a very small fire exit, etc. Glasses in the building also become hazardous during that time. There should be an emergency exit/ window option in the glass buildings. Stairs should be wide depending on the number of people in the building. He also emphasized that there should be a fire door and refuse area in the high-rise buildings.

He also acknowledged that there is a lack of proper supervision from responsible authorities in enforcing their laws. There is also a deficiency of coordination and accountability among the authorities.

Chapter 6
Observations and Way Forward

6.1 Key Observations

Some of the important observations and problems were discussed here.

- **Lack of Synergy Between FSCD And BNBC Regulations Regarding High Rise Building**

  There are a number of rules and regulations on the fire protection & prevention issues. There are also number rules and regulation on building construction. But when high-rise buildings are in consideration, there are differences in them, like in high-rise building definition, pump capacity requirements etc.

- **No Budget/ Allocation on Fire Preparedness**

  Building authorities, office owners, shop owners don't give much importance to fire hazards. Accordingly, they do not allocate enough budgets for purchasing firefighting equipment.

- **Lack of Knowledge on Fire Hazard Management**

  Common people, even the building managers have little understanding of the concept of the fire hazard and related subject matter. How it is formed, types, what types of extinguisher are used what type of fire, actions in time fire, etc.

- **Unwillingness to Comply with the Building Code**

  Most of the buildings especially high-rise buildings don't follow the national building construction code. The building owner, developer violated the building code very extensively. It is becoming the national character that we don't follow building construction-related rules and regulations.

- **Unapproved and Illegal Building Stories**

  In the study area, it was found that some buildings illegally constructed one floor even two stories at the roof which is very dangerous. The building owner and developer should strictly maintain the approved building design.

- **Lack of Awareness on Fire-Related Acts and Regulations**

  In Bangladesh, we have enough laws, regulations, and codes for fire prevention and preparedness. These regulations are standard and updated. But building

owners, tenants, even building authorities do not aware of these laws and regulations.

- **No Fire Pump House at the High-Rise Buildings**
  According to Fire Protection and Prevention Law 2003, every high-rise building should have a dedicated fire pump house with a specific capacity of pumps. Except one, no building has this type of fire pump house.

- **Not Understanding the Importance of Alternative Stare Case**
  Some building has only one staircase. If that staircase becomes unusable during the emergency period then it will be a disaster. There must be a second staircase and it should be in useable condition.

- **Not Installing Smoke, Heat Detection System, Fire Alarm System**
  Most of the buildings don't have any automatic smoke and heat or multi detection system. Even they didn't install a fire alarm system. Sometimes these systems can help to identify the fire incident at an early stage.

- **Not Keeping the Provision for Fire Elevator**
  No building has a fire elevator. But it was a mandatory pre-condition for every high-rise building. Building authorities should install facilities to use at least one elevator as a fire elevator in time of emergency.

- **Not Keeping Enough Fire Extinguishers, Not Refill Them Timely**
  Most of the offices and buildings have a portable fire extinguisher as the main firefighting equipment. But the number is very small compared to the requirement. Again most of them were past the expiry date, not refilling them in a timely.

- **No Regular Monitoring from Fire Service or RAJUK**
  Fire Service or RAJUK are the two important authorities who approved the building plans and have the responsibility to ensure proper compliance with their regulation. But there no regular monitoring from Fire Service or RAJUK.

- **No Knowledge of Fire Command Station**
  According to BNBC, every high-rise building should have a fire command station with specific facilities. But no building in the study area has this kind of station.

- **No / Lake of Firefighting and Evacuation Drill**

  According to BNBC, every building should practice firefighting and evacuation drills. Every high-rise building should practice one every six months. It is one of the most important problems.

- **Lake of Training on Fire Management and Rescue Services**

  It is a common problem in Bangladesh. Most of the offices do not have enough trained people to suppress the incident at the initial period.

- **Not Knowing the Fire Equipment Use**

  It is found that the office has a fire extinguisher; even employees said that they know how to use it. But when they asked to use it, they cannot operate it. So it is important that they should practice the operation.

- **Not Repairing Electing Warring Regularly / Poor Quality Warring**

  Most of the time-poor quality electrical wearing and equipment cause fire incidents which contribute alone 50% of all causes. So, regular checking and repairing of electing warring are very important.

- **No Proper Management of Electing Warring of the Substation at the Basement**

  It was also found that electing warring at the basement with substation; the generator was not properly organized and maintained. They were not maintained at all according to fire regulations. As they were out of people's sight, they were huge negligence at basement electrical work.

- **Not Doing Fire Risk Assessment Regularly**

  In most of the buildings, there was no fire risk assessment. It was not done by the building authority or fire service. Even authorities do not even feel that it is necessary. It should be made mandatory that every building should have a fire assessment.

- **Not Having any Firefighting and Evacuation Plan**

  No building has a fire safety plan. But according to BNBC 2006, a fire safety plan must be developed for each building and that must have the endorsement of the local fire services authority regarding its adequacy and appropriateness.

- **Not Having A Fire Management and Evacuation Committee**

  According to law, after getting the occupancy certificate, a firefighting & rescue committee need to be formed within one month. This committee will develop and manage the fire safety plan.

- **No Fire Compatible Doors**

  According to law, high-rise buildings must have fire-rated doors. But in the study area, almost no building has fire-rated doors. There were wooden doors, iron doors but no fire-rated doors.

6.2 Way Forward

Building authorities, user and experts from fire service, disaster professionals has given some important recommendation for better fire management for the buildings, especially for high-rise buildings.

- **Strict Implementation of the Building Code, Laws, and Regulation**

  In Bangladesh, most of the building developers, building owners do not want to follow building code. Authorities who have the responsibility to implement should strictly monitor the implementation of the building code. Strong penalties need to be given to the violators to set an example for violation.

- **Awareness Building of Developers, Owners on BNBC**

  In reality RAJUK, Fire Service does not have the capacity to monitor the huge construction operation at the field level. Awareness should be built among the private sector developers as well as owners to follow building code for their own protection.

- **Strengthen the Capacity of RAJUK and Fire Service**

  It is one of the most important and widely discussed topics to increase the RAJUK manpower. DNCC former mayor Anisul Haque said that we have 5,000 fire service members whereas we need at least 50,000 members. Strong and regular monitoring from the fire service and RAJUK need to be ensured.

- **Organize Training on Fire Management and Rescue**

  Training needs to be provided to office employees, members of the building management committee, security guards, staff, residents, etc. most fire incidents can be stopped at the initial stage by trained people.

- **Implement Recommendation From Fire Service**

  Fire service people have regularly done fire inspections. After inspection, they provided recommendations and suggestions. In most cases, the building owner does not implement their recommendations. Their recommendations must be implemented and follow up.

- **Mandatory Reception of Occupancy Certificate**

  According to regulations, building owners need to take occupancy certificates from both RAJUK and FSCD. But enforcement of this rule is very weak. Building owners didn't bother to take occupancy certificates. But in recent times, few owners, developers take occupancy certificates. Authorities must ensure proper compliance with the occupancy certificate.

- **Strong Coordination Between RAJUK and Fire Service**

  There is a lack of coordination between RAJUK and FSCD. A mechanism should be established to effective coordination and collaboration. A joint committee visit should be introduced before the inauguration especially for high-rise buildings**.**

- **Construct/Install Emergency Fire Exit, Installing Fire Rated Door**

  Fire doors are important. It prevents the fire and smoke from spreading across the building. It keeps the fire contained in a particular compartment or room. It gives residents a longer time to escape and allows the firefighters to rescue anyone who is trapped and put out the fire.

- **Install and use High-Quality Electrical Equipment and Wiring**

  On fire management electrical Safety is important. Faulty equipment can cause shock, burns, fire, and even fatalities. To protect from this hazard high-quality electrical equipment need to be installed.

- **Install and Maintenances of the Substation by an Expert from DESA/DESCO/PDB**

  Proper installation and maintenances of substations are also very important. They should be regularly overhauled and maintained by expert technicians from DESA/DESCO/PDB or appropriate authority.

- **Use of Fire-Rated Fittings for Interior Decoration**

  In recent times, buildings and offices are meticulously organized with different decorative materials. Wood, artificial trees, polyethylene, plastic, synthetic materials, foam, turf, color, etc. are highly combustible. They can act as fuel on the fire. The important concern is that most people are not aware this is a potential problem.

- **Install and use a Fire Hydrant**

  Bangladesh does not have a fire hydrant system. Fire hydrants are most important and are an essential component in fire protection systems as they allow firefighters to access a strong and steady flow of water supply during an operation.

- **Allocated Budget for Fire Preparedness**

  Fire preparedness required a handsome budget. Once constructed building owners do not want to spend much on fire preparedness, again some are recurrent costs. So most important is to allocate a budget for fire mitigation and preparedness.

- **Regular Checking of Burner as well as Car Gas Cylinder Expiry Date**

  Expired or faulty car gas cylinders are a potential source of the fire. A system can be established to check the car gas cylinder expiry date while entering the building parking area or the expiry date can be written on the body of the car.

- **Compliance Certification should be Hanging on the Public Place**

  According to regulations, building owners need to take a number of certifications from different government authorities like RAJUK, FSCD. Most of the times building owners didn't bother to take certificates. If it is made mandatory to show the certification in public place in the building, then owners were bound to take the certifications. Authorities must ensure proper check and compliance with the rules.

- **Digital Mapping of Water Source**

  Initiatives need to be taken to identify the water sources location which will help to quickly identify the source, its capacity, number of fire truck requirement etc. Digital maps can be also prepared to increase the availability and accessibility.

Chapter 7
Conclusion

Dhaka city with a huge population with weak services and facilities further increases its vulnerability. Government offices have very inadequate control over the growth trend. In recent times, the number of high-rise buildings is growing day by day covering commercial, residential, industrial, and even hospital buildings. Fire is the most occurring urban disaster and can cause huge loss of life and property in a very short period especially in high-rise buildings.

Again Dhaka is also vulnerable to seismic risks. Immediately after an earthquake, fire will break out all over the city. So Fire safety issues should be given priority at first. FSCD is mainly responsible for fire incident management and search & rescue services in Bangladesh. But several agencies are also involved in the overall process. RAJUK, City Corporation, Department of Disaster Management has important roles to play in fire hazard management. Again there is a huge lack of coordination between these departments.

In Bangladesh is a common scenario that, there are enough laws and regulations but a very low level of enforcement. It is also common that building owners, developers, office, industry owner's even common people do not want to abide by the laws and comply with the regulations. Sometimes building authorities do not recognize the importance of fire management thus do not allocate enough budgets for taking preventive measures. One, two, or three organizations cannot control fire incidents and provide service to citizens.

Special attention should give to high-rise buildings, RMG sector, industries, slum, semi-structured as well as all levels. It is also evident that individual people have very poor knowledge of fire management. The effective capacity of a structure, individual, community depends on its exposure to risks. For safer cities, we have to work with each sector and actors as well as individual level.

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Appendix-A

Department of Architecture
Postgraduate Program on Disaster Management
BRAC University, Dhaka, Bangladesh.

(All Information will be used for research purpose only)

Vulnerability and Knowledge Level Assessment of Fire Risk of High Rise Building in Dhaka city: A Study of Mohakhali Area

Questionnaire for Knowledge Level Assessment

Questionnaire No:…….

Date:……..

General Information:

a) Name of the Respondent:……

b) Name of the building……..

c) Office Name & Address ……..

d) Duration of working in this place: From…….to…… … Years

Household & Other Information:

e) Family type: a)Bachelor, b)Single, c)Joint, d)Mess, e)Others (specify)

f) Total Family Member:……..……..

g) Age:……..……..

h) Sex:……..……..

i) Religion:…….……

j) Education:……..

k) Occupation:…….…..

l) Income:……..

Knowledge level assessment questions

0 – No idea,
1 – Fundamental Awareness (basic knowledge)
2 – Novice (limited experience)
3 – Intermediate (practical application)
4 – Advanced (applied theory)
5 – Expert (recognized authority)

Question	Yes	No	If yes then how
1. Do you know how a fire starts?			-heat, fuel, ignite source, oxygen
2. What are the potential sources of fire in your opinion?			- Gas - Electric short circuit - Disposal of burning cigarette and match stick. -A/C System -Installing a malfunctioning electrical appliance - Cooking/ stove - Chemical materials reaction - Blast/ explosion - Mosquito coil - Machine blast - Dripped electric wire - Open lamp - Lightning - Ignorance
3. What will you do in time of the fire?			-only shout -leave the house immediately -switch off the electric line -switch off gas line -collect money, certificate, dolil, -collect jewelry -collected children -then go out
4. What you will use in the time of the fire?			-Elevator -Staircase
5. How do you extinguish a fire?			-
6. Do you know the fire service number?			-
7. What do you do if you are caught by fire/ dress?			- -
8. Do you know your building evacuation route?			- -
9. Do your buildings has any assembly point?			-
10. Do you know the designated assembly point?			-
11. Do you have any fire Emergency Plan			-

Question	Yes	No	If yes then how
12. Can you ring fire alarm?			-
13. Do you have firefighting equipment/systems in your house?			-
14. Can you operate a fire extinguisher?			-
15. Can you operate the riser?			
16. Do you ever read the instruction on how to operate a fire extinguisher?			-
17. Do you know the nearest police station's number?			-
18. Do you have any idea about 999?			
19. Can you assume what will happen after an earthquake?			-
20. Did you participate in any fire drill ever?			-
21. Do you receive any training on fire & rescue?			-
22. Do you think fire training is essential?			
23. Do you switch off AC/fan while leaving room/office?			
24. Do you know or have any idea about fire protection laws, rules, and regulations?			
25. Do you know power cut off /unplugging			
26. Do you ever experience fire incidents?			

Appendix-B

Department of Architecture
Postgraduate Program on Disaster Management
BRAC University, Dhaka, Bangladesh.
(All Information will be used for research purposes only)

Vulnerability and Knowledge Level Assessment of Fire Risk of High Rise Building in Dhaka city: A Study of Mohakhali Area

Questionnaire for building manager/ authority

Questionnaire No:…….
Date:……..

General Information:

1. Name of the Respondent:……
2. Respondent Designation:…….
3. Name of the Office……..
4. Building Name & Address ……..
5. Building type: Residential, Official, Commercial, Industrial, Educational, Mixed-Use (specify)
6. Construction Year:……Total floor no.:…..Per Floor Area:…Total Floor area:…
7. The number of floors according to RAJUK approved plan:……
8. Stories: ……Building Height:……Building Width:…….
9. Number of offices in the building:……..
10. Number of owners of the building:……
11. Respondent Mobile no:……..

Fire Vulnerability Assessment

1. Physical and Structural vulnerability	**Description**	**Materials**
1. Land uses (details)	a. Residential, b. Official, c. Commercial, d. Industrial, e. Educational, f. Mixed Use (specify) Use wise percentage. Floor wise.	
2. Floor Area Ratio (FAR):		
3. Ownership	Single owner, Multiple owners, Corporate owner, Rented	
4. Accessibility	• Width of the main road (meter/ft) • Height of the main entrance • Distance from the main road • Distance from other water sources • The road inside the plot	

	• Empty space inside the plot • Does the adjacent road have sufficient width to enter a fire lorry or ambulance? • Side Road condition
5. Description of the roof use	Occupied……% Empty……..%
6. Potential fire sources in the building	
7. Vulnerable floors	
8. Potential Fire sources outside buildings	
9. Inside materials (mainly categories)	a. Furniture b. lab c. server room d. machinery e. Godown f. A/C g. others (specify)
10. Inside building materials	• Are the decorations materials fireproof • Are the false ceiling fireproof
11. Is there any restaurant in the building?	If yes give details (no. of the burner, gas cylinders, etc,)
12. Is there any office use gas burner or gas cylinders?	If yes give details (no. of the burner, gas cylinders etc,)

2. Economic vulnerability	**Yes**	**No**	**If other, describe**
1. Did you spent money for maintenance? If yes how much? (last 1 year)			
2. Did you spent money for Fire equipment/preparedness? If yes how much? (last 1 year)			
3. Do your building/ asset has (fire) insurance? If yes, how much?			
4. Type of assets/ cost of assets			
5. Tentative damage scenario of a fire incident			

3. Social vulnerability	**Yes**	**No**	**If other, describe**
1. Building occupancy (person) 24 hours (9-5pm,6-1,1-9) (male and female)			**(9am-5pm,5pm-1 am, 1 am-9am)**
2. Vulnerable population			
3. Population density of the area?			
4. Do you have the building fire emergency plan?			
5. How much importance do you give for fire hazard?			
6. Do you practice evacuation drill/ how many times in a year			

1. Information on Building Water supply system	Yes	No	If other, describe
1. Is water storing capacity of underground water reservoir? ……			
2. At this moment how much water is available?.....			
3. Overhead water tank type (Plastic/Rcc/Fero cement etc)			
4. Water storing capacity of overhead water tank?			
5. At this moment how much water is available?.....			
6. Is there a relay pump and intermediate reservoir after 14th floor (every 26 m)?			
7. Is the driveway extended up to the underground water reservoir?			
8. Are the wet riser and sprinkler connected with the overhead water tank?			

2. Information on staircase/ Alternative staircase	Yes	No	If other, describe
1. Is there any firefighting floor plan?			
2. Is there any fire exit sign?			
3. Is the exit sign lighted (through red light)?			
4. Is the staircase extended up to basement?			
5. Is there any backup light at the staircase?			
6. Total number of stairs			
7. width of a stair			
8. Is the stair landing area, lobby is free from heat and smoke			
9. Is there any fire rated auto enclose system (if the building is more that 14th floor)			
10. Are the doors fire rated (for at least 1 hour)?			
11. Are the side walls fire rated (for at least 2 hours)			
12. Closing and opening of stair fire doors are OK?			
13. Is there safety lobby at each floor?			
14. Is the staircase is free or blocked? Free/ blocked			
15. Is there any emergency fire exit (separate stair)			
16. Is the door open directly outside of the building?			

3. Information on riser	Yes	No	If other, describe
1. Is there any riser system?			
2. Floor area of each floor……..			
3. No. of riser at each floor:…… Total riser……			
4. Dia-meter of each riser……..			
5. Location of the risers			
6. Is there a 30-meter-long hose pipe (dia 38mm) connected with riser?			
7. Are the hose pipe connection same as fire brigade type (dia 2.5 inch)			

4. Information on automatic sprinkler	**Yes**	**No**	**If other, describe**
1. Is there any automatic sprinkler system?			
2. How many sprinklers at each floor…….			
3. Total number of sprinklers……			
4. How many upright sprinklers …….			
5. How many pendent sprinkler ……			
5. Water supply sources for firefighting	**Yes**	**No**	**If other, describe**
1. Available sources…….			
2. Water pressure at main riser……..			
6. Firefighting pump house			
1. Main pump capacity……...gpm			
2. Standby pump capacity……gpm (diesel/ electric)			
3. If yes? It will starts after how many seconds ……			
4. Is the automatic jockey pump operated by electricity/ battery?			
5. jockey pump capacity……..gpm			
6. Is the pump house door is fire rated (at least 2 hours)			
7. Pump suction ……positive/ negative			
8. Are the Pumps connected with standby generator?			

7. Information on smoke and heat detection system	**Yes**	**No**	**If other, describe**
1. Is there any smoke & heat detection system in the building?			
2. How many smoke & heat detector at each floor?.....			
3. Total number of smoke & heat detector?.....			
4. Heat detector…….. Multi detector……			
5. Fixed heat detector? Yes/ no at Laundry/ Kitchen/ Generator room/ Transformer room/			
6. If the building is central air conditioned, is there any smoke detector and fire dumper?			
7. Are the detection systems active?			

8. Information on fire alarm system	**Yes**	**No**	**If other, describe**
1. **Is there any fire alarm system? Yes/ No**			
2. Is there any fire alarm at basement/ each floor /staircase/ elevator/ lobby/ store / other (specify)			
3. Is there any Public Announce (PA) system/ loudspeaker? Yes/ No			
4. Is there any strobe light? Yes/ No			
5. Is the PA system controlled by command center?			

9. Information on emergency lighting	Yes	No	If other, describe
1. Is there any emergency light at			
a. Fire command station			
b. Pump house			
c. Generator Room			
d. Sub station			
e. Fire elevator			
f. Lobby			
g. Other place (specify)			
2. Are the emergency lights are connected with dual source			
3. Are the number of lights are enough?			

10. Information on fire elevator	Yes	No	If other, describe
1. How many elevator in the building, elevator wise passenger number			
2. How many of them called/used as fire elevator			
3. Is the elevator marked as fire elevator			
4. Are all elevator has fire elevator compatibility (if the building is more than 14th floor)(dual power supply, has by pass system,)			
5. Do you frequently maintenance the elevator in your building?			

11. Information on sub-station room	Yes	No	If other, describe
1. Where is your sub-station location?			
2. Are the doors fire rated (for at least 2 hour)?			
3. Are the side walls fire rated (for at least 4 hours)?			
4. Is the cable drain filled with sand?			
5. Slab of the drain made with fire proof materials?			
6. Is the sub-station has earthed?			
7. Is there any cable tray?			
8. Is it has auto shutdown system?			
9. Is there any fire stopper?			
10. **Is there any ventilation system?**			

12. Information on standby generator room	Yes	No	If other, describe
1. Where is your standby generator room location?			
1. Is there any standby generator?			
2. Are the doors fire rated (for at least 2 hour)?			
3. Are the side walls fire rated (for at least 4 hours)?			
4. Is the cable drain filled with sand?			
5. Slab of the drain made with fire proof materials?			

6. Is there any automatic transmission system			
7. Is the generator has earthed?			
8. Is there any cable tray?			
9. Is it has auto shutdown system?			
10. Is there any fire stopper?			
11. Is there any ventilation system?			

13. Information on service duct	**Yes**	**No**	**If other, describe**
1. Is there any service duct in the building?			
2. Are the doors/opening fire rated (for at least 2 hour)?			
3. Are the side walls fire rated (for at least 4 hours)?			
4. Does only the electric wire go through electric duct?			
5. Are the electric duct junctions sealed by fire proofing materials?			
6. Do you frequently clean the ducts?			

14. Information on refuge area/ assemble area	**Yes**	**No**	**If other, describe**
1. Is there 15 sqm refuge area (for 20-26 meter high building)			
2. Is there any refuge area in every 5 floor (for 26+ meter buildings)			
15. Information on ramp, driveway and parking			
3. Is the basement and ground floor constructed according to building code (BNBC)			
4. Total ground floor area:…….. Total Parking area……			
5. Height of the Basement Car parking entrance and Is the height has marked			
6. Total Number of Basement…….a) basement area…… 7. Basement parking area……c) Others use area…….. specify			
8. **Is there any mechanical air ventilation system at basement?**			
9. **Is there any fire separation wall at the basement (if more than 750sqm)**			
16. **Information on Portable fire extinguisher**			
1. How many fire extinguisher at each floor			
2. Total fire extinguisher…….. (Chemical……/CO2……)			
3. Is there any CO2/Nitrogen/ FM-200 automatic gas fire suppression system at computer room, lab, server room etc			**If yes, then specify**

17. Information on Fire Command Station (FCS)	Yes	No	If other, describe
1. Is there any Fire Command station at ground floor			
2. Is the firefighting plan hanging in the wall?			
3. Is there any repeater control panel (display board)?			
4. Is there any PA system/ laud speaker?			
5. Is there any indicator monitor?			
6. Are the important keys stored here?			
7. Are emergency number displayed?			
8. Is there any trained staff attends all time at FCS?			
9. Is there any lightning protection system in the building?			
10. Is there any aviation light mast (150 ft high)			
11. Is there repeater control panel at each floor			

18. Information on electrical aspects	Yes	No	If other, describe
1. Overhead electric line distance from building			
2. Have you used quality electric wire and fittings?			
3. Do you have any weak connections/problems?			
4. Do you regularly examine the gas line?			
5. Has the DESCO/DESA taken any step to charge for faulty/feeble connections?			
6. Is there any facility for automatic shutdown of electricity if any vibration occurs?			
7. Do you frequently examine the electric wire and wearing by an expert electrician for your building?			

19. Information on Building management committee	Yes	No	If other, describe
1. Fire history of the building			
2. Is there any Fire management and evacuation committee?			
3. Have you done Fire Risk Assessments of your building?			
4. Number of trained personnel on firefighting, first aid and rescue			
5. Do you ever practice fire extinguish drill/ how many times in a year			
6. Do you practice evacuation drill/ how many times in a year			
7. Do the buildings have an assembly point?			
8. Are emergency number displayed meeting room?			
9. Do you know that there is a Fire protection & Safety Act?			
10. Do you preserve register books			
a. Earthing register			
b. Fire & evacuation drill register			
c. Maintenance register			
d. Electrical safety training register			
e. Thermal scanning register			
f. others			

Comments:……
……

Respondent signature:……

Mobile Number:…….

Appendix-C

Department of Architecture
Postgraduate Program on Disaster Management
BRAC University, Dhaka, Bangladesh.
(All Information will be used for research purpose only)

Vulnerability and Knowledge Level Assessment of Fire Risk of High Rise Building in Dhaka city: A Study of Mohakhali Area

Questionnaire for Office Owner/ Shop Owner

Questionnaire No:…….
Date:……..

General Information:

a) Name of the Respondent:……
b) Respondent Designation:…….
c) Name of the Office/ shop:……..
d) Building Name & Address ……..
e) Building type: Residential, Official, Commercial, Industrial, Educational, Mixed Use (specify)
f) Employee information:
g) Total Number of floor:……Per Floor Area:……Total Floor area:……
h) Respondent Mobile no:……..

Vulnerability Related Questions

Questions	Yes	No	Describe
Do you frequently examine the electric wire and wearing by an expert electrician for your building?			
Have you done Fire Risk Assessments of your office/shop?			
Have you any fire protection system in your office?			
Have you any emergency evacuation plan?			
Describe the office decoration materials?			
Is there any fire trained staff?			
Employee number, Male ……. Female…….			
Have you any Day care center in your office?			
Vulnerable population Aged, Child, PWD			
Are emergency number displayed?			
Do you think security guard should have fire training is essential?			
Do you practice fire drill?			
Have you done anything on fire awareness?			
Other useful information			

Comments:……