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FIRE HAZARD VULNERABILITY ASSESSMENT OF COMMERCIAL HIGH-RISE BUILDINGS OF DHAKA, BANGLADESH

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Abstract

A detailed building survey was conducted to assess the fire hazard vulnerability of high-rises in the Banani area of Dhaka. Assessments were done by interviewing building management and experts. The buildings were assessed rated based on thirty-three indicators. The study reveals that around 47% of the surveyed buildings are in a high level of vulnerability. The remaining 37% are medium, and around 16% are less vulnerable. All the buildings constructed before 1993 (before the drafting of the BNBC - Bangladesh National Building Code and any act and regulation of fire protection and prevention) are highly vulnerable. The buildings constructed between 1993 and 2006 (the Fire Prevention and Fighting Act - 2003 came into force), before the enactment of the BNBC, 62% were in medium, and the rest (38%) were in high vulnerability level. Those were constructed after the enactment of the Dhaka Building Construction Rules 2008 also enforced); only 12.5% are high, 50% medium, and 37% less vulnerable. We found that safety regulations (BNBC, building construction rules) and properly implementing the fire safety acts/rules can drastically enhance safety standards. Policymakers and other stakeholders can find this research outcome helpful regarding fire safety enforcement.

Key words: Fire hazard, Vulnerabilities, High-rise buildings, Dhaka.

Introduction

Dhaka, the capital of Bangladesh, is expanding spatially and vertically rapidly due to a high urbanization rate and a burgeoning population (Rahman *et al.*, 2020; Rashid *et al.*, 2023). However, the city is growing unplanned, and the concentration of different types of economic activities and diverse land use patterns (mixed use of land for commercial, residential, and industrial purposes) sometimes flout safety regulations, making fire safety a complex riddle to solve. Moreover, the storage of chemicals in residential areas

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without proper safety measures (Sahebi *et al.*, 2020) and more than 35000 slums (Nazem and Sultana, 2021) exacerbated the risk of fire incidents. The nature of the fire incident in Dhaka is diverse. Dhaka's fire incidents' occurrence ranges from factories, garments, industries, residential buildings, high-rise buildings, chemical storage-originated fires, and fires in slums to fires in marketplaces. There is only a small number of research on fire incidents in Dhaka. Alam and Barai (2004) categorize fire hazards and identify several zones as the most hazardous for fire incidents. Islam and Adri (2008) studied public perception and policy issues related to fire hazards in Dhaka. Wadud *et al.* (2014) assesses fire risk in ready-made garments by developing a fire risk index. Jahan *et al.* (2015) identified the fire risk of chemical warehouse and residential unit areas in Dhaka. Rahman *et al.* (2015) have done vulnerability mapping to illustrate the fire vulnerability of Dhaka. Azad *et al.* (2018) researched the fire risk of industries in Gazipur and Dhaka. Islam and Hossain's (2018) study were on the mitigation perspective of fire hazards in Dhaka. Sahebi *et al.* (2020) evaluated the fire risk in the Nimtoli area, where a devastating fire incident occurred in 2010. Tishi and Islam (2019) studied the distribution pattern of fire incidents in different land use and infrastructure. Chisty and Rahman (2020) explore the coping capacity of fire disasters in old Dhaka. Rahman *et al.* (2022) studied individual-level fire hazard preparedness of Dhaka dwellers. Huda's (2022) research was on user-level fire hazard awareness of high rises in the Mohakhali area. Our literature review reveals inadequate research focus on fire hazards in Dhaka. However, fire is the most frequently occurring urban hazard in Dhaka (Huda, 2022).

For this reason, this research has been done to determine the vulnerabilities of high-rise buildings to fire incidents. The building vulnerability is assessed based on several indicators related to fire safety standards. The chosen area for the study is the neighbourhood of Kemal Ataturk Avenue in the Banani-Gulshan area, as there is a previous history of devastating fire incidents in high-rise buildings, and many commercial multistorey buildings are located there.

Study area: On 28 March 2019, FR Tower, located in the Kemal Ataturk Avenue of Banani of Dhaka, experienced a devastating fire incident, resulting in the tragic death of 26 people (Huda, 2022). That incident underscored the critical shortcomings of fire safety, such as faulty construction, inadequate fire-fighting equipment, poor emergency management measures, and insufficient knowledge of the operation of existing equipment. In response to that tragedy, this research was carried out on 19 high-rise commercial buildings in the vicinity of FR Tower, along the Kemal Ataturk Avenue, between 2019 and 2020 (Fig. 1). The Bangladesh National Building Code (BNBC) 2006 categorizes buildings over 20 meters as high-rise buildings; however, within the BNBC

2020, the definition of high-rise is updated, and over ten storeys/ 33 meters are now considered high-rise buildings (Huda, 2022; MoHPW, 2024a; MoHPW, 2024b). According to the Fire Protection and Prevention Law 2003, buildings more than six storeys are considered as high-rise (Huda, 2022). We considered the previous definition of high rise and included 7-26 storeys building in our research. We have followed two steps in our building selection process. The first step was a census (all buildings close to the vicinity of the FR tower were taken into consideration), followed by purposive sampling. During the census (done during the reconnaissance survey), we identified the building based on a few criteria for the detailed survey. The criteria are as follows: The building must be a high-rise, fully or partially used for commercial purposes, and close to FR Tower. We could not access all the buildings, and the building management was not interested in participating in the survey. As a result, in the second step, we selected 19 buildings using purposive sampling (see Tongco, 2007) methods from the selected building in the first step.

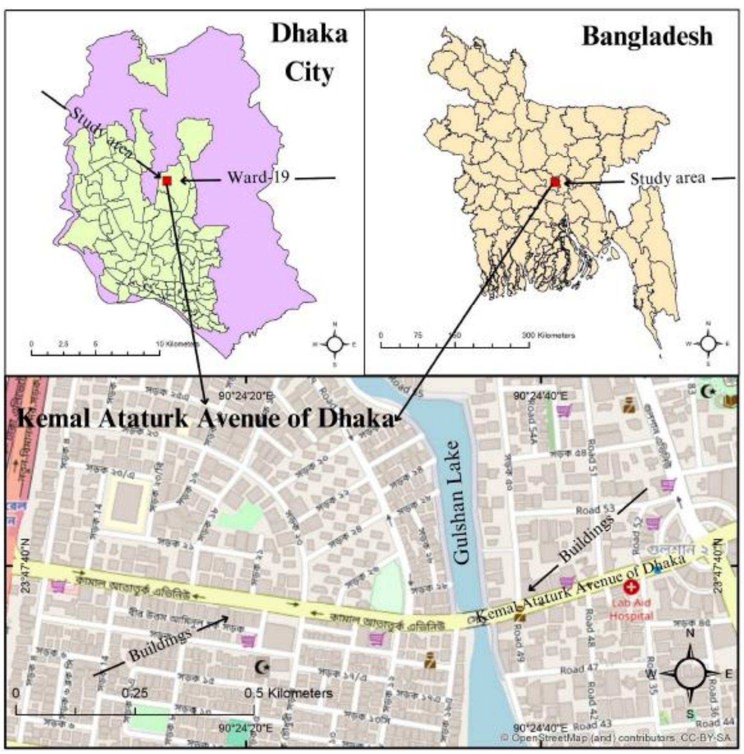

Fig. 1. Location of the study area.

Materials and Methods

Vulnerability is defined as the susceptibility of individuals, communities, assets, or a system to the impact of a hazard, which is determined by a group of conditions, including physical, social, economic, and environmental (UNDDR, 2024). We emphasise the assessment of physical vulnerability (the ability of the built environment- building road and other infrastructure to withstand the impact of any hazard) (Woodruff *et al.*, 2018) of buildings and user-level susceptibility to fire hazards. A total number of 19 high-rise buildings (7-26 storeys) have been evaluated in this research. The building was chosen during a reconnaissance survey. Expert opinion was taken, and the Department of Fire Service and Civil Defence (DoFSCD) checklist was considered to develop the building's indicator-based fire safety framework. From 2019 to 2020, the lead author conducted a detailed building survey. The lead researcher interviewed the management of all surveyed buildings and maintained a field notebook during the survey. Weighing and grading the indicators was done by averaging the scores of five experts. A composite vulnerability score was derived for each building from the weighted and graded parameters. Previous studies by Wadud *et al.*, 2014, Rahman *et al*., 2015, Rahman *et al*., 2017 and Sahebi *et al*., 2020 used weighted and graded indicators to assess fire hazard vulnerability and risk. Based on the composite score and expert opinion, the buildings are grouped into high, medium, and low vulnerability levels.

Parameters for fire vulnerability assessment: Thirty-three (eighteen quantitative and fifteen qualitative) parameters were selected for the fire hazard vulnerability assessment (Table 1).

Development of weight: A weight value of 1-5 is assigned to each indicator (Table 2). Weighting is intended to identify the importance of the indicators in terms of the impact of fire hazards (Table 3). Thirty-three parameters (eighteen quantitative and fifteen qualitative) were selected for the fire hazard vulnerability assessment (Table 1). The weight of each indicator is detailed in Table 3.

Grading of parameters: Each indicator has been given a grade depending on the impact of those indicators on a particular building. The qualitative indicators are rated based on the description collected during the field survey with the help of expert opinion from excellent to very poor, with corresponding grading points detailed in Table 4. The quantitative indicators are rated based on the deviation from the required condition to comply with fire safety standards (Wadud *et al.*, 2014).

Table 1. List of the quantitative and qualitative indicators.

Quantitative Parameters/Indicators	Qualitative Parameters/Indicators
1. Smoke detector	1. The practice of fire drill
2. Fire alarm	2. Ventilation of emergency exit
3. Unlocked emergency exit	3. Ventilation of the main staircase
4. Width of emergency exit	4. Lighting facilities of the main staircase
5. Refilled fire extinguisher	5. Lighting facilities of the emergency exit
6. Width of the main exit	6. Exit sign and refuge area
7. Distance from adjacent buildings	7. Accessibility of water
8. Sprinkler	8. Main electric switchboard
9. Skilled/trained people for firefighting	9. Emergency light
10. Fire door	10. Roof accessibility
11. Alternate power/ generator operator	11. Control room
12. The existence of a restaurant with kitchen	12. Electric connections checking
13. Distance from electric pole/transformer	13. Generator room
14. Main electric switchboard	14. Main exit
15. DoFSCD notice	15. Reserve water tank
16. Lift and lift operator	
17. Floor area	
18. Number of floors	

Table 2. Definition of weight for each indicator adopted from Wadud *et al.*, 2014.

Weight	Description of consequences
5	Most important—if absent, there could be serious damage to life and properties.
4	Important—if absent, life and properties could be considerably damaged.
3	Essential—in the absence, fatalities may be avoided. However, significant injuries and property damages still occur.
2	Essential—in the absence, loss of properties and injuries will be considerable.
1	Preferable —not essential, however desirable

Smoke detector: There should be one smoke detector in every 75 sq. meter area, according to Firefighting Rules 2014 (DoFSCD, 2014). The required smoke detector number has been calculated using the following formula for each building, and then the deviation has been calculated.

$$Number\ of\ smoke\ detector = \frac{total\ floor\ area\ (in\ sq\ m)}{75\ sq\ m}$$

Table 3. Indicators used in surveys with their average weight.

Indicators No.	Indicators/Parameters	Description of indicators/parameters	Weight (Xi)
1	Smoke detector	Availability and number of smoke detector	5
2	Fire alarm	Availability and number of fire alarms on each floor	5
3	Unlocked emergency exit	having unlocked emergency exits	5
4	Width of emergency exit	Deviation from ideal width	4.8
5	Main exit	Number of main exits for getting out of the building	4.6
6	The practice of fire drill	Provision and frequency of fire drill	4.6
7	Ventilation of emergency exit	The ventilation system in the emergency exit/ staircase	4.6
8	Lighting facilities of emergency exit	Availability and type of lighting facility in emergency exit/staircase	4.6
9	Refilled fire extinguisher	Number of refilled extinguishers	4.6
10	Exit sign and refuge area	Proper exit sign on each floor, provision of refuge area in the building	4.6
11	Accessibility of water	Availability of water for emergency use	4.6
12	Width of the main exit	Deviation from the ideal width	4.4
13	Main electric switchboard	Location of main electric switchboard (for easy access)	4.2
14	Roof accessibility	Unobstructed/easy access to the roof (with open space on the rooftop)	4.2
15	Emergency light	Availability and connection system of emergency light	4
16	Fire Door	Availability of a fire door on each floor separating the emergency exit	4
17	Sprinkler	Availability and number of sprinklers (deviation from required number)	4
18	Reserve water tank	Number of reserve water tanks (having an extra tank for firefighting)	4
19	Distance from adjacent buildings	Deviation from ideal distance	3.8
20	Lighting facilities of the main exit	Availability and type of lighting facility in main exit/staircase	3.8
21	Control room	Availability of a well-organized control room	3.8

22	Skilled/trained people for firefighting	Number of skilled people for firefighting and their level of skill	3.8
23	Electric connections checking	Yearly/monthly checking of all electric connections/equipment	3.8
24	Ventilation of the main exit/staircase	The availability of the ventilation system for the main exit/ staircase	3.6
25	Distance from the electric pole/transformer	Deviation from an ideal distance	3.5
26	Alternate power/ generator operator	Number of operators for generator	3.5
27	Main electric switchboard	Number of operators of the main electric switchboard	3.4
28	Generator room	Location and condition of the generator room	3.4
29	DoFSCD notice	DoFSCD notice (fire emergency advice) on each floor	3.25
30	The existence of a restaurant with kitchen	Number of floors having restaurant or kitchen	3.2
31	Lift and lift operator.	Type of lift (availability of fire lift) with operator number	2.8
32	Number of floors	Number of floors greater than six	2.6
33	Floor area	Total floor area	2

Table 4. Grade points of the indicators (Wadud *et al.*, 2014).

Grade point (Yi)	Qualitative indicator	Quantitative indicator based on deviation
1	Excellent	0- 25%
0.75	Good	26%-50%
0.5	Moderate	51%-75%
0.25	Poor	76%-100%
0	Extremely Poor (If it does not exist)	If it does not exist or deviation exceeds 100%

Fire alarm: According to experts, at least one fire alarm should be on each floor. So, the deviation was measured by calculating the number of floors with no fire alarm.

$$Deviation = \frac{number\ of\ floors\ having\ no\ fire\ alarm}{total\ floor\ number} * 100$$

Unlocked emergency exit: During the fire incident in the FR tower in 2019, emergency exits on many floors were locked, and the people in that building could not come out. Keeping emergency exits under lock and key is a common practice in Bangladesh. We calculated the percentage of floors with unlocked emergency exits in terms of the total number of floors and assigned grades according to Table 4.

Width of emergency exit: The FR tower had an emergency exit of approximately 0.61m iron staircase. Getting out of the building was risky, even in the normal time using that exit. The standard width of the emergency exit must be at least 1.5m, according to Fire Fighting Rules 2014 (DoFSCD, 2024b). We calculated the deviation of the emergency and main exit from 1.5m.

Refilled fire extinguisher: According to the opinion of experts, there should be one fire extinguisher in every 550 sq. ft. area. So, the required extinguisher has been calculated using the following equation.

$$Number\ of\ Required\ extinguisher = \frac{Floor\ area\ (in\ sq.ft.)}{550\ sq.ft}$$

Then the deviation has been calculated using the following equation:

$$Deviation = \frac{Required - Existing}{Required} * 100$$

Distance from adjacent buildings: Grading has been done based on the distance and description of buildings from survey and minimum requirements of side and rear space mentioned in BNBC for business and mercantile occupancy.

Sprinkler: Typically, one sprinkler is required within 120-200 sq. ft. However, the expert consulted for this study suggested that ideally there should be one sprinkler within 100 sq. ft. We employed the following formula to determine the spacing deviation:

$$Number\ of\ Required\ Sprinkler = \frac{Floor\ area\ (in\ sq.ft.)}{100\ sq.ft}$$

Then the deviation has been calculated as follows:

$$Deviation = \frac{Required - Existing}{Required} * 100$$

Skilled/trained people for firefighting: Trained people play a great role during fire hazards. All people using the building must have basic firefighting knowledge and be aware of the firefighting facilities of the building. There should be enough trained people for firefighting in each commercial building who can perform emergency responses (dousing a fire with extinguishers, helping with evacuation) during any fire event. We have surveyed the building in detail (firefighting facilities, use of buildings) and collected information about the number of trained people, their training, and practice-related information. Then the building was graded based on the collected information.

Fire door: The spread of fire and smoke can be prevented by installing fire doors. Fire doors also ensure safe evacuation through the emergency exits. For assessment, the ratio between the floor with a fire door and the floor having no fire door was calculated. Additionally, we assessed whether the doors identified as fire doors complied with fire safety standards or were simply wooden or steel doors described as fire doors. Collected information was used to rate the performance of the building to fire susceptibility.

Alternate power/ generator operator: Each building should have three operators (according to experts). So, anyone can always be present. Buildings were graded based on the deviation of the number of operators and their duty hours.

Existence of a restaurant or kitchen: Fire can ignite in a restaurant. Building with no restaurant is rated as excellent. Buildings with restaurants are rated from extremely poor to good according to the number of restaurants and their safety compliance.

Distance from electric pole/transformer: The Bangladesh National Building Code stipulated that buildings must keep a minimum horizontal distance of 1.75 m from any high voltage electric lines (up to 33 kV) and 1.25 m for low to medium (<33 kV) voltage line during construction (MoHPW, 2024b). A building with no space with open electric wire is rated as extremely poor. Excellence is assigned to buildings having space more than 1.75 m. The building's space, however, is 1.75 m or less than 1.75 m is rated good to poor (Table 4) based on the calculated deviation during the field survey.

Main electric switchboard: There should be three operators (according to experts) in each building working in shifts to ensure twenty-four hours of coverage (safety of electricity and critical facilities). We collected information about operators along with their working procedures. Then, the buildings were rated based on the information.

DoFSCD notice: DoFSCD issues guidelines on actions to take during a fire with emergency contact information. It is recommended that the building authority display these notices evidently on every floor for quick communication during fire emergencies. The deviation has been calculated considering the number of floors without such notice.

Lift and lift operator: According to expert views, there should be at least one liftman for each lift; at least 1 of 2-3 lifts must be fire lifts. A fire lift is a lift specially designed and operated safely during a fire in a building. The lift and lift operator information were collected and graded during the survey.

Floor area: A building with a large floor area typically requires more comprehensive firefighting facilities. In this study, buildings with a floor area under three thousand square feet are rated excellent, observing other factors such as fire alarms, smoke detectors, and additional safety measures to meet the requirements. In reverse, the floor area exceeding five thousand square feet was considered extremely poor if other safety measures were non-compliant with the standards. Moreover, during observation, it was noted that the allocation of fire safety equipment is sufficient regarding its accessibility and effectiveness across the building.

Number of floors: We considered buildings to have more than six floors as high-rise buildings (MoHPW, 2024a). The firefighting challenge increases with the number of floors or heights of buildings. We calculated % of deviation of the number of floors from the 6th floor.

Calculation of vulnerability score:

Finally, the fire hazard vulnerability score has been calculated using the following formula: $Fire\ Vulnerability = \sum_{i=1}^{n} Xi * Yi$

(Rahman *et al.*, 2015, Rahman *et al.*, 2017, Sahebi *et al.*, 2020)

Here, *Xi* = weight of the indicator and *Yi* = grade point of the indicators

Result and discussion

Assessment of fire safety condition: Based on 33 criteria, buildings are assessed and categorized from extremely poor to excellent, as outlined in Table 3 and Fig 4. Many buildings fall into extremely poor categories in different criteria due to non-compliance with safety standards regarding smoke detectors, fire drill practices, ventilation of emergency exits, emergency doors, lights, sprinklers, and control rooms (Fig 2). On the other hand, the highest number of buildings fall into good to excellent categories in the criteria of the main exit, lift and lift operator, electric connection checking, the width of the main exit, and the main switchboard (Fig 3).

The indicator-wise fire safety condition of the selected building is shown in Fig. 4. Most of the buildings (around 60%) perform extremely poorly to poor in DoFSCD notice, ventilation in main exit/staircase, trained firefighters, reserve water tank, sprinkler, smoke detector, fire door, exit sign and refuge area, lighting facilities and ventilation in emergency exit, fire drill, condition of control room (see Fig. 4). The surveyed buildings perform (around 60%) well in indicators like lift operator, a restaurant in the building, electric switchboard safety, checking of electric connections, generator operator, the width of the main exit, emergency exit, accessibility of water and fire alarm (see Fig. 4).

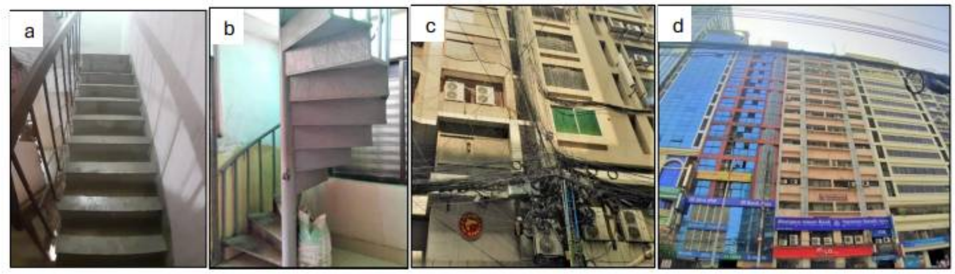

Fig. 2. Illustration of extremely poor to poor condition of exit (a.), narrow roof access (b.), dangerous electric wire (c.), and attached buildings (d.). (Source: Fieldwork, 2019-20).

Fig. 3. Illustration of excellent to good examples of well-equipped control room (a. inset), hydrant with pressurize valve (a.); Fire extinguisher (b.), fire alarm (b. inset upper right) and direction of extinguisher user procedure (b inset lower right); Well-ventilated exit (c.), emergency light (c. inset upper left), exit sign (inset upper middle) and exit doors (c. inset upper right). (Source: Fieldwork, 2019-20)

Assessment of Building Vulnerability: The aggregated vulnerability score for each building was derived from the combined score of the building. After multiplying the weight value and grade value of a particular indicator for a particular building, the products of all indicators have been summed up to have the final vulnerability score of a certain building. The buildings are categorized into low, medium, and highly vulnerable based on vulnerability scores and expert opinion (Table 5). The evaluation uses a scoring system where a higher score denotes less vulnerability to fire hazards—such buildings are safer in many criteria and categorized into good or excellent. On the contrary, a lower score pointed to a higher vulnerability, with many indicators rated as extremely poor or poor.

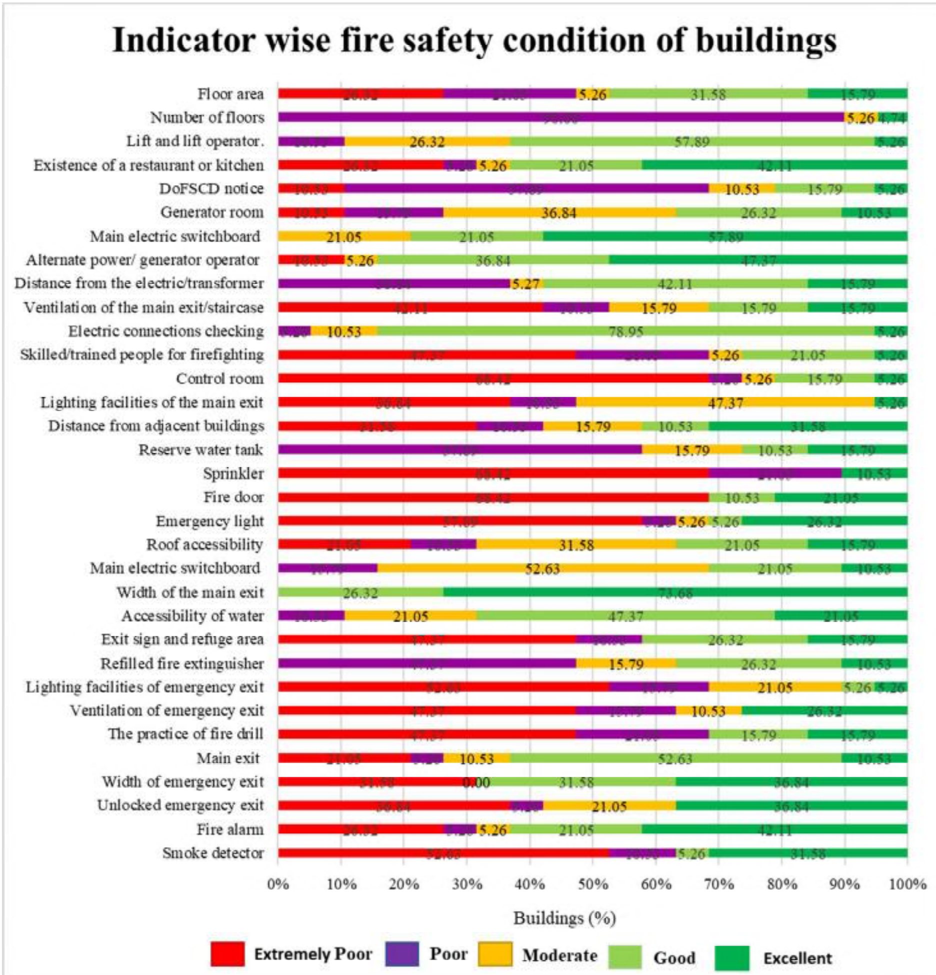

Fig. 4. Indicator-wise fire safety condition of surveyed buildings (Source: Fieldwork, 2019-20).

Table 5. Vulnerability score of buildings.

Vulnerability score range	Level of vulnerability	Number of buildings
29-55	High	9
56-82	Medium	7
83-109	Low	3

The Table 5 above shows that most buildings (9 out of 19) are highly vulnerable, with scores ranging from 29 to 55. Seven buildings are medium vulnerable, and only three are in low vulnerable conditions. So, the situation indicates that most buildings have been constructed flouting BNBC rules and are non-compliant with fire safety standards. Although some buildings have adopted some safety measures, they still need improvement (firefighting, fire emergency plan, fire safety drill) to prevent fire incidents and fire-related damages.

Building vulnerability, construction time, regulatory framework: The first act (the Building Construction Act 1952) on building construction in this region was promulgated in 1953 and has since undergone several amendments (Islam and Adri 2008). The first Bangladesh National Building Code was released in 1993. However, it was not officially gazetted until 2006 (Table 6). Out of nineteen surveyed buildings, three were constructed before 1993, eight between 1993-2006, and 7 after 2006 (Table 6). The evaluation reveals that nine are highly vulnerable, seven are medium vulnerable, and three are low vulnerable to fire hazards (Table 6).

Table 6. Building vulnerabilities in terms of construction time (Islam and Adri, 2008; Huda, 2022; Hossain *et al.*, 2022; Afrose, 2023; DoFSCD, 2024a).

Building Construction Time	Level of vulnerabilities		
	High	Medium	Low
Before 1993 (BNBC First Published)	3	0	0
1993-2006 (Fire Prevention and Extinguishing Act, 2003; however, BNBC was not Gazette.	5	3	0
After 2006 (BNBC gazette in 2006; Dhaka Metropolitan Building Construction Act of 2008 enforced, Fire Prevention and Extinction Rules, 2014 was formulated)	1	4	3

All the buildings built before 1993 are highly vulnerable to fire hazards (Table 6). Five buildings are highly vulnerable, and three are moderately vulnerable among the eight buildings, constructed between 1993 and 2006. Among the buildings built after 2006, only one is highly vulnerable, 4 are moderately vulnerable, and 3 are low vulnerable. Most of the buildings built before 2006 were identified as highly vulnerable. Though BNBC was already formulated then, it was not applied in the construction process, nor have any modifications been made to comply with safety standards. With the formulation of the legal framework, we have seen that the safety condition of the buildings has improved (Table 6). However, it is not satisfactory. The reason may be a lack of monitoring from the planning and construction phase to the use phase.

Highly vulnerable buildings: There was no or less than the required space between these buildings. Moreover, this building lacks a proper emergency exit, or the exit is narrower than the 1.5 m standard. These buildings do not comply with necessary safety standards regarding a functional control room, the requisite number of smoke detectors, sprinkler systems, and professionally trained firefighting teams. There was no provision for firefighting drills. In some cases, exit signs are merely written on paper, which is unlikely to be effective during an emergency. Negligence is also observed in the maintenance of the emergency exit. The exit is often kept locked or blocked. The exits were not clean, lacked sufficient light, and were not well-ventilated.

Moderately vulnerable buildings: We found seven buildings in moderately vulnerable conditions (three constructed between 1993-2006 and four after 2006). These buildings are equipped with smoke detectors, fire alarms, and emergency exits that are not locked. These buildings have professionally trained firefighting personnel and well-ventilated main and emergency exits. These buildings achieve moderate to good ratings in most of the indicators. Even in some indicators, these have received excellent scores, for example, the width of the main exit. These building is rated as moderately vulnerable due to under-performance in several key areas, for example, space between adjacent buildings, frequency of practicing fire drills, functionality of control room, presence of sprinklers, provision of emergency exit door, smoke detector, emergency exit lighting facilities.

Low vulnerable buildings: Our research identified only three buildings in low vulnerable conditions constructed after 2006. The buildings are built in compliance with the BNBC. Most of the indicators of these buildings are rated as good or excellent. These buildings have sufficient space gaps with adjacent buildings and are located at a safe distance (1.75 m) from electric poles, transformers, and hanging electric wires. The main and emergency stairs are well-ventilated, with a width exceeding 1.5 m. Emergency exits are kept unlocked consistently. Fire extinguishers are routinely checked and refilled. Every building has the necessary smoke detectors and fire alarms. Furthermore, these buildings are well-equipped with a control room and a professionally trained firefighting team. These buildings have provisions for regular fire drills. None of the buildings have a restaurant on any floor. They have a well-equipped control room and a well-trained firefighting team. These buildings have a fire drill provided regularly (more than five times a year). The building authorities have installed necessary emergency signs and safety notices of DoFSCD on different floors of the buildings. Smoking within these buildings is prohibited. The management team regularly checks electricity connections. They also have a reserve water tank for use in emergencies. However, the staircase to access the roof was narrow in two out of three buildings. One building does not have sprinklers but performs excellently in all other indicators.

Presently, there are many regulatory frameworks and safety standards for building safety (Table 6). However, most buildings surveyed in this research were non-compliant with safety standards. According to the Dhaka Metropolitan Building Construction Act of 2008 (Dhaka Mohanagar Imarat Nirman Bidhimala 2008), an occupancy certificate is compulsory. According to experts, most buildings do not have occupancy certificates or violate the certificate for space use. It is not practical to suggest the reconstruction of all these buildings. However, proper modification can improve the safety standards of these buildings. The expert interviewed in this study emphasizes the proper and corruption-free monitoring of the safety standards of the building (from planning and construction to the use phase) to improve fire safety in Dhaka.

Conclusion

Fire incidents are alarmingly increasing in Dhaka. The situation is worsening due to unplanned urbanization and the prolific growth of high-rises buildings. Building construction and use are sometimes done by flouting the BNBC, DoFSCD regulations, and the Dhaka Metropolitan Building Construction Act of 2008. Safety concerns were raised by the government and other stakeholders after the devastating FR tower incident in 2019. It is alarming that we found nine out of 19 buildings are highly vulnerable to fire incidents. These buildings lack proper fire safety measures (smoke detectors, adequate fire alarms, emergency lights, sprinklers, skilled workforce for fire safety, control rooms, and fire drills).

Moreover, in many cases, we found that emergency exits were blocked or locked and did not comply with safety regulations. However, regulation measures positively correlate with safety standards, as recently constructed buildings comply with fire safety standards. Those buildings built before 2006 (before the gazette of BNBC) are the most vulnerable, needing more fire safety measures. On the other hand, the newly constructed buildings (after the formulation and enactment of fire safety and building safety regulations) mostly comply with fire safety measures.

Reconstruction of these vulnerable buildings is not a practical solution. However, these buildings' fire safety standards and emergency management capabilities can be enhanced through modification and continuous monitoring.

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