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FIRE RISK ASSESSMENT OF MULTI-STORIED BUILDINGS AT A RESIDENTIAL AREA IN KHULNA CITY

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ABSTRACT

Fire incidents are increasing in urban areas in recent areas and posing a great threat to human lives and properties. The unplanned urban housings without necessary fire safety provisions are responsible for these accidents. In Khulna city alone, there is a large number of residential buildings which are constructed violating the rules and regulations of the Bangladesh National Building Code (BNBC 2015) and Bangladesh Fire Service and Civil Defence (BFSCD). These buildings have no fire safety measures at all. 20 buildings are surveyed through a questionnaire interview, survey and discussion. Findings show that among the 20 surveyed buildings, 75% of them are in a highly vulnerable condition and are at high-risk fire hazards. 25% of them are at medium risk. Some buildings are too old and it was found that they did not follow the proper building fire safety code. For the case of relatively newly constructed buildings, it is observed that they maintained the proper rules for construction but did not have proper fire safety measures. They do not have evacuation routes or sufficient fire extinguishers that are a must at the time of emergency. Fire safety planning, designing and modification of these buildings with the help of expert personnel by following the proper fire safety guidelines are needed for these buildings. Sufficient surveillance and supervision are also needed to reduce the risk of fatal fire incidences in residential areas.

Keywords: *Fire accident, BNBC, BFSCD, evacuation, fire safety.*

1. INTRODUCTION

Fire Hazard has become an alarming issue in Bangladesh as many incidents occur in recent times (Rahman, 2014). Most of the accidents cause huge economic loss and high mortality (Khan et al., 2017; Sakib et al., 2020). The main reasons for all these accidents are unplanned housing plans, rapid urbanization (Opie et al., 2014). Around 250,000 fire incidents took place from January 1997 to December 2018 in Bangladesh (Sakib et al., 2020). The reported incidences of fire were 7140, 7135 and 9642 between 2004 and 2006 respectively in Bangladesh. In addition to human injury and mortality, property damage was reported to be more than 0.6 billion Taka (Bangladesh money) in the capital of Bangladesh on average each year due to fire incidents (Sayeduzzaman and Islam, 1992). To prevent these accidents and mitigate accidental death with huge economic loss, fire risk assessment is necessary. Fire risk assessment is nothing but to describe how a residential building/area, commercial area, industrial factory/area are safe from fire hazards (Šakėnaitė and Vaidogas, 2010). It helps to take proper steps to make the building safer.

The objective of this study is to assess the risk of fire in a residential area. Fire risk assessment is very much important for a residential area. Risk analysis can be done both – quantitative and qualitative. This assessment is done by indexing building/factory by weighting risk indicators and describing the impact (Wadud et al., 2014). In this paper, fire risk assessment is done throughout the residential housing society of Nirala situated at the heart of Khulna city. Khulna is one of the major cities in Bangladesh. It is not much developed industrially and economically, due to unplanned building

structures. Here, a large number of residential apartments are constructed violating the rules and regulations of the Bangladesh National Building Code (BNBC 2015).

Fire safety provisions are included in BNBC 2015 to maintain a safe infrastructure. In residential buildings, a fire exit door must be available and accessible for all residents. The width of stairways shall be maintained at least 1.5 m for safe evacuation. Most of the fire accidents get severe for the inadequacy of supply water. Therefore, all buildings must have a rooftop tank for fire protection. Firefighting equipment (e.g. CO2 extinguisher, Water mist suppression, Foam suppression, ABC powder) shall be placed inside the building and must be accessible. An exhaust fan must be placed in the Kitchen to prevent fire accidents from gas leakage. The HVAC system must be designed and installed properly for preventing spreading fire through the duct. These issues are primary to minimize fire risk
.
For this assessment, 20 buildings were taken for the questionnaire survey and all of them were four or more than four-storied buildings. Risk indexing was done by creating a score range with the importance of risk indicators. All the parameters were surveyed according to the BNBC 2015 code. Indicator's weight importance was taken by acknowledging from BNBC and Bangladesh fire service and civil defense- (BFSCD). Almost all residential apartments didn't follow the BNBC code properly and were very much vulnerable to fire hazards. These unplanned building designs and unawareness of people in fire safety guidelines lead to a very dangerous situation. Finally, a conclusion along with some recommendations has been stated to lead the residential area safer that will help Khulna city corporation to take proper steps.

2. METHODOLOGY

2.1 Surveying and Inspection

In the Nirala area, there were 20 buildings which are 4 storeyed or more. A questionnaire survey was done for the study. The survey process was done physically. Detailed questions have been asked.

- Fire extinguisher
- An emergency escape route.
- The dimension of stairways.
- Expiry date of fire extinguisher
- Water reservoir system.
- Exhaust fan in kitchen
- Ventilation system

The whole survey was done following the BNBC 2015 code. The following facts about the building substructures observed in the buildings of the study area were:

- Whether there were any extinguishers on every floor of the buildings or not.
- Whether the fire extinguishers have the correct expire date or not.
- Whether there is an emergency route to escape safely during a fire accident or not.
- Whether there is a stair dimension is okay or not.
- Whether all buildings have their reservoirs or not.
- Whether all buildings' ventilation systems are OK or not.
- Whether there is a fan in the kitchen or not.

2.2 Risk indicator weighting

There are many types of fire risk indexing methods and the famous methods are FRAME index, Gretener's index, fire system assessment system index, hierarchical approach, Dow's fire and explosion index (Watts, 1991). The criteria are grouped into different categories in most of these indexes containing different facts of fire safety, such as fire prevention, emergency response, compartmentalization, detection and warning etc. All these indicators are taken from the Bangladesh National Building Code (BNBC 2015) and weighted the score. This process is done by understanding

the importance of these factors. For calculating the Fire risk index (FRI), a linear additive model is used and the equation is,

$$FRI = \left(\frac{\sum_{i=1}^{n} WiXi}{\sum_{i=1}^{n} Wi}\right) \quad (1)$$

where w_i is the importance of parameter i, x_i is a dimensionless score or grade points for the parameter i and n is the number of total parameters. The weight score w_i is used to integrate the differences in the value of the parameters relative to one another which we developed from BNBC are shown in Table 1. The round number was used in the weight factor. 3 means the most important and without these major losses can occur like mortality and major property damage. 1 means not much important but needs for safety. The grade points or scores x_i indicate the 'measurement' of the risk, the outcome of the accident or protection in fire safety given by a parameter i (BNBC 2015). The grade score was done in the range of 0-2 where 0 means risky and 2 means safe.

Table 1: Weight score of different parameters

Parameters and Code	Weight score
Exit door: Each occupant of a room or space shall have access to at least one exit or exit access door.	3
Easy access to exit door: All exit doors shall be openable from the side they serve without the use of a key.	3
Dimension of stairways: The required width of exit stairways shall be at least 1.5 meters for a residential building	3
Water supply system: For water supply system with inadequate pressure to feed the firefighting equipment or roof gravity tank	2
Extinguisher accessibility: The portable extinguisher shall be placed near the exit travel and it shall be easily accessible.	2
Extinguisher availability: Fire hazard areas of a building like a kitchen, public area, storage, electrical distribution point etc. shall be installed with portable fire extinguishers.	3
Sealed flammable liquids: Flammable liquids used for domestic purposes shall be kept adequately sealed in approved containers at all times.	1
Obstruction on the escape route: Stoves and heaters using an open flame or otherwise shall be so located as not to create any obstruction on the escape route in case of fire. such appliance shall not be located directly on or near the foot of stairs.	1
Exhaust fan: Exhaust fans used in the kitchen shall be placed on a peripheral wall of the building or to duct connected directly to outside and shall be made of non-combustible materials.	2
Ventilation in storage: Smoke and heat vents shall be installed in a single-storeyed windowless building, underground structures.	1
HVAC maintenance: Air conditioning and ventilation systems shall be installed and maintained in such a manner that the fire, fumes or smoke do not spread from or area of the fire to other parts of a building through the ducts or vent.	2

(Source: BNBC-2015 code for parameters and codes)

3. RESULTS AND DISCUSSION

The survey clearly shows that most residential buildings are far more vulnerable to fire accidents. In most of the residential buildings, the BNBC code wasn't followed. If a fire accident occurs at any time, there was no suitable way for the fire brigade to reach the spot. Most of the buildings had no water reservoir of their own. Within 200 feet of the area, there was neither a pond nor a reservoir. According to our survey, there was no emergency escape route in any of these buildings. Of the 20 surveyed buildings had no fire extinguisher to deal with fire accidents. Only one building had a fire extinguisher. But sadly, these fire extinguishers were outdated which was now turned into explosives. Furthermore, these were not kept where they should have been stored. Most of the stairs for movement were not made following the BNBC code. The BNBC code was not followed in the 18th of 20 building. It was very

risky to go down using these stairs during a fire. According to the BNBC code, a residential building should have a minimum width of the stair is 1.5 meters. But the width of these stairs in these buildings was too less that if a fire accident occurs, people would be injured more in the quick evacuation process.

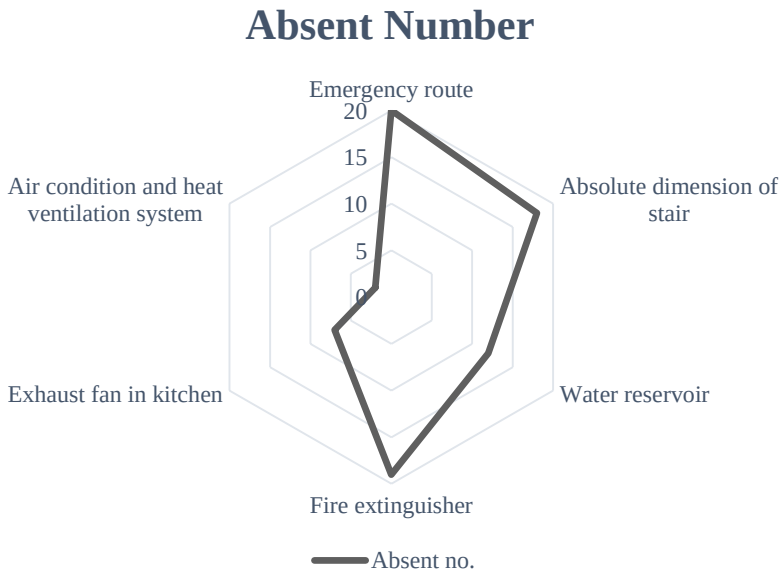

Figure 1: Radar graph of the absence of different parameters in buildings

The air conditioning and heat ventilation system in 2 of the 20 buildings under survey was very poor. Again, no exhaust fan in the 7 houses kitchen. In most cases, it has been observed that at the time of the fire accident, the fire brigade could not access their water-filled vehicles due to excess narrow roads. Figure 1 clearly defines those materials that were absent in our 20 surveyed residential buildings. After calculating the fire risk index, most of the buildings were found very risky. The calculation strategy was more score means safer. The FRI of 20 samples is shown in Table 2.

Table 2: FRI of 20 sample buildings

Sample	FRI	Sample	FRI	Sample	FRI	Sample	FRI
1	1.00	6	0.72	11	1.27	16	0.27
2	0.54	7	0.36	12	0.36	17	0.45
3	0.72	8	0.36	13	0.45	18	0.36
4	1.18	9	0.36	14	0.54	19	0.45
5	0.54	10	0.45	15	0.63	20	0.54

(Source: Field survey data analysis)

All the samples were divided into 3 categories for risk: Low, Medium and High. The sample which had a value range of 0-0.65, was labeled as high risk. Medium risk and low risk were labeled in value range about 0.65-1.35 and 1.35-2 respectively. It is seen that no building was safe and 5 buildings were medium safe which is shown in Figure 2.

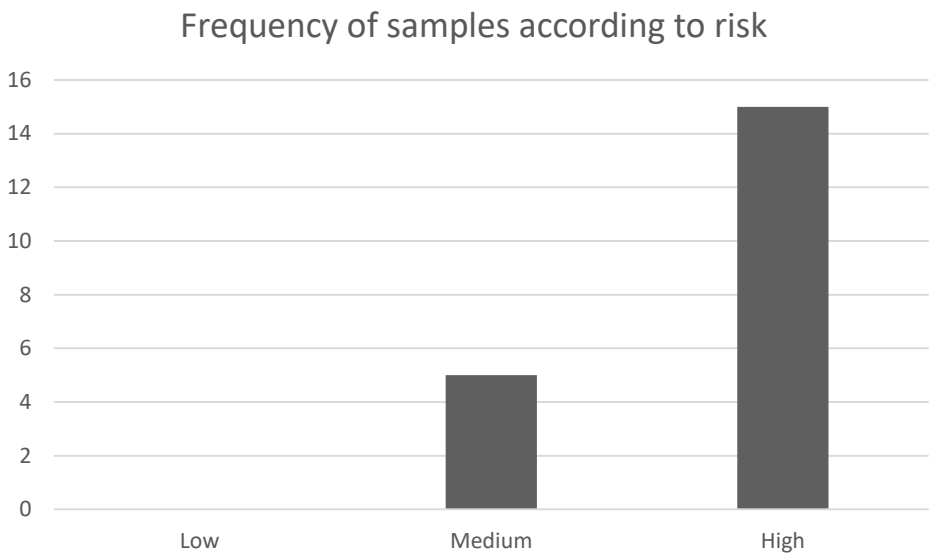

Figure 2: Frequency distribution of samples according to risk

4. CONCLUSIONS

According to our surveyed buildings, 15 buildings were highly at fire risk. Most of the buildings were located in narrow streets. At the time of fire accidents, the fire brigade cannot reach that place with their vehicles and emergency equipment. The best way to prevent a fire hazard in such a situation is to install a fire hydrant after 200 feet. Therefore, the fire defence can get a sufficient water supply to control the fire very quickly. Since most buildings do not have an emergency escape route, there must be provided a stairway with steel. That should be attached outer wall of the building. Dimension of stairways, doorways are not maintained properly in these buildings. Lack of awareness was seen in placing an exhaust fan in the kitchen.

This study is conducted for a small residential area. A questionnaire survey was done which covered the fire safety provisions in BNBC 2015. For these types of study, surveys need to be completed critically. Fire risk indexing can be done in various methods. Both qualitative and quantitative studies can be done simultaneously.

The government should impose a law to keep firefighting equipment compulsory in every residential building. Dry chemical powder (DCP) is also available in Bangladesh.it should be placed near the LPG gas cylinder in the kitchen. The windows of the kitchen should always be opened. People have to be very careful about using combustible materials. People can be made aware through newspapers, leaflets and social media. Above all people need to raise awareness. Only then it can be possible to escape the horrors of the fire accident.

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