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Fire Hazard Risk Assessment and Remedial Measures of Anderkilla Ward in Chattogram City, Bangladesh

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Abstract

Fires pose significant threats to urban settings, and understanding the specific risks in this densely populated area is essential for developing effective remedial measures. Through a field survey, this study identifies key fire hazard parameters, evaluates their potential risks, and proposes actionable remedial measures to enhance fire safety in Anderkilla Ward (No. 32) of Chattogram City. Two hundred eighteen (218) buildings from three different occupancy types (residential, industrial, and market buildings) were surveyed and analyzed for this study. The results indicate that most buildings (79.36%) are at high risk and require strategic remedial measures. This study recommends various measures that can serve as a foundation for urban planners, local authorities, and policymakers to mitigate fire risks and ensure the safety of residents.

Keywords: *Fire hazard; Fire risk assessment; Occupancy type; Fire safety; Remedial measures.*

1 Introduction

The World Bank report reveals that over 50% of the global population currently resides in urban regions, and this percentage is projected to increase 1.5 times by 2045 (World Bank, 2023). This concentration of people, assets, and economic activities in cities amplifies the risks associated with extreme events. Urban areas host critical infrastructure — assets or systems essential for societal well-being and governance (Urbina et al., 2021). Most of these vital structures are positioned in city centers and are profoundly susceptible to the impact of both natural and man-made disasters. Natural hazards, such as earthquakes, hurricanes, and tsunamis, and man-made risks like fires and explosions, can potentially disrupt indispensable services like electricity, water, and roads. These disruptions can lead to widespread consequences for communities and their emergency responses. Therefore, it is crucial to safeguard critical urban infrastructure against such disruptions (Urbina et al., 2023).

Bangladesh, highly disaster-prone due to its geographical positioning, has encountered significant natural and human-induced catastrophes. Overpopulation, unregulated structures, utility mismanagement, and apathy contribute to these crises. Fire-related disasters, particularly lethal ones, impact residential and industrial buildings, causing casualties and property damage. Approximately 285,000 fire hazards were reported in the country between January 1, 1999, and December 31, 2020, according to information from the Fire Service and Civil Defense, resulting in an estimated financial loss of almost Tk 6,900 crore (Unb, 2021). Mainly dry conditions, short circuits, cooking stoves, and improper disposal of burning items causes the fire hazards. Many residential structures are used for industrial purposes without modification, ignoring safety codes like the Fire Act 2003 and BNBC 2020 that are susceptible to fire-related incidents (Hasan et al., 2022).

Chittagong City stands as the country's second-largest urban center after Dhaka. The city is susceptible to fire hazards due to unplanned construction, improper land usage, narrow roadways, and a deficiency in fire safety infrastructure (Hasan et al., 2021). Evaluating the city's vulnerability to fire risks is paramount in identifying potential hazards, relevant factors, and vulnerabilities. Therefore, this study focuses on an important ward (Ward 32, Anderkilla) within the city. It aims to assess potential risk conditions and propose corrective actions that can heighten safety measures and minimize the impact of fires in the urban settings.

2 Research Methodology

2.1 Study Area

Chattogram, the second-largest metropolitan city in Bangladesh and a significant economic hub is situated between 22.14˚N and 22.2430˚N latitude and between 91.46˚E and 91.53˚E longitude, on the right bank of the Karnaphuli River (Rahman et al., 2011). The city encompasses 41 wards, housing a population of approximately 6.0 million within an area of 155 sq. km. For this study, Anderkilla Ward (No. 32) was selected, covering an area of 1.062 sq. km and accommodating a population of 108,000 (Figure 1). The busiest ward is positioned at the heart of the city and holds historical and commercial significance.

Figure 1. 32 No. Anderkilla ward map with the ward's map of Chattogram City Corporation (CCC).

2.2 Pre-field Work and Data Collection

A comprehensive pre-field work was conducted to understand the ward's entire layout, encompassing population, area size, markets, and residential and industrial buildings. Data collection forms were prepared in alignment with BNBC 2020 Fire Protection (Part IV) requirements. The data collection form included 24 parameters (inspection items) that were set to be surveyed.

For this study, a selection of 137 markets, 79 residential buildings, and 2 industrial buildings was made using random sampling. Field data was gathered for each building, considering occupancy types, building conditions, road width, electric infrastructure, and living conditions of inhabitants. The focus was on identifying violations of fire regulations. GPS coordinates were recorded by completing the data collection form for each building. Various photographs were taken throughout the data collection process, as illustrated in Figure 2.

Figure 2. Images of different buildings and their surrounding conditions.

2.3 Fire Risk Index Calculation

Fire risk assessment involves both qualitative and quantitative methodologies. Qualitative approaches encompass narratives and checklists, while quantitative methods include probabilistic or indexing techniques. The indexing method was chosen for this study due to its practicality and user-friendliness (Watts & Hall, 2016).

The Fire Risk Index (FRI) summarizes a building's fire risk and enables performance comparison with other structures. The FRI (%) was computed using Equation (1) from the weighted average model (Wadud & Huda, 2017).

$$\text{FRI (\%)} = \frac{\sum_{i=1}^{n} WiXi}{\sum_{i=1}^{n} Wi} \times 100 \quad (1)$$

Here, Wi represents the weight assigned to the parameter's significance. The weight values, ranging from 1 to 5, reflect the importance level, with 1 denoting the most crucial and 5 signifying non-essential but desirable. Notably, Wi values were determined based on previous studies and expert input. Xi represents the dimensionless grade point assigned based on the presence or absence of the parameter. A value of 0 was assigned if the parameter (inspection item) was present, while a value of 1 was assigned if absent (Hasan et al., 2022). A higher FRI score of 100% indicates the highest fire risk, whereas a lower FRI score of 0% indicates the lowest fire risk for a building.

2.4 Data Analysis and Presentation

Data analysis is an integral aspect of the data collection process. After acquiring field survey data, the collected information was analyzed and presented using MS Excel and ArcGIS software. In the ArcGIS software, GPS coordinates and FRI (%) values for each building were input to generate individual fire hazard risk maps.

3 Results and Discussion

3.1 Building Type and Its Conditions

Ward 32 encompasses a mix of various occupancy types, as outlined in BNBC 2020. A significant portion of the 218 surveyed buildings were in deteriorated condition, constructed without following the building regulations. Remarkably, approximately 80.27% of the buildings are non-engineered.

Within Anderkilla Ward, residential structures vary in height, ranging from five stories and above. Notably, this survey discovered that the highest proportion of residential buildings, accounting for 31.65% (25 out of 79), consist of five stories (Figure 3). It's important to mention that many commercial and industrial buildings lack adequate fire protection measures. Additionally, the separation distance between distinct building types was often found to be below the minimum requirement set by the BNBC code.

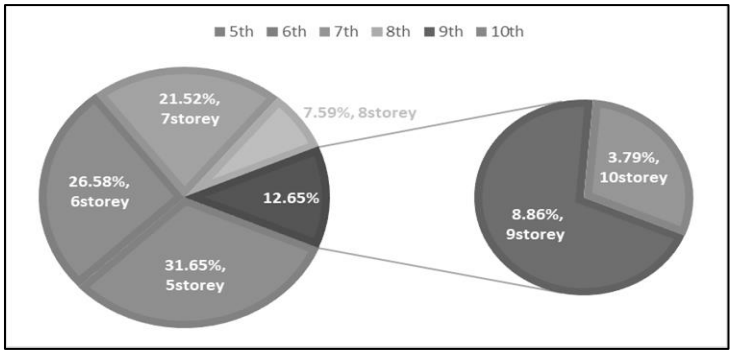

Figure 3. Residential buildings distribution based on the story

3.2 Building Fire Risk Hazards

All buildings have been categorized into three groups according to their FRI (%) values: Type-I (0.0%–33.33%) denotes low risk, Type II (33.33%–66.66%) signifies medium risk, and Type III (66.66%–100.0%) represents high risk. Notably, most structures in the ward fall under Type II and Type III, indicating high and medium levels of fire risk.

The study revealed that among residential buildings, about 84.81% of buildings are classified as high risk, 8.86% as moderate risk, and the remainder as low risk (Figure 4(a)). Among the total 137 market buildings, 22.63% exhibit medium risk, while the remaining 77.37% are assessed to be in high-risk conditions (Figure 4(b)). The two

industrial buildings are identified as having a medium-risk condition (Figure 5). When considering the entire dataset of 218 buildings, an impressive 79.36% are identified as high risk, 18.35% as medium risk, and the remainder as considerably lower risk regarding fire hazards.

The above findings indicate a significant prevalence of fire-risk conditions within the wards. Overall, the following contributing factors have been identified for these risks: (1) improper mixed land use during development, (2) densely concentrated population, (3) inadequate road width for fire service vehicle access, (4) presence of non-engineered older structures, (5) lack of water storage and adequate open spaces in buildings, (6) insufficient or absent fire protection facilities, (7) absence of fire hydrants, (8) absence of provisions for fire drills, (9) inadequate ventilation systems, (10) subpar electrical wiring systems, and (11) the absence of emergency fire safety plans and equipment.

Nearly similar observations have been reported in various regions of the country. For example, Hasan et al. (2022) conducted a study in the Reazuddin Bazar area of Chattogram City, identifying factors such as non-compliance with building codes, the absence of fire detection systems, and the presence of combustible materials as key contributors to moderate to high fire risk hazards. Similarly, another study focusing on the Nimtoli area in old Dhaka emphasized fire-prone conditions attributed to densely populated localities, unplanned urban expansion, mixed land use, storage of chemicals in residential zones, and a lack of awareness among residents (Sahebi et al., 2021).

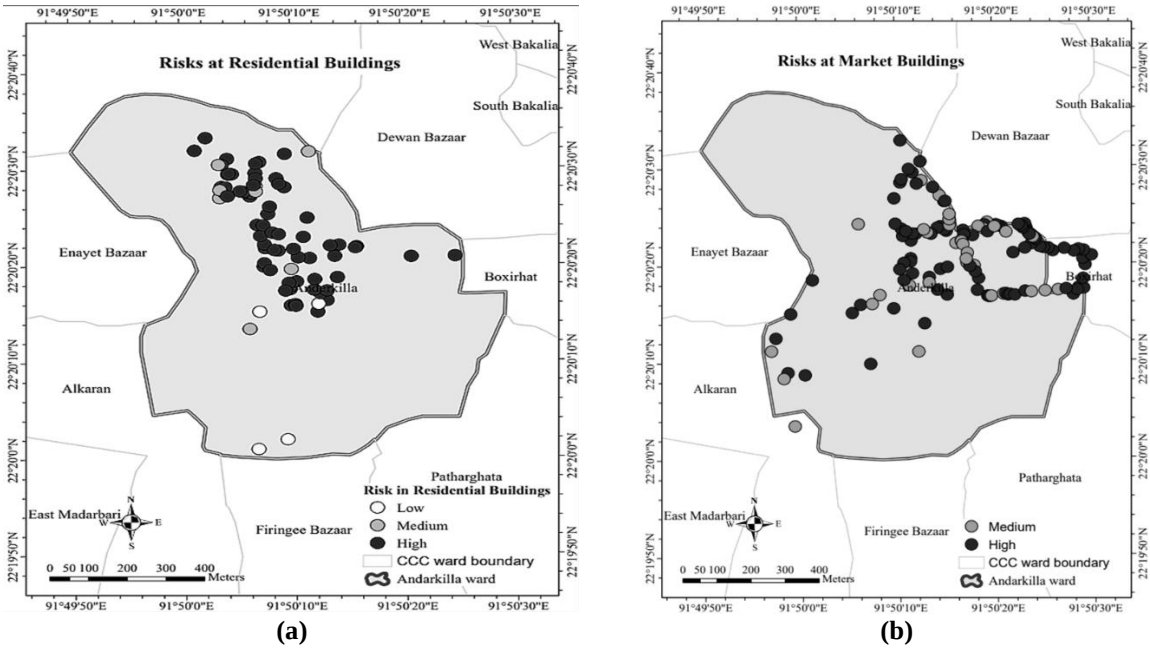

Figure 4. Fire hazard risk map of (a) Residential and (b) Market buildings.

4 Remedial Measures

The findings of the study highlight a significant absence of almost all inspection items, indicating the area is at a high risk of fire hazards. Thus, the necessity arises to propose measures that can substantially diminish its vulnerability to fire risks, ensuring the safety and well-being of its residents. Based on the study, the following recommendations are given to prevent and combat fires within the ward area effectively:

- **Installation of Fire Alarm Systems:** Deploy advanced fire alarm systems incorporating audible and visual alerts. These systems should be strategically positioned within buildings to notify occupants and facilitate evacuation during fire emergencies.
- **Regular Smoke Detector Checks:** Conduct frequent inspections and maintenance checks on smoke detectors to ensure optimal functionality. Routine assessments should monitor battery levels and overall performance to ensure early fire detection capabilities.
- **Clear Fire Exits:** Ensure fire exits remain unobstructed and easily accessible. This practice aids in halting fire propagation and facilitates safe and efficient evacuation procedures.

- **Conduct Fire Drills:** Regularly conduct fire drills involving all building occupants to familiarize them with emergency protocols and evacuation routes. Practicing these drills enhances preparedness and reduces panic during real emergencies.
- **Electrical Wiring Inspection:** Thoroughly examine all electrical wiring for defects, damages, or indications of wear. Swiftly address any identified issues by engaging certified electricians and adhering to safety protocols while handling electrical components.
- **Accessibility of Fire Extinguishers:** Install readily accessible fire extinguishers at strategic points within buildings. Ensure occupants are trained in proper usage to respond to and contain small fires before they escalate promptly.
- **Designated Smoking Areas:** Establish designated smoking zones with appropriate disposal mechanisms to mitigate the risk of discarded cigarette butts causing fires.
- **Equipment Maintenance:** Regularly maintain and assess all equipment to confirm optimal operational status. Timely addressing faulty equipment is crucial, as malfunctioning devices can pose significant fire hazards if left unattended.
- **Implementation of Building Codes and Inspection:** Enforce prevailing BNBC construction codes to ensure that buildings have adequate fire safety facilities. Regular inspections by relevant authorities should be conducted to enforce the rules of fire safety plans.
- **Increase Public Awareness:** Heighten public awareness among local authorities, residents, and pertinent stakeholders through platforms such as social media, television, and radio broadcasts. Organize training programs on the importance of collaboration between govt and private organizations, fire safety equipment usage, and practical actions to be taken during and after fire hazards occur in the area.
- **Establish an Integrated Framework:** Develop a framework that integrates strategies for enhancing building fire safety, as illustrated in Figure 6.

Figure 5. Fire hazard risk map of Industrial buildings.

Figure 6. An integrated framework for implementing strategies to enhance fire safety in buildings. Updated figure adopted from Kodur et al. (2019).

4 Conclusion

This study assesses the fire risk conditions in Anderkilla Ward (No. 32) of Chattogram City. The evaluation reveals that buildings in this area face medium to high fire risks due to insufficient safety management, inadequate infrastructure, rapid urbanization, limited spacing between structures, narrow access roads, and non-compliance with regulations. The study suggests remedies, such as installing fire alarm systems, checking smoke detectors regularly, establishing clear fire exits, conducting fire drills, inspecting electrical wiring, placing fire extinguishers conveniently, designating smoking zones, and maintaining equipment. These measures also offer a strategic framework to reduce fire risks, focusing on community awareness, collaboration with local authorities, and proactive fire safety efforts. Overall, the study provides valuable insights for urban planners, policymakers, and local authorities, offering a basis for informed decisions to create a safer environment benefiting Anderkilla Ward's residents and similar areas across the country.

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