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Research Article

Consider the Challenges of Fire Safety in Structures

*Mustapha Aliyu Yusif [1], Hafizu Hamza Ali [2], Adamu Abubakar Abdullahi [3], Idris Muhammad [4], Abubakar Usman Khalil [5]

[1,2,3,4,5] Department of Civil Engineering, School of Technology, Kano State Polytechnic, Nigeria.
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***Corresponding author:** Mustapha Aliyu Yusif*
Department of Civil Engineering, School of Technology, Kano State Polytechnic, Nigeria.

Abstract
Fire safety in buildings is essential for maintaining building functionality, preventing fatalities, and safeguarding property. It entails incorporating both active and passive fire protection such as sprinklers and alarms into the design, such as compartmentalization and fire-resistant materials. The quick spread of smoke in high-rise buildings, managing intricate layouts, providing sufficient firefighter access, putting in place dependable and well-maintained systems, and improving occupant awareness and training are some of the major obstacles.

Keywords: *Challenges, Fire outbreak; Buildings; Gas Leakage, Fire Extinguishers, Properties.*

I. INTRODUCTION
Buildings like institutions or schools are places where fire safety implementation is crucial. Children and adolescents make up the majority of those present in schools; they are quickly alarmed and difficult to control in times of emergency or crisis. In order to handle this problem and stop more mishaps, proper management may be necessary. When a school is on fire, the damage might be catastrophic. Such harm entails loss of life, property, and educational operations. Major fires have shown that not everyone can always make a safe escape from a burning structure. As a result, it's crucial to slow down the spread of flames by installing fire prevention devices, such as portable fire extinguishers and gas leak detecting systems [2], [3], and [4]. Before a fire gets out of control, a trained user of fire extinguishers can assist in putting it out. There are specific locations that need to be inspected in order to prevent fires, as well as emergency protocols that must be followed, like locating potential hotspots for fires, high-risk areas, and fire's potential effects. It is crucial to understand that fire safety encompasses more than only the operations of sprinkler systems, fire departments, detection, structural endurance, fire prevention, and risk management. The management must regularly check on risky places like scientific labs and storerooms that are included in fire safety procedures. All materials must be kept orderly and tidy. Furthermore, the connection between firefighting and human behavior is a particularly challenging problem. Poorly acquiring, filtering, and comprehending time-dependent information results in a lack of situation awareness, which can exacerbate emergency circumstances and cause further casualties as well as property losses. The simple definition of "management" is the combining or coordination of certain actions or programs made up of a manager and a team to accomplish particular goals. Management in the context of fire safety refers to the integration or coordination of a number of initiatives or plans aimed at reducing the risk of fire-related harm. These courses cover topics like escape routes, personnel training, housekeeping, regular inspections, and fire prevention. Eight components' inspections, education and training, fire suppression, emergency service, assessment of fire possibility, fire prevention, and reports as well as record-keeping and communication should be included in a fire safety management program. If this isn't done, one or more strategies could fail. Because one strategy could depend on another, more strategies could also fail, increasing risk [1].

II. LITERATURE REVIEW
out the first empirical studies on how people react to fire (USA). The interaction between building design and a safe escape received much less attention at that time because researchers pretended that buildings were constructed so that they were safe enough in a fire. Instead, they concentrated on the relationship between human behavior (social) and fire development. The findings showed that the conduct of the building's occupants either before or during the incident is related to the extent of a fire. Interviews with individuals who lived through the Arundel Park fire (1956) revealed that

inhabitants who were in the building with family members later re-entered it [6]. Other academics became aware of the role played by human behavior in fires in the 1970s, which changed how fire safety was perceived and sparked a number of study and instructional initiatives. Then, in Canada, a significant study investigating the evacuation of huge office buildings was carried out between 1969 and 1974. Wood conducted extensive research of firefighter behavior in homes in 1972 in Great Britain. Firefighters conducted 2139 interviews with participants in 952 fires using a common questionnaire. Then, in 1977, Bryan did a comparable study in the USA based on Wood's research technique, interviewing 584 people who were engaged in a total of 335 fires, half of which were residential and half of which were commercial. Both works demonstrated (again) that after initially fleeing a burning building, family members frequently return inside. Both studies also showed that people frequently walk-through smoke while trying to flee and that those involved in house fires work to put them out. Despite the fact that the two investigations were carried out in nations with quite different cultural backgrounds, the overall conclusions were the same. People inside a structure often have to rely on themselves or wait for help from those around in the early stages of a fire. Only until the first and most crucial steps have been taken can the professional emergency services, such as rescue operations by firemen and emergency care by paramedics, be of aid. Because of this, how people behave in the beginning is crucial to their ability to survive. It can be defined as the actions people do based on how they perceive the situation, how they want to act, and the factors they take into account before acting. As a result, "evacuation behavior" describes how people act during an escape. The most important component of a building's fire protection features is the potential for a safe escape. "Fire safety" relates to preventing fires, controlling the spread of fire and smoke, putting out a fire, and increasing the likelihood of a rapid and safe departure. Politicians' and the general public's perspectives on this problem are reflected in fire safety regulations. As a result, laws in many nations call for a "defend-in-place strategy" in places like hospitals where patients are confined to their beds. This method avoids the need to evacuate by moving residents to a safe area on the same floor. An evacuation plan is typically used for buildings where there are gatherings of people. But as the tragedies at the department store L'Innovation (Belgium, 1967), the Beverly Hills Supper Club (Kentucky, 1977), the Stardust nightclub (Ireland, 1981), the Happy Land Social Club (New York, 1990), and the Station Nightclub (Rhode Island, 2003) have highlighted, a safe escape from a burning building is not always possible for everyone. Since the existing fire safety standards had not effectively supported the evacuation of individuals from these buildings, some of these fatal accidents were the result of major code violations and traditionally led to modifications to those regulations. Our understanding of how occupants respond to fire is still relatively limited at this time. However, in order to optimize fire safety rules, it is crucial to comprehend why specific occurrences have resulted in a large number of casualties or why an apparently catastrophic catastrophe only left a small number of people injured. These inquiries served as the basis for a literature study that tries to pinpoint the crucial elements that affect the effectiveness of fire response. "Fire response performance," a book, presented the findings. Beginning around the turn of the 20th century [7], the research of building evacuation was primarily concerned with how people moved through doors, stairs, and hallways. Several researchers, in particular Paul's, Fruin, Predtetschenski, Milinski, Habicht, and Braaksma [8–10], gathered comprehensive data on travel speed and occupant density. What they discovered had a significant impact on how fire safety construction requirements are currently approached globally. The research has produced several specific architectural solutions, including the minimum width for evacuation staircases, the maximum flow rate capacity for fire exits, the necessary quantity of fire exits, and others. As a result, the present required actions to maintain fire safety in buildings are mostly technological in nature and infrequently take into account how a structure is typically used. More importantly, it appears that consideration of actual evacuation behavior in the event of fire has been overlooked. The interpretation of a building's fire safety shifted from a technological to a more behavioral approach at the turn of the 20th century. An occupant response shelter escape time (ORSET) model, for instance, was developed by Sime (1999, 2001) [11,12]. This theoretical approach integrates engineering and architectural aspects of building fire protection with human behavior during building evacuation (psychology, facilities management). Premovement index, visible access/wayfinding design/index, methods of escape, and occupancy population and activity profiles are the occupancy risk factors used to represent the ORSET. Sime views occupancy as the interaction between individuals and their surroundings, and it is considered that occupancy and behavior are influenced by one's environment. People are seen in terms of (stable) personality traits, abilities, and individual qualities according to the conventional psychological perspective. Sime contends that individuals do not react the same manner in one physical (and social) setting as they do in another. This shows that people behave in ways that reflect their ability to adjust to their environment as well as the information and opportunity structures made available to them by various environments [12]. This method also suggests that the likelihood of a safe escape depends not only on an individual's personal traits or the "use and occupancy classification" of the building in which they happen to be; it may also be influenced by the structure's layout, floor plan, and (interior) design. For instance, the likelihood of surviving a fire is significantly influenced by the presence of fire safety features like escape routes and emergency exits. On one hand, the location of the fire affects this availability. Beginning at the turn of the 20th century, the first studies of movement velocity and movement time were made. Since then, numerous researchers from around the world have made significant contributions to this field, including Fruin (USA), Paul's (USA), Predtetschenski and Milinski (Germany) [8–10], Habicht and Braaksma (Canada) [10], and Jin [13]. It is possible to estimate the necessary escape periods for a variety of building types and building populations because the time required for relocation is rather well documented [8]. In order to do this, the findings of Paul's and Fruin's investigations have been transformed into mathematical tools that are now incorporated into fire engineering laws and standards of practice. Jin added something significant when he discovered that walking behavior in smoke-filled areas differs from that shown in other studies in locations free of smoke contamination. Furthermore, the conduct of the elderly, youngsters, and people with certain impairments differs from what was anticipated and taken into account in the earlier calculating methods mentioned. With a study on the evacuation of a high-rise structure, significant investigation into the evacuation of the functionally challenged started in the 1970s. Boyce, Shields, and Silcock, among others [8-20], have also done significant examinations into this matter. Studies on the defend-in-place strategy and the safe usage of elevators during fire evacuations were specifically done. The idea of making elevators appropriate for evacuation in the event of a fire dates back to the early 1980s [21], but there isn't much actual data showing how using them affects survival rates. The analyses of the WTC 9/11 tragedy are the most significant to date, with estimates that self-evacuation and the usage of elevators in the South Tower saved 3000 people [22]. The research from the WTC in 1993 and the WTC 9/11 tragedy are essential to our comprehension of human behavior in high-rise building evacuations (2001). Researchers provided information on issues like escape and pre-movement times, pre-movement behaviors, stairway flow rates, and elevator utilization. First-person testimonies from publications like newspapers, radio and television shows, e-mail correspondence, and a variety of websites were used as the basis for an early study by Fahy and Proulx [23]. 435 survivors from the two WTC towers were represented by the 475 stories that were examined in total. In additional study [24 28] by Galea and colleagues, about 300 WTC survivors were questioned, resulting in nearly 6000 pages of transcripts and a wealth of specific information about the evacuation of the twin buildings. More than 1,000 survivors were interviewed for a third research endeavor by Averill and colleagues. A High-rise Evacuation Evaluation Database (HEED), which is available to academics worldwide, contains all of the data acquired from investigations into the WTC 9/11 disaster. According to study by Sime, Proulx, and Fahy [29,30], pre-movement time is a more crucial component of the necessary escape time than the time required to go to a safe location. In addition, event investigations have revealed a link between a protracted evacuation and a high rate of fire fatalities or injuries, particularly in lodging facilities and apartments. As a result, the pre-movement period and pre-movement behavior are now seen as crucial elements of the evacuation procedure. In the past 20 years, there have been a number of research on the former. Previous analyses, in particular those of the Cocoanut Grove Dance Hall fire in Boston in 1942 and the Beverly Hills Supper Club fire in Southgate, Kentucky, in 1977, had already shown that a delayed evacuation had led to a significant number of fatalities. However, at the time, researchers attributed the fatalities to the unique features of these two fires. Though pre-movement delays are significantly less extensively recorded and measured [2], it is now recognized that there is a delayed evacuation in almost every fire [9]. Most of the evacuation (simulation) models that exist are based upon calculations in which the distance to exits, walking velocity and the flow rate capacity of corridors, doors and stairs are decisive [31]. This is the result of prior research, which predominantly focused on these aspects of evacuation. Few simulation models are based on human behavior in evacuation scenarios, such as the preference for specific routes or exits, or the time needed to gather and interpret information. This is due to the dearth of quantitative research information on these topics. Further study is needed since some of the behaviors displayed during evacuations are not fully understood [31]. Sime, for instance, contends that floor plans should be linked to appraisals and that occupancy concerns need to be better operationalized in case study work. Evacuation is the third option, while taking cover and waiting to be rescued is the other. Even though the fire brigade was not summoned to 78 percent of household fires in Great Britain and 75.2 percent of those in Australia, there is very little information in the literature about a building's residents putting out a fire [32This indicates that approximately 75% of the fires in these nations either extinguished themselves or were put out by the efforts of the residents. Regarding the "shelter and wait" technique, it has been observed that in a number of fires, people tended to walk through smoke or even decided to jump out of a building [33,34]. However, the tactic of telling guests or residents of apartment buildings to remain in their apartments is probably a successful technique to ensure their survival during a fire [5], [35,36].

III. THE CONSIDERATION OF FIRE SAFETY IN STRUCTURES

Load-bearing walls Any building must have load-bearing walls as well as a solid foundation. In order to move vertical loads from slabs and beams to other suitable structural components and finally to the foundation, these walls must be strong enough. To survive the impacts of fire, these walls need be a certain thickness. To serve as fire barriers for an extended period of time, they should be thicker in section. The IS code-1642 provides the precise section thickness (1989). 2. Flooring Bricks, concrete, stones, tiles, etc. are frequently used as flooring materials since they are thought of as a part of fire-resilient building. However, timber flooring or other flooring types that are more prone to fire must be utilized if the use of such materials is not practical. Thicker joists should be used in the construction for wooden floors. Additionally, there should be more space between these joists. Alternately, flooring can be covered in protective insulator covers. Materials like bricks and ceramic tiles might be examples of this. 3. Framed Structures Steel and reinforced concrete constructions are also possible types of framed buildings. Under intense fire, steel buildings typically twist and deform. In order to protect them, metal lath or plaster is applied. The minimum thickness for these materials should be 10 cm, whether they are made of bricks, concrete, or tiles. Frame members (beams and columns) in reinforced concrete should have enough concrete covering to provide their best performance in a fire. This cover should have a minimum thickness of 5 cm. 4. Partition walls Building fire-resistant partition walls typically involves the use of reinforced cement concrete (R.C.C.), reinforced brick concrete (R.B.C.), asbestos cement board, hollow concrete, etc. However, metal lath and plaster are used to cover timber partition walls when they are constructed. 5. Ceiling Plaster, metal lath, and asbestos cement board are frequently utilized in the ceiling framework to increase fire protection. For further stability and strength, the floor joists and ceiling joists must be directly connected. 6. Doors Ensuring the doors and windows' integrity during construction is essential because they serve as the escape routes in the event of a fire emergency. Since they have a higher heat resistance than regular glass panels, they must be glazed and fitted with reinforced glass panels. A step in providing fire protection is using metal door frames. 7. Stairs Of the case of a fire, windows and doors in one- or two-story structures offer sufficient escape routes. However, in multi-story buildings, the placement of the staircase is crucial. It needs to be equally reachable from all areas of the structure. For stair construction, it is recommended to use R.C.C. as far as the material is concerned. For further security, enclosure walls around the stairwell should be constructed using fire-resistant materials. 8. Roofs In terms of fire safety, a flat roof is usually preferable. This is because, in the event of poor wind conditions, fire spreads more quickly on a sloped surface. However, if a pitched roof must be erected, fire-resistant materials should be used to build or cover the ceilings [36].

IV. CHALLENGES IN STRUCTURES' FIRE SAFETY

1. Accessibility:
   Ensuring that firefighters have clear and rapid access to all parts of a building, especially upper floors in high-rise structures, is a major challenge.
2. Complex Designs:
   Modern, complex, or high-rise buildings can present intricate layouts that complicate evacuation and fire suppression efforts.
3. Fire and Smoke Spread:
   High-speed spread of smoke and heat can quickly fill escape routes, making evacuation impossible, particularly in high-rise buildings.
4. System Reliability and Maintenance:
   The effectiveness of active systems like sprinklers, alarms, and smoke control depends on their proper installation, regular inspection, and ongoing maintenance, which is often a challenge.
5. Occupant Awareness and Training:
   Occupants need to understand fire safety protocols, escape plans, and how to operate fire equipment, but awareness and training levels are often insufficient.
6. Urbanization and Congestion:
   Increased urbanization and congestion contribute to a higher risk of fire, demanding better fire safety infrastructure and compliance.
7. Varying Building Materials:
   While some materials are inherently more fire-prone, even non-combustible materials can lose structural integrity under high temperatures, complicating fire performance assessments [37].

V. CONCLUSION

To provide complete building safety, fire safety management must be properly executed by a full commitment from the building's users and inhabitants, educational building authorities, or local government authorities. Each of these makes a substantial contribution to achieving the goals of fire safety management. Nonetheless, there are some recommendations and improvements that ought to be done for the administration of fire safety in every educational establishment. Equipment must be changed or properly maintained in order to function as intended. Ignoring small issues and not being aware of them might occasionally have serious negative consequences down the road. The management should appoint subject-matter experts to perform jobs that call for their expertise, such electrical installation. In conclusion, building owners, employees, or management teams must adopt appropriate attitudes or behaviors in order to maintain effective fire safety measures, despite the fact that implementing fire safety management is now quite costly [38].

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