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APPLICATION OF PASSIVE FIRE PREVENTION AND PROTECTION MEASURES IN 3 STAR HOTEL: A CASE STUDY OF MAIDUGURI INTERNATIONAL HOTEL MAIDUGURI

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Abstract: *Passive fire prevention and protection measures in 3 star hotel is the collection of non- active components of the building that slow or stop the spread of fire, smoke and heat. The objectives were to determine; fire protection in hotel buidungs; effectiveness of compartmentalization; the importance of fire rated wall, doors, and glasses as a system of passive fire protection measure. The data was collected through case study and physical observation obtain on materials used in Maiduguri International Hotel here in Maiduguri. Data collected were analyzed using photographs and diagrams. Finding shows that the hotel was gotten down by fire some years back and currently not functional but renovation has taken place right now when collecting data for the study. When observation and enquiry made it was realized that fire rated elements of building that can serve as passive fire protection was also used. The walls are reinforced concrete with gypsum-based plastering. Floors are solid concrete slabs with ceramic tiles finishing, ceilings are gypsum based ceiling tiles, doors used not all are fire rated doors but some has 1-hour fire resistance period, glasses are non-fire-rated and are combustible, have very low fire resistance quality which can lead to fire spread and propagation. It is recommended that compartmentalization should be strongly use in floors between partition of rooms and other enclosed space, and the use of fire rated doors that has 2- hour or more than that for both for internal and external can help, fire rated ceilings and fire rated glass can also help in limiting the propagating and spreading of fire from one point to other.*

Keywords: *Hotel Design, Fire Protection, Compartmentalization,*

Introduction

Hotel design by considering the aesthetics, functionality, symbolism and product design and discovered that symbolism and aesthetics in hotel design influence booking intention through quality expectation and emotional arousal (Beak & Ok, 2017). And also claimed that design also plays a crucial role in the decisionmaking process of consumers when they compare hotels. A successful hotel design can lead to reduced staffing levels and maintenance costs, increased sales, greater efficiency, higher gross operating profit and the need for lower capital investment (Ransley & Ingram, 2001).

Passive Fire Protection is the design and construction methods used to contain fires and prevent their spread within a building, without relying on active systems like sprinklers or alarms. The goal of PFP is to enhance the safety of the occupants and minimize property damage by using material

and structural elements that are resistance to fire. Passive Fire Protection (PFP) stands as an indispensable mechanism within structures, purposefully designed to hinder the rapid spread of fire. It plays a pivotal role in safeguarding occupants by granting crucial time for safe evacuation and supporting firefighters in effectively managing fires. Unlike active fire systems reliant on human intervention, PFP operates autonomously, seamlessly integrated into a building's structural framework (Arewa *et al.,* 2021)

The PFP consist of fire containment, utilizing fire-resistant elements like walls and doors to halt the spread of fire and smoke. Compartmentalization techniques segment buildings into fire zones, curbing fire expansion and limiting its reach. Ensuring structural integrity becomes paramount to withstand fire stress and prevent structural collapse, while regulating smoke movement aids in creating clearer evacuation pathways. Furthermore, robust fire-resistant systems endure fire impacts, facilitating safe evacuation, and strict adherence to building codes to uphold safety standards is imperative (Kurniawan *et al.,* 2018).

Fire compartmentation is the basis of effective passive fire protection in your building. It consists of structural fire safety measures such as fire-resistant partitions and fire doors. Those are used to divide the building into smaller compartments, limiting the spread of fire and smoke throughout the different rooms and floors. As a requirement when a building is over 30m in height, each story must be separated by a fully-compliant compartment floor. (Mak,2011).

Local building codes and regulations serve as guidelines governing building design and construction concerning fire safety (David *et al.,* 2019). These regulations typically fall into two categories: passive fire control systems and active fire control systems (Barnett, 2002). They emphasize avoidance of fire risks, assessment of unavoidable risks, and combating identified risks at the point of ignition (Fire Safety Code, 2013; National Building Code, 2006; NFPA, 2008). Passive fire control focuses on design elements such as escape routes, compartmentation, and access for firefighters (David *et al.,* 2019).

Exterior walls and interior walls between fire compartments are required to have a fire resistance rating of up to 4 hours (1.0 or 1.5 hours in most cases), depending on occupancy and distance to the boundary. (Document MP9:1989) The required minimum thicknesses vary from 75 mm for one hour to 175 mm for four hours.

Fire rated interior partition walls are: Masonry partition wall is partitions without load bearing built with various blocks. Masonry partitions mainly consist of clay brick partition walls, block partition walls, hollow brick partition walls, etc. When the thickness of partition wall is the same, the fire resistance depends on the type of blocks. Fire resistance of different kind of partition walls is different. Another factor that affects the fire resistance of partition walls is the masonry method. And the fire resistance ratio of the empty partition walls is inferior to stuffed partition. The masonry partition wall has high fire resistance and good heat insulation, but its unit density is larger than other kinds of partition walls. (Wang & Zhang 2018).

Skeleton partition wall is a light partition composed of stud and panel. The stud partition structure is flexible and can be erected to any height and thickness, and its interior can be filled with fireproof and heat insulating materials. According to the type of stud, stud partition can be divided into steel stud partition wall, wooden stud partition wall and gypsum stud partition wall. (Wang & Ang 2004).

The slat partition wall is assembled with partition plate whose height equals to the room. Slat partition wall can be divided into combustible plate partition and non-combustible plate partition (G. Thomas, 2002). Combustible plate partitions include plywood partitions, plasterboard

partitions, particleboard partitions, and Tabor partitions. Non-combustible plate partition walls mainly include calcium silicate board partition wall and metal plate partition wall. Their thickness is mostly 60- 120mm, and the quality is light and convenient in construction. For slat partition walls, main factors affecting the fire resistance is the panel type with which fire endurance vary (Kolaitis & Founti, 2013). As the skeleton partition wall, thickness of the plate and wall decoration will affect the fire resistance of the slat partition wall. The slat partition walls are of light quality, high strength, energy saving, earthquake resistance. It increases the use area, reduce the project cost and has some other advantages.

A fire door is a door with a fire-resistance rating (sometimes referred to as a fire protection rating for closures) used as part of a passive fire protection system to reduce the spread of fire and smoke between separate compartments of a structure and to enable safe egress from a building or structure or ship. (Mak,2011).

According to Mark (2011). Fire rated walls are classified into FD30, FD60, FD90, FD 120 and FD 240. FD30 fire doors offer 30 minutes of fire resistance. These doors are commonly used in residential settings and low-risk commercial areas. They provide sufficient time for occupants to evacuate safely and help prevent the spread of fire and smoke. FD60 fire doors provide 60 minutes of fire resistance. These doors are typically used in higher-risk areas, such as commercial buildings, schools, and hospitals. They offer enhanced protection against fire and smoke, giving occupants more time to evacuate and firefighters additional time to respond. FD90 fire doors offer 90 minutes of fire resistance and designed for high-risk environments, such as industrial settings or areas where flammable materials are stored. They provide extended protection against fire and smoke, crucial for containing fires in hazardous locations. FD120 fire doors provide 120 minutes of fire resistance. These doors are used in critical areas that require the highest level of fire protection, such as data centres, power plants, and other high-risk facilities. They offer maximum protection against fire and smoke, ensuring the safety of occupants and valuable assets. FD240 fire doors provide 240 minutes (4 hours) of fire resistance. These doors offer the highest level of fire protection and are used in extremely high-risk environments or areas requiring maximum fire containment. They are typically found in specialized industrial facilities, critical infrastructure installations, or other locations where prolonged fire resistance is essential for safety and asset protection.

Fire-rated glass is a specialized type of glass designed to withstand extreme heat and prevent the spread of fire and smoke for a specified duration. It is commonly used in doors, windows, and partitions where transparency is required but fire resistance is essential. Fire-rated glass can maintain its integrity and performance during a fire, providing safe evacuation routes and protecting building occupants (Pilkington, 2021). Tempered glass is heat-treated to enhance its strength. In fire-rated applications, it can resist heat for short periods, typically around 20 minutes. It is commonly used in fire doors and interior applications where minimal fire resistance is required (Pilkington, 2021). Ceramic glass is known for its high heat resistance and can withstand temperatures up to 1,400°F. It is often used in doors, windows, and walls requiring longer fire-resistance ratings, ranging from 45 to 90 minutes (Saint-Gobain, 2022). Ceramic glass is typically transparent or translucent, making it suitable for maintaining visibility in spaces that need fire protection. Wired glass contains a mesh of wire within the glass that holds the fragments together during a fire. It can provide fire resistance for 45 to 60 minutes. However, due to safety concerns regarding impact resistance, wired glass has become less common in modern applications (Underwriters Laboratories, 2020).

Fire rated laminated glass consists of multiple layers of glass bonded together with a fire-resistant interlayer. It can provide fire resistance for up to 120 minutes, offering both fire protection and resistance to impact, making it ideal for high-traffic areas like stairwells and corridors (Guardian Glass, 2023).

Methodology

Study Area

The study was conducted in Maiduguri the capital city of Borno state. It is located at the central part of the state and fall within the latitude 11°50'48.91''N longitude 13°9'25.63''E. It covers an area of approximately 50778km^2 and has a population of about 1,907,600 as of 2007. Maiduguri shares boundaries with Mafa to the east, Benisheik to the west, Konduga to the south and Nganzai local government to the north. It is located within the Sudan savannah region of Northern Nigeria with tree distinct seasons; namely dry cold, dry hot and wet season

Research Design

A descriptive study aims to obtain existing data from the passive fire protection measure at Maiduguri International Hotel. Research variables are from the results of the literature review that has been carried out. Based on this, it requires primary data obtained from field observations as well as secondary data in the form of information related to the location and various literature needed.

Case Study: Maiduguri International Hotel

The Hotel own by Borno State Government and established in 1982. Maiduguri International Hotel is a 3-star hotel located along Damboa Road in Maiduguri the capital city of Borno State. The Hotel is 7- floor vertical building consisting of 150 rooms and suites, conference and banquet halls, restaurant and bar, swimming pool, gym and fitness center, business center and 24-hour security.

Fig.1: Map showing the location of Maiduguri international hotel

Source: Gland Measure, 2024.

Result and discussion

Fire Rated Walls: Exterior walls and interior walls between fire compartments are required to have a fire resistance rating of up to 4 hours (1.0 or 1.5 hours in most cases), depending on occupancy and distance to the boundary. (Document MP9:1989)

It is a non-combustible fire separator that subdivides a structure or divides neighboring structures to resist fire growth and has a fire-resistance rating as specified in this code as well as strength to maintain intact under fire circumstances for the required fire-rated period. Geopolymer bricks can be manufactured to be fire resistant. As a result, high-calcium fly ash geopolymer may be employed as a fire-resistant material. (Ivison, 2017)

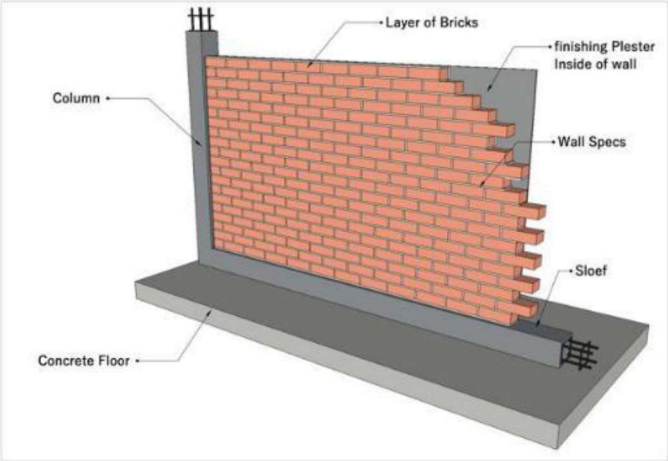

Fig.2: Traditional plastered brick wall as a means of passive fire protection

Source: Thermal Environment Control of Buildings using Installation of Plants and Metal Panels on Brick Walls,2021

The exterior walls are fire rated walls: reinforced concrete with gypsum-based plastering and bricks cladding for fire resistance and insulation was used. These can resist fire for a long period of 3 to 4 hours as shown below on the photograph below.

Plate 1: Hotel external wall constructed with Bricks and solid concrete block walls

Source: Author's Fieldwork, 2024

Plate 2: Hotel internal fire rated wall at lift area

Source: Author's Fieldwork, 2024

Fire partition walls are walls inside a building that subdivide specific rooms and floors. The vertical assembly partitions extend from the floor up to the ceiling and constructed with gypsum-based material. Gypsum is a non-combustible material and makes no contribution to fire: it works, in fact, as a built-in sprinkler. One square meter of a 12,5 mm gypsum board contains approximately two liters of water of crystallization in the gypsum core. Its high-water content provides up to 90 % of the fire resistance protection of gypsum boards. The calcination process takes place when the gypsum is exposed to heat at a temperature of at least 80 °C, and this water prevents the fire from penetrating the board while it is evaporating. The calcination process is mostly complete when the gypsum board reaches a temperature of 125 °C and becomes an anhydrate, CaSO4. This process requires much energy and time

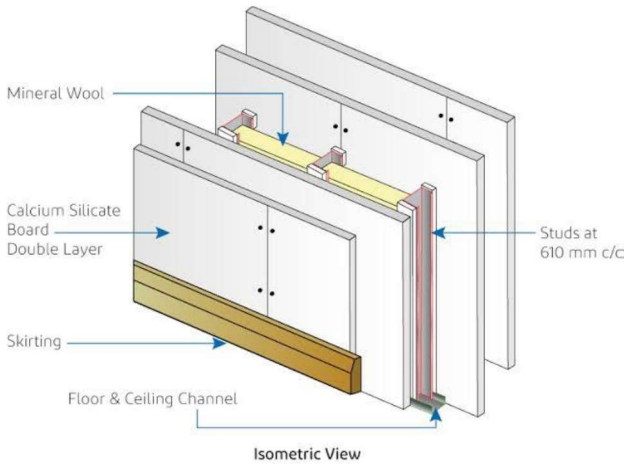

Figure:3 Showing Fire rated Partition wall with gypsum based and mineral wool inside Source: (International Building Code [IBC], 2018).

Internal walls:
Internal walls of the hotel are partition walls coated with gypsum-based plastering with wool inside. The material used is fire resistance material, heat and sound insulator.

Plate 3: Hotel Internal partition wall constructed with Gypsum based with wool insulating material inside
Source: Author's Fieldwork, 2024

Plate 4: Hotel internal fire rated wall
Source: Author's Fieldwork, 2024

Fire Rated Doors: A fire door is a door with a fire-resistance rating (sometimes referred to as a fire protection rating for closures) used as part of a passive fire protection system to reduce the spread of fire and smoke between separate compartments of a structure and to enable safe egress from a building or structure or ship. (Mak,2011).

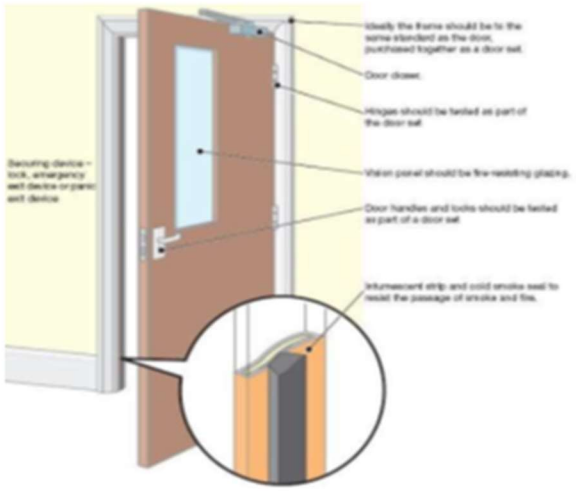

Figure: 4. Showing FD60 Fire Doors
Source: (Mak,2011).

Figure:5. Showing FD60 Fire Doors
Source: (Mak,2011).

Internal and External doors used in the hotel not all are fire rated doors but some of the double doors that are associating lobbies and corridors of the hotel has 1-hour fire resistance period but the internal doors are not fire rated walls they are combustible.

Plate5: Maiduguri International hotel double doors 1 hour fire rated door
Source: author's field work (2024)

plate 6: Single door non fire rated door

Source: Author's field work (2024)

Fire Rated Glass:

Fire-rated glass is a specialized type of glass designed to withstand extreme heat and prevent the spread of fire and smoke for a specified duration. It is commonly used in doors, windows, and partitions where transparency is required but fire resistance is essential. Fire-rated glass can maintain its integrity and performance during a fire, providing safe evacuation routes and protecting building occupants (Pilkington, 2021).

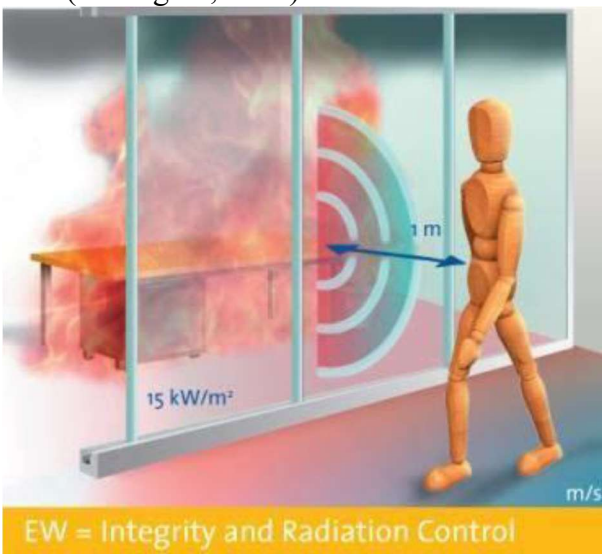

Fig.6: Fire rated glass as a means of passive fire protection

Source: (Pilkington, 2021).

Perspective view of Maiduguri International Hotel showing horizontal windows. The Image was taken after the fire incident that occurred few years back, and clearly seen the level of destruction of combustible clear non fire rated glasses that was used in the windows.

Plate 7: Maiduguri International Hotel pesrpective view showing damages cause by fire to non fire rated glass used in the hotel

Source: Author's field work, 2024.

Conclusion

Passive Fire Protection measures are incorporated into the construction to offer solidity into the walls and floors, separating the building into sections with compartments. Such security is either gotten from by the materials used to construct the structure or is added to the building to enhance its fire resistance. In the Maiduguri International Hotel building the passive fire protection systems is good but compartmentalization that was lacked, even though with the construction of elements like walls and floors with fire rated materials fire can still spread through some unrated fire resistance materials like doors, windows ceiling and glass of the hotel.

Recommendation

This study recommends that compartmentalization should be use in next rehabilitation of the Maiduguri international hotel, such as the internal walls must be of a material fire resistance such as solid bricks or block concrete wall or gypsum board with fire resistance coating. Fire resistance glass is also recommended to be used in the next rehabilitation such as wired glass contains a mesh of wire within the glass that holds the fragments together during a fire, Ceramic glass is known for its high heat resistance and can withstand temperatures up to 1,400°F. It is often used in doors, windows, and walls requiring longer fire-resistance ratings, ranging from 45 to 90 minutes (Saint-Gobain, 2022). Tempered glass is heat-treated to enhance its strength. In fire-rated applications, it can resist heat for short periods, typically around 20 minutes. It is commonly used in fire doors and interior applications where minimal fire resistance is required (Pilkington, 2021).

fire-rated doors should be located at both internals and externals door points. Furthermore, the fire escape door used in the building is not up to standard, fire-rated doors is what should be implemented. Creating a comprehensive fire safety system starts with the basic passive protection elements required by law. Fire-rated doors in hotels are imperative to keeping people safe and allowing them to safely evacuate the building in the case of an emergency. Fire doors play an important part in the passive safety of hotel employees and guests. Standard fire ratings range from 20 to 180 minutes, depending on code criteria. Fire-rated doors must be self-closing and firmly latching. To preserve the means of egress, they must remain closed during a fire.

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