



Passive Fire Prevention Integration Strategies in Shopping Mall Design: A Case Study of Abuja, Nigeria

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Abstract

Fire safety within retail complexes constitutes a critical concern owing to elevated occupancy levels, intricate spatial configurations, the substantial risk of human casualties and asset destruction during fire incidents. Nigeria's primary dependence on active protection mechanisms including sprinkler systems and audible alarms frequently overshadows the incorporation of passive fire prevention approaches, resulting in numerous retail centres remaining susceptible to fire hazards. This research investigates passive fire prevention approaches within retail centres across Abuja, seeking to ascertain fundamental components, evaluate their efficacies, examine implementation obstacles, and suggest approaches for future developments. An integrated descriptive framework was utilized. Structured instruments were distributed to architecture professionals, facility administrators, and safety personnel, supplemented by direct location evaluations and examination of fire safety regulations. The investigation identified fire-resistant building materials, spatial compartmentalization, smoke management systems, and properly designed evacuation pathways as the most potent components. Surveyed retail centres revealed that existing configurations predominantly emphasize active fire protection systems, while passive approaches remain underutilized. Merely 10.63% of centres incorporated fire-resistant evacuation routes, and less than one-third supplied adequate smoke management or emergency vehicle access. Principal obstacles identified include inadequate enforcement of safety regulations (RII 0.756), elevated expenses of fire-resistant materials (RII 0.754), restricted awareness among parties, and insufficient professional preparation. Passive fire prevention approaches remain underutilized within Abuja's retail centres, despite their essential function in improving fire safety. The study advocates strengthened regulatory enforcement, implementation of affordable fire-resistant materials, enhanced professional instruction, and design frameworks that incorporating passive approaches alongside active systems.

Keywords: Fire protection, passive prevention, retail complexes, spatial separation, Abuja

1.0 Introduction

Retail complexes with their striking architectural expressions represent characteristic features of 21st-century global development, emerging throughout numerous urban centres worldwide (Moradi, 2022). Consumers gravitate toward environments reflecting their identities, becoming focal points for particular social and recreational pursuits (Elejo & Abdulrahman, 2016). Fires within retail complexes have generated extensive financial destruction and resulted in untimely fatalities, adversely affecting victims, their relatives, and the broader nation across psychological and economic dimensions (Bayo & Kayii, 2020). Earlier investigations into retail complex fires indicate that human-related elements encompass negligent utilization of

electrical devices, tobacco consumption and improper disposal of cigarette remnants, gas releases from cooking cylinders, inappropriate fuel storage, overburdened electrical outlets, deteriorated electrical wiring, unauthorized electrical connections, and general deficiency in safety consciousness (Mubita et al., 2023). These elements represent the most frequent ignition sources. The British Standard characterizes fire protection as "actions incorporated within building design or installation to diminish danger from fire" while fire prevention constitutes "actions to avert fire initiation" (Kincaid, 2022).

Nigeria's advantageous circumstances regarding location, governance, economic activity, and other operational aspects have generated substantial expansion in commercial activity (Olonade et al., 2021). Due to elements including shifting population characteristics, increasing urban concentration, expanding middle-income groups, and evolving retail habits, Nigeria's commercial sector anticipates approximately 200,000 square meters of construction space (Eleajo & Abdulrahman, 2016; Sakketa, 2023). The most destructive, costly, and disruptive sources of building damage originate from fires, predominantly occurring within retail complexes in Nigeria, positioning fire safety among the most essential and specialized considerations in constructing public facilities (Eleajo & Abdulrahman, 2016). Given the numerous fire-related damages documented globally, investigators and specialists must persistently explore innovative prevention approaches (Arowolo et al., 2021). Active and passive fire prevention approaches must be utilized together to guarantee secure and pleasant retail experiences, particularly during fire emergencies. Passive fire prevention becomes incorporated within building design, unlike active protection equipment including sprinklers or warning devices, ensuring continuous protection and conformity with fire safety requirements (Kodur et al., 2020; Zhang, 2023).

To put the problem in a proper perspective, fire incidents within designed retail complexes endanger individuals and their possessions. Numerous attempts have sought to decrease building fire hazards (Odaudu, 2021). Retail complexes in Nigeria depend on emergency services to suppress fires instead of utilizing facility fire safety equipment. This pattern has generated societal difficulties, rendering it essential for commercial centres to employ both active and passive fire protection equipment. The substantial losses resulting from retail complex fire incidents reveal structural deficiencies in prevention on an international scale. These catastrophes have demonstrated the insufficiency of depending exclusively on active fire systems including sprinklers and alarms. Effective evacuation pathways, spatial separation, and fire-resistant materials exemplify passive fire protection approaches essential for minimizing damage and fire propagation. Nevertheless, incorporation of such passive approaches remains restricted within numerous retail complexes across Nigeria.

This investigation aims to identify and incorporate appropriate passive fire prevention measures aligning with architectural and operational requirements of retail complexes in Abuja. Specific objectives encompass: identifying fundamental passive fire prevention components essential for improving safety within retail complexes; evaluating efficacy of existing architectural configurations in accommodating passive fire prevention approaches; examining obstacles encountered in incorporating passive fire prevention measures within retail complex designs; and integrating optimal passive fire prevention approaches for retail complex design in Abuja.

The geographical context of the study, Abuja, the Nigeria's capital city, occupies the nation's central region. During December 1991, Abuja formally became Nigeria's capital, superseding

Lagos. The city shares boundaries with Nasarawa State toward the east, Kaduna State toward the north, Niger State toward the west, and Kogi State toward the south. Abuja lies within the Nigerian savannah between latitudes 8°25'N and 9°20'N and longitudes 6°45'E and 7°30'E. The Federal Capital Territory encompasses 7,315 square kilometers within savannah terrain featuring moderate climatic conditions. Temperatures fluctuate between 30°C and 37°C throughout dry periods, with dry season temperatures decreasing to approximately 17°C (Agunleti & Arikawe, 2014).

2.0 Conceptual Review

2.1 Fire Safety within Retail Complexes

Fire safety encompasses measures designed to prevent or avoid fire occurrence, with the control of development and consequences of accidental or intentional fires while maintaining resulting losses within acceptable boundaries (Kodur et al., 2020). Given the potential for widespread casualties, economic interruption, and structural failure during fire incidents, fire safety proves essential within public spaces including retail complexes where substantial crowds assemble for extended durations (Nimlyat et al., 2017; Audu, 2021).

2.2 Concept of Fundamental Fire Triangle

Fire constitutes chemical interaction among three components: combustible material, oxygen, and thermal energy. These elements represent the triangle's three supporting sides. Until all three converge, fire cannot commence. Combustion occurs when atmospheric oxygen combines with combustible vapours released by fuels, producing heat at molecular levels when activated by matches, sparks, or flames (John, 2014). The fire tetrahedron incorporates four elements: combustible material, ignition source, oxidizing agent (typically ambient oxygen), and chemical reaction sequence (Ramamurthi, 2023).

2.3 Passive Fire Prevention Approaches

Fire prevention measures incorporate integrated design elements, fire detection and warning systems, and fire suppression equipment. When fires erupt within designed facilities, individuals and their possessions face danger (Doherty, 2024). Passive fire prevention becomes incorporated within building design, ensuring continuous protection without mechanical activation requirements.

Fire-Resistant Materials: Materials specifically engineered or processed to endure elevated temperatures and resist ignition encompass concrete, steel with intumescent coatings, gypsum panels, fire-resistant glass, treated timber, masonry, stone, mineral wool, fiberglass, and cementitious boards. These materials retard fire propagation, provide extended evacuation periods, minimize property destruction, and ensure conformity with fire safety regulations.

Spatial Compartmentalization: This proves essential within passive fire prevention techniques by providing refuge areas for building occupants, facilitating firefighter access and departure for evacuation purposes (Mohammed & Abdulrahman, 2023). Through preventing vertical and horizontal fire spread, spatial separation enables occupants to escape during fire incidents.

Smoke Management Measures: Smoke management systems within retail complexes prove crucial for maintaining breathable atmosphere, preserving visibility, and providing secure

evacuation pathways (Khalil & Khalil, 2020; Lei et al., 2022). Smoke ventilation systems extract smoke and introduce fresh air through mechanical and natural ventilation approaches. Smoke curtains or barriers constructed from fire-resistant materials contain and direct smoke movement (Halawa & Safwat, 2021).

Evacuation Pathways and Emergency Exits: Evacuation pathways refer to continuous, unobstructed routes from any building location to public areas, comprising exit access, exit, and exit discharge (Bukowski & Tubbs, 2016). Emergency exits represent doors or escape routes specifically designed to enable rapid evacuation, equipped with features including panic hardware and fire-rated construction.

2.4 Nigerian Fire Safety Regulations and Standards

The National Building Code establishes minimum specifications for building design and construction throughout Nigeria. The Code's Section 5 addresses safety measures and fire prevention, requiring fire-retardant materials or coatings on walls, floors, and roofs incorporating timber components. Staircases must utilize steel, iron, and reinforced concrete according to Section 5.3.5. Section 5.3.7 mandates sprinkler systems within all administrative structures (Ekhaese & Ndimako, 2023). According to the Fire and Rescue Act of 2007, automatic fire sprinklers must be installed throughout every room of structures exceeding 24 meters above ground level.

3.0 Methodology

3.1 Research Design

This investigation employed a descriptive methodology for collecting and analyzing information utilizing both primary and secondary sources. Primary information was obtained through direct site observations, structured questionnaires distributed to occupants, architectural professionals, facility administrators, and safety personnel, and detailed discussions with essential stakeholders. Secondary information originated from architectural drawings, fire safety regulations and standards, and pertinent literature.

3.2 Population and Sample Selection

Eight retail complex buildings were chosen, with four utilized as detailed case studies throughout Abuja, Nigeria. A sample comprising 300 questionnaires was distributed to ensure pertinent and varied viewpoints. The population encompassed retail complexes within Abuja, architectural professionals, facility administrators, and safety personnel responsible for complex operations.

3.3 Analytical Methods

Statistical instruments including mean values and Relative Importance Index (RII) were utilized to quantify fire safety measure levels. The RII calculation formula is: $RII = \frac{\sum W}{A \times N}$, where W represents weight assigned to each statement, A represents maximum possible response integer (5), and N represents total respondent count. Case study comparisons emphasized similarities, differences, and optimal practices.

4.0 Results and Discussion

4.1 Participant Characteristics

Analysis of participant information from 207 respondents revealed 70.7% male and 29.3% female representation, indicating male-dominated professional environments. Age distribution showed 48.8% aged 26-35 years, 28.5% aged 36-45 years, and 17.4% aged 18-25 years. Professional backgrounds encompassed 31.8% architectural professionals, 20.9% engineering specialists, 18.9% facility administrators, and 14.93% fire safety personnel. Experience levels indicated 42% with 1-5 years, 38.5% with 6-10 years, and 7.7% with 11-15 years. Significantly, 61.3% had participated in projects involving fire safety considerations.

4.2 Summary of Essential Passive Fire Prevention Components

Table 1 presents the assessment of key passive fire prevention elements essential for enhancing safety in shopping malls. The results demonstrate substantial consensus regarding fire-resistant material importance (mean 3.82) and recognition of passive measures (mean 3.62). However, awareness of compartmentalization scored lowest (mean 2.65), indicating necessity for enhanced education concerning this essential fire prevention component. The investigation's emphasis on fire-resistant materials and unobstructed evacuation routes corresponds with Kodur et al. (2020) and Zhang (2023), who emphasized passive fire protection incorporation within architectural designs.

Table 1: Assessment of Essential Passive Fire Prevention Components

S/N	Variable	(Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly Agree)	Mean Value
1	Recognition of Passive Fire Prevention Measures	13 (6.3%)	23 (11.1%)	45 (21.7%)	74 (35.6%)	52 (25.2%)	3.62
2	Awareness of Compartmentalization	38 (18.3%)	58 (27.9%)	63 (30.3%)	37 (17.8%)	12 (5.8%)	2.65
3	Importance of Fire-Resistant Materials	14 (6.7%)	9 (4.3%)	57 (27.5%)	48 (23.1%)	79 (37.9%)	3.82
4	Awareness of Fire Exits, Staircases, and Evacuation Routes	23 (11.1%)	31 (15.0%)	46 (22.1%)	62 (29.9%)	45 (21.7%)	3.36
5	Understanding the Role of Smoke Barriers	23 (11.1%)	38 (18.3%)	43 (20.7%)	42 (20.3%)	61 (29.3%)	3.39

Source: Authors Survey (2026)

4.3 Existing Passive Fire Prevention Measures within Abuja Complexes

Assessment of current complexes exposed substantial deficiencies in fire safety implementation. Merely 10.63% of complexes contained fire-resistant evacuation routes, indicating inadequate enforcement of construction standards. Unobstructed exit access appeared within 41.06% of complexes, suggesting that while some advancement exists, numerous complexes still lack adequate evacuation pathways. Emergency vehicle access existed within only 29.95% of complexes, a critical deficiency impeding emergency responders' ability to reach and manage fire emergencies. Interior emergency areas were documented within merely 14.98% of complexes, and 3.38% of complexes lacked any observed passive fire prevention measures.

4.4 Summary of Obstacles in Passive Fire Prevention Integration

Table 2 presents the Relative Importance Index analysis of challenges encountered in integrating passive fire prevention measures. "Weak enforcement of fire safety regulations" ranked highest with RII 0.756, indicating its position as the most substantial obstacle. "High cost of fire prevention measures" followed closely with RII 0.754. The least critical concern was "Difficulty obtaining fire-resistant materials" (RII 0.498), suggesting that enforcement and expense present more pressing challenges than material accessibility. These findings correspond with Daramola & Ibrahim (2021), who identified financial and regulatory barriers to comprehensive fire safety measure implementation.

Table 2: Relative Importance Index (RII) of Implementation Obstacles

S/N	Variable	ΣW (Weighted Sum)	RII	Rank
1	High cost of fire prevention measures	781	0.754	2
2	Lack of awareness about passive fire prevention strategies	720	0.695	4
3	Difficulty in obtaining fire-resistant materials	517	0.498	5
4	Weak enforcement of fire safety regulations	783	0.756	1
5	Complexity of incorporating passive fire prevention strategies	712	0.688	3

Source: Authors Work (2024)

4.5 Summary of Case Investigation Findings

Jabi Lake Complex, Abuja: This 30,000 m² retail space is strategically positioned along Jabi Lake shores, oriented southwest to capture natural views. The complex incorporates interconnected walkways, escalators, and extensive parking. Emergency staircases and exits are present, though the facility depends substantially on artificial illumination and ventilation. The design effectively maximizes spatial utilization with organized parking and circulation systems.

Ceddi Plaza, Abuja: Located within the Central Business District, this five-story complex with basement accommodates 55 specialty retail establishments. While emergency staircases and exits are available, the facility lacks designated fire assembly points. Circulation space within the complex proves insufficient, and illumination and ventilation depend primarily on mechanical systems utilizing three 750KVA standby generators.

Ikeja City Complex, Lagos: This 23,000 sq. ft. retail centre comprises two levels with 96 retail establishments and three anchor tenants. The complex incorporates emergency staircases, exits, and unobstructed exit access. Construction materials include hollow concrete blocks, marble flooring, and steel sections for roof support. However, vehicle pathways remain inadequately separated from pedestrian routes, creating potential safety concerns.

Mall of America, United States: The nation's largest retail complex features four levels with 555 retail establishments. Strategic anchor store placement at each corner generates circuit arrangements producing substantial pedestrian flow. The complex utilizes glass skylights for natural illumination and thermal regulation, supplemented by artificial lighting for signage and wayfinding. Two multi-level parking structures adjacent to the main building serve visitors.

Willow Shopping Centre, Australia: This 30,800 m² centre employs circuit horizontal arrangements with anchors at each wing, facilitating convenient movement. The complex utilizes fire-resistant construction materials with firefighting equipment strategically positioned throughout each level. However, distance from building core to exits proves considerable, and dependence on mechanical systems for thermal regulation, cooling, and ventilation remains substantial.

Canal Walk Complex, South Africa: Africa's largest retail centre at 125,000 m² accommodates over 400 retail establishments. The complex employs interconnected corridor spaces with skylights extending throughout walkway lengths for natural illumination. While controlled access enhances security, parking space proximity to the building creates safety concerns, and passive security measures including bollards and planters remain absent.

5.0 Conclusions and Recommendations

5.1 Conclusions

Retail complexes represent sophisticated architectural structures attracting substantial crowds encompassing shoppers, workers, and service providers. Ensuring occupant protection during fire incidents constitutes a fundamental responsibility in designing and constructing these commercial spaces. This investigation examined passive fire prevention approach incorporation within retail complex design throughout Abuja, revealing that while passive measures including fire-resistant materials, spatial separation, and clearly designated evacuation pathways prove essential for improving safety, their incorporation within architectural configurations remains restricted.

Despite widespread utilization of active fire protection systems, numerous complexes throughout Abuja continue neglecting passive measure importance, leaving them susceptible to fire hazards. Principal obstacles identified encompass inadequate enforcement of fire safety regulations, elevated expenses of fire-resistant materials, restricted awareness among involved parties, and insufficient professional preparation. The investigation found that merely 10.63%

of complexes incorporated fire-resistant evacuation routes, and less than one-third supplied adequate smoke management or emergency vehicle access.

It is evident that passive fire prevention approach incorporation within Abuja's retail complexes proves inadequate, primarily attributable to restricted awareness, elevated expenses, and regulatory challenges. The findings emphasize necessity for strengthened regulatory frameworks, enhanced professional instruction, and increased public consciousness to ensure passive fire prevention approaches become adequately incorporated within future retail complex designs.

5.2 Recommendations

Based on investigation findings, the following recommendations emerge:

- i. **Regulatory Implementation:** Government agencies should strengthen enforcement of fire safety regulations throughout planning and approval processes. National Building Code provisions addressing fire-resistant materials, spatial separation, and evacuation pathways require rigorous monitoring and enforcement.
- ii. **Early Design Incorporation:** Architectural professionals should prioritize passive fire prevention features during initial design phases, including strategic positioning of fire exits, spatial separation, smoke management systems, and fire-resistant materials. These elements should become embedded within layouts ensuring smooth evacuation and minimizing fire spread.
- iii. **Material Selection:** Developers should specify fire-resistant materials including concrete, gypsum, fire-resistant glass, and intumescent-coated steel throughout retail complex construction. Locally accessible cost-effective alternatives should be identified and certified for fire resistance.
- iv. **Capacity Enhancement:** Continuous professional development programmes should concentrate on fire safety design, simulation instruments, and innovative materials. Architectural professionals, engineering specialists, and facility administrators require instruction regarding passive fire prevention approach integration.
- v. **Stakeholder Collaboration:** Multi-sector platforms should unite designers, developers, policymakers, and fire safety specialists to share optimal practices and build consciousness regarding long-term safety advantages. Collaboration among architectural professionals, engineering specialists, and fire safety experts proves essential for effective complex design.
- vi. **Fire Safety Assessments:** Regular fire safety assessments should be conducted within existing complexes evaluating conformity with safety standards and identifying areas requiring improvement. These assessments should examine emergency exits, signage, fire-resistant materials, and smoke management systems.
- vii. **Public Consciousness:** Consciousness initiatives regarding fire safety should be implemented improving conformity and safety within complexes. Occupants and staff should receive education regarding evacuation procedures and emergency exit locations.

5.3 Contributions to Knowledge

This investigation provides substantial contributions to architectural design and fire safety domains. It identified critical fire hazards including inadequate spatial separation, restricted utilization of fire-resistant materials, and improperly designed emergency exits compromising safety within commercial spaces. The research supplies comprehensive frameworks for incorporating passive fire safety measures within complex designs, emphasizing spatial separation importance, smoke management systems, and effective evacuation pathways.

The investigation empirically validates awareness-implementation disparities regarding passive fire prevention and strengthens connections between regulatory enforcement and building safety performance. Through statistical obstacle ranking utilizing Relative Importance Index analysis, it offers evidence-based priorities for enhancing fire safety within Nigerian retail complexes. The finding that inadequate fire safety regulation enforcement represents the most substantial obstacle (RII 0.756) demonstrates urgent necessity for strengthened regulatory mechanisms.

This work serves as a valuable resource for enhancing regulatory standards, raising safety consciousness, and guiding future commercial building designs minimizing fire hazards and protecting lives and property. It contributes to architectural practice by offering frameworks for fire-safe complex design throughout Nigeria, thereby advancing knowledge, policy, and practice within fire safety architecture.

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