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Implications for Urban Safety Policy in Nigerian Markets: Material Combustibility, Passive Fire Protection, and Fire Spread

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Abstract

Market fires pose a serious threat to urban safety in Makurdi, the capital of Benue State, resulting in significant financial losses, interruption of livelihoods, and damage to vital infrastructure. The extensive use of highly flammable building materials, insufficient passive fire protection measures, and lax enforcement of fire safety rules are all major contributors to the frequent occurrence of these disasters. In order to investigate the relationship between material combustibility, passive fire protection, and fire propagation, this study focuses on Makurdi marketplaces. A mixed-methods approach was used, which included laboratory testing of common market building materials, historical fire incident research, interviews with traders and fire safety officials, and field surveys of market structures. The findings show that while common materials like untreated wood, thermoplastics, and thin aluminum roofing sheets accelerate flame propagation, materials with inherent fire resistant qualities, such as gypsum boards, fire-rated concrete, and intumescent coatings, effectively slow fire spread. The lack of performance-based criteria for market buildings is one of the major gaps in Makurdi's application of Nigeria's National Fire Safety Code, according to the report. In order to increase Makurdi markets' resistance to fire dangers, these findings highlight the critical need for policy changes that incorporate material fire-resistivity criteria, improve passive fire protection, and bolster regulatory monitoring.

Keywords: Material combustibility, passive fire protection, market fires, fire spread, urban safety policy, Nigeria

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1. INTRODUCTION

Urban markets represent a significant component of the built environment in Nigerian cities, functioning as major centers for commercial activity and employment, particularly within the informal sector. In Makurdi, the capital of Benue State, markets form an essential part of the city's economic infrastructure by supporting livelihoods and facilitating access to goods for a growing urban population (Adelekan & Fregene, 2015; Odufuwa, 2020). Despite their functional importance, many urban markets in Nigeria exhibit poor building performance with respect to fire safety, making them highly susceptible to fire-related losses and structural failure.

Market fire incidents have increased in frequency across Nigerian cities in recent years, with reported cases in Lagos, Aba, Onitsha, Kano, Ibadan, and Makurdi. These incidents frequently result in extensive damage to market structures and stored goods, leading to severe economic losses and prolonged disruption of commercial activities. Data from the Federal Fire Service indicate that market fires account for a substantial share of urban fire incidents nationwide, with cumulative losses estimated at hundreds of billions of naira over the past decade (Federal Fire Service [FFS], 2023). The persistence of such incidents suggests fundamental deficiencies in building materials, construction practices, and fire safety provisions within market facilities.

A major contributor to fire vulnerability in Nigerian markets is the extensive use of combustible construction materials combined with informal and unregulated building methods. In Makurdi markets, stalls are commonly constructed from untreated timber, plywood, plastic sheets, foam panels, and lightweight metal roofing materials, often without professional design input or compliance with building regulations (Afolayan et al., 2021). These materials are characterized by low fire resistance and high combustibility, which promote rapid fire growth and horizontal flame spread once ignition occurs. Their widespread use reflects cost-driven construction decisions and limited regulatory control over market development (Olawuni & Adebayo, 2019).

In addition to material-related issues, the absence of passive fire protection measures significantly compromises the fire performance of market buildings. Passive fire protection elements such as compartmentation, fire barriers, fire-rated partitions, and fire-resistant structural components are critical for limiting fire spread and maintaining structural integrity during fire exposure (Babrauskas & Peacock, 2018). In most Makurdi markets, these measures are either absent or poorly implemented. Stalls are typically arranged in dense configurations without fire separation, roofing systems are continuous across multiple units, and internal circulation spaces are narrow or obstructed. These characteristics allow fire to propagate rapidly across large sections of the market once ignition occurs.

Fire spread in market environments is further intensified by high internal fuel loads and unfavorable spatial layouts. Market stalls often contain large quantities of combustible merchandise, including textiles, plastics, paper products, and packaged goods. When combined with overcrowded stall arrangements and limited ventilation control, these conditions create a high potential for rapid fire development and loss of containment (Hopkin, 2018). Ignition sources are commonly associated with electrical faults, open flames, or unsafe cooking practices, after which fire spread can quickly exceed the capacity of available firefighting infrastructure (Adelekan, 2016).

The observed fire safety deficiencies in Makurdi markets also highlight broader gaps in the

application and enforcement of building and fire safety regulations. Although statutory building codes and fire safety guidelines exist in Nigeria, enforcement within informal commercial developments remains limited. Inadequate coordination among planning authorities, fire services, and market management structures further constrains effective fire risk mitigation (Odufuwa & Alade, 2021). As a result, market buildings often evolve without systematic consideration of fire performance, material selection, or passive protection requirements.

From a building engineering perspective, repeated market fire incidents indicate a need for improved understanding of how construction materials and passive fire protection strategies influence fire spread and structural performance in informal commercial buildings. Losses sustained during such events not only affect traders and local economies but also highlight the limitations of current construction practices in meeting basic fire safety objectives.

Against this background, this study examines selected markets in Makurdi as a case study for assessing the influence of material combustibility and the absence of passive fire protection measures on fire spread in urban market buildings. By evaluating commonly used construction materials and existing building configurations, the study aims to provide evidence-based insights to support improved market design, regulatory compliance, and fire safety performance in similar urban contexts.

2. Literature Review

2.1 Material Combustibility and Fire Behavior

Material combustibility refers to the tendency of a construction material to ignite, sustain combustion, and contribute energy to a developing fire when subjected to thermal exposure (Drysdale, 2011; Karlsson & Quintiere, 2000). In building environments, particularly in informal and semi-formal structures, the combustibility characteristics of materials play a decisive role in determining fire growth rate, heat release, and overall fire severity. The selection and arrangement of combustible materials directly influence ignition probability, flame spread, and the potential for early flashover (DiNenno et al., 2016).

Combustible materials such as untreated timber, plywood, and thermoplastic products are commonly associated with rapid ignition and high rates of heat release. These materials contain organic compounds that undergo thermal decomposition when exposed to heat, releasing flammable gases that sustain combustion and accelerate fire development (Babrauskas, 2016). Experimental studies have demonstrated that low-density organic materials exhibit high peak heat release rates, significantly reducing the time to flashover in enclosed or semienclosed spaces (Tan & Lim, 2022). Once flashover occurs, fire spread becomes difficult to control, often resulting in extensive structural damage and total loss of the affected space (Karlsson & Quintiere, 2000).

Thermoplastics present additional fire hazards due to their melting and dripping behavior under elevated temperatures. As heating progresses, these materials soften and produce molten droplets that can propagate flames both horizontally and vertically, while also generating dense smoke and toxic combustion products. In commercial environments where plastics are widely used for wall linings, roofing sheets, and stored merchandise, their contribution to fire intensity and smoke production can severely compromise occupant tenability and firefighting effectiveness (Babrauskas, 2016; Purser, 2017).

In contrast, non-combustible and fire-resistant materials exhibit markedly different fire performance characteristics. Materials such as reinforced concrete, masonry, and gypsum-based products do not contribute fuel to a fire and generally possess high thermal inertia. This property enables them to absorb and dissipate heat without rapid temperature rise, thereby slowing fire development and delaying structural degradation (Drysdale, 2011). Gypsum boards, for instance, release chemically bound water during heating, which absorbs thermal energy and reduces surface temperatures under fire exposure (Hassan et al., 2023). Fire-treated composite materials similarly achieve improved fire resistance through chemical modification or protective coatings that limit ignition and flame spread.

The application of fire-resistant materials has been shown to reduce peak heat release rates and extend the available time for evacuation and firefighting intervention. Research in building fire engineering indicates that structures incorporating non-combustible linings and fire-treated components experience slower fire growth and reduced fire spread compared with buildings constructed predominantly from untreated organic materials (Hassan et al., 2023; DiNenno et al., 2016). These differences are particularly critical in densely occupied commercial spaces where fire loads are high and escape routes are often constrained.

In urban markets within developing cities, material combustibility is further influenced by construction practices and maintenance conditions. Incremental construction, aging materials, informal modifications, and the accumulation of combustible goods can significantly alter the fire behavior of building assemblies over time (Afolayan et al., 2021). Consequently, understanding the combustibility characteristics of materials commonly used in market buildings is essential for reliable fire risk assessment and the development of effective mitigation strategies.

Overall, material combustibility remains a central determinant of fire behavior, influencing ignition likelihood, fire growth dynamics, and the extent of fire spread. The widespread use of highly combustible materials in informal market structures highlights the need for improved material selection, fire treatment practices, and regulatory oversight to enhance fire safety performance in such environments (Afolayan et al., 2021; Adelekan, 2016).

2.2 Systems for Passive Fire Protection

Materials and architectural elements incorporated into buildings to stop or delay the spread of fire without active intervention are referred to as passive fire protection, or PFP. Fire-resistant coatings, compartmentation, fire rated walls, and ceilings are a few examples. Effective PFP systems have been shown to prevent fire spread in commercial buildings by up to 70% (Asadian et al., 2024). PFP is required by building codes in developed nations, especially for commercial spaces with heavy occupancy. However, because of financial limitations, ignorance, and lax enforcement of laws, passive fire prevention is not widely used in Nigerian marketplaces (Olayinka, 2021).

2.3 Fire Spread in Market Environments

Market buildings present distinct fire safety challenges due to their spatial configuration, construction practices, and operational characteristics. Unlike conventional commercial buildings, markets are often developed incrementally, resulting in dense stall arrangements, continuous roof systems, and limited consideration for fire separation. These characteristics

create conditions that are highly conducive to rapid fire spread once ignition occurs, particularly in environments dominated by combustible materials.

One of the primary factors influencing fire spread in market environments is the close proximity of stalls and the absence of effective fire compartmentation. Interconnected stalls facilitate both horizontal and vertical flame spread, allowing fire to move quickly across large sections of a market (Rahman et al., 2021). When partitions between stalls are constructed from combustible materials such as timber, plywood, or plastic sheets, they offer little resistance to flame penetration. As a result, fires that originate in a single stall can rapidly engulf adjacent units, escalating from a localized incident to a large-scale conflagration within a short period.

Continuous rooflines represent another critical pathway for fire spread in market buildings. In many markets, lightweight roofing materials such as corrugated metal sheets, plastic panels, or composite materials are installed without fire breaks or thermal barriers. Although some metal roofing materials are non-combustible, they can transfer heat rapidly, igniting combustible contents or structural elements beneath them (Drysdale, 2011). Where combustible roofing or ceiling linings are present, fire spread above stalls is further accelerated, often bypassing ground-level firefighting efforts and leading to widespread roof collapse (Afolayan et al., 2021).

High internal fuel loads significantly intensify fire spread in market environments. Markets typically store large quantities of combustible goods, including textiles, paper products, plastics, foam materials, and packaging. These materials contribute to high heat release rates once ignited, increasing flame intensity and shortening the time to flashover (Karlsson & Quintiere, 2000). Studies have shown that fires involving mixed commercial fuel loads develop more rapidly and generate higher temperatures than those involving structural materials alone, thereby increasing the likelihood of uncontrollable fire spread (Babrauskas, 2016).

Ventilation conditions within markets also influence fire behavior and spread. Narrow internal corridors, obstructed pathways, and poorly planned openings can create ventilation-controlled fire conditions, where sudden changes in airflow lead to rapid fire growth or backdraft events (Drysdale, 2011). In open-sided or partially enclosed markets, wind-driven fire spread can further exacerbate flame propagation across stalls, particularly when combustible materials are exposed (Hopkin, 2018).

The absence of firebreaks and passive fire protection measures remains a defining weakness in many market buildings. Firebreaks, compartment walls, and fire-rated partitions are designed to contain fires within limited areas and slow their spread. However, in informal and semi-formal markets, such provisions are rarely incorporated into the original design or subsequent expansions. Rahman et al. (2021) emphasize that the lack of compartmentation allows fires to escalate rapidly, overwhelming available firefighting resources and resulting in extensive losses.

Overall, the literature demonstrates that fire spread in market environments is driven by a combination of dense spatial layouts, continuous roof systems, high fuel loads, and inadequate passive fire protection. These factors interact to produce rapid fire development and large-scale damage, highlighting the need for improved market design, material

selection, and regulatory enforcement. Understanding these dynamics is essential for developing effective fire mitigation strategies tailored to the unique characteristics of urban market buildings.

2.4 Nigerian Regulatory and Policy Framework

Although they lack specific, performance-based standards for market structures, Nigeria's National Building Code (2018) and National Fire Safety Code (2022) offer broad guidelines on fire safety. According to academics, the continued use of combustible materials and the disregard for passive fire safety measures in public marketplaces are caused by this regulation vacuum (Onwumere et al., 2022).

3. Methodology

3.1 Design of Research

Quantitative material testing and qualitative field data were combined in a convergent mixed methods study methodology. This method allowed for a thorough evaluation of the socio institutional elements affecting fire safety as well as the technical material performance.

3.2 Study Area

Makurdi metropolis, Benue State, was selected due to its history of recurrent market fires and diverse market building typologies. The study focused on Modern Market, Wadata Market, and Wurukum Market.

3.3 Material Assessment

Standardized fire exposure experiments based on ISO 834 temperature time curves were conducted on samples of widely used market construction materials, including untreated lumber, corrugated aluminum sheets, reinforced concrete, fired-clay blocks, and gypsum boards. Performance was assessed based on deformation, ignition time, and time to structural failure.

3.4 Data Collection

The study used both quantitative and qualitative methods in its integrated approach to data collection. In order to produce quantifiable data on the most common building materials, safety awareness, and fire response experiences, survey instruments were given to a subset of market operators, construction professionals, and fire department personnel. In addition, representatives of policy organizations and regulatory bodies were interviewed qualitatively to investigate institutional readiness for market fire incidents, governance frameworks, and enforcement strategies. In order to track trends in fire incidence, fire propagation routes, and the role of material properties in fire development, recorded data of prior fire outbreaks were also methodically examined.

3.5 Data Analysis

To support the empirical assessment of fire risk conditions, descriptive statistical methods were used to examine quantitative data obtained from structured questionnaires distributed throughout certain marketplaces in Makurdi Metropolis, Benue State. In order to generate quantifiable indications of fire vulnerability within the market setting, this required summarizing replies on stall building materials, electrical installations, storage practices, and the presence or lack of fire protection equipment. Systematic coding and thematic analysis were applied to qualitative information gathered from key informant interviews with Benue State Fire Service officers, traders' associations, and market management authorities. The integrated assessment of fire risk throughout Makurdi's market settings was guided by the identification of context-specific patterns pertaining to material combustibility, fire preventive and response techniques, institutional readiness, and regulatory compliance.

4. Results and Discussion

4.1 Material Combustibility and Fire Spread

The results show that untreated wood and plastic-based items caught fire minutes after being exposed to heat, which accelerated the horizontal spread of flames across the stalls. Despite being non-combustible, corrugated aluminum roofing became distorted in hot weather, increasing ventilation and causing roof collapse and fire intensity.

4.2 Role of Passive Fire Protection

There was less structural damage and a slower rate of fire spread in markets with passive fire protection features including fire-rated concrete walls and gypsum board barriers. One of the main causes of significant fire losses in Makurdi marketplaces was found to be the lack of compartmentation.

4.3 Policy Implications

The results show that the specific risk conditions seen in market environments are not adequately taken into account by the current fire safety laws. In particular, the continuous use of risky construction techniques has been made possible by the absence of legally binding regulations for fire-resistant materials and passive fire safety systems. The structural resilience and fire safety performance of market facilities would be significantly improved by the inclusion of performance-based fire safety benchmarks in national regulatory frameworks.

5. Conclusion

The study reveals that the rapid spread of fires in Makurdi markets is largely driven by the use of highly combustible materials and the lack of passive fire protection measures. These factors exacerbate fire vulnerability in densely constructed market spaces. The findings highlight the urgent need for a preventive approach in urban fire safety policy in Benue State, emphasizing the adoption of fire-resistant materials and the enforcement of mandatory passive fire protection standards to mitigate the frequency and impact of market fire incidents.

6. Policy Recommendations

1. Establish requirements for market structures' fire resistance based on performance.

2. All newly constructed and remodeled markets must have passive fire protection equipment.
3. Create local labs for testing fire resistance.
4. Strengthen local government enforcement of fire safety regulations.
5. Encourage the use of fire-resistant materials by offering incentives and educating traders.

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