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SAFETY ASSESSMENT IN THE CONSERVATION OF HERITAGE BUILDINGS: A CASE STUDY OF TRADITIONAL MOSQUES IN NEGERI SEMBILAN, MALAYSIA

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Abstract

The preservation of heritage buildings while maintaining structural integrity and functional usability presents a challenge in protecting cultural and historical value. This research examines old timber mosques in Negeri Sembilan, Malaysia, which are increasingly threatened by decaying materials and insufficient safety protocols. The main objectives are to evaluate the safety conditions and determine possible preservation methods for these valuable heritage structures. Five (5) mosques have been qualitatively examined via field observations, systematic safety assessments and semi-structured interview protocols with related parties. Maintenance issues such as timber degradation, fire hazards, outdated electrical systems, and limited access to emergency exits are the lead causes of safety issues. The findings relate to the absence of conservation initiatives and compliance with safety regulations. This study focuses on the necessity of systematic safety assessments in historic conservation frameworks. It outlines a strategic approach to maintaining traditional authenticity while complying with contemporary safety standards, highlighting the need for community involvement in targeting sustainable heritage management.

Keywords: Safety Assessment, Heritage Building Conservation, Cultural Heritage, Traditional Mosque

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INTRODUCTION

Heritage buildings are part of the architectural identity of a society, as each reflects historical and cultural aspects which are valuable and irreplaceable. The preservation process is crucial to foster national heritage, cultural continuity and educational value (Feilden, 2003). Unfortunately, most such valuable structures were built long before modern building codes and safety standards being introduced. This has resulted in structural deterioration, outdated materials, high risk of fire, poor accessibility, and vulnerability to earthquakes (Douglas, 2006; Yung & Chan, 2012). These are significant obstacles for heritage professionals specifically adapting building for continuous use or public access without compromising originality.

In the past, the conservation process emphasized historical and original materials rather than modern safety approaches (Jokilehto, 1999). However, the adaptation and reuse of these buildings demonstrate an increasing demand among the public for buildings with heritage values. This requires an integrated approach which addresses both conservation and safety in a balanced manner.

Efforts to sustain heritage assets may not be successful due to failure to assess and mitigate safety risks (Orbaşlı, 2008). This study responds to this critical gap by proposing an integrated safety assessment approach tailored for heritage buildings. Using a case study methodology, it aims to examine common safety risks, evaluate current conservation practices, and propose a practical framework to enhance safety practices for heritage buildings.

RESEARCH BACKGROUND

Heritage Building Conservation

Heritage building conservation intends to safeguard architectural, historical, and cultural values while ensuring the transmission of authenticity to future generations. Early conservation philosophy, as emphasized by Feilden (2003), prioritised the preservation of original fabric and minimal intervention. However, conventional conservation practice has evolved globally to recognise the need for a balanced approach that integrates authenticity with functional requirements, user safety, and regulatory compliance. International charters and recent studies highlight that heritage buildings must remain safe, accessible, and usable to ensure their continued relevance and sustainability.

In Malaysia, heritage conservation is governed by the National Heritage Act 2005, which provides a statutory framework for the protection and management of culturally significant buildings. While the legislation emphasises safeguarding historical and architectural principles, practical implementation often faces challenges in reconciling conservation principles with modern safety and operational demands. Recent studies indicate that conservation projects may

still prioritise aesthetic and historical integrity over occupant safety and building performance, underscoring the need for more integrated conservation strategies that align heritage values with contemporary standards (Ismail & Ahmad, 2022).

Safety Assessment in Heritage Structures

Buildings over 50 years old with cultural significance are classified as heritage structures in Malaysia under the National Heritage Act 2005. Since many of these buildings were built before modern safety standards were established, they often do not have crucial features like fire detection systems, emergency exits, or sufficient structural reinforcement. As a result, this lack of safety measures presents considerable risks to those who use or occupy these heritage buildings, especially public ones (Douglas, 2006; Yung & Chan, 2012).

Globally, safety assessments for heritage buildings are increasingly using adaptive methods that enable the integration of modern safety standards while preserving historical features. In Malaysia, however, implementing safety guidelines from authorities like BOMBA and the Uniform Building By-Laws (UBBL) is often difficult due to limited space, material restrictions, and strict regulations. Recent events, such as fires in heritage shophouses in George Town, Penang (Trisha, 2023) and structural issues at Masjid Lama Kampung Pelangai (Abd Rahim et al., 2022), demonstrate the vulnerability of heritage buildings and emphasize the importance of proactive, safety-focused conservation planning.

Structural Integrity in Heritage Contexts

Structural integrity, defined as a building's ability to safely withstand applied loads without failure, is a critical segment of heritage conservation. Aging materials, traditional construction techniques, prolonged environmental exposure, and inadequate maintenance often compromise the structural performance of heritage buildings (Yusoff et al., 2020). Globally, advancements in non-invasive diagnostic technologies have significantly improved the assessment of structural conditions in heritage contexts.

In Malaysia, recent applications of UAV-based photogrammetry and laser scanning have enhanced the documentation and monitoring of traditional timber structures, including heritage mosques in Negeri Sembilan (Zakaria et al., 2022). These technologies allow for accurate condition assessment while minimizing physical intervention. Despite such advancements, many heritage buildings still lack comprehensive structural evaluations, increasing the risk of failure during rehabilitation or adaptive reuse projects. This gap underscores the importance of integrating digital documentation tools into common conservation practice.

Risk Management in Heritage Conservation

Risk management in heritage conservation involves the identification, assessment, and mitigation of threats resulting from natural hazards, human activities, and technical failures (Jigyasu, 2019; Khan & Khan, 2023). International best practices now incorporate risk-based approaches within conservation planning to improve resilience and ensure long-term sustainability. Fire risk remains a significant concern, primarily due to outdated electrical systems and unsuitable retrofitting solutions (Baharuddin et al., 2014).

In Malaysian context, effective risk management is often limited by fragmented governance structures, insufficient technical capacity, and regulatory inconsistencies between conservation and safety requirements (Norazian & Wahab, 2022). These challenges highlight the necessity for integrated systems that align heritage preservation principles with contemporary safety and risk management strategies. Enhancing this integration is crucial for improving the resilience, safety, and sustainability of heritage buildings, particularly those that serve active community and religious roles.

RESEARCH METHODOLOGY

Qualitative case study

This research uses a qualitative case study approach to evaluate the current safety conditions and conservation practices of five traditional heritage mosques in Negeri Sembilan, Malaysia as shown in Figure 1. The mosque studied includes Masjid Lama Padang Lebar (Rembau), Masjid Lama Kampung Pelangai (Kuala Pilah), Masjid Lama Tanah Datar (Rembau), Masjid Lama Kuala Dulang (Jelebu), and Masjid Lama Parit Istana (Kuala Pilah). These mosques were selected due to their historical significance and traditional Vernacular Malay timber architecture. Some are in continued use by local communities and some are abandoned.



Figure 1: The dilapidated state of Masjid Lama Parit Istana, Masjid Lama Kampung Pelangai, Masjid Lama Tanah Datar, and Masjid Lama Padang Lebar.

(Source: Author, 2025)

Data collection: observation and site inspection

Data collection focused on basic safety assessments through direct field observations and site inspections. A structured checklist was developed based on national building safety codes and heritage conservation guidelines to

systematically evaluate structural integrity, fire safety, electrical installations, accessibility, and emergency preparedness. Factors examined included roof stability, load-bearing timber columns and beams, presence of cracks or termite infestation, adequate fire exits, safety of electrical connections, and firefighting equipment availability.

Semi-structured interview

Interviews were conducted with mosque caretakers, community members, and local heritage officials to gather data on maintenance routines, safety concerns, and repair initiatives. These interviews explored the challenges involved in reconciling heritage preservation with contemporary safety standards.

Comparative analysis

Common safety issues among the mosques, related to deteriorating timber structures due to age and insect infestation; insufficient fire safety measures; outdated or exposed electrical wiring; and limited accessibility for emergency evacuation are the comparative analysis focus for this study. Each site study variation was based on the level of maintenance and community involvement. This safety assessment methodology provides practical framework for safety risk in heritage buildings and emphasizes the importance of integrating basic safety heritage and user wellbeing.

ANALYSIS AND DISCUSSION

Table 1 shows the safety assessments of the five heritage mosques in Negeri Sembilan. These reveal several recurring issues that reflect broader challenges faced in the conservation of heritage buildings, particularly those constructed with traditional timber architecture.

Table 1: Safety assessment of heritage mosques, Negeri Sembilan

Safety Issues	Safety Assessments	Challenges & Limitations	Supporting Arguments
Structural Integrity and Timber Degradation	- Timber structural elements showing deterioration: termite infestation, wood rot, and cracking. - Lack of regular structural health monitoring. - Risk of collapse without intervention.	No use of UAV photogrammetry or laser scanning. Urgent need for non-invasive monitoring in conservation.	Yusoff et al. (2020); Zakaria et al. (2022)
Fire Safety Deficiencies	Insufficient fire exits, emergency lighting, and fire extinguishers.	Retrofitting fire safety systems is difficult due to regulatory and	Douglas (2006); Trisha (2023); Rashid et al. (2023)

Safety Issues	Safety Assessments	Challenges & Limitations	Supporting Arguments
	- Timber's high combustibility increases fire risk. - Fire incident in Penang highlights vulnerability.	architectural authenticity constraints.	
Electrical Systems and Fire Risk	- Outdated, exposed wiring not meeting current safety standards. - Caretakers lack expertise and resources for safe upgrades. - Electrical faults are a major fire cause.	Need for specialized interventions balancing electrical safety and heritage conservation.	Baharuddin et al. (2014)
Accessibility and Emergency Preparedness	- Emergency access and evacuation routes are absent or poorly planned. - Narrow/obstructed entrances. - Poor accessibility for disabled persons.	Conflicts between modernization and original spatial design. Risks occupant safety and communal use viability.	Ismail & Ahmad (2022); Alvarenga Coutinho (2021)
Community Involvement and Maintenance Practices	- Better maintenance and safety monitoring in mosques with active community involvement. - Community efforts are limited by technical and financial capacity.	Highlights need government or institutional support for capacity building and risk management.	Yung & Chan (2012); Norazian & Wahab (2022)
Regulatory and Conservation Challenges	- Existing codes (BOMBA, UBBL) designed for modern buildings, cause compliance issues. - Adaptive reuse complicates safety compliance. - Need for flexible, context-sensitive regulations.	Balancing safety compliance with the preservation of heritage authenticity is complex and critical.	Abd Rahim et al. (2022); Douglas (2006); Plevoets & Van Cleempoel (2011); Rashid et al. (2023)

Structural Integrity and Timber Degradation

The primary concern across all sites was the deteriorating condition of timber structural elements, as shown in Figure 2. Observations noted signs of termite infestation, wood rot, and cracking in load-bearing columns and beams. These findings align with Yusoff et al. (2020), who have emphasized that aging materials and environmental exposure significantly compromise the structural integrity of heritage timber buildings in Malaysia. Without timely intervention,

such degradation increases the risk of partial or total collapse, endangering users and the preservation of cultural heritage.

Furthermore, the absence of regular structural health monitoring is clearly apparent. While advanced techniques such as UAV photogrammetry and laser scanning have been demonstrated as effective non-invasive tools for assessing timber mosque conditions (Zakaria et al., 2022), none of the mosques have undergone systematic monitoring. This gap indicates a critical need to incorporate such technologies in routine conservation practices to proactively detect structural weaknesses.



Figure 2: The deteriorating condition of timber structural elements.

(Source: Author, 2025)

Fire Safety Deficiencies

All mosques exhibited insufficient fire safety measures. Inadequate or non-existent fire exits, lack of emergency lighting, and absence of fire extinguishers were common. This shortfall is particularly alarming given the heightened risk of fire in timber structures, as timber is combustible and can rapidly deteriorate fire resistance over time (Douglas, 2006).

The fire incident in Penang's heritage shop houses, which caused significant damage, underscores the vulnerability of heritage buildings to fire hazards (Trisha, 2023). The mosques under study here similarly risk catastrophic loss without the installation of basic fire detection and suppression systems. However, retrofitting modern fire safety installations poses challenges due to regulatory constraints and the desire to maintain architectural authenticity (Rashid et al., 2023).

Electrical Systems and Fire Risk

Outdated and exposed electrical wiring was a pervasive issue. Many mosques still rely on original or minimally upgraded electrical systems that do not comply with

contemporary safety standards. According to Baharuddin et al. (2014), faulty or improperly maintained electrical installations are a significant cause of fire in heritage buildings.

The interviews with mosque caretakers revealed limited technical expertise and resources to upgrade these systems appropriately without damaging the heritage fabric. This demonstrates the necessity of implementing targeted solutions that enhance electrical safety and simultaneously uphold conservation objectives.

Accessibility and Emergency Preparedness

Emergency access routes and evacuation procedures were either absent or inadequately planned. Several mosques had narrow or obstructed entrances, complicating evacuation during emergencies, as shown in Figure 3. Accessibility for persons with disabilities was also notably lacking, reflecting a wider issue in heritage building management where modernization needs conflict with original spatial constraints (Ismail & Ahmad, 2022; Coutinho, 2021). This lack of preparedness not only increases the risk to occupants, but also undermines the viability of continued communal use, especially as some mosques continue to serve active worshippers.



Figure 2: Narrow or obstructed entrances.
(Source: Author, 2025)

Community Involvement and Maintenance Practices

A notable contrast was observed between mosques actively maintained by local communities and those which have been abandoned or neglected. Community involvement played a significant role in informal maintenance, safety monitoring, and conservation advocacy. This aligns with Yung and Chan's (2012) assertion that social sustainability and stakeholder engagement are critical factors in successful heritage conservation.

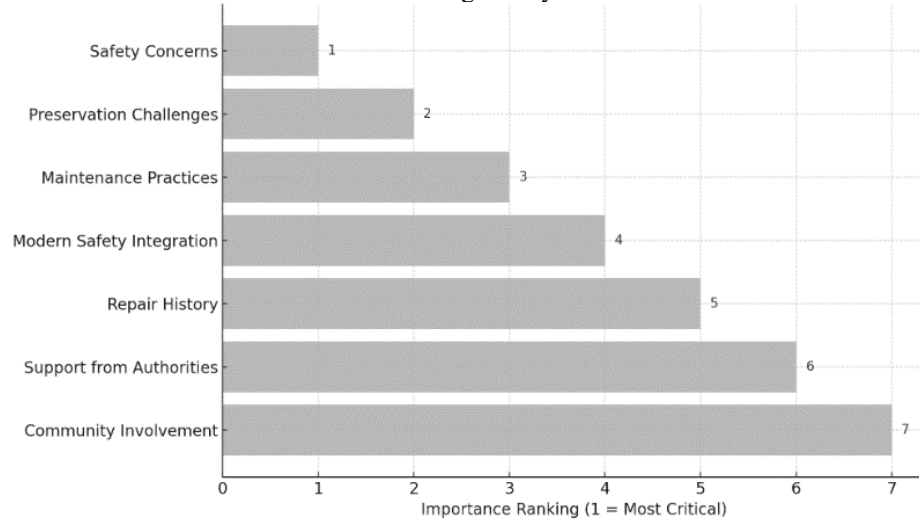
However, community efforts are often constrained by limited technical knowledge and financial resources, emphasizing the need for governmental and institutional support to enhance capacity building and risk management (Norazian & Wahab, 2022). Table 2 shows the findings based on the interviews with the authorities, the community, and mosque committees.

Table 2: Safety assessment of heritage mosques, Negeri Sembilan

The concern	Users/ Authorities	Safety measures and assessment
Maintenance Practices	Mosque Caretakers	Routine cleaning is conducted, but technical maintenance (e.g., roof leaks, and timber checks) is irregular due to a lack of expertise and funding.
Safety Concerns	Community Members, Caretakers	Major concerns include exposed electrical wiring, lack of fire extinguishers, and termite infestations.
Repair History	Caretakers, Local Officials	Repairs are mostly reactive and often done without professional consultation; the use of non-traditional materials is reported.
Preservation Challenges	Heritage Officials, Community Members	Difficulty in sourcing traditional timber; conflict between preserving original features and ensuring safety compliance.
Community Involvement	Community Members	Strong emotional attachment to mosques, but limited participation in formal conservation efforts.
Support from Authorities	Mosque Committees, Local Officials	Inconsistent funding and limited technical guidance from heritage authorities.
Modern Safety Integration	All Groups	General agreement on the need for upgrades (e.g., fire safety systems), but concerns over altering mosque authenticity.

The most critical issue identified was *Safety Concerns*, followed by *Preservation Challenges* and *Maintenance Practices*. The following visualization helps highlight the users, committee, and authorities to priorities in heritage mosque conservation.

Table 3: Interview-Based Ranking of Key Conservation Measures.



Regulatory and Conservation Challenges

The findings echo the broader challenge of applying existing building safety codes and heritage conservation guidelines coherently. While regulations such as those from BOMBA and UBBL are designed for modern structures, heritage buildings' unique characteristics frequently result in regulatory conflicts and compliance difficulties (Abd Rahim et al., 2022; Douglas, 2006).

Adaptive reuse, while a common conservation strategy, further complicates safety compliance due to spatial reconfiguration and modern usage demands (Plevoets & Van Cleempoel, 2011; Rashid et al., 2023). This necessitates flexible, context-sensitive regulatory frameworks that reconcile safety with authenticity preservation. Enforcement must be undertaken as well. Based on the overall number of enforcements taken, further analysis was done to determine, by ranking, the top five highest number of enforcement actions according to the studied years, from 2017 until 2020.

The findings reveal that the application of modern safety regulations to heritage buildings remains a significant challenge, largely due to regulatory rigidity and limited flexibility in existing guidelines. Practitioners reported difficulties in complying with requirements such as fire escape provisions, electrical upgrades, and structural reinforcements without compromising the original architectural fabric. This has resulted in selective or minimal safety interventions, particularly in active religious buildings such as mosques.

At the same time, the study found that community involvement plays a crucial role in mitigating these limitations. Local communities and mosque

committees actively participate in routine maintenance, monitoring building conditions, and reporting safety concerns, contributing to the building's continued functionality and use. However, this involvement is largely informal and experience-based, with limited technical guidance. The findings suggest that stronger collaboration between authorities, conservation professionals, and local communities, supported by clearer adaptive guidelines, could enhance both regulatory compliance and safety outcomes in heritage conservation practice.

CONCLUSION

The five heritage mosques in Negeri Sembilan are experiencing multiple challenges related to structural, environmental, social, and regulatory factors, which collectively threaten both the physical integrity of these historic timber buildings and the safety of their users. The main issues of the deterioration involved particularly termite infestation and wood rot, which severely compromise structural stability and necessitate urgent remedial action to ensure building safety. This finding aligns with existing literature highlighting the crucially to continuously monitor and intervene to prevent irreversible damage and structural failure in heritage timber buildings (Yusoff et al., 2020).

Additionally, significant deficiencies related to structural concerns in terms of fire safety and electrical infrastructure have been identified across all mosques. The unavailability of proper fire exits, firefighting equipment and modern electrical connections heightened the risk of fire, particularly with timber mosques (Trisha, 2023). These safety gaps underscore the persistent disconnect between heritage conservation objectives and contemporary building safety requirements, a challenge well documented in the field (Douglas, 2006; Rashid et al., 2023).

Furthermore, issues relating to accessibility and emergency preparedness expose the inherent tension between preserving original architectural configurations and meeting modern functional and safety standards. Limited provision for safe evacuation routes and accessibility for individuals with disabilities reflects a widespread challenge in heritage conservation, where strict adherence to original spatial layouts often conflicts with regulatory demands (Coutinho, 2021; Ismail & Ahmad, 2022).

Community engagement emerged as a crucial factor influencing maintenance and safety conditions. Mosques actively supported by local communities demonstrated notably better upkeep and safety practices, affirming the importance of social sustainability in heritage conservation (Yung & Chan, 2012). However, community efforts are frequently constrained by limited technical expertise and resources, underscoring the need for greater institutional support and capacity building.

Finally, this study has revealed systemic limitations within regulatory frameworks and risk management approaches. Current Malaysian safety codes and heritage guidelines, primarily designed for modern buildings, often prove inadequate or inflexible when applied to heritage structures, impeding effective conservation and safety compliance (Abd Rahim et al., 2022; Norazian & Wahab, 2022). Adaptive reuse, while beneficial for prolonging the functional life of heritage buildings, introduces additional safety challenges that demand innovative, context-sensitive solutions balancing preservation and occupant safety (Plevoets & Van Cleempoel, 2011; Rashid et al., 2023).

In summary, ensuring the safety and conservation of heritage mosques requires an integrated approach balancing preservation with modern safety needs. This should include routine, non-invasive structural health monitoring through advanced technologies such as UAV photogrammetry and laser scanning, enabling the early detection of timber deterioration. Additionally, sensitive upgrades to fire safety and electrical systems are essential to protecting users while maintaining the mosques' historical integrity. Emergency preparedness and accessibility measures must be enhanced in ways which respect heritage constraints while aligning with current safety standards. Community involvement should be strengthened through technical guidance and financial support to foster a sense of ownership and stewardship. Furthermore, flexible and adaptive regulatory frameworks are needed to support heritage-specific safety interventions and ensure coordinated risk management. Implementing such a comprehensive framework is vital to safeguarding these cultural landmarks, ensuring they remain safe, functional, and enduring for both the present and future generations.

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DISCLOSURE STATEMENT

The authors declare that there is no conflict of interest related to this publication. The study did not involve experiments on humans or animals that required formal ethical approval; however, any interviews or field data were conducted with

informed consent and respect for confidentiality. All authors contributed to the research design, data collection, analysis, and writing of the manuscript, and have approved the final version. The data supporting this study are available from the corresponding author upon reasonable request.

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