

Diagnosing timber defects in Malay traditional houses from occupants' perspectives: A case study of Rumah Kutai in Perak, Malaysia

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Abstract

Rumah Kutai, one of the oldest forms of traditional Malay houses in Perak Tengah, represents an important part of Malaysia's architectural heritage. However, many of these timber structures are increasingly affected by deterioration caused by environmental exposure, biological attacks, and maintenance challenges. This study investigates the common timber defects found in Rumah Kutai and examines the factors contributing to their occurrence from the perspectives of owners and caretakers. A qualitative case study approach was adopted, supported by field observations and a survey involving 15 respondents. The findings reveal that termite infestation, wood-boring insect attacks, and timber decay are the most common defects, with wall panels and floorboards being the most affected components. Moisture exposure and natural ageing were identified as the primary causes of deterioration. The study also found that maintenance is generally reactive rather than preventive, largely due to high repair costs and a shortage of skilled traditional craftsmen. These findings highlight the need for improved conservation strategies that combine traditional knowledge, preventive maintenance, and appropriate restoration practices to ensure the long-term preservation of Rumah Kutai as a valuable cultural heritage asset.

Keywords: *Timber defects, Rumah Kutai, traditional Malay houses, heritage conservation, timber deterioration, maintenance practices.*



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INTRODUCTION

Malaysia's traditional Malay houses represent more than just architectural beauty; they embody the ingenuity, adaptability, and cultural values of the Malay community. Built predominantly from timber, these structures were designed to harmonize with the tropical environment, emphasizing natural ventilation, elevated flooring, and intricate craftsmanship (Salleh, Abdullah, & Ab. Jalil, 2023). Among the many forms of traditional Malay houses, the *Rumah Kutai* in Perak stands as a unique heritage model that illustrates early adaptation to the environment and mastery in timber construction. It represents a historical link between the Malay way of life and sustainable vernacular architecture.

However, many of these houses are now at risk due to aging, lack of maintenance, and exposure to tropical climatic conditions such as heavy rainfall, humidity, and termite infestation (Ishak, Ali, Omar, & Hashim, 2007). Timber, though durable and flexible, is a natural material that deteriorates over time when subjected to biological, environmental, and mechanical stresses. Research indicates that deterioration is often accelerated by improper repair techniques and inadequate awareness among homeowners regarding preventive maintenance (Isa et al., 2021).

The *Rumah Kutai*, which originated in the Perak Tengah region, reflects the earliest timber house typology in Perak and is believed to have existed since the late 18th century. Characterized by its raised floor, steep pitched roof, and elaborate carvings, it serves both functional and cultural purposes. However, the survival

of Rumah Kutai today is endangered by extensive timber decay and neglect. The increasing number of these houses falling into disrepair highlights the urgency of assessing and diagnosing timber defects to ensure that conservation measures are implemented effectively (Baharuddin, Ab Rashid, Bakhari, & Bahardin, 2020)

Understanding timber defects in heritage buildings is critical for preserving Malaysia's cultural identity. Timber deterioration not only affects the physical integrity of the building but also leads to a gradual loss of traditional knowledge, values, and skills associated with heritage construction (Mydin, 2016). According to Wahab, Rahman, and Ismail (2018), diagnosing timber conditions enables proactive maintenance strategies that can prevent irreversible structural failures. Therefore, this research focuses on identifying the common types of timber defects in Rumah Kutai, examining their causes, and suggesting possible solutions for conservation and maintenance.

Additionally, the study aligns with Malaysia's broader heritage conservation efforts under the National Heritage Act 2005 (Act 645), which emphasizes protecting cultural properties of significant historical value. Diagnosing and documenting timber defects in Rumah Kutai supports sustainable heritage management and raises community awareness about the importance of preserving traditional wooden architecture.

Moreover, this study emphasizes the importance of integrating scientific diagnosis with traditional knowledge in the maintenance of timber heritage buildings. While many modern conservation approaches focus primarily on technical solutions, the cultural dimension such as the craftsmanship techniques, selection of local timber species, and traditional jointing methods plays an equally important role in ensuring the authenticity and longevity of Rumah Kutai. Combining contemporary conservation methods with indigenous practices can produce more sustainable outcomes, aligning with Malaysia's goal to balance heritage preservation and community engagement in the management of traditional structures (UNESCO, 2021).

RESEARCH OBJECTIVES:

Based on the research gap identified above, this study was conducted to achieve the following objectives:

1. identify and classify the types of timber defects commonly found in Rumah Kutai in Perak Tengah; and
2. to analyze the underlying causes contributing to the occurrence of these timber defects.

LITERATURE REVIEW

Traditional Malay houses are predominantly constructed using timber due to its availability, workability, and suitability for the tropical climate. Timber allows flexibility in structural movement, natural ventilation, and thermal comfort, making it an ideal material for Malaysia's hot and humid environment. Elevated floors, lightweight construction, and open layouts further enhance climatic responsiveness and occupant comfort (Baharuddin et al., 2020). Bioclimatic assessments of Malay traditional architecture indicate that although passive design techniques such as elevated flooring enhance airflow and microclimatic cooling, they also leave peripheral timber components susceptible to moisture from the ground and increased ambient humidity (Adib et al., 2025).

Rumah Kutai is one of the earliest traditional house typologies in Perak and is typically found along riverbanks and early settlement areas. The architectural form reflects social hierarchy, cultural practices, and adaptation to environmental conditions. Structurally, Rumah Kutai relies heavily on timber columns, beams, floor joists, wall panels, and roof elements connected through traditional joinery systems such as mortise-and-tenon joints and wooden pegs (Isa et al., 2021). These joints provide flexibility and resilience but require precise craftsmanship and consistent maintenance to remain effective. Mechanical studies of traditional joinery reveal

that unventilated mortise-and-tenon joints are particularly susceptible to localized wood fiber compression and rotational displacement under cyclic thermal stress and moisture changes (Zakiyudin et al., 2026).

Despite its historical and architectural significance, Rumah Kutai faces increasing threats due to neglect, urban development, and changing lifestyles. Many houses are no longer occupied or are altered using modern materials that are incompatible with traditional timber construction. Studies indicate that inappropriate renovation practices often accelerate timber deterioration rather than prevent it (Alia et al., 2022). Moreover, recent field assessments of heritage building modifications emphasize that uncoordinated roof changes and incompatible structural additions often interfere with original rain shedding routes, channeling runoff onto untreated load-bearing timber columns (Mohd Khazli et al., 2024). Therefore, understanding the original architectural principles and construction logic of Rumah Kutai is essential for diagnosing defects and proposing appropriate conservation measures.

Biological deterioration is one of the most critical and destructive forms of timber defects in traditional Malay houses. Termite infestation is widely recognised as the primary cause of structural timber damage, particularly in houses located on moist soil or near water sources. Subterranean termites attack timber internally, often leaving the outer surface intact, which makes early detection difficult (Ishak et al., 2022). Legal and structural diagnostic assessments further highlight that these subterranean termite tunnels represent concealed latent flaws, which can easily escape routine surface inspections while surreptitiously undermining structural stability (Azni et al., 2025). In Rumah Kutai, termite damage is commonly observed in columns, floor beams, and stair components that are close to the ground.

Fungal decay is another significant biological defect associated with prolonged moisture exposure. Conditions such as roof leakage, poor drainage, rising damp, and inadequate ventilation create an ideal environment for fungal growth. Brown rot, white rot, and soft rot reduce timber strength by breaking down wood fibres, leading to brittleness and eventual failure (Isa et al., 2021). Non-invasive assessments of moisture thresholds indicate that keeping wood moisture content over 19–22% establishes a vital point for swift fungal spore germination and decay spread in tropical hardwood components (Building Condition & Materials Research Group, 2026). Fungal decay often develops gradually and may remain unnoticed until visible deformation or collapse occurs.

Wood-boring insects further contribute to biological deterioration, particularly in older timber elements. These insects create small holes and powdery residue, indicating internal damage. Although their impact is slower compared to termites, prolonged infestation can significantly reduce timber density and structural capacity. The prevalence of biological defects highlights the importance of moisture control, regular inspection, and preventive treatment in heritage timber buildings.

Physical defects arise from natural ageing, environmental exposure, and inherent timber movement. Cracking and checking are common defects caused by uneven shrinkage during drying and repeated exposure to fluctuating humidity and temperature. These cracks often appear in large structural members such as beams and columns and may allow moisture penetration, accelerating biological deterioration (Salleh et al., 2023). Empirical studies on defects in Perak traditional houses reveal that vertical wall panels and wooden floorboards show the highest concentration of physical defects, making up more than 40% of all documented architectural deterioration (Mohd Isa et al., 2025).

Warping, twisting, and cupping are frequently observed in wall panels, floorboards, and roof components. These defects usually result from improper seasoning of timber, inconsistent moisture levels, or exposure to direct sunlight. Warped elements can affect structural alignment, reduce usability, and compromise occupant safety (Baharuddin et al., 2020).

Surface-related defects such as staining, swelling, peeling finishes, and surface erosion are indicators of prolonged moisture exposure. While often considered cosmetic, these defects may signal deeper material

degradation. Ignoring early physical defects can lead to more severe structural issues over time, particularly in heritage houses with limited maintenance. Comparative environmental research on tropical microclimates indicates that elevated humidity and salt-rich air in coastal areas notably enhance wood fiber swelling, cracking, and surface finish separation in comparison to inland areas (Salleh & Mohtar, 2026).

Malaysia's tropical climate significantly influences the rate and extent of timber deterioration. High humidity increases timber moisture content, promoting fungal growth and dimensional instability. Heavy rainfall and seasonal monsoons expose timber components to prolonged wet conditions, particularly in houses located near rivers such as Rumah Kutai. Finite element analysis of timber load-bearing members subjected to moisture stress from climate effects shows a direct reduction in the structural modulus of elasticity (E), increasing the likelihood of permanent mechanical deformation in *tiang seri* components (Alsheikh Mahmoud & Hashim, 2025).

Flooding poses a major threat to lower structural components, causing prolonged submersion and contamination of timber. Repeated wetting and drying cycles weaken timber fibres and reduce durability. In addition, prolonged exposure to sunlight and ultraviolet radiation leads to surface degradation, colour fading, and surface checking.

Inadequate maintenance remains one of the most significant contributors to timber deterioration. Many homeowners lack technical knowledge, financial resources, or access to skilled craftsmen capable of carrying out appropriate repairs. As a result, maintenance is often reactive rather than preventive, allowing defects to worsen over time (Salleh et al., 2023). Studies of building conservation initiatives throughout Malaysia indicate that insufficient preventive measures against persistent moisture exposure and dependence on reactive maintenance are the primary factors leading to swift structural decay (Najihah et al., 2024).

Temporary repairs using incompatible modern materials are commonly observed in traditional houses. Such interventions may trap moisture, disrupt traditional joint systems, or create stress concentrations, leading to accelerated deterioration (Mydin, 2016). The absence of systematic inspection schedules further increases the risk of unnoticed damage.

The durability of traditional Malay houses is strongly influenced by timber species. Historically, high-quality hardwoods such as Chengal and Resak were selected for their resistance to decay and insect attack. However, these species are increasingly scarce and expensive, leading to the use of inferior replacement materials in repair works (Aini et al., 2022).

Mismatch between original and replacement timber can result in uneven moisture movement, differential shrinkage, and joint failure. Even durable hardwoods may deteriorate if improperly seasoned or inadequately protected. Understanding timber properties is therefore essential for effective conservation planning.

Traditional conservation practices emphasise minimal intervention, reversibility, and retention of original materials. Selective replacement and traditional joinery techniques preserve authenticity while maintaining structural performance. However, the number of skilled traditional carpenters is declining, posing challenges to heritage conservation (Muhammad et al., 2025).

Modern conservation approaches incorporate scientific assessment methods such as condition surveys, moisture testing, and structural evaluation. Preventive treatments including termite control, fungicidal coatings, and protective finishes are increasingly used, guided by heritage conservation principles (Department of National Heritage Malaysia, 2020). To enhance condition evaluations, researchers emphasize that incorporating digital Entity-Relationship (ER) database modeling into frameworks for managing building conditions enables conservationists to methodically monitor defect development and prioritize actions across heritage timber assets (Bahardin et al., 2022; Nur Fadhilah et al., 2022).

Adaptive reuse has emerged as a strategy to enhance sustainability by giving heritage buildings new functions while preserving architectural character. When properly managed, adaptive reuse increases community engagement and economic viability. Technical diagnosis of defects is only one side of the conservation challenge. Equally significant is the consideration of cultural heritage, identity, and community engagement. Studies emphasize that heritage buildings are not static objects; they are part of living communities and cultural landscapes. Preserving architectural authenticity including timber joinery techniques, traditional motifs, and spatial configuration is critical in diagnosing and repairing these buildings in a manner respectful to their original form (Kamarudin, 2021). The social dimension is also significant: local owners, craftsmen, and stakeholders often play a central role in the maintenance and conservation process. For *Rumah Kutai*, this is particularly important, given its rarity and cultural value. Reports note that maintaining Kutai houses can be expensive, and owners may lack sufficient technical or financial resources to restore them properly. Engagement with communities is thus essential to ensure that diagnostic findings are translated into actionable maintenance plans that align with both heritage values and owner capacities.

Further, conservation strategies must balance intervention with authenticity. Too aggressive repair may compromise traditional craftsmanship; too little maintenance may allow defects to worsen. The literature underscores the need for conservation plans that integrate both technical diagnosis and heritage-sensitive restoration, ensuring that interventions do not erase the cultural meanings embedded in timber, form, and ornamentation.

RESEARCH METHOD

Research methodology refers to the systematic process used to collect, analyze, and evaluate data to answer research questions and achieve the objectives of a study. It outlines the scope of work and explains the specific methods adopted to obtain reliable, accurate, and comprehensive data. In this study, the methodology focuses on diagnosing timber defects in traditional Malay houses, specifically the *Rumah Kutai* typology located within the Perak Tengah region of Perak, Malaysia. The framework is designed to evaluate physical conditions, classify common defects, and establish the underlying environmental and human-related causes of material degradation. To achieve these goals, this study adopts a qualitative case study research design. This method is augmented by primary field observations, stakeholder interviews, and an analytical survey of homeowners and caretakers.

This study employs a qualitative-dominant case study approach to gain an in-depth, contextual understanding of real-world timber degradation. Qualitative methods are highly suitable for architectural heritage research, as they prioritize detailed physical descriptions and lived maintenance histories over purely statistical data.

Step 1: Sampling And Case Study Selection

This research uses purposive sampling to select case study buildings and survey respondents. This non-probability sampling approach selects targets based explicitly on their architectural authenticity, geographical positioning, historical age, and exposure to environmental stressors. To establish a robust analytical baseline, three specific architectural and historical benchmarks were enforced for the selected properties such as typological & status consistency, material integrity and temporal & geographic bounds. The fieldwork focuses intensively on three (3) specific house case studies located within the Perak Tengah district, chosen to represent varying stages of historic timber exposure:

Table 1. Three Selected Case Study

Types	Explanation	Figure
Case Study A (Kampung Telok Bakong Hulu)	A residential structure exceeding 100 years of age (built late 19th/early 20th century). It serves as a prime baseline for long-term hardwood performance (<i>Cengal</i> and <i>Meranti</i>).	
Case Study B (Kampung Telok Bakong Hulu)	A residential structure exceeding 50 years of age, demonstrating traditional interlocking joinery systems under continuous residential use.	
Case Study C (Kampung Tua)	A residential structure exceeding 70 years of age, providing critical data on how traditional stilt-supported systems adapt to multi-generational occupancy.	

Step 2: Survey Respondent Sampling

A sample size of 15 key informants was selected for the questionnaire interview component. This cohort consists of radiography of property owners 93.3 %and primary caretakers/tenants (6.7%). Selecting long-term residents is vital: 66.7%of the sample possesses more than 20 years of direct interaction with the house, and 33.3% possesses 10 to 20 years of continuous observation. This depth of experience provides highly reliable data on seasonal flooding, termite history, and historical repair interventions.

FINDINGS & DISCUSSION

In this section, we synthesize the key trends and systemic challenges regarding timber degradation and conservation practices in traditional Rumah Kutai houses within the Perak Tengah region, drawing on empirical field data and homeowner surveys. In this analysis, trends refer to recurring, widely observed defect patterns and physical vulnerabilities across the case studies, while challenges refer to persistent socioeconomic limitations, resource gaps, or human barriers that constrain effective building preservation. Across the collected data, nine interrelated dimensions of timber diagnosis and property upkeep structure this synthesis:

1. Observation of timber defects
2. Types of timber defects identified
3. Most affected building components
4. Severity of timber defects
5. Main causes of timber defects
6. Lack of maintenance practices

7. Challenges in preserving Rumah Kutai
8. Repair methods and skilled craftsmen

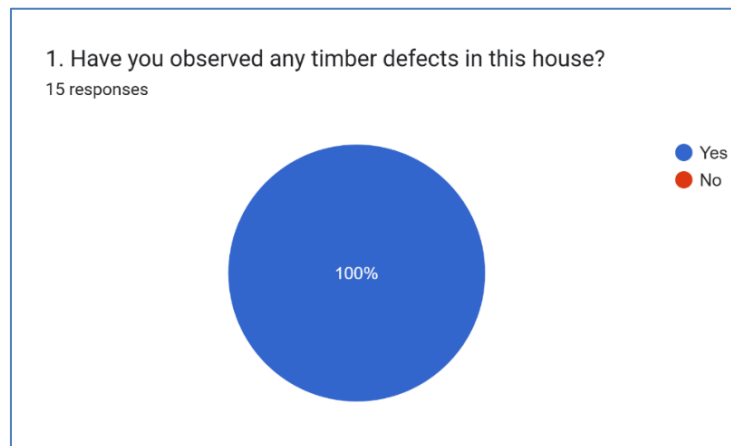


Figure 1. Observation of Timber Defects

Observation of Timber Defects: The survey results indicate that all respondents confirmed the presence of timber defects within their houses. This demonstrates that timber deterioration is a common issue affecting traditional Malay houses and remains a major concern among homeowners and caretakers. The widespread occurrence of defects is not unexpected considering the age of the buildings and their continuous exposure to environmental conditions. Timber structures are naturally vulnerable to moisture, biological attacks, temperature fluctuations, and long-term wear. These factors contribute to gradual deterioration and reduce the durability of timber components. The findings support previous studies which suggest that timber deterioration is one of the most significant challenges in preserving traditional heritage buildings. Regular inspections and preventive maintenance are therefore necessary to minimise further deterioration and prolong the lifespan of these structures.

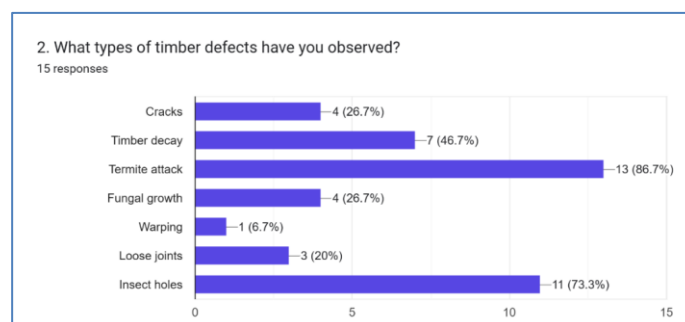


Figure 2. Types of Timber Defects Identified

Types of Timber Defects Identified: The data shows several types of timber defects in the studied houses, with biological damage being the most common. Respondents identified more than one type of defect in their houses. The most common issue is termite attack, which affects 86.7% of the houses. These termites damage the inside of the timber by hollowing it out, making the structure weak without obvious external signs.

Insect holes were also reported by 73.3% of respondents, caused by wood-boring insects that slowly reduce the strength of the timber. About 46.7% of respondents reported wood rot and decay, where the timber becomes soft and weak due to moisture exposure over time. Other defects include structural cracks (26.7%), fungal growth (26.7%), loose traditional joints or *pasak* (20.0%), and warped timber (6.7%).

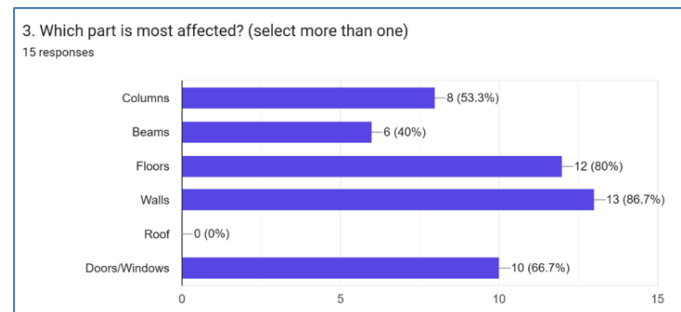


Figure 3. Most Affected Building Components

Most Affected Building Components: The results show that certain parts of the building are more affected than others due to exposure to weather and moisture. Timber wall panels are the most affected component at 86.7%, followed by floorboards at 80.0% due to rising damp and humidity from the ground. Doors and window frames are affected at 66.7% because they are frequently exposed to movement and weather changes. Structural columns (*tiang*) show damage in 53.3% of cases, especially at the base area. Structural beams are affected in 40.0% of houses, mainly due to roof leaks that allow water to spread into the timber structure.

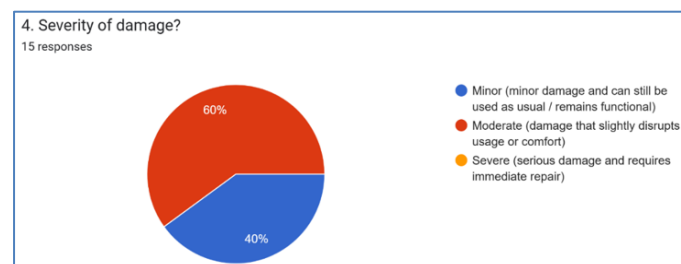


Figure 4. Severity of Timber Defects

Severity of Timber Defects: The results indicate that 60.0% of respondents classified the observed defects as moderate, while 40.0% considered them minor. No respondents reported severe defects affecting their houses. This finding suggests that although timber deterioration is widespread, most defects have not yet reached a critical stage. Nevertheless, moderate defects should not be ignored because they have the potential to develop into more serious structural problems if left untreated. The findings highlight the importance of implementing preventive maintenance strategies before defects become severe. Early detection and timely repair works can significantly reduce maintenance costs while preserving the structural integrity of traditional timber houses.

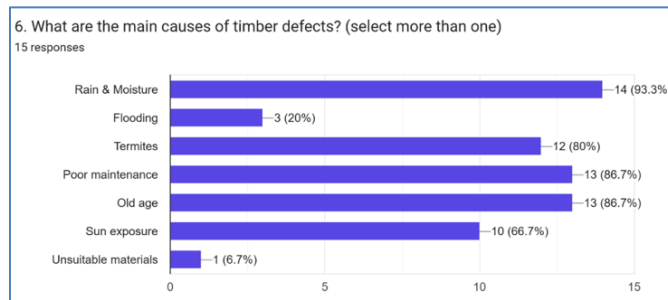


Figure 5. Main Causes of Timber Defects

Main Causes of Timber Defects: The main cause of timber deterioration is moisture and rain exposure, which was reported by 93.3% of respondents. This is followed by termite infestation (86.7%) and the natural ageing of timber (86.7%). Poor maintenance practices were also identified by 80.0% of respondents as a contributing factor. Other causes include strong sunlight and UV exposure (66.7%), seasonal flooding (20.0%), and the use of unsuitable replacement materials (6.7%). These factors together speed up the damage process of the timber structures.

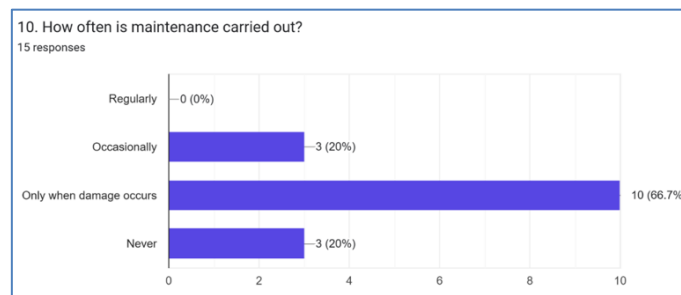


Figure 6. Maintenance Practices

Lack of Maintenance Practices: The study found that most houses are not properly maintained on a regular basis. About 66.7% of respondents only carry out repairs when problems become serious. Another 20.0% do occasional maintenance, while 13.3% do not carry out any maintenance at all. None of the respondents practice regular preventive maintenance, which causes small defects to develop into bigger problems over time.

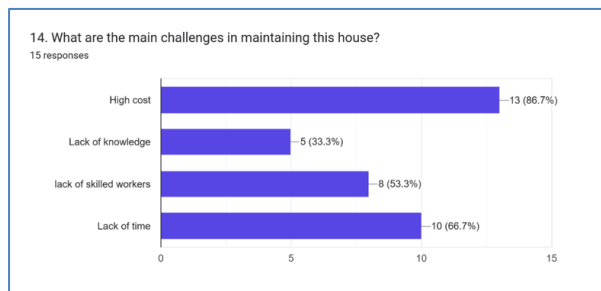


Figure 7. Challenges in Preserving Rumah Kutai

Challenges in Preserving Rumah Kutai: There are several challenges in maintaining Rumah Kutai. The main issue is high repair cost, reported by 86.7% of respondents, especially for quality hardwood materials. Another major challenge is the shortage of skilled traditional craftsmen (66.7%).

In addition, 53.3% of respondents face limited time to carry out maintenance, while 33.3% lack knowledge about proper conservation methods. These challenges make it difficult for owners to properly preserve the traditional houses.



Figure 8. Repair Methods and Skilled Craftsmen

Repair Methods and Skilled Craftsmen: When repairs are done, owners use different methods. About 53.3% use a mix of modern materials and traditional timber, while 46.7% still use traditional repair methods only. For labour, 60.0% of respondents hire skilled traditional craftsmen, while 40.0% use general contractors or do repairs themselves. The use of modern materials sometimes affects the original structure and may cause compatibility issues with traditional timber systems.

CONCLUSION

This study examined the timber defects affecting Rumah Kutai in Perak Tengah and identified the main factors contributing to their deterioration. The findings show that timber degradation is a widespread issue among the houses studied, with every respondent reporting the presence of defects. Moisture exposure resulting from the tropical climate, together with biological agents such as termites and wood-boring insects, were found to be the primary causes of deterioration. Timber wall panels and floorboards were identified as the most vulnerable building components due to their continuous exposure to environmental and biological conditions. The study further reveals that although most respondents considered the current condition of the defects to be moderate, maintenance practices remain largely corrective rather than preventive. Many owners only undertake repairs when the damage becomes serious, increasing the risk of further structural deterioration over time. Financial limitations and the declining availability of skilled traditional craftsmen were also identified as significant challenges that hinder proper conservation and restoration efforts. Consequently, some homeowners have opted to use modern materials during repair works, which may compromise the authenticity and traditional character of the buildings.

In conclusion, the long-term survival of Rumah Kutai depends on a balanced approach that combines traditional craftsmanship with modern conservation practices. Greater support is needed in the form of financial assistance, technical guidance, and training programmes to encourage proper maintenance and preservation. Strengthening awareness among homeowners and promoting preventive maintenance strategies can help reduce the rate of deterioration while preserving the cultural and architectural significance of these historic timber houses for future generations.

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