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Structural and Functional-Symbolic Roles of Traditional Malay *Tanggam* Joinery in Sustainable Timber Construction: A Case Study in Peninsular Malaysia

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ABSTRACT

Traditional Malay wooden houses embody an integrated architectural response to climate conditions, material efficiency, and construction knowledge developed over generations. A key element of this architecture is the tanggam joinery system, a mechanical interlocking technique that connects structural components without nails or metal fasteners. This study examines typological patterns and functional-symbolic roles of traditional Malay tanggam joinery in traditional Malay houses across four regional house typologies of Peninsular Malaysia: Kedah, Perak, Melaka, and the East Coast. A qualitative multiple case study approach involving 11 representative houses was employed, with an integrated literature review, field observations, photographic documentation, geometric assessment, and cross-regional comparative analysis conducted over six months. The findings reveal three principal roles of tanggam: (i) structural load-bearing, (ii) structural non-load-bearing, and (iii) integrated structural-symbolic applications. The results demonstrate that tanggam functions not merely as a carpentry technique but as an embedded structural logic within traditional Malay timber construction. Its mechanical interlocking configuration facilitates adaptability, disassembly, maintenance, and material longevity. The findings highlight the relevance of traditional joinery knowledge as a conceptual and technical foundation for sustainable timber architecture, which contributes to SDG 11 (Sustainable Cities and Communities) and heritage conservation initiatives.

Keywords: Functional-symbolic integration, Regional typology, Sustainable construction, Timber construction, Traditional Malay houses, *Tanggam* joinery.

1. INTRODUCTION

Traditional Malay wooden houses in Peninsular Malaysia represent an integrated response to environmental conditions, material efficiency, and vernacular construction knowledge developed over generations. As a key component of Malay cultural heritage, they prioritize adaptability, modularity, and longevity in a humid tropical climate [1]. Central to their construction is the *tanggam* joinery system, a vernacular mechanical interlocking method to connect primary structural components such as columns (*tiang*), beams (*rasuk*), and roof trusses (*kasau*) without nails or metal fasteners [2]. From a construction perspective, *tanggam* serves as a sustainable connecting system that facilitates flexibility, efficient load transfer, and ease of disassembly while preserving structural integrity. Prior studies have shown that this joinery system contributes to the long-term performance of traditional timber structures under tropical environmental conditions [3],[4],[5] while also embodying intangible cultural meanings related to craftsmanship, regional identity, and symbolic expression. Figure 1 shows an example of a traditional Malay house.

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Figure 1: An example of a traditional Malay house. *Field documentation photographs by the author (2025).*

Despite its structural and cultural significance, prior studies have largely focused on general construction techniques or on isolated typological documentation of traditional Malay houses [3], [5], [6]. While some research has examined the typology and architectural value of *tanggam* systems, comparative investigations focusing on their distribution, adaptation, and aesthetic interpretations across different traditional house styles remain limited [2],[6],[7]. Similarly, although *tanggam* has been emphasized in architectural studies, most studies focus on specific regions or individual components, leaving broader cross-regional construction patterns underexplored [5],[8]. Moreover, the potential of integrating these *tanggam* joinery systems into contemporary design and construction applications, particularly in sustainable timber construction and modular product or furniture systems, has received minimal systematic investigation [8],[7].

However, systematic structural-functional mapping of *tanggam* across regional typologies of traditional Malay houses remains limited in existing studies. Therefore, this paper aims to identify and classify the typological patterns of *tanggam* joinery and analyze their structural and symbolic roles within traditional Malay wooden houses across Peninsular Malaysia. To achieve the objective, a qualitative research framework was employed, integrating typological analysis, functional-symbolic role evaluation, and regional comparative analysis. Data were gathered through field observations and photographic documentation, focusing on key architectural elements, including roof trusses, columns, walls, doors, and window assemblies. The findings provide insights into how traditional timber connection systems support adaptability, disassembly, and longevity in contemporary architectural practice.

1.1 Traditional Malay Wooden Houses in Peninsular Malaysia

Traditional Malay houses provide a foundational context for understanding timber joinery systems, as their structural framework embodies an advanced tradition of interlocking wooden construction. These houses are typically characterized by raised timber structures on stilts (*rumah tiang seri*), steeply pitched roofs, and flexible modular layouts that enhance ventilation,

thermal comfort, and adaptability to the tropical climate [8],[9],[10]. Their structural design facilitates the effective load distribution and ease of maintenance, allowing the houses to accommodate changing functional needs over time [3],[5].

Prior research has highlighted the significance of nail-free timber joinery in traditional Malay houses as a construction technique that enables disassembly, relocation, and reassembly without major structural damage [2]. This construction approach demonstrates an initial implementation of sustainable timber construction principles, incorporating mechanical interlocking connections, minimal reliance on metal fasteners, and long-term material reuse. Consequently, traditional Malay wooden houses offer valuable precedents for adaptable and sustainable connection solutions in contemporary architectural practice.

1.2 The *Tanggam* Joinery as a Structural Connection Mechanism

In traditional Malay timber construction, a robust connection system is essential to integrating all primary building elements into a stable structural framework. The primary structural framework of a Malay house serves as the essential support system, significantly influencing the building's longevity and durability. This framework consists of various joinery connections, each designed for specific structural roles, including linking columns (tiang) and beams (rasuk), supporting roof trusses, and reinforcing floor structures [2]. These interconnections ensure continuity along critical load paths and enable effective load transfer throughout the construction system.

Beyond structural classification, the categorization of *tanggam* joinery also reflects an inherited architectural vocabulary shaped through historical evolution. Malay construction terminology developed through hybrid compositional influences, particularly during periods of architectural transition[12]. This perspective suggests that variations in *tanggam* types across regions may represent not only structural adaptation but also broader cultural and semantic transformations within the built environment. Collectively, these classifications provide a structured basis for understanding *tanggam* as a systematic structural connection mechanism within traditional Malay timber construction rather than as an isolated craftsmanship technique.

Figure 2: An example of *tanggam* in a traditional Malay house. *Field documentation photographs by the author (2025).*

Table 1: Structural classification of *tanggam* joinery in traditional Malay timber construction, adapted from [4], [7], [8], [11].

Structural Level	Structural Role	Typical Components	Function of Structural System
Primary *tanggam* system	Load-bearing structural	*Columns (tiang),beams (rasuk), Members (kasau), floor and roof structures (alang, bendul*, and *tetupai)*	Transfer structural loads through the main structural framework and ensure continuity of load paths within the house system.
Secondary *tanggam* system	Non-load-bearing structural	Doors, windows, wall panels, decorative architectural components	Support encloses the element and traditional detailing without carrying major structural loads.

1.3 Classification of *Tanggam* Joinery

Table 2 outlines the classification of Malay *tanggam* joinery according to functional category, joint type, related construction elements, and purpose. The classification was synthesized from documented knowledge on traditional Malay house construction and structural systems. Practical design applications further demonstrate the functional efficiency of specific *tanggam* configurations, both load-bearing and non-load-bearing applications [13].

The primary structural system of a traditional Malay house consists of the construction frame, floor system, and roof structure [2], [3]. In floor construction, several *tanggam* types are employed to connect structural components, including *tanggam berparit, tanggam bertebuk,* and *tanggam lekap* or *gegas,* depending on functional and load-bearing requirements. Among these, through mortise-and-tenon joint configurations comparable to *tanggam tebuk,* which demonstrate higher structural reliability, as joint geometry and tenon dimensions significantly influence stiffness and load transfer behaviour, as reported in previous timber joint studies [14],[15]. This characteristic supports the application of *tanggam tebuk* in critical load-bearing connections such as post (*belira–tiang*) joints.

In roof construction, *tanggam* joinery connects primary structural elements and provides overall roof stability. Common joints such as *tanggam lekap and tanggam berparit* are widely used, while more complex joints, including *tanggam lubang* dan *puting*, are applied at major connection points involving elements such as *tunjuk langit, alang pendek, kayu perabung*, and *kasau jantan*.

In traditional Malay houses, wall construction is generally non-load-bearing and therefore utilizes simpler joinery methods. Prior studies indicate that walls primarily serve for ventilation and spatial partitioning [8],[9],[11]. Ventilation walls consist of windows, doors, and decorative timber panels, whereas barrier walls include components such as *dinding janda berhias* and *dinding berpanel*. For these components, simpler joints, such as tanggam lidah and lurah, are typically sufficient. In door and window assemblies, frequently used joints include *tanggam lekap, tanggam berparit,* and *tanggam lubang dan puting.*

Table 2: Structural Classification of Malay *Tanggam* Joinery by Functions and Construction Elements, adapted from [2],[3],[6],[7],[13].

Category	*Tanggam types*	Construction Elements	Purpose
1. Surface Widening Joint *(Tanggam Melebar)*	*Tanggam Lidah dan Lurah*	Floor, wall	It is used to join wooden planks side by side to form wider surfaces, such as wall and floor panels.
	Tanggam Glu Gesel	Wall	
	Tanggam Tetingkat	Wall	
2. Lengthwise Joint (*Tanggam Memanjang)*	*Tanggam Skaf*	Roof, floor	It is used to connect timber pieces end-to-end to form longer structural components such as floor beams, roof rafters, and other longitudinal elements.
	Tanggam Sambung Jari	Roof, floor	
	Tanggam Sambut Lekap	Roof, wall	
	Tanggam Plat Sambung	Roof, floor	
3. Angular Joint *(Tanggam Siku)*	*Tanggam Temu*	Floor	It is used to connect wooden components at angles, perpendicular or diagonal intersections, such as floor structures, roof frames, and corners of panels.
	Tanggam Temu Tetingat	Floor, wall	
	Tanggam Rencong Biasa	Roof	
	Tanggam Bajang Biasa	Roof, wall	
	Tanggam Berparit	Roof	
	Tanggam Runcing	Floor	
4. Framing Joint (*Tanggam Pemidang)*	*Tanggam Lekap*	Wall	It is used to make a frame joinery system and to construct and reinforce non-load-bearing components such as doors, windows, wall panels, and decorative frames.
	Tanggam Kekang	Wall	
	Tanggam Lubang dan Puting	Roof, floor, wall	
	Tanggam Penetap	Wall	
	Tanggam Tebuk	Roof, floor	

1.4 Regional Styles and Construction Identity

Traditional Malay houses in Peninsular Malaysia exhibit regional variation arising from differences in environmental conditions, material availability, and local construction practices shaped by cultural, religious, and social principles [8],[16],[17],[18]. Despite these differences, common construction characteristics are observed across regions that include wooden structural systems, rectangular layouts, pitched roof forms, and wooden assembly methods that facilitate climatic responsiveness and adaptation [5],[6].

Traditional Malay houses in Peninsular Malaysia may be grouped into four principal house

styles: Kedah, Perak, Melaka, and East Coast. These styles differ in structural configuration, roof articulation, and common construction logic based on timber framing and interlocking joinery systems. Variations in *tanggam* application contribute to regional architectural identity by influencing structural configuration and assembly techniques, distinguishing Malay timber construction from Western fastening building systems [5],[6].

2. MATERIALS AND METHODS

2.1 Research Framework

This study adopts a qualitative multi-case analytical framework comprising three stages: typological classification, functional-symbolic analysis, and regional comparison. The research workflow is illustrated in Figure 3.

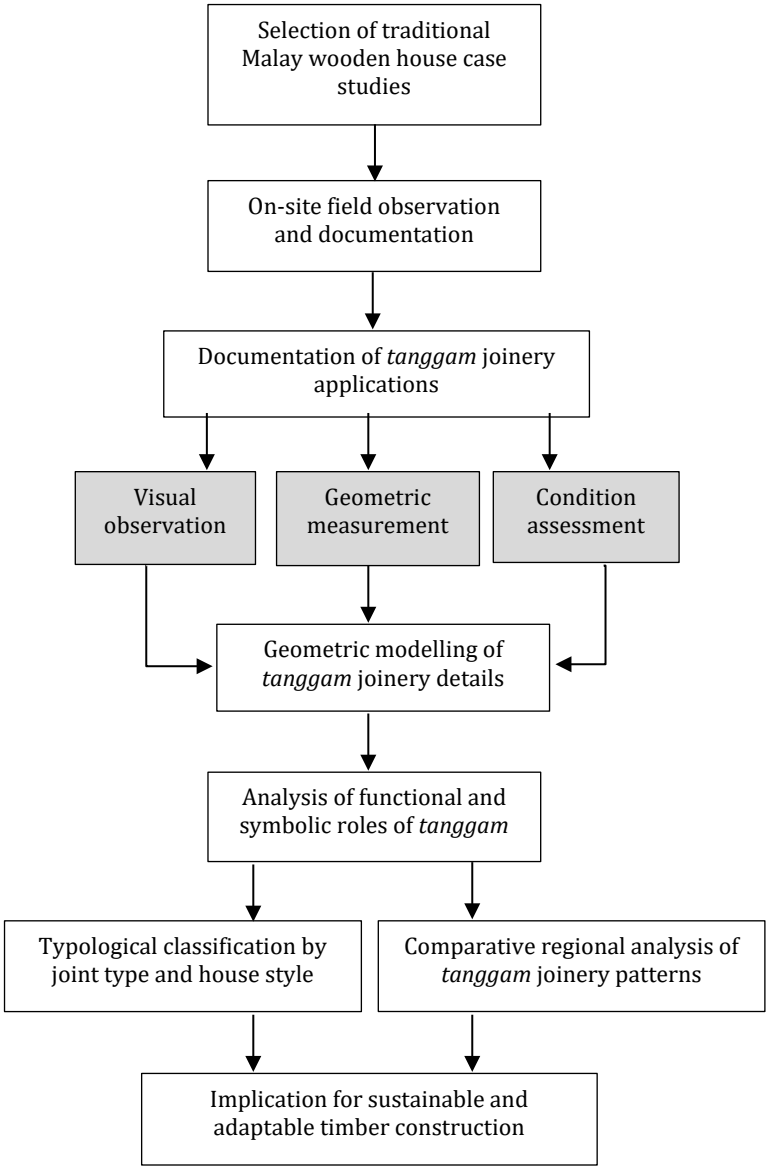


Figure 3: Research framework for analyzing *tanggam* joinery in traditional Malay wooden houses.

2.2 Data Collection

Data were collected through systematic field observation, photographic documentation, and geometric measurement, focusing on roof, floor, and wall connection systems. Site visits were conducted at selected heritage locations, including Malaysia Heritage Studios, Rumah Tradisional Bukit Palah in Melaka, and the Terengganu State Museum. In addition, secondary data were obtained from design publications, measurement drawings, and ethnographic documentation related to the construction of traditional Malay wooden houses.

2.3 Case Study Analysis

A total of 11 representative houses were analyzed. Selection criteria included architectural integrity, preservation condition, and availability of accessible joinery details. Field observations were conducted between January and June 2025, focusing on exposed roof, floor, and wall connection systems. A comparative study was conducted to identify similarities and differences in joinery patterns across the four regional styles.

In addition, documented studies informed the selection of traditional Malay houses across regional styles, including Kedah[12],[18], Perak[6],[19],[11],[20] Melaka [11],[17],[21], and the East Coast regions[22],[23],[24],[25].

2.4 Data Analysis

The data analysis employed a combined typological and functional-symbolic approach to evaluate the types of *tanggam* joinery observed in selected traditional Malay wooden houses across Peninsular Malaysia. The analysis integrated three stages: (i) typological classification of *tanggam* joinery based on joint form and construction location, (ii) analysis of functional and symbolic roles using a structured evaluation table, and (iii) comparative regional styles analysis across the four traditional wooden house styles.

3. RESULTS AND DISCUSSION

3.1 Structural Mapping of Traditional Malay House Components

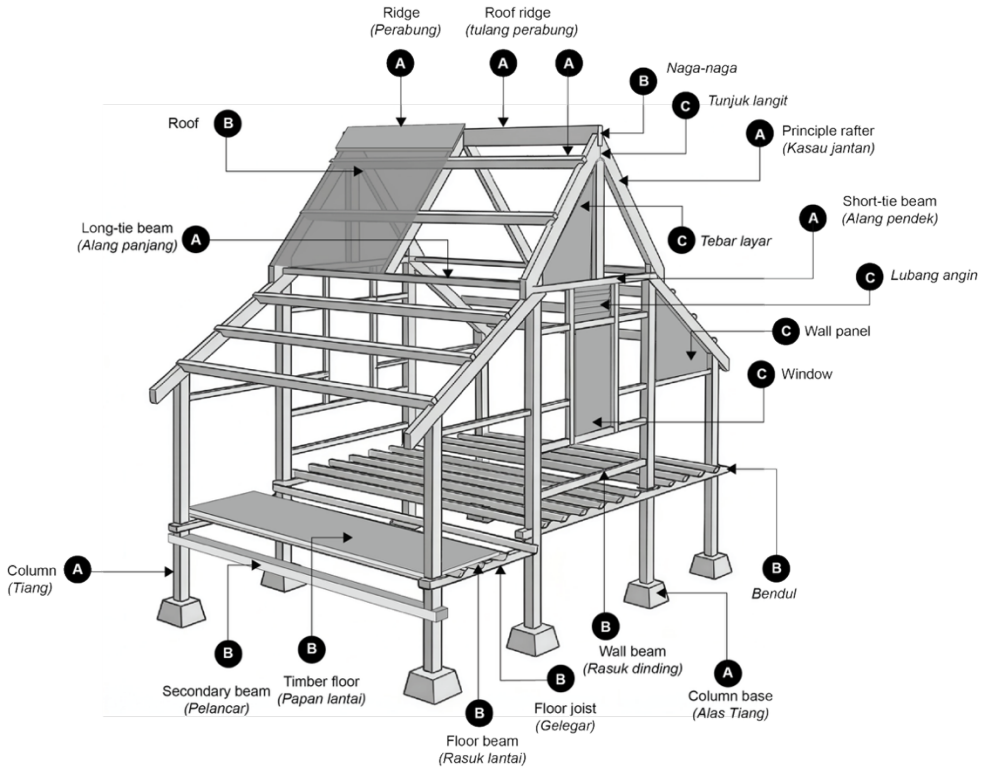
The analysis of selected traditional Malay houses across Peninsular Malaysia reveals a hierarchical structural system comprising primary, secondary, and non-structural components. As illustrated in Figure 4, several key structural elements were identified, including the *perabung, rasuk, tiang, kasau, bendul,* and *gelegar,* which collectively form the main structural framework of the house [2], [7], [26]. This structural hierarchy offers the basis for understanding the positioning and functional role of *tanggam* joinery within the overall timber construction system.

Primary structural elements function as the main load-bearing members that transfer roof and floor loads to the foundation and maintain overall structural stability. These components typically include columns (*tiang*), beams (*rasuk* and *alang*), ridge members (*perabung*), and principal rafters *(kasau jantan).*

Secondary structural elements support the floor and roof framing systems and distribute loads to the primary structure. Examples include floor joists (gelegar), secondary beams (pelancar), and other supporting roof members such as *kasau* and *gulung-gulung.*
Non-structural components primarily serve enclosure, ventilation, and architectural articulation rather than load-bearing roles. These elements include walls *(dinding)*, doors *(pintu),* windows *(tingkap)*, stairs *(tangga)*, and roof coverings (bumbung), which contribute to spatial enclosure

and environmental comfort [7], [16]. Decorative components such as *tebar layar* and carved panels further enhance the aesthetic identity of traditional Malay architecture.

Additionally, *tanggam* joinery serves symbolic and decorative functions in traditional Malay architecture. Some tanggam joints are also associated with carved architectural elements such as *tebar layar, pemeleh, tunjuk langit, sisik naga, sulur buyung, ande-ande, kepala cicak, tiang gantung kerawang, lebah bergantung, kekisi, gerbang, sesiku keluang, pagar musang, kepala pintu, kepala tingkap, lubang angin* [1],[25]. These components reflect the cultural expression and structural assembly in traditional Malay timber construction.



Legend:
A-Primary structural component
B- Secondary structural component
C-Non-structural component

Figure 4: Structural hierarchy of a traditional Malay wooden house (illustration by the author,2025). Component terminology adapted from [3],[26],[27],[28].

3.2 Typological Roles of *Tanggam* Joinery

Following the structural mapping presented in Table 3, the typological roles of *tanggam* joinery are examined according to their structural level of application within the house construction system. In summary, different joinery configurations correspond to specific structural demands and building components.

Load-bearing *tanggam* joints are predominantly applied to primary structural members, including columns (tiang), beams (rasuk and alang), and roof rafters (*kasau).* Joints such as *tanggam tebuk, tanggam berparit,* and *sambung jari* provide strong mechanical interlocking

connections that support vertical load transfer, structural continuity, and modular framing. This joint plays a crucial role in maintaining the elevated construction system and structural stability of traditional Malay houses.

Table 3: Typological Classification of *Tanggam* Joinery According to Structural Application in Traditional Malay House. *Source: Field documentation photographs by the author (2025).*

Category	*Tanggam* Type	Structural Level of Application	Typical Application	Figure
1. Surface Widening Joint *(Tanggam Melebar)*	*a)Tanggam Lidah dan Lurah*	Secondary	Wall panels, window frames, decorative door joints.	 Figure a
2.Lengthwise Joint (*Tanggam Memanjang)*	*b)Tanggam Skaf*	Primary	Beam extensions, longitudinal framing elements.	 Figure b
3. Joint *(Tanggam Siku)*	*c)Tanggam Temu*	Primary	Structural frame corners, staircase landings.	 Figure c
	d)Tanggam Bajang	Secondary	Window frames,door panels,decoration framing.	 Figure d
	e) Tanggam Runcing	Primary	Floor or structural corners.	 Figure e

4. Framing Joint *(Tanggam Pemidang)*	*f)Tanggam Lubang dan Puting*	Primary	Staircases, roof trusses, connecting roof ridge-rafters' connections	 Figure f
	g)Tanggam Lekap	Secondary	Roof panel, wall assembly, doors, windows.	 Figure g
	h)Tanggam Tebuk	Primary	Floor beams to columns.	 Figure h

In contrast, other *tanggam* joints are commonly used in secondary framing and enclosure elements, such as wall panels, doors, windows, and stair assemblies. In these applications, the joints primarily facilitate the assembly of timber components while allowing flexibility for maintenance, replacement, and ventilation.

Certain *tanggam* are also associated with carved architectural elements such as *tebar layar, tunjuk langit, pemeleh*, and decorative panels. These elements demonstrate that joinery contributes not only to structural assembly but also to the cultural and aesthetic articulation of traditional Malay architecture.

The morphological configuration of *tanggam* joinery reflects a direct relationship between joint geometry, structural function, and architectural expression. Joints such as *tanggam tetingkat* and *tanggam bajang biasa* are typically used in primary structural systems, which exhibit simpler, more robust geometries that prioritize strength and stability. However, joints applied in secondary often display greater geometric variation and decorative articulation.

In summary, the typological analysis confirms that joinery operates as an integrated construction language embedded within the architectural hierarchy of traditional Malay houses. Rather than functioning as isolated craftsmanship, *tanggam e*mbodies an integrated construction logic that supports structural performance, modular timber assembly and cultural expression while enabling sustainable timber constructions.

3.3 Regional Comparative Analysis of *Tanggam* Joinery

Comparative analysis across the four regional typologies revealed distinct differences in *tanggam* application and conceptual emphasis, as summarised in Table 4**.** The levels of structural and symbolic emphasis (low–high) were qualitatively assessed based on the frequency, spatial distribution, and architectural prominence of *tanggam* applications documented through field observations and supporting literature.

In the Kedah and Perak styles, *tanggam* joinery primarily emphasizes practicality and modular construction with limited symbolic articulation. These typologies reflect a construction logic prioritizing structural rationality, modular repetition, and responsiveness over decorative articulation.

In contrast, the Melaka and East Coast styles exhibit a stronger integration of structural and symbolic roles. In these regions, *tanggam* joinery is more frequently combined with carved and decorative elements, resulting in hybrid joint configurations that contribute to both structural performance and cultural expression. The East Coast typology demonstrates the most pronounced structural-symbolic integration, where *tanggam* simultaneously performs critical load-transfer functions and reinforces architectural identity through elaborate carved articulation.

These regional variations highlight how a shared timber construction system is interpreted through differing socio-cultural values, aesthetic priorities, and environmental contexts. While the structural logic of *tanggam* remains consistent, its expressive intensity varies regionally, revealing the dynamic interplay between performance, identity, and architectural evolution in traditional Malay houses across Peninsular Malaysia.

Table 4: Regional Comparison of *Tanggam* Joinery Concepts and Symbolic Emphasis. *Source:* State classification adapted from [28].

Regional Typology	States	Structural Emphasis	Symbolic Emphasis
Kedah Style	Perlis, Kedah, Pulau Pinang	Functional/Practical	Low
Perak Style	Perak, Selangor	Modular/Rational	Low
Melaka Style	Melaka, Johor, Negeri Sembilan	Decorative integration	High
East Coast Style	Kelantan, Terengganu, Pahang	Structural-symbolic integration	High

4. CONCLUSION

The findings demonstrate that *tanggam* functions as a systematic timber connection mechanism that integrates structural stability, modular construction logic, and cultural integration within traditional Malay wooden houses. The mechanical interlocking configuration allows timber components to be assembled without reliance on metal fasteners, while providing efficient load transfer and structural continuity. These characteristics support material conservation, ease of maintenance, and extended construction lifespan, reflecting principles consistent with sustainable timber construction.

The study contributes to the documentation and interpretation of traditional Malay joinery by clarifying the typological patterns and functional roles of *tanggam* within the structural hierarchy of traditional houses. The findings provide a structured reference for researchers, architects, conservation practitioners, and designers interested in traditional timber construction systems and their relevance to contemporary sustainable building practices that align with SDG 11 (Sustainable Cities and Communities) by providing renewable, low-carbon building materials for resilient urban development.

Although this study is limited to documented case studies and literature analysis, future research involving expert validation and structural performance evaluation could further examine the mechanical reliability and sustainable performance potential of the *tanggam* system in contemporary construction contexts.

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