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I-CReST 2025:139-109 – Traditional Timber Joinery and Local Materials in the Mak Ani Heritage House: Sustainable Construction in Negeri Sembilan Vernacular Architecture

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ABSTRACT

The traditional Malay houses of Negeri Sembilan reflect a unique socio-cultural system rooted in Adat Perpatih, inherited from the Minangkabau community. The Mak Ani Heritage House, located in Kampung Parit Istana, Kuala Pilah, stands as a rare example of vernacular architecture that has remained structurally intact for over a century. Remarkably, it was constructed entirely without the use of nails. This study focuses on documenting traditional timber joinery techniques and the application of locally sourced materials that have contributed to the house's longevity and environmental sustainability. A critical issue addressed in this research is the growing risk of losing traditional carpentry knowledge due to insufficient technical documentation and the influence of modernization. Using a qualitative approach, including site observation, measured drawings, semi-structured interviews, and literature review, this study identifies various joinery systems such as mortise and tenon (tanggam lubang & puting),through beam joint (tanggam penyalur), notched joint (tanggam takuk), half lap joint (tanggam lekap), tongue and groove (tanggam lurah dan lidah), wooden pegs (pasak), and wedges (baji), all of which are applied in a modular and flexible construction method. The findings reveal that these traditional techniques are not only sustainable but also share fundamental principles with modern prefabricated building systems, being demountable, reassemble, and relocatable. The use of naturally treated hardwoods such as merbau and meranti further enhances the house's structural resilience. As a whole, the Mak Ani Heritage House represents a model of vernacular construction that embodies both functional structural integrity and a deep cultural understanding of the tropical environment. This study aspires to serve as a technical and cultural reference for future conservation and innovation in traditional Malaysian architecture.

Keywords: Heritage house; traditional timber joinery; sustainable architecture; local materials; prefabricated system

1. INTRODUCTION

The traditional Malay houses of Negeri Sembilan reflect the social and cultural system of the community, rooted in the Adat Perpatih customs inherited from the Minangkabau and assimilated with local culture. The architecture of these traditional houses not only serves as shelter but also demonstrates a deep understanding of the tropical climate, adaptation to the natural environment, as well as aesthetic and symbolic values in the lives of the people [9], [10]. One well-preserved example of this architectural heritage is the Mak Ani Heritage House in Kampung Parit Istana, Kuala Pilah. This house was chosen as it represents one of the few remaining original examples of Negeri Sembilan's traditional architecture, having stood for over a century while maintaining its original structure without significant modern alterations. Built without the use of nails, the house remains structurally sound due to the skill of local

craftsmen in applying traditional timber joinery techniques such as tanggam, pasak, and baji, which have been identified as the primary methods of connection in traditional Malay houses [1], [12].



Fig. 1. Mak Ani Heritage House in Kampung Parit Istana, Kuala Pilah
Source: KAWANS, Politeknik Port Dickson

The main structure of this house is constructed from Merbau timber and is supported by twenty (20) primary columns. It features raised-floor construction, tiered roofing, and an effective cross-ventilation system, making its design well-suited to the tropical environment and climate. These characteristics demonstrate the application of sustainable architectural principles, such as the use of local materials, passive ventilation, and spatial flexibility [4], [8]. The selection of the Mak Ani Heritage House as the subject of study is also due to its representation of a traditional house typology that remains in good condition, complete with original elements such as the long curved roof (atap lontik), serambi (veranda), rumah ibu (main house), attic (loteng), tiang seri (central post), and intricate traditional carvings rich in cultural symbolism. Studying this house offers an opportunity to explore joinery techniques and spatial arrangements that have not been extensively documented from a technical perspective in existing literature. Furthermore, the house's location within its original village setting allows for a comprehensive analysis of its integration with the landscape and village layout.

Previous research by Lim (1987), Said (2006), and Omar & Johar (2013) has discussed various aspects of traditional Malay architecture, including symbolism, form, and carving details [5[, [6], [7]. However, there is a lack of in-depth studies focusing on joinery systems, construction materials, and the technical adaptability of these structures [2], [11]. Therefore, this study on the Mak Ani Heritage House is crucial in strengthening the documentation of built heritage, particularly in relation to traditional woodworking craftsmanship. The entire structure reflects sustainable architectural principles, achieved without reliance on modern technology, yet it remains sturdy and long- lasting. This situation proves the existence of a traditional building system that is not only aesthetically and symbolically rich but also highly responsive to environmental needs. Nevertheless, the forces of modernization and the lack of technical documentation threaten this knowledge with gradual erosion and possible extinction.

In response, this paper aims to uncover and document the construction techniques of the house, particularly the timber joinery system and the selection of building materials, which contribute to its structural durability without the use of nails or modern construction materials. Through site observation, measured drawings, interviews with the owner and heritage carpenter, and technical analysis, this paper outlines the key construction elements of the Mak

Ani Heritage House as an effort to preserve traditional carpentry knowledge. The findings are hoped to serve as a reference in empowering sustainable building practices rooted in local wisdom.

2. OBJECTIVE

This study was conducted with the following objectives:

i. To identify the traditional construction techniques used in the building of the Mak Ani Heritage House in Kampung Parit Istana, Kuala Pilah, including the basic structural aspects and carpentry methods.
ii. To analyze the traditional timber joinery systems such as *tanggam, pasak,* and *baji* used in key structural elements of the house, including columns, flooring, walls, roofing, and ventilation systems.
iii. To assess the role of local building materials in contributing to the structural durability and long-term sustainability of this traditional house in the context of the local climate and environment.

3. METHODOLOGY

This study employed a qualitative research approach that emphasizes observational and interpretive methods to examine the traditional construction techniques of the Mak Ani Heritage House in Kampung Parit Istana, Kuala Pilah. Data collection was carried out through four main methods. Firstly, systematic site observation was conducted to assess the physical structure, document the layout, and identify traditional joinery systems, supported by photographic documentation and detailed field notes. Secondly, measured drawings were produced based on accurate measurements of key structural components such as columns, beams, floors, stairs, and roofing elements, providing a technical basis for spatial and structural analysis. Thirdly, semi-structured interviews were conducted with descendants of the house's owner and individuals involved in its maintenance to gather oral histories and insights into traditional carpentry methods, construction history, and the original functions of various spaces within the house. Finally, a literature review was undertaken to contextualize the findings, drawing from academic journals, architectural texts, heritage documentation, and previous studies on traditional Malay architecture, particularly within the Negeri Sembilan context. The combination of these methods allowed for a comprehensive and culturally grounded analysis of the house's construction system, ensuring that both technical and intangible aspects of architectural heritage were thoroughly examined.

4. COLUMN AND SPATIAL LAYOUT

The study of the Mak Ani Heritage House, located in Kampung Parit Istana, Kuala Pilah, reveals that its structure has remained intact despite being over a century old. The construction is based entirely on a traditional timber framework, assembled without the use of nails, employing joinery techniques such as *tanggam, pasak* (wooden pegs), and *baji* (wedges). One of the key findings of this research details the arrangement of the primary columns, auxiliary columns, and hanging columns that form the structural framework of the house. All columns rest on *batu sendi* (stone footings), which function as a protective barrier to prevent moisture from seeping into the wooden structure, an essential feature in traditional Malay architecture for durability and termite resistance.

The core structure is built upon twelve (12) main columns arranged in four rows and three bays, forming a structural grid that supports the entire main body of the house. This layout creates three distinct spatial zones: the *serambi* (front veranda), the central *rumah ibu* (main house) divided into two sections, and the *dapur* (kitchen) located on the right side of the *rumah ibu*. At the *rumah ibu* stands the *tiang seri*, or main post, which serves as both the structural and spiritual axis of the house. This was the first post erected during the construction process, symbolizing the center of structural balance and the ancestral lineage in the Adat Perpatih cultural system.

To meet daily functional needs, additional columns were constructed beyond the main grid. On the right side of the serambi, four auxiliary columns were erected to form the anjung or entrance porch, functioning as a transitional space between the exterior and interior, and serving as an informal guest reception area. In addition, two more columns were added at the front of the *serambi* to support an extended roof that covers the main entrance staircase. This not only protects the stairs but also creates a welcoming area that bridges the ground level with the interior space.

Furthermore, two additional columns also were added on the right side of the *rumah ibu* (in the third and fourth rows) to accommodate a lateral kitchen extension. This kitchen extends longitudinally to the right side of the house, differing from the typical layout of Malay traditional houses, where kitchens are usually situated at the rear. In addition, two more columns were erected to form the *pelantar dapur* (kitchen platform), which functions as a space for washing, daily storage, and other domestic activities. This platform plays an essential role in supporting the household's daily operations and reflects the efficient spatial planning of traditional houses.

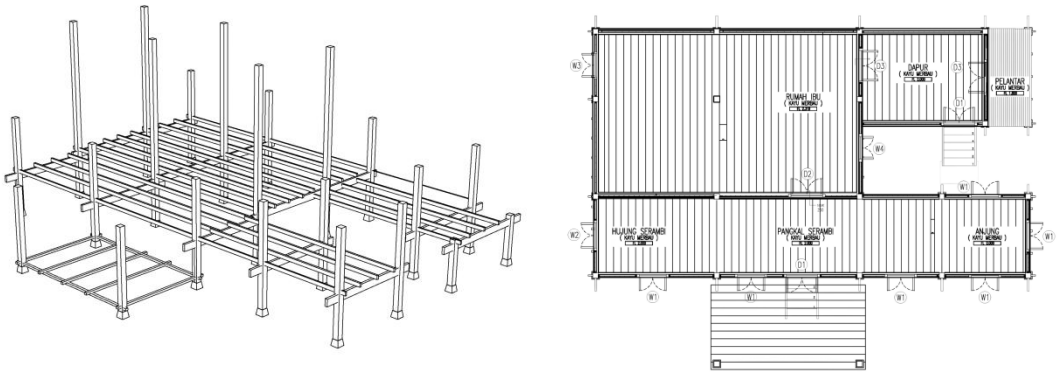


Fig. 2. Merbau hard wood column structure of Mak Ani Heritage House in Kampung Parit Istana, Kuala Pilah

Source: KAWANS, Politeknik Port Dickson

In total, the house rests on twenty two (22) ground reaching columns, comprising both primary and additional structures. A notable architectural element observed is the presence of six *tiang gantung* (hanging columns), the structural elements suspended from the overhead beams that do not touch the ground. These hanging columns support two key upper structural components: the roof structure of the *rumah ibu* and *serambi*, and the loft floor (*loteng*) located above the *rumah ibu.* Interestingly, the six (6) hanging columns exhibit three (3) distinct design variations, particularly in the shapes of their column heads and carved ornamentation. Among the identified styles are heads shaped like the *buah buton* (buton fruit) and square forms, accompanied by side carvings that serve both structural and symbolic purposes. These design variations reflect a high level of traditional craftsmanship and the artisans' ability to design structurally responsive systems that also embody cultural and spiritual meanings.

Table 1. Column structure in the Mak Ani Heritage House

No	Type of Column	Quantity	Notes
1	Main columns (4 rows × 3 bays)	12	Includes 1 tiang seri (central column)
2	Auxiliary columns (entrance porch)	2	Main Entrance
3	Auxiliary columns (*anjung*)	4	Right side of the serambi
4	Auxiliary columns (kitchen)	2	Right side of the rumah ibu
5	Auxiliary columns (kitchen platform)	2	Rear kitchen extension
	Total physical columns (ground supported)	**22**	
6	Hanging columns (support roof & loft)	6	3 distinct design variations

5. STRUCTURAL & JOINERY SYSTEM

The Mak Ani Heritage House in Kampung Parit Istana, Kuala Pilah demonstrates the application of a complex and integrated traditional timber joinery system, constructed entirely without the use of nails or metal components. Observations and structural documentation reveal that earlier craftsmen employed various types of joinery techniques depending on the function and location of each building component, in accordance with heritage carpentry principles that emphasize precision, material understanding, and structural integrity.



Fig. 2. Sections drawing of Mak Ani Heritage House
Source: KAWANS, Politeknik Port Dickson

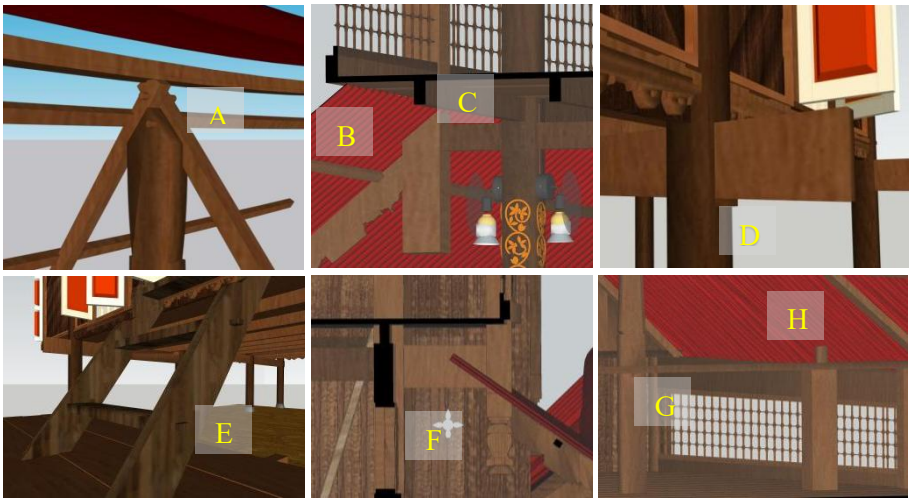
The main types of joinery techniques identified and their corresponding building elements are summarized in Table 2 below:

Table 2. Joinery system of the Mak Ani Heritage House

No	Type of Joinery	Location	Function
1	Mortise and Tenon *(Tanggam Lubang Puting)*	Columns to roof beams, rafters to roof beams, hanging column connections, stair steps	Connects major structural components securely and stably
2	Channel Joint *(Tanggam Salur)*	Column to floor beam connections	Provides strong and stable support for primary framework
3	Half-Lap Joint *(Tanggam Lekap)*	Cross beams, kitchen platform, side connections to columns, loft beams to hanging columns	Supports lightweight components, reinforced with wooden pegs (*pasak*)
4	Notched Joint *(Tanggam Takuk)*	Rafters and ridge beams of the rumah ibu and serambi	Supports roofing, reinforces rafters against wind and rain
5	Tongue and Groove *(Tanggam Lidah dan Alur)*	Floorboards, wall panels (vertical and diagonal), loft floorboards	Ensures tight and seamless joints, prevents air gaps and moisture penetration

6	Wooden Pegs *(Pasak Kayu)*	Present in almost all primary joints of roof and loft structure	Locks joints securely without the use of metal fasteners
7	Wedges *(Baji)*	Column bases and selected floor joints	Tightens joints and allows for adjustments during assembly

All the joints were constructed using *dry-fit techniques*, allowing each component to be assembled and disassembled without damaging the original structure. The use of traditional tools such as chisels, wooden mallets, and hand saws reflects the craftsmen's precision and the fine workmanship achieved through manual methods. The combination of various joinery types demonstrates a sustainable construction system that is durable and responsive to both functional needs and the tropical environment.



Legend:

A/G - Wooden Pegs *(Pasak Kayu)*

B - Notched Joint *(Tanggam Takuk)*

C - Half-Lap Joint *(Tanggam Lekap)*

D - Channel Joint & wedges *(Tanggam Salur & baji)*

E, F, H - Mortise and Tenon *(Tanggam Lubang Puting)*

Fig. 3. Joinery system of Mak Ani Heritage House
Source: KAWANS, Politeknik Port Dickson

The wall structure of the Mak Ani Heritage House also shows adaptive design that not only fulfill structural requirements but also enriches the aesthetic value of traditional Malay architecture in Negeri Sembilan. Observations reveal two types of wall board arrangements: vertical and diagonal, each applied according to the function of the space and the orientation of the house. Vertical board arrangements are used in the main areas of the house, such as the *rumah ibu* and *serambi*. These boards are tightly joined using tongue and groove techniques, producing a strong and neat surface. This method is suitable for areas requiring structural stability and resistance to external weather. Visually, the vertical arrangement conveys a formal and orderly image, consistent with the social function of these interior spaces in a traditional house setting. Meanwhile, other wall sections are arranged diagonally, typically at a 45 degree angle, particularly in the upper parts of the house or on specific facades. This technique serves not only as decoration but also reinforces the wall against wind pressure and wood movement due to climate changes. It enhances visual variety and adds aesthetic richness to the house facade.

6. MATERIALS

A detailed observation of the structural elements of Rumah Warisan Mak Ani reveals the strategic use of locally sourced building materials, carefully selected for their durability, availability, and suitability to the tropical climate. These materials reflect a deep understanding of their physical properties and the environmental conditions in which the house was built. The

selection process was not arbitrary but rather informed by traditional knowledge passed down through generations of craftsmen, ensuring that each component of the house fulfilled both functional and climatic needs. The table below summarizes the key structural components and the types of timber used in the construction:

Table 3. Building materials of Rumah Warisan Mak Ani

No	Structural Component	Type of Timber Used
1	Columns & Beams	Merbau Wood
2	Rafters & Wall Plates	Merbau Wood
3	Walls & Floors	Meranti
4	Wooden Pegs (Pasak)	Merbau Wood
5	Hanging Post	Carved Square Merbau
6	Roof Structure	Merbau Wood

Merbau timber is extensively used for the main structural components of the house—such as columns, beams, rafters, and wall plates due to its classification as a tropical hardwood that is highly resistant to termites and moisture. In contrast, Meranti wood, which is lighter and easier to shape, is used for walls, facia board, opening and flooring. Its smooth surface and ease offinishing make it ideal for non-load-bearing elements that are less exposed to external weathering.



Fig. 4. Meranti wood applied at floor, decorative facia and wall panel at Mak Ani Heritage House
Source: KAWANS, Politeknik Port Dickson

The timber used in the house is typically air-dried naturally, with some pieces soaked in water prior to construction to improve resistance against dampness and insect infestation. As highlighted by Nasir (1985), this drying process is essential to ensure the dimensional stability of the wood, preventing expansion and shrinkage over time [1]. Such treatment reflects the builders' deep understanding of the material's properties and their application of traditional preservation techniques to ensure the house's long-term durability. Timber was cut and refined using traditional hand tools such as chisels, hand saws, and wooden mallets, all of which require a high level of skill and precision.

Overall, the selection and use of building materials in Rumah Warisan Mak Ani demonstrate the traditional craftsmen's sophisticated knowledge of timber's physical and mechanical characteristics. Their ability to balance functionality, aesthetics, and sustainability in material choices aligns with modern green building principles. This traditional approach can serve as a valuable model for contemporary construction, particularly in promoting the use of durable, locally sourced, and environmentally friendly materials.

7. DISCUSSION

Findings from the study of Rumah Warisan Mak Ani in Kampung Parit Istana, Kuala Pilah, affirm that the traditional timber-based architecture of Negeri Sembilan demonstrates a high degree of structural ingenuity, flexibility, and sustainability. The house features a core grid of

twelve primary columns arranged in four rows and three columns, with additional columns at the *anjung* (veranda), side kitchen, and rear kitchen platform. This structural layout not only serves functional needs but also accommodates the social and cultural practices of the local community. The tiang seri (main column), located at the centre of the *rumah ibu* (main house), symbolizes the spiritual and cultural core of the home, deeply rooted in the matrilineal system of Adat Perpatih.

Furthermore, six *tiang gantung* (hanging columns) support the roof structure and the attic floor, reflecting a sophisticated understanding of suspended load systems. These columns do not rest directly on the ground but are instead hung from horizontal beams, requiring precise joinery and load distribution techniques. Their placement contributes to both vertical and lateral stability, particularly in supporting cantilevered roof projections like *bumbung pisang sesikat*. The carved embellishments on these columns also reflect aesthetic and spiritual values embedded in the architecture.

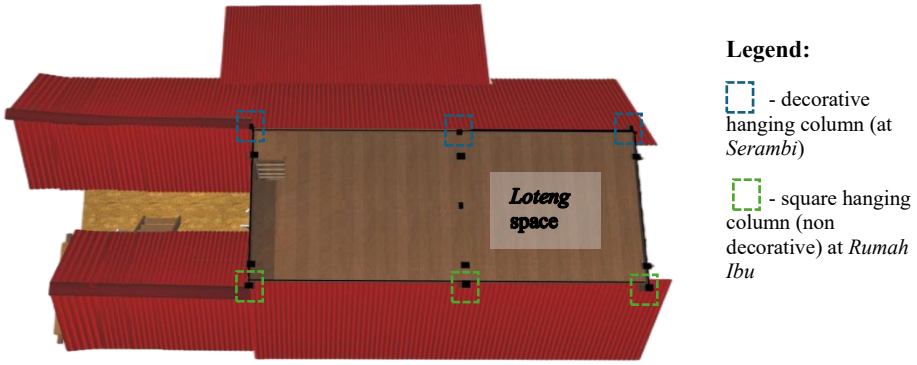


Fig. 5. The position of *Tiang Gantung* (hanging column) of Mak Ani Heritage House
Source: KAWANS, Politeknik Port Dickson

The house's joinery system highlights the uniqueness of traditional Malay carpentry, executed entirely without nails or metal fasteners. Various *tanggam* (wood joints) such as mortise and tenon *(lubang-puting)*, channel *(salur)*, lap joints *(lekap*), notches *(takuk)*, tongue-and-groove *(lidah dan alur)* are strategically applied based on structural location and load distribution. Wooden pegs *(pasak)* and wedges *(baji)* act as locking and tightening mechanisms. The entire system is constructed using dry assembly techniques *(pasang kering)*, allowing disassembly and reassembly without structural damage. This approach parallels the concept of modern prefabrication technologies like the Industrialised Building System (IBS), where modular components are designed for rapid assembly, modification, or relocation.

The house's modular and adaptive design also facilitates relocation a key trait for earlier generations who often moved due to shifting agricultural lands. This adaptability resonates with contemporary needs for fast-erecting, eco-sensitive, and flexible buildings. Moreover, the use of local hardwoods such as merbau, meranti, and cengal, naturally treated against insects and moisture, ensures long-term durability. The structural columns and beams are crafted from heavy hardwoods, while the walls and floors use lighter timbers for ease of shaping and thermal efficiency. The varied arrangement of wall boards vertical and diagonal not only showcases carpentry skill but also improves wind resistance, airflow, and structural stability. Diagonal arrangements in particular help mitigate timber warping and enhance visual character.

In conclusion, Rumah Warisan Mak Ani stands as a vernacular architectural model that integrates structural logic, cultural meaning, and sustainability. This study offers valuable insight into traditional construction techniques that are increasingly at risk of being forgotten.

By understanding these foundational principles, such heritage practices can inspire the development of locally rooted, sustainable IBS housing systems that are flexible, efficient, and culturally resonant.

8. CONCLUSION

Mak Ani's Heritage House is a manifestation of exceptional traditional craftsmanship, deeply rooted in cultural values and adapted to local climatic needs. Despite being over a century old, the structure remains remarkably intact, demonstrating the effectiveness of metal free joinery techniques, the use of quality local materials, and a modular spatial layout that allows for adaptability over time. The application of traditional woodworking methods such as mortise and tenon joints, wooden pegs, and wedges not only strengthens the structural integrity but also enables the house to be assembled, dismantled, and relocated a concept that resonates with today's prefabricated building systems like the Industrialized Building System (IBS). This approach affirms that traditional construction principles can be revitalized in contemporary contexts to produce housing that is sustainable, flexible, and heritage-driven. From a technical standpoint, this timber structure showcases the long-term durability of passive architectural strategies, including cross-ventilation, natural lighting, and the selection of weather-resistant local materials. The ability to disassemble and reassemble the structure further enhances its potential as a mobile heritage model. The intricate carvings are not merely decorative; they also function as passive ventilation elements, reflecting a deep understanding of the integration between aesthetics and function. In conclusion, Mak Ani's Heritage House is not only architecturally significant but also serves as a living narrative of Adat Perpatih, the matrilineal kinship system, and Malay timber craftsmanship. This technical study hopes to serve as a reference for heritage conservation efforts and as an inspiration for modern sustainable construction approache**s.**

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