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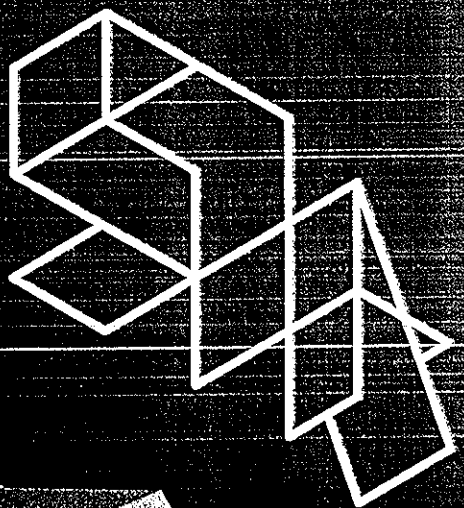
# PROCEEDINGS



24-26 November 2015

Built Environment

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WISDOM OF THE TROPICS PAST, PRESENT & FUTURE

# PROCEEDING

## WISDOM OF THE TROPICS: PAST, PRESENT & FUTURE

**INTERNATIONAL JOINT-CONFFERENCE**
**SENVAR-iNTA-AVAN 2015**
24-26 November 2015
Faculty of Built Environment,
Universiti Teknologi Malaysia,
Johor Malaysia

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# PREFACE

*Bismillahirrahmanirrahim*

All praise to Allah s.w.t the Most Gracious and the Merciful for giving all His Rahmah and Barakah to complete the International Joint Conference proceedings of SENVAR-iNTA-AVAN (SiA2015) jointly organised by Institut Sultan Iskandar (ISI) - Centre For The Study of Built Environment in The Malay World (KALAM) of Universiti Teknologi Malaysia - Graduate School For International Development & Cooperation (IDEC) of Hiroshima University - Center for Advanced Studies in Architecture (CASA) of National University of Singapore, and supported by Universiti Teknologi Malaysia (UTM), Hiroshima University (HU) from November 24 to 26, 2015 in Universiti Teknologi Malaysia, Johor Bahru, Malaysia.

The theme for SiA2015 Conference is "Wisdom of the Tropics: Past, Present & Future". SiA2015 conference brings together an international community of experts to discuss the state-of-the-art, new research results, perspectives of future developments, and innovative applications relevant to sustainable building design, vernacular architecture, tropical architecture, urban planning, climate change, green technology, socio-economic and sustainable habitat.

More than 200 scholars and researchers from different background and countries were invited to submit their papers, and of these, about 100 people submitted their full papers. These reviewers represent 10 different countries, which provided a broad set of perspectives to the research arena. I would like to thank all these reviewers for their time and effort in reviewing the papers. Without this commitment it would not be possible for the proceedings to be published. The quality of the accepted papers are attributed to the authors and also to the reviewers who have guided the necessary improvement.

Enough thanks cannot be expressed to our distinguish key note speakers Architect Kengo Kuma, Architect Razin Mahmood making themselves available and all other participants, sponsors, supporters, volunteers and media for all their valuable contributions in the conference. Also, special thank you to the Vice Chancellor UTM Prof. Datuk Ir. Dr. Wahid Omar, Director of The Centre of Built Environment in the Malay World or Pusat Kajian Alam Bina Dunia Melayu (KALAM) Associate Professor Dr.Raja Nafida binti Shahminan, Research Fellow from Graduate School for Internatioanl Development and Cooperation (IDEC) Hiroshima University Associate Professor Dr. Tetsu Kubota, Director of CASA (Centre for Advanced Studies in Architecture) National University of Singapore Associate Assistant Professor Dr. Widodo Johannes, Deputy Director of Institut Sultan Iskandar Associate Professor Dr. Syed Ahmad Iskandar bin Syed Ariffin and all the organizing committee members that have worked so hard to ensure that this conference and the publication of the proceeding a great success. The SiA2015 conference and proceedings are a credit to contribution of a large group of people and thus we should be proud of the outcome.

Best Regards,

Chair,
Prof Dr Mohd Hamdan Ahmad
SiA2015 Conference
20 November 2015

# Visual Inspection on Sources and Factors of Deterioration in Wood Components of Malay Traditional House

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Wood is one of the principal materials for the construction of Malay traditional houses. However, the wood components are subject to deterioration due to the hot and humid tropical country like Malaysia. Therefore this study aims to investigate the sources and factors of deterioration on wood components of a traditional timber house, namely Rumah Dato' Panglima Gajah in Negeri Sembilan. The house was selected as a case study due to its distinctive form and historical values. The main objectives of this study were to examine the types and properties of wood and to identify the sources and factors of wood deterioration in the house. Qualitative methods of data collection were employed including historical and site analyses, personal interview and site visit. Also, series of laboratory analyses were conducted in two different stages. The first stage of analysis was done to determine the type of wood, its properties and moisture content (MC). In the second stage, environment test was conducted to determine the Relative Humidity (RH) and surrounding temperature of the houses. Visual analysis was conducted on the wood components of the houses to identify and determine the types and factors of deterioration. The result shows that *Meranti* and *Cengal* woods were used for the house construction. The wood deteriorations are caused by environmental, biological and physical factors. The study found that *Cengal* has a minimal deterioration effect because of its higher density and higher resistance toward the environmental condition, termite attack and fungal infestation as compared to *Meranti*. The study suggests that environment surrounding of the house is the main factor of deterioration. Future research could be conducted to explore the suitable treatment for decayed wood. The Malay traditional houses need to be protected to ensure its heritage values are maintained in good condition.

Keywords: Malay Traditional house, wood deterioration, preservation of Malay heritage

## Introduction

The Malay traditional house is a very important heritage to be preserved for the future generation due to its local architectural feature in distinctive form. It manifests the creative and aesthetic skills of the past generation of Malays in using local timbers

as construction materials. The house can be classified as a vernacular architecture, which means the local architecture by the people, and also architecture without architect of the Malay Peninsula before the colonialism period (Yuan, 1991; Zulkifli and Abdullah Sani, 2006). The house is based on the traditional principle of building that built by the locals and not a product of the professional (Mohd Sabrizaa, Norhasandi and Sufian, 2009). Most of the material used is readily available local material such as timber, bamboo and palm (Syed Ahmad Iskandar, 2004; Ismail et al. 2006). Ismail (2005) states that most of the Malay traditional house used local timber such as Bolanocarpusheimii (cengal), Shorea sp. (meranti), and DamarLaut.

The design of Malay traditional house is nearly perfect house form which is appropriate to local climate condition of Malaysia. The house does not only express the way of life of its inhabitants but also it is extremely well designed to suit the warm and humid Malaysian climate that can be classified as tropical with high temperatures, high humidity and heavy rainfall (Arazi Idrus et al., 2011). This environmental condition would lead to timber deterioration. Deterioration terms can be defined as a natural process that cannot be stopped (Ozen, 2015); it can only be slowed. Eaton and Hale (1993) posit that wood defects such as physical decay, excessive moisture content, dimensional instability and chemical deterioration can be grouped into non-biological deterioration and biological deterioration which are caused by non-living and living organisms, respectively. Most of Malay wooden houses especially the century-old structures in Malaysia are also affected by physical decay that causes by biological, non- biological, chemical and physical factors. There is a need to investigate the types of deterioration on the wood components of the traditional timber houses and its contributing factors especially for those which are still intact as dwelling units. The identification of wood deterioration in the houses would help the residents to keep the houses from further damage.

Wood is one of the most popular materials for the construction of old Malay traditional houses. During the old periods, the organic material like wood were abundantly found and became one of the earliest building materials that has significant properties (MTIB, 1990), and is widely used until today. Tropical timber species are the most popular materials for both structural and non-structural parts in the construction of the traditional houses. These include carved components in forms of ventilation, door, roof and wall panels which strengthen the regional identity of the traditional houses (Zumahiran and Ismail, 2013). However, wood components of the houses are subject to decay especially those made from non durable types of wood and the Malaysian climate has become one of the major deterioration factors. Although several components are made from naturally durable hardwoods, for example *Chengal* (Neobalanocarpus heimii), *Merbau* (Intsia Bijuga) and *Red Balau*

(Shorea balangeran), these old components have tendency to deterioration over a period of time. The woods are usually used for the construction of structural components of Malay traditional house. The non-structural components including doors, windows and decorative wood carvings are usually fabricated using hardwoods and softwoods. However timber is among the most vulnerable materials and is decayed by the effects of adverse environmental conditions of tropical climate like Malaysia and the extent of damage depends on both, the type of timber and the conditions. Similarly, the timber house is vulnerable to deterioration because of the vulnerability of timber material.

In the context of old Malay traditional houses, types of timber used for building components are not easily identified and a variety of timber species are used for different types of components. Some are more vulnerable than others. Hence, there is a need to investigate the types of timber used for the components of the timber houses. The wood characteristic properties of the components would then be identified consequently through scientific analysis. Therefore the aim of this study is to conduct a scientific investigation on the wood characteristic properties apart from identification of the types of deterioration on the wood components. The objectives of the study are: 1) To examine the types and properties of timber used for the components of the selected Malay timber house, 2) To identify the sources and factors of deterioration on the wood components. Although much is known about wood-degrading agents and the kinds of damage they do, many facets of potentially useful information remain to be developed in these fundamental of wood deterioration especially with respect to tropical wood components found in old Malay traditional houses.

The Malay traditional house is one of the richest components of Malaysia's cultural heritage. Therefore, this type of traditional heritage is an object of important studies since the last three decades. Many previous studies of local and international scholars have emphasis in exploring the preservation of traditional buildings and its cultural heritage either through theoretical or technical research. Among the major concerns were on preservation of historical buildings (e.g. Mohd. Sabrizaa and Sufian (2008); Vatan (2010); Arazi et al. (2011), issues on socio-cultural and architectural heritage (e.g. Harding (2003); Vecco (2010), and re-adaptation of old house (e.g. Nur Hidayatuljamilah, (2012); Amir and Nur Dalilah (2012); Zumahiran Kamarudin (2015). Thus far, research in identifying the wood characteristic properties of the components of old traditional house through scientific analysis is few and received least attention. While other studies focused on heritage and conservation of traditional houses, issues on its socio-cultural and architectural heritage and the meanings of its existence in the past and present built environment. Little of similar research was carried out to study

the wood characteristic properties and factors that cause deterioration of the wood. This research fills the gap. Thus it is the focus of this study to look at those aspects on a collection of wood components of the selected old timber houses built in the year of early twentieth century.

**Research Methods**

This research has it owns cogent approach and rigor in the collection and analyses of data whereby 2 different techniques of data collection, namely qualitative and quantitative methods were employed to achieve the objectives of the research. The qualitative methods include historical analysis, personal interviews, and site visit to the selected house, namely Rumah Dato' Panglima Gajah in Kuala Pilah, Negeri Sembilan, Malaysia (Figure 1).

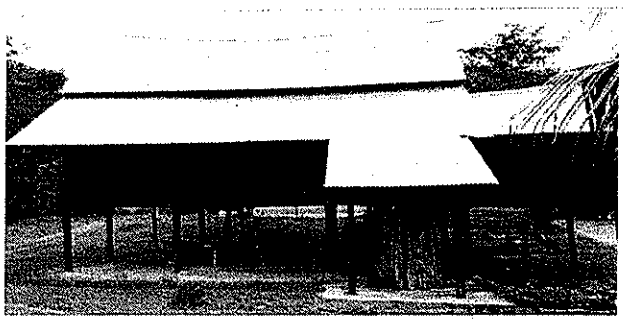


**Figure 1: Rumah Dato' Panglima Gajah in Negeri Sembilan**

The house was selected as a case study due to its distinctive architectural form of Negeri Sembilan, locally known as *Rumah Bumbung Panjang* (long-roofed house). It has been identified as one of the oldest heritage houses in the Peninsula Malaysia region that was built in 1908. During the site visit, the survey of the house condition was conducted through visual inspection.

Prior to the condition survey, a historical analysis of the selected old traditional house, personal interview with experts and authorities from related agencies were conducted to obtain background information of the Malay traditional house. Background Information on the types of Malaysian timber and its characteristic properties were obtained through personal interviews with the related authorities including Forest Research Institute Malaysia (FRIM) in Kepong Selangor Darul Ehsan, Malaysia and Malaysian Timber Industry Board (MTIB). This includes identification of timber species in relation to traditional house components. Visits to Forest Research Institute Malaysia (FRIM) and Forestry Department Peninsular Malaysia (FDPM) in Kuala Lumpur are necessary to obtain the background information.

The scientific investigation was conducted in two different stages which is in line

with the two research objectives and the expected outcome. Stage 1 involved identification of the type of timber species and properties (physical and chemical) of the wood components that were obtain from the exterior parts of Rumah Dato' Panglima Gajah which was conducted in Wood Anatomy Laboratory, Forest Research Institute Malaysia (FRIM). The wood samples obtained from the walls of *rumah dapur* (kitchen) and *rumah ibu* (core area) were analysed via macroscopic and microscopic methods to determine the types and properties of wood. Macroscopic method of wood identification is important and compulsory step in the scientific study of wood components. In this process, the cut surface of wood specimen was examined under magnification hand lens as shown in Figure 2A. A visual examination of the wood samples does not always bring enough information about the original species and that a microscopic analysis is more reliable.

A B

**Figure 2: Species identification of the selected wood samples are performed via the macroscopic and microscopic methods**

In microscopic anatomy of wood (MAW), a scientific analysis was conducted on the wood samples using Scanning Electron Microscope (SEM-EDX) to determine the visual and physical properties including wood density test (WDT) and moisture content test (MCT). The microscopic test was conducted for more specific identification on wood as shown in Figure 2B. There were 4 steps involved in this process, namely wood softening and wood embedding, wood sectioning, staining of wood section and transferring and labeling of wood section slices. The test was conducted to characterize the physical and chemical properties of wood surfaces and to observe the wood structure in details via microscopic magnification. Most of laboratory tests were conducted under supervision of a wood expert from FRIM, Rohana Idris. The result was obtained to show the types of wood used for the selected house components.

Stage 2 concerns visual analysis on the sources and factors of deterioration of the

wood components of the houses. The analysis was conducted to identify and determine the types and factors of wood deterioration of the selected timber house. Later, the categories of wood deterioration factors also were identified based on the type of wood species.

Environment test also was conducted using Alnor Velocity Meter (AVM) to determine the Relative Humidity (RH) and surrounding temperature of the house which affects the wood characteristics. This step of study aims to determine whether the surrounding relative humidity influences the wood deterioration. The test is important to find out whether the surrounding environment of the house is one of the main factors of deterioration other than the wood properties itself.

**Results and Discussion**

The identification of the type of timber species and properties of the wood components has gone through macroscopic and microscopic analysis. The results indicate that wood sample A is identified as Light Red Meranti which is classified as light hardwood. The texture for light Red Meranti is coarse but even and usually interlocked producing stripe figure on the radial surface. Wood sample B is identified as Cengal wood which is classified as heavy hardwood. General characteristic of Cengal wood are the texture of wood is fine, even and medium in texture and the grain is interlocked.

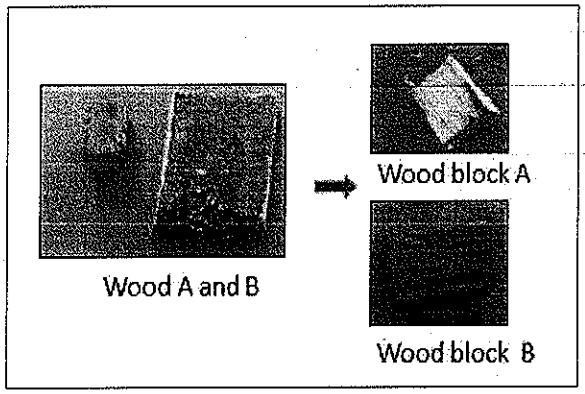



**Figure 3: Wood samples A and B for identification of wood species and properties**

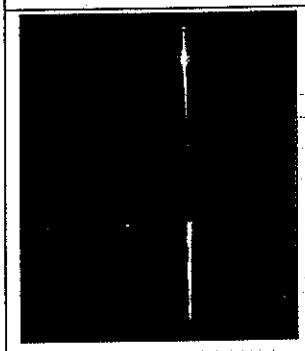
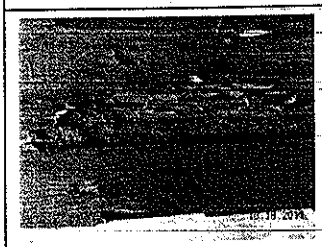
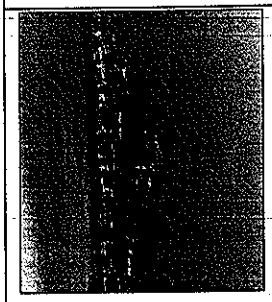
As found through the moisture content analysis done on wood samples A and B, the level of moisture in Wood sample A (Cengal wood) is higher than Wood sample B (Meranti wood). Wood with higher moisture content has more strength in its structure. The surface of wood is more stable and not too dry. Fiber structure in Cengal is more compact than those in Meranti. Fiber wood in Meranti have many pores and less compact. The terms hardwood and softwood refer to the botanical origins of woods

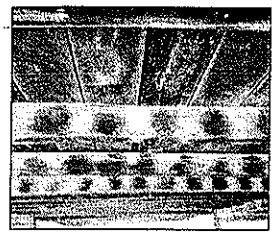
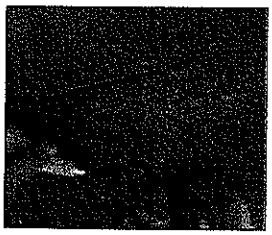
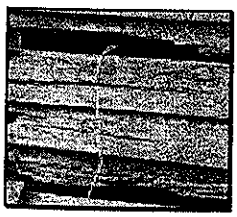
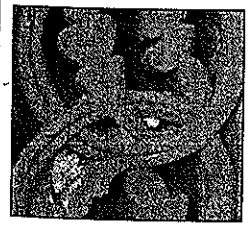
and not to their density or physical hardness (Jacjay, 2010).

The identification of the type of timber species and properties of the wood components through scientific analysis is necessary to find out the relationship between wood properties and wood deterioration. Eaton and Hale (1993) suggests that it is important to understand the three-dimensional structure of the material in order to recognize the avenues that wood-destroying microorganisms are able to gain entry into wood.

The results of visual inspection and analysis on the selected wood components of the houses indicate that various sources and factors have caused the wood decay. It was found that insect attacks, the moisture content of the wood, and the environmental conditions are main factors that caused the major wood decay of the house components. The analysis on the causes of the decay had been done thoroughly and various defects that were found on the house are summarized in Table 1 with brief description.

**Table 1: Sources of defects and its contributing factors**

| Defects | Descriptions |
|---|---|
|  Defect 1:Cracked wall | The timber wall of kitchen had a cracked damage. From the observation, this defect occurs when there are fluctuations of Relative Humidity that may cause cracking of wood. When the weather is cool, the wood shrinks and the wood expands when the weather is hot. When this situation persists, the wood crack. |
|  Defect 2: Termite damage | It was virtually hard to discover and identify the spot of destruction by termite at the house. This is due to the major destruction made by woodborers. However, the termite damage is especially visible at the *Rasuk* (wood beam) which is one of the main structural components. |
|  Defect 3: Growth of fungi spore | This wood deterioration was found at the door frame. The white stain that has been identified as the fungi spore also known as white rot. The spores are subjected to sufficient moisture that they tend to grow fine white strands. High moisture surrounding support the growth resulted in wood decay condition. |

| | |
|---|---|
|  Defect 4: Cracked floor | The floor at the main area of the house is apparently cracked. The noticeable effect of cracked wood decay is probably caused by the high exposure to rain and sun. Rain makes the wood swell and warp, and the sun dries it out and makes it crack. |
|  Defect 5: Fungi growth | The wood-decay fungus is visible at the floor beams. This type of Fungi probably lignicolous fungi that not only grow on wood but actually cause it to decay. The growth of the fungi probably has taken place when water pass through the floor resulted in high moisture content. This condition becomes one of major factors of the fungi growth. |
|  Defect 6: Termite infestation | The termite infestation was found at the roof structure of the house that may cause damage to the component. This roof component also is exposed to termite attack although large surface area like wall component usually appeals to termites as food source. The insects get nutrition from the wood component and other material containing cellulose. |
|  Defect 7: Mold growth | Mold growth is present on underneath of floor surface of the house. Wood that is damped becomes the food sources for the mold where there is high moisture content outside the house. |
|  Defect 8: Wood rot | Fungal growth was found mostly at the timber boards of the kitchen wall. It occurs with the presence of water or high moisture because of rain and surrounding temperature. Decay of the wood by a fungus which resulted in a change of colour, deteriorated and cracked condition. |
|  Defect 9: Insect tunnels | Insect tunnels were found at the wood carving panel of the core area. There was a Carpenter Bee house inside the carving. The bees do not actually eat the wood but drill tunnels as a place to lay their eggs. Their preference is to find an old hole and drill further into the wood each year before laying their eggs. |

| | |
|---|---|
|  Defect 10: Wood borer damage | Wood borer decay was found at the wooden pillar at the outer part of the house. There are two types of insect attack on this pillar which are wood borer and carpenter bee. These two types of insect had produced big and small holes on the wood. Perhaps, the type of wood (hardwood or softwood), the moisture content of the wood, and the environmental conditions appeals to the insects |

Based on the data collected from environmental test, the area of the house can be categorized as humid area because the average of Relative Humidity is more than 65 % while the temperature is in between 26 Celsius to 33 Celsius. However the Relative Humidity on that area keep changing and according to NPS Museum Handbook (2012) wood itself may be shrinking and swelling during the changes of Relative Humidity (RH). If this constantly occurs, it may lead to the wood rot. The results of analysis suggest that environment surrounding of the house is the main factor of deterioration rather than the wood properties itself.

Hardwood especially is naturally very durable and can last for thousands of years without substantial change. However, environment surroundings such as light and heat are causes for decay of wood (Hoadley and Bruce, 1980). Most of the decay is started in poor environmental conditions for storage and display of the wood. Meanwhile, Ozen (2015) found in his study that factors of wood deterioration can be categorized into two types which are biological factors and non-biological factors. All biological activities proceed at a much faster rate in tropical region than in temperate zones and decay of wood may be three or four times more rapid than it is.

Heavy hardwood like Cengal is a type of timber that provides specialised structure to resist the effects of adverse environmental conditions. As Wilkinson (1979) notes that hardwood is a durable material and would last indefinitely as it does not deteriorate spontaneously. Although all woods are subject to bio-deterioration, some are more vulnerable than others. Findings from the research suggest that Meranti wood is more vulnerable than Cengal wood and subject to bio-deterioration due to its properties and moisture content. Cengal are naturally durable and have high resistance to termite attacks and fungi infestation based on its properties (Malaysian Timber Council, 2007).

The case study for this research is a traditional house in which the main material and construction used is a wooden material. Hence fungal and insect attacks are the main sources of damages. These are due to a high moisture content and temperature. Most of wooden components founded in exterior and interior parts of the house had major decay that caused by different agents of deterioration. The analysis had been

done on the exterior parts and it was found that an environmental factor becomes one of the main causes of wood deterioration.

Today, many existing old Malay traditional houses in Malaysia, for example in Negeri Sembilan are still occupied by dwellers although they are not in good condition. The owners of the houses still keep them despite of their deteriorated condition due to the tropical environment. Many owners or residents of old traditional houses still maintain the building for original use and function while safe-keeping their vernacular characters. However, the Malaysian climate has become one of the major deterioration factors of the Malay houses especially on its wood components and these components are vulnerable to physical decay. Wood decay can have a significant impact on wood quality and wood strength (Wang et. al., 2014). Because of this reason, a number of houses are abandoned by their owners and they are usually deteriorated faster than those under upkeep. The houses that are maintained are usually less vulnerable to deterioration and protected from further damage. As such, the research findings suggest that there is relationship between the type and characteristic properties of timber used for the construction of the houses and the durability and deterioration resistance of the wood components.

**Conclusion and Recommendation**

The study found that through macroscopic and microscopic analysis, two types of wood, namely Cengal and Meranti were used for the construction of structural components of Rumah Dato' Panglima Gajah. From the visual inspection on house defects, it was found that insect attack, the moisture content of the wood, and the environmental conditions are main factors that caused the major wood decay of the house components. Timber has been one of the most useful resources for Malays in the past and is a major component in most traditional houses. Timber has many positive structural and aesthetic properties apart from being an energy-efficient and renewable resource. Detail study on the house and types of hardwood of its wood components can ensure their material and cultural values are protected.

The findings are useful to determine proper techniques of preservation and conservation for the wood components. The conservation of this old traditional house, for example requires rapid action from related parties in keeping the cultural property from being further deterioration. This requires future study to explore the different ways of treatment process based on identified wood deterioration. The Malay traditional house like Rumah Dato' Panglima Gajah needs to be protected as to ensure its tangible past is well maintained and preserved for future generation. This old house have intrinsic value and most of their components are part of cultural heritage, for examples roofs, walls, doors, windows and aesthetic components of wood carvings.

The house was constructed with higher-quality materials such as rare hardwoods like Chengal and Red Balau. The outcomes of this study could serve as material indicator for the durability and deterioration resistance of the hardwoods. This has potentials for leading to improved usefulness of the wood for house components in ensuring its safekeeping for continuous existence.

**Acknowledgement**

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