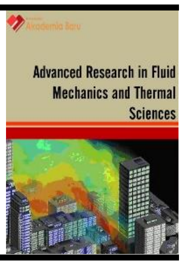
Penerbit Akademia Baru

Journal of Advanced Research in Fluid Mechanics and Thermal Sciences

Journal homepage: www.akademiabaru.com/arfmts.html
ISSN: 2289-7879



Longhouse Combustibility: A Study on Architectural Design and Construction Materials

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ARTICLE INFO

Article history:
Received 29 October 2020
Received in revised form 3 January 2021
Accepted 9 January 2021
Available online 12 February 2021

ABSTRACT

Fire hazard is a common threat in longhouses in Sarawak. Among things that are crucial in fire prevention is the evacuation route, in which highly dependent on house construction and layout. This study aims to observe the evolution of the Iban longhouse architectural design and materials used to build the longhouse. The qualitative analysis method was applied through 2D photo analysis as well as on-site visual observation and measurement. Construction materials used have been surveyed to determine its combustibility. It has been noted that longhouses have evolved over the years, from traditional to semi-traditional and modern longhouses design. The changes include the layout design and construction materials of the longhouses. Traditional and semi-traditional longhouses are often built using wooden materials that are highly flammable, while modern longhouses are made from concrete materials. The types of construction materials contribute to fire severity. It can be concluded that the longhouse architectural design, along with its construction materials, plays an essential role in the understanding of fire hazard, which will serve as fundamental on the longhouse fire reduction.

Keywords:
longhouse design; combustion materials; fire hazards

1. Introduction

The Ibans of Sarawak are synonymous with their longhouse architecture, and it has long existed as a mode of rural settlement. Longhouse is not unique to only Iban culture but is built in various parts of the world by numerous communities. Other indigenous people of Borneo like Kelabit and Kadazan, as well as Iroquois [1], Siberut [2], Danubian [3], Viking [4], and Kaluli [5] dwelt in longhouses. A few people of the tribe or several numbers of extended families stay in a longhouse, although it may also constitute the entire village. Nowadays, the traditions of settling in longhouse

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https://doi.org/10.37934/arfmts.80.2.3341

start to disappear, where most of the population stays in the new housing area. Nevertheless, an indigenous ethnic of Sarawak in Borneo, known as Iban, still sustains their traditional live culture, making longhouse as living spaces, albeit the architecture and construction materials evolve. The Iban community is the largest ethnic in Sarawak [6].

Many Ibans living in the longhouse (rumah panjai) have their unit or room called bilek under the same roof. An average longhouse has 20 – 30 bilek. The shared hall outside bilek is called the ruai. It is a common area for Ibans to do activities such as meetings, wedding ceremonies, Gawai celebrations, and other functions. Each longhouse is led by a headman called Tuai Rumah. There are some Ibans no longer stay in longhouses. Nevertheless, they sustain the customs of gathering and socializing at the most respected person's house [7].

Fire is regarded as one of the greatest threats to longhouses. In 2019 alone, one death and more than RM10 millions of losses recorded due to longhouse fire. Table 1 shows the statistics of fire according to zones in Sarawak, Malaysia [8]. Whilst Malaysia's Uniform Building By-Laws 1984 (UBBL 1984) has set the "Fire Safety Philosophy," longhouses construction still not abiding the rules. As such, studies on longhouse design is crucial in order to minimise the likelihood of fire and to find a general model that helps the occupants to leave safely and promptly in the event of fire. Although most of the fire cases are caused by human activity, insufficient fire safety systems also contribute to the incidents. Longhouses residents are relatively more vulnerable to fire risk due to the scale and structure of the building, as well as the absence of an evacuation route.

This paper presents findings from three different types of longhouses. The evolution of architectural design, its function, and construction materials used in constructing the longhouse will be discussed. Prediction of fire happens at longhouse is forecasted through a combustibility survey.

Table 1
Statistics of longhouse fire in Sarawak, Malaysia (Year 2015-2020)

Zone	Year					
	2015	2016	2017	2018	2019	2020 (Jan-Jul)
Kuching	0	0	0	0	0	0
Samarahan	1	1	1	0	0	2
Sri Aman	3	2	4	7	8	2
Sibu	5	8	9	6	8	2
Bintulu	4	4	2	5	3	5
Miri	3	4	8	4	2	1
Limbang	1	1	2	2	0	0
Total	17	20	26	24	21	12

2. Methodology

This study employs a qualitative analysis of Iban longhouse architecture and the materials used in the construction. Preliminaries studies such as ownership and geographic location were done prior to the selection of the longhouses. The longhouses located in several areas of Sarawak have been studied by considering their type; traditional, semi-modern, or modern architecture. Other selection factors include accessibility, Tuai Rumah prior permission, and the time constraint.

The methods used in this study were on-site visual observation to identify the progress in the design and material adopted. The longhouse length and area were measured by using a digital laser distance measurer and measuring wheel. The architectural structure, the construction materials used, and the longhouse details feature were presented in the form of photographs. Set of photographic images served as evidence as well as to detect any overlooked components during visual monitoring. All these observations were recorded in the logbook for documentation.

For the analysis process, several parameters have been highlighted - the longhouse functions and their evolution, the improvement of construction materials used, as well as the gradual changes in the techniques for building the longhouses. Field observation and personal interviews with residents concerned were carried out, and for each longhouse visited, all necessary measurements of the building itself were taken and reported in the record card. The combustibility of construction materials used to build the longhouse was also surveyed.

3. Results

3.1 Architectural and Construction Materials

Three types of longhouses have been studied. The evolution of the architectural design and materials used to construct the building can be seen as the paper discussion progress from one type of longhouse to another. Nonetheless, the longhouses elements function remains the same.

3.1.1 The traditional longhouse

Figure 1 and 2 presents the selected traditional architecture longhouse that is located at Ulu Sebauh, Bintulu Division, RH Jack Sera (House of Jack Sera), and its floor plan, respectively. Most of the traditional longhouses are built high above the ground with wooden stairs without a handrail. The front part of the longhouse is a veranda or known as tanju, used as a lounge or drying space (Figure 1(b)). The middle part is the body of the house consists of pantar (sub-gallery) that is connected to ruai (main gallery). Ruai is a common space where daily activities like weaving and handicraft making are carried out, as well as special events like Gawai and funeral ceremonies. It is a long continuous roofed gallery that runs along the entire length of the longhouse. Further back is tempuan (aisle), which connects the family room (bilek) and the kitchen.

One of the uniqueness of the longhouse is the absence of bedroom. Family room is the multifunction room without any divider or wall, where the family unit eats, sleeps, and keeps their belonging therein. The design of a typical traditional longhouse does not include a bathroom, where the residents utilizing the nearby river to do the cleaning.

Most of the materials used in traditional longhouse construction are from the nearby forest. Geographically, this type of longhouse, including RH Jack was built by the riverside at the edge of the jungle. The house is mainly constructed using hardwood, where the beams were made of round wood, and main post has been built from Belian (Eusideroxylon zwageri) wood or Selangan Batu (Shorea maxwelliana) wood. Another exclusive design of this longhouse is the usage of Belian wood, cut in a rectangular slice as a roofing structure.

Belian wood is a type of hardwood that has exceptional strength and durability. Besides, it is also common for traditional longhouses to utilise palm-tree leaves as roof cover. The compartment and exterior wall, as well as the floor, was constructed using round bamboos or sometimes the wood barks. In the old days, tree barks were used as walls, whilst the base was built from bamboo. Since the traditional longhouses are made from wood and have an improper wiring system, these two factors acted as an ideal combination for a fire hazard.

(a) (b)

Fig. 1. (a) An example of traditional Longhouse, RH Jack Sera. (b) Tanju

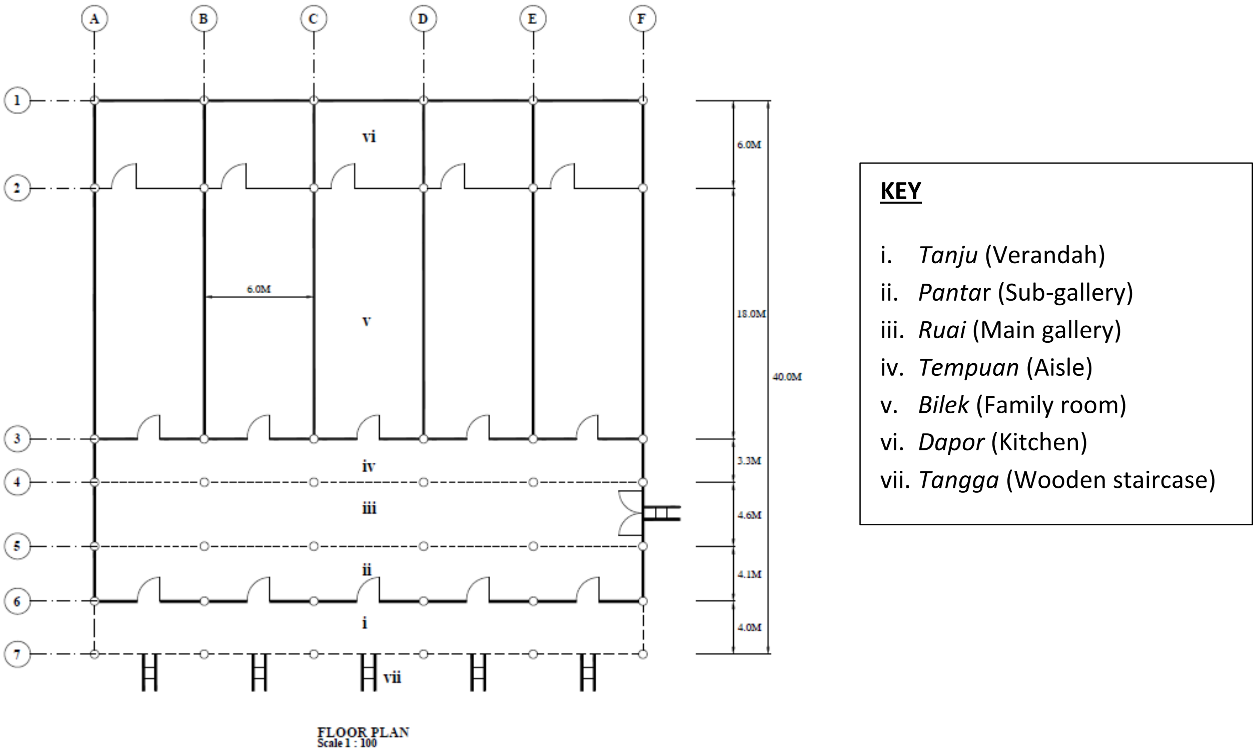


Fig. 2. Floor plan of traditional longhouse

3.1.2 The semi-modern longhouse

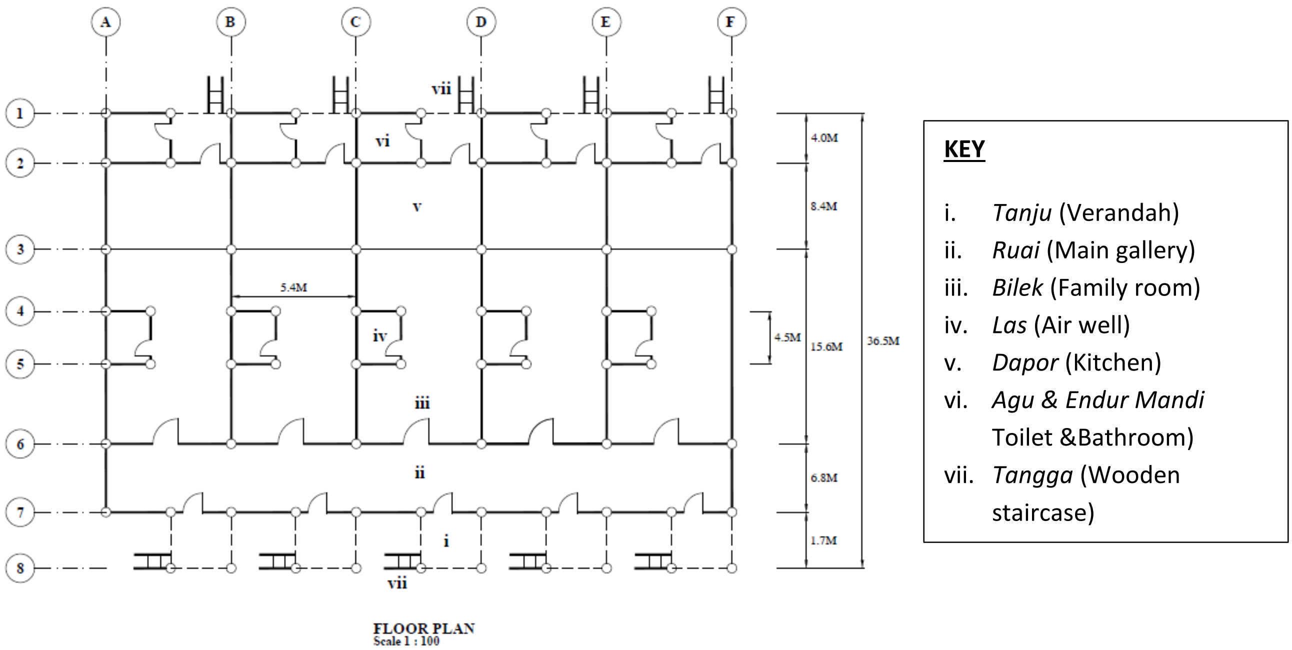
RH Daniel Munking, a longhouse located at Kuala Annau is an example for a semi-modern longhouse. Similar to the traditional longhouse, this longhouse is also situated near to the river as a means of transportation and food sources such as fish and prawn. Figure 3 shows the photos and the floor plan of the longhouse.

Compared to the traditional longhouses, the semi-modern longhouses are typically often built on stilt, but with reduced height. However, some of the semi-modern longhouses were also made on the ground. The semi-modern longhouses have a similar arrangement with a traditional longhouse, but pantar is omitted from the design, and the size of tanju and ruai is smaller. Essential elements of a modern house like bathrooms and toilets are included in the design.

Whilst the architectural design remains the same for most parts of the longhouse, the materials used in the construction changed drastically. One of the main factors triggering evolution is the extensive road construction projects by the state government that linking many rural areas with the town [9]. The improvement in the accessibility resulted in the use of modern construction materials in building the longhouses. As can be seen from Figure 3(a), the roofing is made by zinc with a low ceiling, and the wall is made by wood that is laminated with plywood at the exterior for smooth finishing. The house is also painted with bright colours as compared to a traditional longhouse that prevail the original wood colour. Other construction materials were also used, including nails and iron rods.

(a)

(b)



(c)

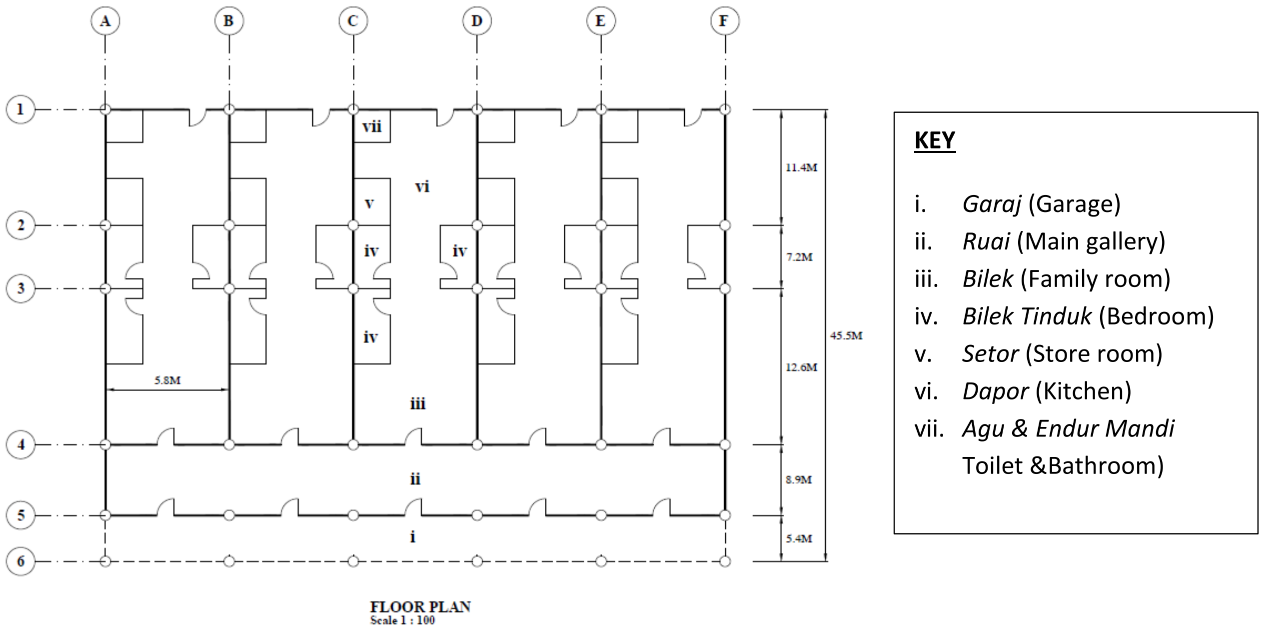
Fig. 3. (a) An example of semi-modern longhouse, RH Daniel Munking, (b) Tanju, and (c) Floor Plan

3.1.3 The modern longhouse

The model of modern longhouse surveyed in this study is RH Tabor Ak Lasah in Ulu Sebauh, Bintulu (see Figure 4). Contrary to the traditional and semi-modern longhouse, this house and many other modern longhouses are mostly built by the roadside. The design of modern longhouses is rather revolutionary as there are no longer represents the longhouse's traditional architecture, but instead looks like a modern terrace house. The exterior of the modern longhouse consists of a garage instead of tanju or plank walk. Contemporary bathrooms with proper piping and sewerage system are also part of the design. Regardless, common gallery or ruai still becomes the heart of the longhouse.

(a)

(b)



(c)

Fig. 4. (a) An example of modern longhouse, RH Tabor Ak Lasah, (b) Ruai, and (c) Floor Plan

Construction materials in modern longhouses are comparable to other types of urban housing where cement, sand, and steel are the main components. The roofing is usually made from clay tile or slate shingles. The wall stone with tiles or mosaic as flooring is a common view in modern longhouse. Likewise, the construction method gradually changes where proper layout, construction plan, and piling were done to ensure the safety of the concrete building. The longhouses are no longer built on poles, but on land with a driveway or asphalt road in front of the house.

Among the factors that prompted the architecture transformation is that more places can easily be accessed by road, making it is easier to transport construction materials from the town area to the countryside. Streets and other developments implemented by the government dramatically influences modernisation of local society, enhance livelihoods, and increases their purchasing power. As such, materials that was once were very costly to longhouses residents become affordable. Another influencing factor for the construction of modern longhouses is the availability of financial assistance such as loan scheme. Thus, new house construction or renovation of the old longhouse mainly uses sand and gravel; no longer woods acquire from the nearby jungle.

The evolutions offer some advantages to the residents, and eventually to the whole community. The modern longhouse is well equipped with clean water, piping, and plumbing system, hence more hygienic as compared to the traditional and semi-modern longhouse. Apart from that, the built structure of this modern longhouse with modern materials and a proper electrical system reduces or eliminates the risk of fire hazard. However, it loses its unique sense of charm, tradition, and esthetical value.

3.2 Combustibility Survey

The combustibility of the components used to construct each type of longhouses is an essential requirement in characterizing fire performance. The mass of combustible materials dictates the amount of energy released during fire [10]. Generally, the study of combustibility is required for all buildings as one of the factors that contribute to fire loss, including construction types and fire-resistance rating of the building components [11]. Study shows that the rate of injury is higher for buildings constructed from combustible materials [12].

Per the National Fire Protection Association, the classification of hazard is as follow

Low (Light):	Low combustibles with no self-propagating fire thein can occur. E.g.: Concrete with hardwood as support.
Moderate (Medium):	Materials that likely to burn with moderate rapidity. Release voluminous amount of smoke. E.g.: Mixed hardwood with concrete reinforcement
High (Extra):	Materials that likely to burn rapidly. E.g.: Dry wood, bamboo, leaves

The survey is thus focused on several elements in the longhouse that fire is more likely to flare up – wall, floor, ceiling and roof. The results of the survey are tabulated in Table 2. Timber is widely used in traditional longhouse design; as such, it is the most vulnerable to the fire threat. In the past, the houses were built in a combination of light-frame wood system and hardwood (heavy timber) like Belian wood as posts, beams and roofing systems. When the wood is exposed to its burning point around 300^{o}C, fire can be easily ignited. Heavy timber will naturally form char layer when burnt; thus, the layer protects the core and slows down the burning process [13]. However, for light timbers, the burning process occurs rapidly. This is also because of the wood used in traditional longhouses usually were not treated with wire retardants.

Table 2
The results of combustibility survey according to longhouse type and its element

Type of Longhouse	Longhouse element			
	Floor	Wall	Ceiling	Roof
Traditional	H Bamboo/Light Timber (i.e., Tree trunk)	H Bamboo/ Light Timber (i.e., Tree trunk)	- *No ceiling	H *Nipah* leaves/thin *belian* shingles
Semi-modern	M Mixed of solid-sawn lumber with concrete	M Mixed of solid-sawn lumber/plywood/ asbestos with bricks	H Asbestos or Plywood	M Zink
Modern	L Solid concrete with tiles finishing	L Bricks	L Fire-resistance gypsum board	L Spandeck / metaldeck, clay tile

The length of the longhouse is another factor that influences fire pace. Based on Ingberg's fuel-load-fire severity relationship, the higher volumes of combustibles (timber equivalent), the higher heat energy release [14]. Since 90% of the traditional longhouse construction materials are made from timber, the amount of fire load from traditional longhouse is very severe.

On the other hand, the modern longhouse features the safest condition from fire threat as their design and construction materials mostly complied with the legislation and regulations of national standards. Observation and survey on longhouses found that modern longhouses design use the lowest quantity of combustible materials, lowest fire load, thus less vulnerable to fire threat. Studies on fire dynamic and a fuel requirement of combustible timber as opposed to concrete show that the wood requires less fuel flow compared to concrete [15, 16]. On the other hand, the semi-modern longhouse is a mix of traditional and modern longhouse. The combustibility level is medium since the design utilise the use of concrete and treated woods as building materials.

4. Conclusions

The evolution of Iban longhouses architectural design and their construction materials are discussed in this study concerning the fire threat. Due to road accessibility, the increase in household income and the influence of other factors contributed to the evolution of the Iban longhouse architectural design. Henceforth, new materials and techniques have been used. While the modern longhouse features the safest condition, it has lost the aesthetic and charm of the traditional longhouse. As such, data obtained in this study can be used as a foundation for building a safer traditional longhouse while preserving its mesmerizing culture and yet at the same time safe to be occupied.

Acknowledgment
The authors are grateful to Universiti Putra Malaysia for financial support through IPM Putra research grant 9674000.

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