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An investigation of timber frame housing in Vietnamese Mekong River Delta

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ABSTRACT

Timber frame housing is one of the most common structures in many countries in the world. In Vietnam, timber frame buildings are well-known for having special whittling techniques that should be considered a lesson for modern methods. In the Vietnamese Mekong River Delta, the housing in rural areas was built mostly with timber frames, and some housing was built with bamboo frames and used natural materials such as nipa-leave, and coconut-leave. Therefore, the study aims to investigate the characteristics of timber frame housing in the Mekong River Delta. To achieve this, firstly, an on-site investigation of ten local housings in the Vietnamese Mekong River Delta is carried out. Secondly, the architectural characteristics of local housing are introduced, and finally, we analyze the details of timber frames. The result shows that the timber frame housing in the Vietnamese Mekong River Delta has the following features: simple structure, light framing, and a flexible connection to other local materials. These characteristics should be considered in detail as a lesson for housing design in the region.

1. INTRODUCTION

According to Pham (2022), most of local people in the Vietnamese Mekong River Delta (VMRD) settle along the river branched. Wood and bamboo are the major structural materials used in their local housing. There are several types of research that deal with the architectural characteristics of housing at VMRD; however, the structural characteristics of local housing are inadequate. Wood construction systems and bamboo construction systems have been used in the local housing at VMRD, according to Pham's research on housing at VMRD, timber or bamboo frame construction was developed in the first period when VMRD was formed and used continuously thereafter (Pham & Oh, 2021). There are stilt housings of the Cham ethnic group in An Giang province that still use the timber frame (Pham & Oh, 2021).

These days, although modern technology is taking the upper hand in the construction industry not only in the world (De Araujo et al., 2016a), but also in Vietnam, the construction of timber-framed housing at VMRD has not declined considerably (Pham, 2022). In addition, the variations in the structural system of the housing include timber frame + concrete frame, bamboo frame + concrete frame, and other types. The other types of structural frames are similar to the common types and use modern materials (De Araujo et al, 2016b) (Kim, 2014). By using the material, those housings differ according to mass, planning layout, and façade features, however, they share similarities in terms of timber or bamboo construction technique. In VMRD, the local housing is constructed by using the combination of many materials, such as timber, or bamboo frames with concrete frames. The timber or bamboo frame are the local materials and are well

known environmentally friendly (Hessari & Chegeni, 2021).

In this study, the general structural frame of local housing in the VMRD is introduced and the architectural features, especially in timber and bamboo frames are presented in detail. To achieve that aim, the on-site investigation was carried out in the VMRD. The local housing in VMRD which constitute the subject of this study, were constructed in the remote areas such as Tra Vinh, Ben Tre, and An Giang.

2. METHOD

To collect data on the timber frame construction in VMRD, this study conducted three subsequent steps as follows:

– **Step 1-** Research-site selection: This study selected the remote areas in VMRD by satellite map and asked the local people about timber housing location (Figure1).

– **Step 2** – Actual survey and field measurement in local housing: Ten local housing were surveyed and measured by three members of the group.

The data was collected by using an electronic distance meter to measure between two sides of building (wall length, building height, etc.). Additionally, we employ photogrammetry techniques to capture the details of the building, its exterior, and its structure.

– **Step 3** – Sketch the timber frame structure of ten of the local housing: The drawings and photos of ten samples were analyzed to show characteristics of timber frame structure.

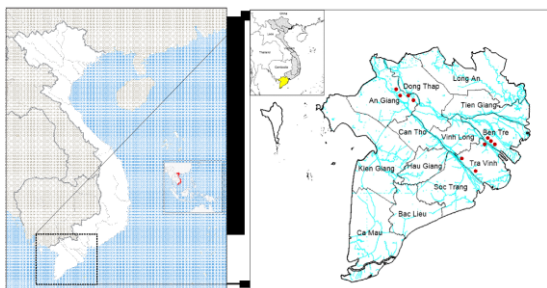


Figure 1. Map of Vietnamese Mekong River Delta (VMRD) and the location of ten of local housings studied

3. RESULTS

The buildings of this construction type (Figure 2) can be found in the rural areas of the Vietnamese Mekong River Delta. The one-story house is a

common type at VMRD, and this type is being built. Local timber-framed housing consisted of the main house with a timber frame, a sub-house with a bamboo frame, and roofs also made of timber frame. The timber frame was built up to the ground-floor level and most were load-bearing. The walls served not only as barriers but also as avoiding the shun light and rain. The materials are brick, wood, or nipa-leave which were used to build the wall and were obtained from nearby areas.



(a) Ben Tre province



(b) Tra Vinh province



(c)- An Giang province

Figure 2. Local housing in VMRD (a), (b) one-story housing, (c) stilt housing

An important element of the timber-framed construction system is the mortise and tenon joints. In general, the mortise and tenon joint is used to combine the column and beam on the corners of the housing. The bamboo frame is a simple combination of joining bamboo by binding it with rope or

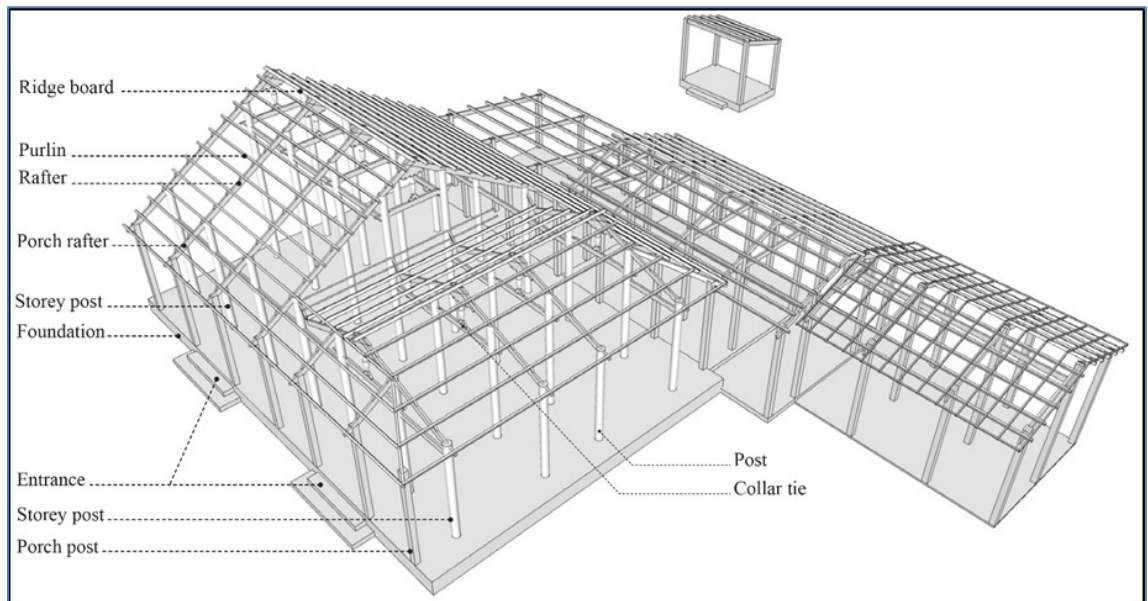
bamboo rope. No tenon technique is used in the bamboo construction system. Historically, two general types of timber frame have been used at VMRD: (1) timber frame for one-story houses which are located in the flat delta or coastline areas, and (2) timber frame for stilt houses that are located in flood areas, or alongside rivers or canals.

3.1. Timber Frame for one-story housing

The timber frame is often built for the main housing. The timber-framed technique is executed by the mortise and tenon joint between the roof frame and the column. In addition, the roof form is very complex with timber roof trusses for the main house and bamboo roof trusses for sub-houses (Figure 3). These housing are typically found in flat terrain and

they do not share common walls. Therefore, all exterior walls are constructed independently using wooden panels, and nipa leaves.

Timber roof trusses use a king post truss which are uprights below the ridgepole. The king post connects the transverse beams below the eave purlins, eliminating many vertical supports. It is mainly used in tiled or corrugated metal sheeting roofs and provides maximum support along the slope of the roof, preventing the braces from sagging (Figure 4). Bamboo roof trusses are a triangular structure. It is braces cross and the ridgepole rests on the top of the fork. This type is used for nipa leave roofs.



View from front



View inside of housing



Timber frame in detail

Figure 3. Timber frame of one-story housing

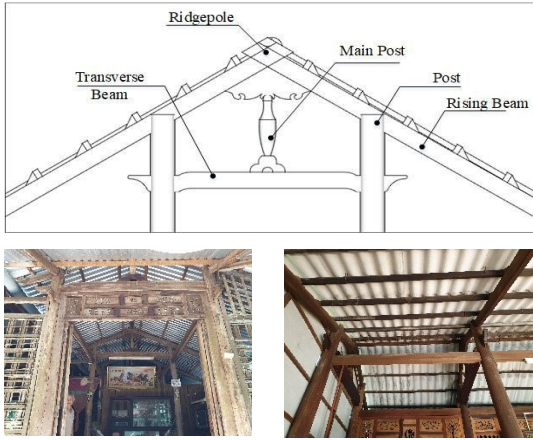


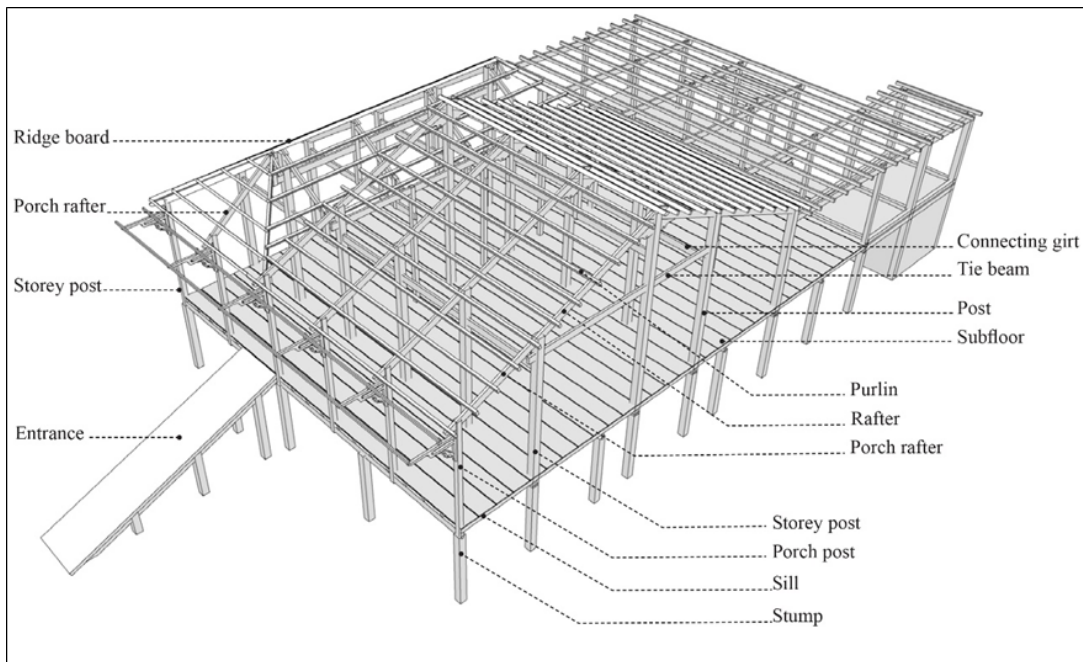
Figure 4. Timber roof trusses

3.2. Timber frame for stilt housing

In the stilt house, there are three main structural elements: timber frames (beams and posts), walls,

roofs, and floors (Figure 5). The timber frames are timber posts and beams; some houses use stone posts. The walls are corrugated metal sheeting or plywood or untreated wood sides. The roof is constructed of tiled or corrugated metal sheeting placed on timber trusses.

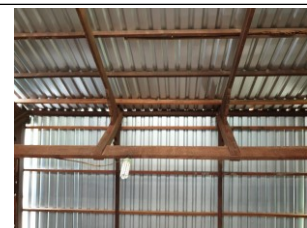
Floor beams are spaced at 0.4 to 0.6 meter intervals, parallel to the short side of the room. Generally, the floor joists are vital structural components in the stilt housing. They are responsible for supporting the loads (people, furniture, building materials, etc.) placed upon them and ensuring the floor does not collapse. All floor of stilt housing has floor joists by 30-40cm wide, however, these spacing and size depend upon the type of housing and the span length they need to cover.



View from front



View of verandah

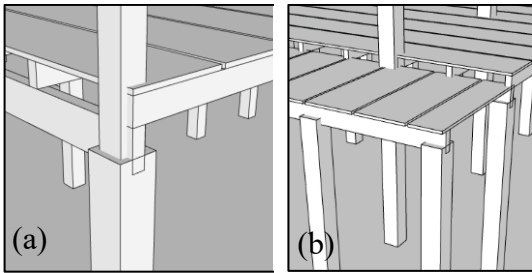


Timber frame in detail

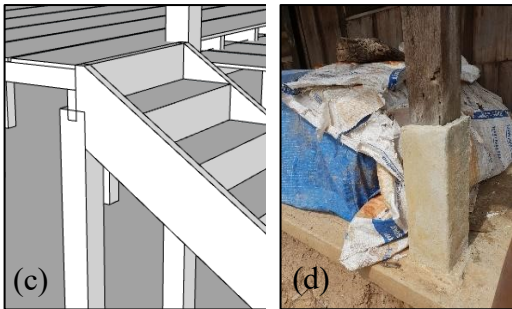
Figure 5. Timber frame of stilt housing

3.3. Structural details of local housing in VMRD

Post: the frame posts were directly placed on the ground with a space of 2 to 3 meters between them. To create the rigid timber frame, the posts and beams were joined with mortise and tenon. The posts and beams usually had square sections. In some houses, the timber frame was always placed on the rectangle foundation using bricks. In some local houses in remote areas, stone posts or concrete posts were used. The posts can be clad in brick or cement which will act not only as weather protection but also as decoration for the houses (Figure 6).



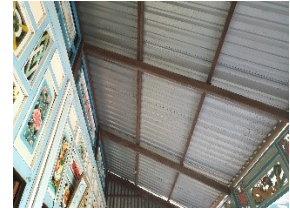
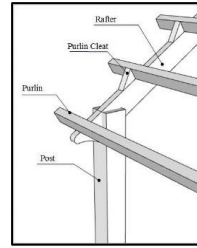
(a)- Timber Post, Bearer and floor joist with mortise and tenon joint; (b)- No timber floor joists for sub-floor



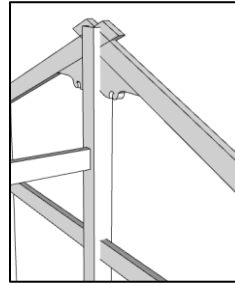
(c)- Timber post and stair with stud joint; (d)- Cement is clad to protect the posts.

Figure 6. Detail of the post and floor joists

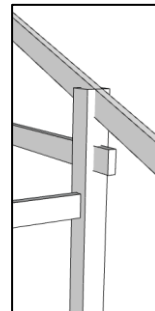
The roof typology of local housing in the VMRD is complex; however, the roof frame was not. The roof trusses were placed on the top rail of the wall frame. The beams of the roof structures are joined with the post by mortise and tenon. The 40x60 cm ridge purlins were placed on the 50x100 rafters. To prevent the purlins from slipping the timber cleats are used along the full length of the rafters to hold the timber ridge purlins in position (Figure 7).



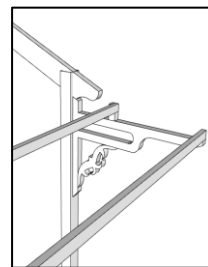
(a)- Purlin Cleat



(b)- Ridgepole



(c)- Transverse Beam and Post with mortise and tenon joint



(d)- Rafter and Post with mortise and tenon joint

Figure 7. Detail of roof trusses

4. CONCLUSIONS

This study aimed to introduce and provide an overview of the timber structural frame of local housing in VMRD. In most parts of VMRD, the size of the local housing is small since they are based on using local materials such as timber, bamboo, and nipa leaves. The frame housing is a simple structure,

with light framing and flexible connection to other local materials.

Over time, timber frames have been developed into several building techniques, and timber frames for local housing are still very common in VMRD. Although timber frames have many problems in moist conditions, lightweight timber frames have been developed in VMRD over time.

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