An Analysis on a Vernacular Design in Wetland Environment Using Reconstruction Simulation Method

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Abstract. This research aimed to reveal the vernacular designs formed by wetland environment and explain how the designs have been able to survive in a condition that the soil or land has low carrying capacity for structures. This research used a 3D-simulation method to reconstructed the situation, and for this purpose, Banjarese house that is Bubungan Tinggi house in South Borneo Province was chosen as the object of the study. By the method, the house was reconstructed digitally to prove that the information about how it had been able to stand firmly on a wetland. The 3D-simulation results were then analyzed so that the information of the construction pattern and the design type were generated. The result of typology analysis showed five types of designs which were then identified as the design concept of vernacular constructions of wetland environment. These five types of construction designs were (1) floating foundation, (2) continuous pillar, (3) pillar-binding beam, (4) beam-binding beam, and (5) pillar-locking beam. These five construction designs altogether formed a firm and stable structure on a wetland environment that known as indigeneous local of wetland vernacular.

Keywords: Vernacular architecture; Wetland; Banjarese; 3D-simulation.

1. Introduction

One of the vernacular architectural designs that can be the source of knowledge due to its ability in solving problems that relate to local environment is the Banjerese house in South Borneo province, Indonesia. Technically speaking, there are two issues encountered by the house, namely the carrying capacity of the soil which is very low and the availability of good and durable materials to build the house especially to survive the wetland environment. The Banjarese house, called Bubungan Tinggi House, (Fig. 2) which was used as the object in this research, showed that the structure could stand in a stable position, with no signal of sinking, and had survived for 147 years (1867-2014). Therefore, this research aimed to explain how the Bubungan Tinggi house was designed as a vernacular architecture on wetland environment

2. Banjarese House

All materials and methods that have been used in the work must be stated clearly and subtitles should be used when necessary. Times New Roman should be used for the entire manuscript. All text should be typed according to the sizes and formats specified in this document.

2.1. Location and Environment

Banjar tribe is one of the native tribes in Borneo Island which is also known as Melayu-Banjar. Unlike the other tribes, for example Dayak who occupy inner land or high land, Banjarese people are spread in coastal areas [1] which are commonly wetland environment.

Figure 1. Distribution Map of Tribes in Borneo Island (Source: Sellato, 1989)

According to the Ramsar Conference, a wetland is a land that is naturally or artificially always seasonally or continuously under either flowing or stagnant water. According to Maltby [2] a wetland is a place that is quite wet for a long time so that vegetation and other organisms can multiply and adapt. Meanwhile, according to Cassel [3], a wetland has three parameters that are hydrology, hydrophytic vegetation, and hydric soil. Some environmental conditions belonging to the wetland category are swamps, marsh swamps, and peat lands. Meanwhile, the water inundating wetlands can be classified into fresh water, brackish water, and seawater.

With its wet or watery conditions, the wetland environments generally has a high level of biodiversity, both flora and fauna. In addition, the wetland is generally quite fertile land and, therefore, it is often converted to farmland, rice fields, and fish ponds. Even more, the existing natural water condition is also often transformed into a modern irrigation system to irrigate the farmlands.

In addition, with its very specific condition, the wetland has a function in and many advantages for human life. According to Dugan [4], the wetland has functions and advantages to (a) recharge ground water, (b) release groundwater, (c) fixate sediment, toxic substances, and nutrients, (d) be recreation and tourism site, (e) control flood, (f) control erosion, (g) produce biomass, (h) protect against storms and become wind barrier, and (i) maintain the micro climate.

Based on these functions advantages, the typology of wetlands (especially in Indonesia) can be divided into four types, namely (a) coastal and marine wetlands (including mangrove forests, brackish forests, mangrove forests, coral reefs and sand flats), (b) marsh wetlands (including peat swamp forest, swamp meadow, marsh grass, and marsh herbs), (c) river plain wetlands (including rivers, flood plains,

valley, and estuaries), (d) wetland lakes, dams, and wetland formation (including rice fields, ponds, lakes, there, and dams).

2.2. Bubungan Tinggi House

Bubungan Tinggi house that was used as the object of this research is situated in Teluk Selong Ulu Village, Martapura District, South Borneo province, Indonesia. The house was built by a merchant named H. Muhammad Arif in 1867. The house was built on a swamp on the Martapura's riverbank, which is the sub-river of Barito River consisting of 16 chambers and was designed in continuous pattern with additional rooms on its two sides [5] (Fig. 2).

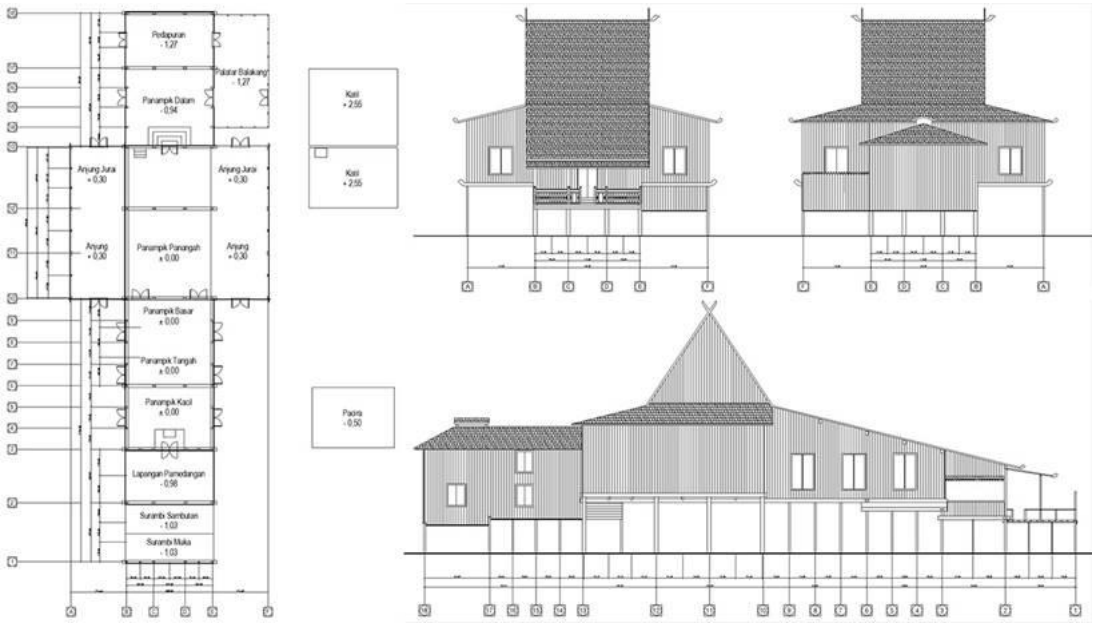


Figure 2. Research Case: *Bubungan Tinggi* House

The structure and functionality of the rooms of Banjarese houses cannot be separated from the condition of the environment which lacks dry land for human's activities. The entire activities are mostly conducted inside the house either on the porch or in the chambers (Table 1).

With regards to the wetland condition which is dominated by swamp and river, the Bubungan Tinggi house, which stands on it, appears massive and heavy (total width 374.21 m2). It is difficult to imagine that the house had been able to stand for more than a hundred years. The house is 36.07 meter long, 13.34 meter wide, and 2.75 to 5 meter tall inside the room, while the tallest point reaches 11 meters. The floor is 2.5 meters elevated above the land surface, making the house stand as a stage. The entire structure was made of Ulin wood (Eusideroxylon zwageri), the strongest and the heaviest wood in Borneo Island. Except the foundation, all parts of the structure were made from this wood. Even the roof, called sirap roof, was made from this wood which was sliced into thin layers at about 2-3 mm attached to one another.

Table 1. Rooms and Their Functions in *Bubungan Tinggi* House

Name of Rooms (Banjarese)	Name of Rooms (English)	Functions
Surambi muka	Front Porch	It functions as a veranda. The first room is used to wipe feet before entering/getting in to the house. Thus, it usually provides a water container/jug. It is necessary because the people's feet are likely to get dirty after contacting with the swamp area.
Surambi sambutan	Middle Porch	It functions as the spot for the house owner welcoming guests and is occasionally used for traditional ceremony such as wedding, as playground for children, and sometimes used for grain drying. In short, it functions like a common front yard.
Lapangan pamedangan	Inside Porch	It is used by the owner to receive guests or by the family members to sit and talk in the afternoon. It is designed to be more closed with a fence around the room.
Pacira	Transition Room	It functions as a foyer.
Pacira (2)	Storage Room	It is used to store farming or fishing tools (located in the basement).
Panampik kecil	Front Parlor	It is the place where children usually sit when there is a traditional ceremony and it is also used for grain storage.
Panampik tangah (paluaran)	Middle Parlor	It is the place where adults usually sit when there is a traditional ceremony.
Panampik besar (paluaran)	Inside Parlor	It is a parlor for distinguished guests. When there is a ceremony, it is where priest/scholars or officials usually sit.
Panampik penangah	Living Room	It is used for family gathering.
Anjung kiri & kanan	Bedroom (on the left-right sides of the house)	It is used for bedroom, praying, and to keep jewelry.
Anjung jurai kiri & kanan	Bedroom (on the left-right sides of the house)	It functions as the extension of bedroom and for delivery room or funeral preparations.
Karawat or *katil*	Children's Bedroom	It is used as a bedroom for children especially those who are unmarried.
Panampik dalam or *panampik padu*	Back/Rear Room	It is used for a dining room, as a place where women do the house work, and for swinging babies.
Jorong	Grain Storage	It is used to keep grain/crops after harvest.
Padapuran or *Padu*	Kitchen	It is used to prepare meals and store water.
Palatar balakang	Back Porch	It used for bathing, washing, and drying clothes.

Reference: author surname and publication date [5]

3. Discussion

This research used a simulation method (Groat and Wang [6]). This method was chosen because it allowed the researcher to use a replica of the original object in order to minimize cost, time, and risk. The replication was done by using analog model or imitating the situation, especially imitating the situation of the construction design. The simulation result was then analyzed with variety and uniformity analysis (typology) to obtain the pattern and type of the structure design.

Referring to this simulation method, this research began with a field observation, especially to collect data of all the components of the house through measurement and documentation. Following this step, the data were used to recreate the analog model. Through this analog model the reconstruction of the Bubungan Tinggi house could be realized. The reconstruction process was arranged by referring to the shape and composition analysis, information collected from the house builders, and the Banjarese's

custom in house construction. The making process of the analog model and its reconstruction-simulation were entirely aided by the open source application SketchUp 6.

4. Results and Discussion

4.1. Reconstruction

Through the reconstruction-simulation using the analog model 547 steps were obtained to explain the construction method of Bubungan Tinggi house. The entire steps are presented in Fig. 3, each of which is presented in an icon. Meanwhile, similar or repeated steps are summarized in one step and represented only by one icon. In other words, the 547 steps presented do not show similar steps that have been done in the previous construction processes. Instead, they are combined for the purpose of the simplicity of the simulation.

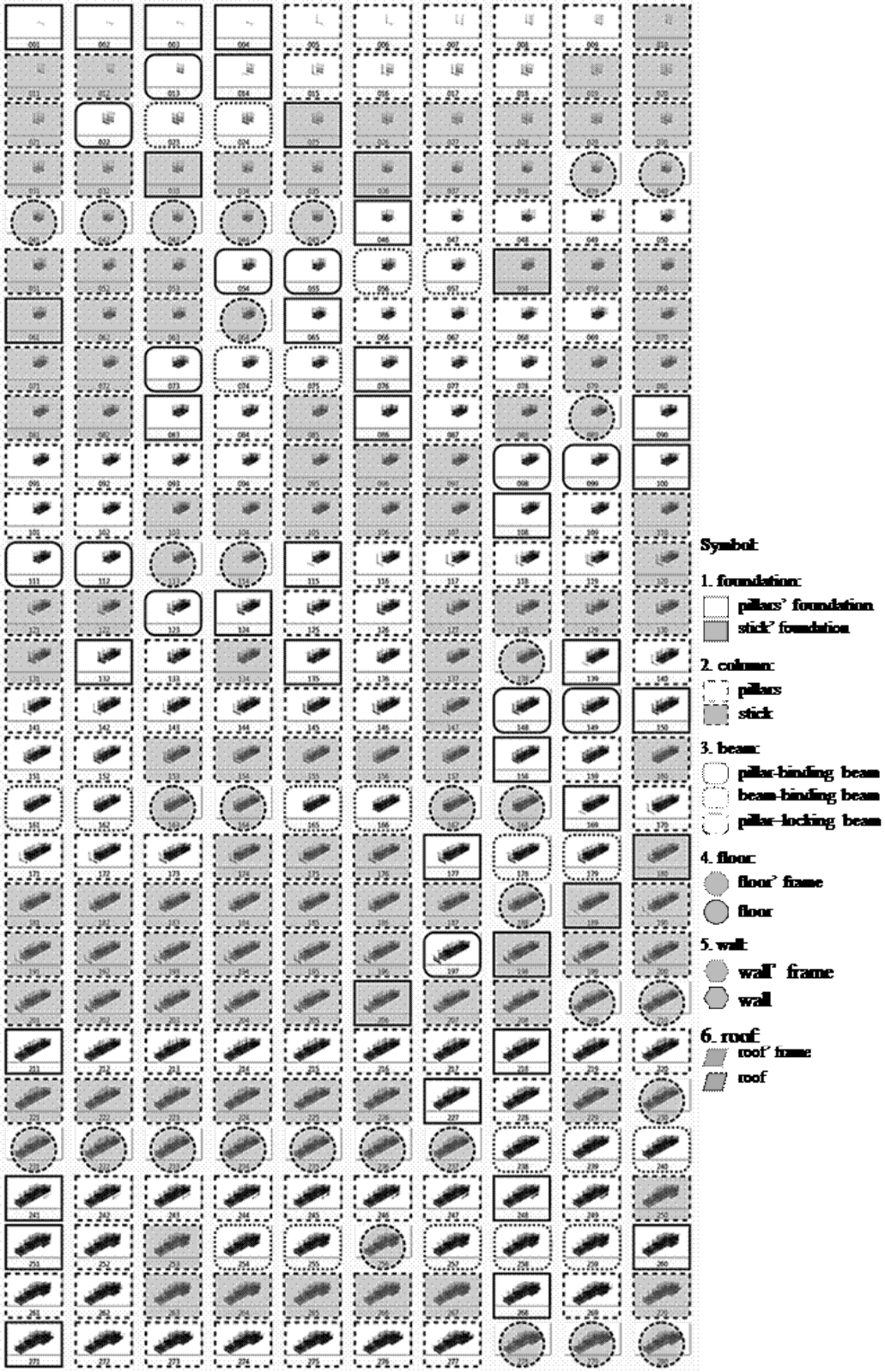
Following this phase, these 547 steps were then analyzed to see their variety and uniformity (Fig. 3 icon with symbol). The analysis resulted in six categories of components, which were classified into two categories of structures. The six categories included foundation, column, beam, floor, wall, and roof. Meanwhile, the two categories of the structure included main construction and supporting construction. The six categories were determined based on their position, while the structures were determined based on their functions, either as forming component or complementing component. The complete categories of the components and structures are presented in Table 2.

Table 2. Category of Component and Structure House

No	Categories		Symbol
	Components	Structures	
1. foundation	a. pillars foundation	main construction / forming	
	b. stick foundation	supporting construction / complementing	
2. column	a. pillars (*tihang*)	main construction / forming	
	b. stick (*tungkat*)	supporting construction / complementing	
3. beam	a. pillar-binding beam (*watun*)	main construction / forming	
	b. beam-binding beam (*panapih*)	main construction / forming	
	c. pillar–locking beam (*sampaian*)	main construction / forming	
4. floor	a. floor frame	supporting construction / complementing	
	b. floor	supporting construction / complementing	
5. wall	a. wall frame	supporting construction / complementing	
	b. wall	supporting construction / complementing	
6. roof	a. roof frame	supporting construction / complementing	
	b. roof	supporting construction / complementing	

4.2. Pattern

In addition to the categories of component and structure, the typology analysis (Fig. 3) also resulted in the pattern that described the construction method of Bubungan Tinggi house. The pattern indicated a regular procedure of construction, which was then interpreted as a "local science/knowledge" of how to build the house of Banjarese. The pattern was classified into two types i.e. regularity pattern based on the house component and regularity pattern based on its structure. The first pattern showed how the construction process was done based on the categories of the house component (Fig. 4a.), while the second one showed how the construction process was done based on the components of the main or the forming structure. The second structure was specialized only to the category of main structure (forming structure), including foundation, pillar, pillar-binding beam, beam-binding beam, and pillar-locking beam (Fig. 4b).


Symbol:
1. foundation:
pillars' foundation
stick' foundation
2. column:
pillars
stick
3. beam:
pillar-binding beam
beam-binding beam
pillar-locking beam
4. floor:
floor' frame
floor
5. wall:
wall' frame
wall
6. roof:
roof' frame
roof

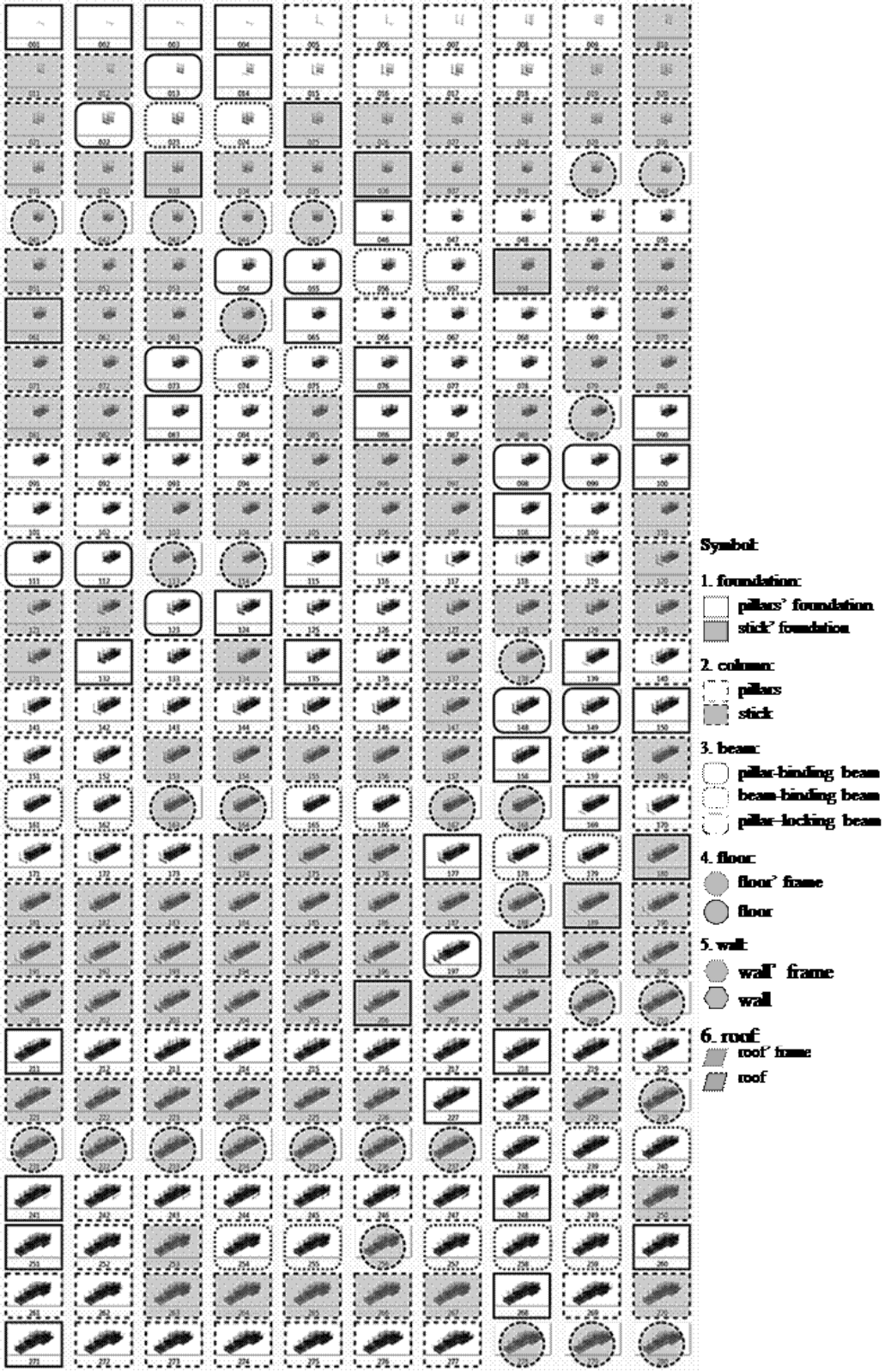


Figure 3. Reconstruction (3D-simulation) and Its Typology Analysis

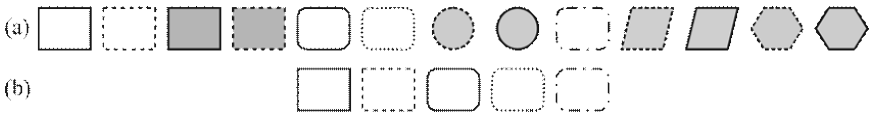


Figure 4. Pattern of the Construction Process of *Bubungan Tingi* House

The analysis on the regularity pattern of the construction procedure resulted in five construction designs which enable the Banjarese house to firmly stand on a wetland so that it is categorized as vernacular architecture of wetland environment. These five construction designs include floating foundation, continuous pillar, pillar-binding beam, beam-binding beam, and pillar-locking beam. The explanation of each construction type is presented below.

The first type of construction, floating foundation, uses a beam, usually Kapur Naga tree, which is positioned as the base (Fig. 5a). The beam is usually between 80 and 100 cm in diameter. However, the size depends on the column construction or the supported pillar, the bigger the beam, the better it will be. Meanwhile, the length of the beam depends on the width of the house. Kapur Naga tree is chosen because of its strength and durability in water or swamp. Naturally, the Banjarese people have used a certain method to preserve wood, which is by soaking it in mud/swamp. In addition, tree beam is chosen for the house foundation because of its ability to "float" the house. Such construction is often used in building floating houses or lanting houses (Fig. 5b), which are built on river. This beam foundation is used to support the pillar, while to support smaller pillar/stick similar type of foundation is used but with smaller sized beam or sliced beam. Unless the stick is between the pillars, it will automatically stand on the pillars' foundation.

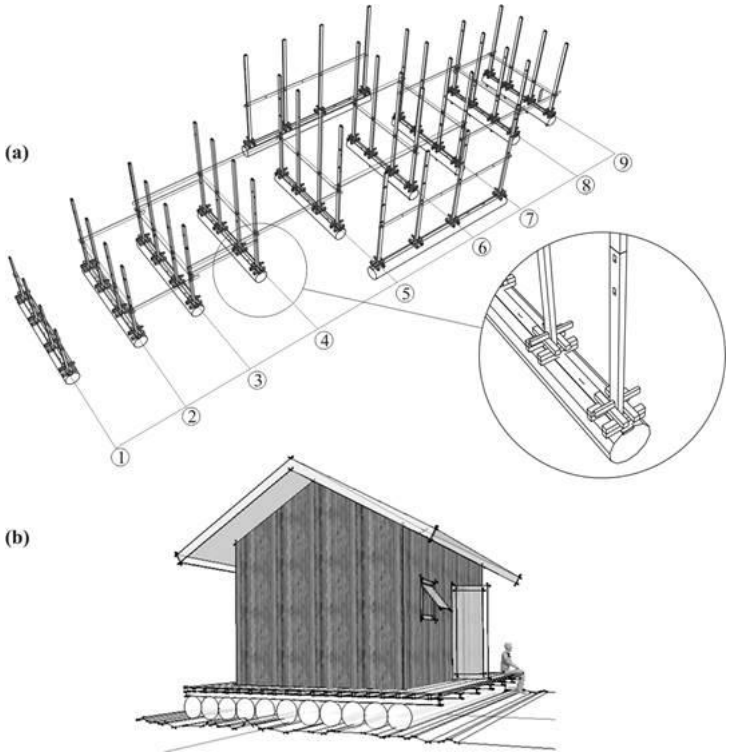


Figure 5. Construction of Floating Foundation Analysis

The second type is continuous pillar. In a Bubungan Tinggi house, there is a column built to distribute the weight from the room to the foundation. This column is differentiated into two types i.e. pillar and stick (Fig. 6). The pillar is rectangular with 15 x 30 cm dimension on the lowest part and becomes smaller as it goes to the top. The main pillar must not have segments so it has to be one single Ulin wood beam standing from the foundation to the beam supporting the roof framework. Meanwhile, the sticks are pillars placed vertically between the house foundation and the floor of the house. These

sticks function to support the floor as they distribute the weight between the main pillars. A stick is smaller than the pillar, which is about 5 x 10 cm in diameter and 2 to 3 meters in length, and their number is higher than the pillar.

Based on the placement the pillar, there are two patterns of pillar placement. In the first one, the pillars are placed parallel and in such a way to fit the width of the house. There are four to six pillars planted symmetrically with the house. In the house that was used in this study there are nine rows of pillars standing from the front part of the house (front porch) to the kitchen, which is the back part of the house (Fig. 6a). In the second placement pattern, there are pillars placed parallel in such a way to fit the length of the house. In this pattern, the number and distance between the pillars depend on the pillars of the first pattern. Therefore, the pillars can only be seen as a row of pillars standing on the right and left side of the house (Fig. 6b). The non-segmented and continuous pillar materials that are placed from the foundation until the roof framework of the house eliminate the awkward impression of the house's substructure and upper structure.

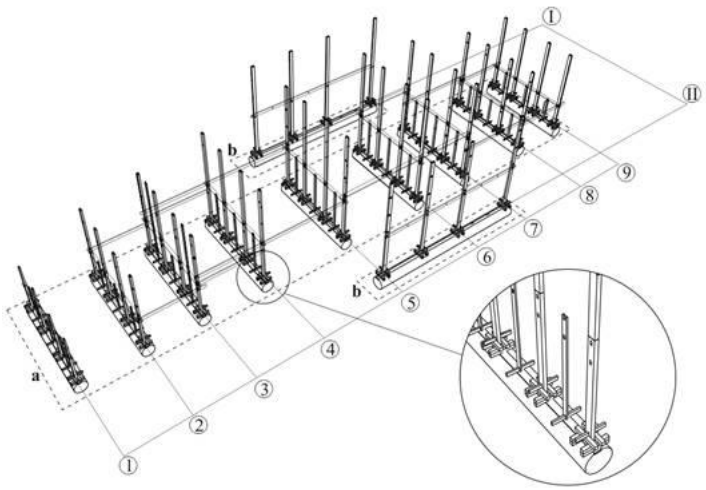


Figure 6. Construction of Continous Pillars

The third construction type is pillar-binding beam. The pillars that have been planted or stood parallel with the width of the house (Fig. 6) are then bound by a binding beam which is equally tall with the floor. This binding beam is called watun beam (Fig. 7). Found in this study were nine binding beams and their number was as many as the number of the row of pillars as shown in Fig. 6. The principle of this pillar-binding beam is similar to the binding principle applied to the foundation. However, unlike the binding beams on the foundation which function as bases or footholds, these nine binding beams simply function as the bonds among the pillars. By installing these beams the house will gain stability in the center part. The binding beam serves as the main component of building structures similar to the foundation-binding beam or sloof in today's concrete constructions. These beams are made of Ulin wood with the dimension of 10 x 30 cm with the length that equals to the width of the house. The installment of these beams is done by inserting each beam (after they have been holed) to the already standing pillars at once from above (Fig. 7a). The beam is positioned in accordance with the elevation of the floor from the ground. Therefore, before installing the beam, the pillars are given footholds to hold the pillar-locking beams (Fig. 7b).

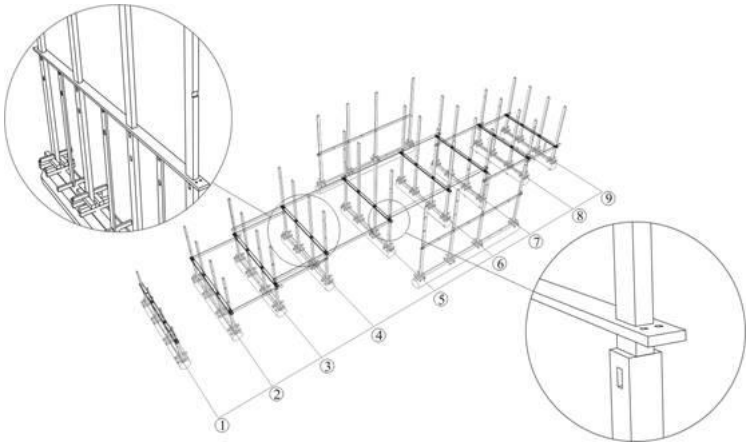


Figure 7. Construction of Pillar-locking Beam

The fourth type is beam-binding beam. Because the pillars are bound by the binding beam (Fig. 7), the pillars tend to have lateral stiffness to one side. In order to strengthen the stiffness to the other side, these binding beams are bound by another beam called panapih (Fig. 8). The principle of this panapih beam is similar to that of the pillar-binding beam (watun beam). The binding beam is the component functioning to create a bond among the watun beams. By having these panapih beams, the house now has two-way lateral stability. The unity among the pillars, pillar-binding beams, and beam-binding beam is able to create a strong bond in the center part of Bubungan Tinggi house. The existence of these two points of stability allows the construction to have technical advantages in solving the problem of low carrying capacity of the land, preventing uneven submersion, and solving technical problems related to joining wood pieces.

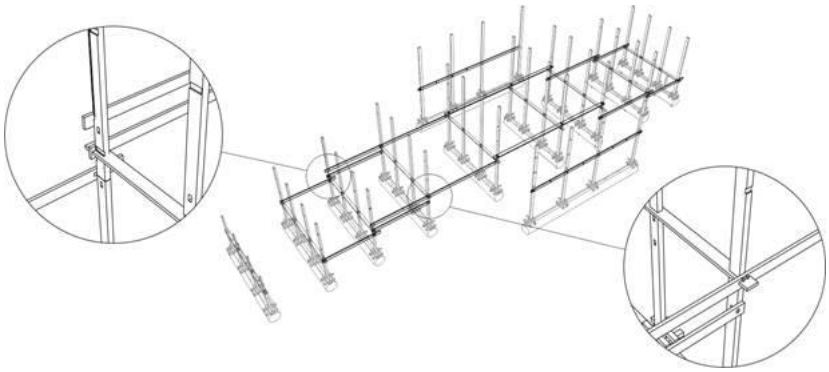


Figure 8. Construction of Pillar-locking Beam

The fifth type is pillar-locking beam. After all of the pillars have stood up, the next step is installing the pillar-locking beam called sampaian beam. The installment begins with the first eight main pillars called tihang pitugur. In the simulated reconstruction (Fig. 3), the process of installing these main pillars is shown by step 5 until the step 9, while the installation of the pillar-locking beams is shown by step 290 until step 296. Figure 9 shows all of the pillar-locking beams which have been installed. After these beams are all installed, all the pillars have been bound or locked and the parts of the construction are unified.

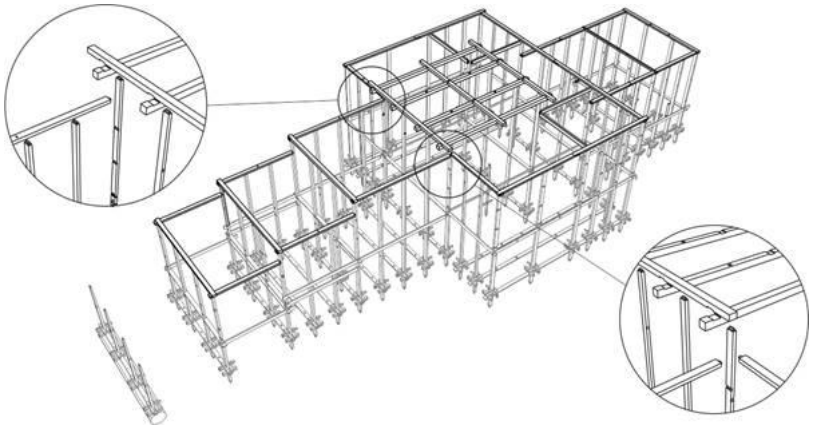


Figure 9. Construction of Pillar-locking Beam

In the construction process of a Banjarese house, the finishing of those five design types is the priority. After the pillar-locking beams are installed, the installation of roof framework and roof slates (*sirap*) can be done. When the roof is installed, it is easier and quicker to work on the other parts of the house such as the floor, wall, or other finishing work.

5. Result

Vernacular design of wetland environment is one of the solutions developed by Banjarese people to solve the problems related to house construction. The design can be viewed from two aspects, the material used and the construction design. Regarding the material, Banjarese people use Ulin wood as the main material for the house not only because of its abundant availability in the surrounding area, but also its ability to deal with the wet environment. Ulin wood is more durable in wet condition so that it is compatible for house construction material. Meanwhile, from the viewpoint of house construction design, Ulin wood allows workers to make various techniques of joint, bond, and develop construction methods. Based on the condition of the environment and the shaped knowledge, Banjarese people have successfully created and proved a house structure which can stand and remains stable even after hundreds of years on a land with low carrying capacity for structures. These two aspects become the shaping elements of the concept of vernacular architecture on wetland environment, especially in the environment of Banjarese tribe in South Borneo Province, Indonesia.

6. References

[1] B. Sellato, Dragon and Hornbill, New York: Van Nostrald, 1989.

[2] E. Maltby, Waterlogged Wealth Why Waste the World's Wet Places, London: Earthscan Publications Ltd, 1986.

[3] D. K. Cassel, “Foreword,” in *Aquic Conditions and Hydric Soils: The Problem Soils. SSSA*, Madison, Wisconsin, Soil Science Society of America, Inc., 1997, p. vii.

[4] P. J. Dugan, Wetland Conservation: A Review Of Current Issues And Required Action, Gland (Switzerland): World Conservation Union (IUCN), 1990.

[5] B. N. Muchamad and I. Mentayani, Anatomi Rumah Bubungan Tinggi, Banjarmasin: Pustaka Banua, 2007.

[6] L. N. Groat and D. Wang, Architectural Research Methods, New York: John Wiley & Sons, 2002.