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Wood Structure System in Traditional Banjar Houses in Indonesia

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Abstract **-** Wood, which is a sustainable material, is widely used for various purposes, including for buildings. The main part of the wooden building lies in the main frame. Wood frame technology is developing quite rapidly, which is generally centered on technology from the Western world. The wood frame technology for traditional houses in Indonesia is unique, which is generally adapted to local conditions, including traditional Banjar houses. Research on traditional Banjar houses has not yet reached an adequate in-depth study of the wooden frame, even though it is unique and responsive to swampland conditions and the local environment. The wooden frame structure and construction system of traditional Banjar houses, apart from adding to the global vocabulary of wooden frames, can also be used as an alternative to wooden frames for conventional buildings. Therefore, this research is important to be carried out. This research was conducted by first taking an inventory of the structural and construction systems of several samples of traditional Banjarese houses, to be analyzed in order to obtain the formulation of the structural and construction system. The existing data and formulations will be combined with the structure and foundation construction that has been obtained in previous studies. A qualitative analysis was also carried out on the obtained formulas to provide an understanding of the forces acting on them and the reactions of the elements and their connections. The method is carried out through secondary data and direct data collection in the field, where the data obtained are compiled and analyzed with a matrix to get the level of regularity of the structure and construction system. The structural and construction systems that have been formulated will be analyzed qualitatively by their actions and reactions in the context of the forces acting on them. It was found that the wooden structure system in a traditional Banjar house consists of 17 structural elements, of which 5 have a major role in the structural system and have unique characteristics compared to other conventional and traditional systems. These structural elements form a solid wooden structural system which is proven by the survival of traditional Banjar houses to this day.

Keywords – structure, traditional Banjar house, wood.

INTRODUCTION

Buildings with wooden structures and constructions are environmentally friendly and sustainable, as long as wood as a renewable material is managed in such a way that its sustainability is guaranteed. The wooden structural system in the form of structural elements and connection systems is quite diverse but continues to be developed through the discovery of new systems and old systems that have not been exposed. One of the oldest sources of wooden structural systems is vernacular or traditional wooden buildings. Including in Indonesia which is rich in a variety of traditional buildings, such as the Joglo with the Rongrongan system (Dakung, 1987), the Toraja House with the Tongkonan system (Sir, 2018)(Hartawan, 2015), and the Betang House with the Jihi and Tungket system (Restyanto, 2012)(Rahman, 2009)(Yukio, 2009).

In South Kalimantan Province, the traditional Banjar house, which has 11 variants (Seman, 2001), has a structural system that has been tested for strength and durability. The structure of a traditional Banjar house which is entirely made of wood from the foundation below to the roof covering at the top is unique because it stands in a swamp or wetland environment. Swamp land that has a low bearing capacity (Iskandar, 2000)(Cohen, et.all., 1996) requires a foundation that is able to withstand the load on it, but is also able to transmit the load to the swamp without decreasing(Harisakti, 2010). Research related to the Banjar traditional house foundation system has been carried out (Huzairin, 2021)(Mareks, et.all., 2015) which concludes that the Banjar traditional house foundation is able to withstand the load from above and is also able to transmit the load to the marshland without significant settlement(Nangkula and Nurhananie, 2011).

Swamp soil in relation to building structures has distinctive characteristics, which in addition to its low bearing capacity, it is also easier to transmit vibrations ((https://news.detik.com/berita/d-1894312/tanah-rawa-jakarta-utara-dan-barat-berpotensi-rasakan-gempa-lebih-besar), so that the source of vibrations in the marshland will be easily propagated to the surrounding buildings. This causes buildings on marshlands to easily receive various vibrations that will affect the structure of the building(Dogangun, et.all, 2006). However, traditional Banjar houses can last for quite a long time without undergoing significant structural changes (building subsidence, slope, fracture or damage to structural elements, deformation of structural connections). The resilience of the traditional Banjar house structure system is indicated to be due to the resilience of the structural system.

Research related to the structural system of traditional Banjar houses has not been carried out in detail. Seman (2001) stated that the traditional Banjar house structure system by means of disassembly and pegs, however, was not explained in more detail and without descriptions(Darma, 2003). Meanwhile, the ULM Architecture Study Program Team (2006) described the structural system of traditional Banjar houses in general.

This study related to the structural system of traditional Banjar houses is very important to be carried out due to several things, namely: the absence of detailed documentation and research; the less population of the remaining Banjar traditional houses; and as an alternative to the structural system of wooden structures on marshlands.

This research is to obtain an innovation of wood frame structures in swamps by utilizing wood from local endemic trees, so it is hoped that it will provide an alternative wood frame technology in swamps that is safe, efficient and environmentally friendly for the community.

METHODOLOGY

This research was conducted through 4 (four) stages, namely: data collection, data compilation, typology analysis, and formulation of the typology of the traditional Banjar house structure. The samples collected were the specific type of traditional Banjar houses i.e.: *Bubungan Tinggi, Gajah Baliku, Gajah Manyusu, Balai Laki,* and/or *Balai Bini*. This type has similarities in terms of the shape of the floor plan, the size of the house, and the shape of the roof. The sample locations were in *Sei Jingah* and *Kuin Utara* in Banjarmasin City, and in *Teluk Selong* in Banjar Regency. This location was taken because the concentration of traditional Banjar houses with the oldest age is found in these 3 areas.

The sample data were arranged based on the structural elements of a traditional Banjarese house, namely*: tihang* (continuous pillars), *tongkat* (short posts), *watun, penampik, susuk* (main floor beam), *gelagar* (secondary beam), floorboard, *suai* (bracing), *belabat* (horizontal wall beams), wall posts, wall boards, *sampaian* (ringbalk), roof frame, *kalang dada* (*gording*), *kasau* (rafters), *ri-ing* (battens), and roof coverings. Each element contains variable data in the form of dimensions, type of wood, the distance between, and the type of connection. The data are arranged in tabular form to facilitate the regularity of the variables between each sample.

The analysis and formulation(Endaswara, 2006) are based on the uniformity of element types, shapes, sizes, positions, and types of connections from the sample, which results in a traditional Banjar house structure system.

RESULTS AND DISCUSSION

Sample Data

The sample locations were in 3 areas, namely: *Sei Jingah* and *Kuin Utara* in Banjarmasin City with 4 and 3 samples respectively, and *Teluk Selong* in Banjar Regency with 3 samples. Figure 1 shows the position of the area.

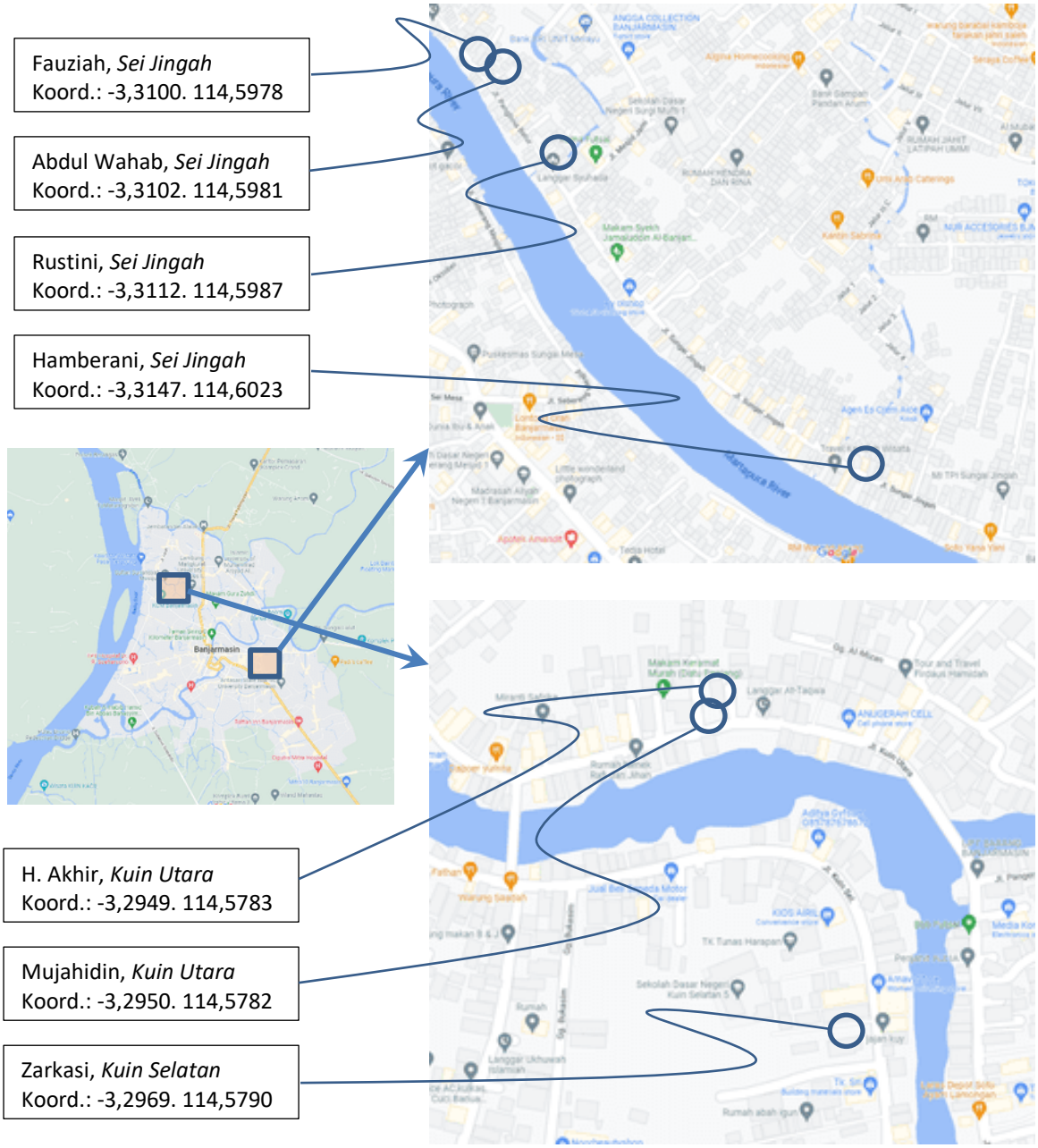

Figure 1: Location of data sample in Banjarmasin.
Source: Google Maps & Author

Figure 2: Location of data sample in Martapura.
Source: Google Maps & Author

Sample data related to traditional house type, age, owner/heir, area, and location are summarized in table 1.

Table 1.
Some general data regarding 9 samples.

No	Sample	*Tipe Rumah Tradisional*	Age	Owner/ Heir	Area (m2)	Location
1	Sample 1	*Balai Bini*	117 years (1905)	Rustini	166	*Jl. Panglima Batur Sei Jingah*
2	Sample 2	*Bubungan Tinggi*	117 years (1905)	Abdul Wahab/ M. Firdaus	95	*Jl. Panglima Batur Sei Jingah*
3	Sample 3	*Balai Bini*	142 years (1880)	Fauziah	180	*Jl. Panglima Batur Sei Jingah*
4	Sample 4	*Balai Bini*	112 years (1910)	Hamberani	87	*Jl. Sei Jingah, Sei Jingah*
5	Sample 5	*Bubungan Tinggi*	100 years (1922)	Mujahidn	134	*Kuin Utara*
6	Sample 6	*Tadah Alas*	108 years (1914)	H. Akhir/ Iwan	171	*Kuin Utara*
7	Sample 7	*Balai Bini*	95 years (1927)	Zarkasi	95	*Kuin Selatan*
8	Sample 8	*Bubungan Tinggi*	211 years (1811)	Mulya/ Fauziah	306	*Teluk Selong*
9	Sample 9	*Gajah Baliku*	142 years (1880)	Badiuzzaman/ Abu Najib	178	*Teluk Selong*

Source: Author.

Regularity of Structural System

The structural systems of the 9 samples show uniformity and regularity, except for a few sections and dimensions of certain elements. A summary of the regularity or irregularity of the 9 samples can be seen in table 2.

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Table 2.
Summary of the regularity or irregularity of the 9-sample structural system.

No	Element	Dimention	Wood Type	Distance Between	Connection Type
1	*Tihang* (Continuous Pillars)	7/15 s/d 11/19	Ulin	1,5 s/d 2,25	Mortise & tenon joints
2	*Tongkat* (Short Posts)	4/11 s/d 7/11	Ulin	1 s/d 1,85	Notch
3	*Watun*	5/14 s/d 8/26	Ulin	--	Mortise & tenon joints
4	*Penampik*	5/14 s/d 4/20	Ulin	--	Mortise & tenon joints with pegs
5	*Susuk* (Main Beam)	5/10 s/d 9/10	Ulin	According to distance of Tihang/ Tongkat	Mortise & tenon joints
6	*Gelagar* (Secondary Beam)	4/6 s/d 6/7	*Ulin* (1-2 samples are meranti)	0,3 s/d 0,4	Nailed
7	*Papan* (Board)	2/13 s/d 2/19	*Ulin* (some are not ulin)	--	Nailed
8	*Suai* (Bracing)	--	--	--	--
9	*Belabat* (Horizontal Wall Beams)	5/7 s/d 7/8	Some are *ulin*, some are not *ulin*	1,15 s/d 1,80	Notch
10	*Tiang Tawing*	6/7	*Ulin*	According to Tihang Distance	Notch
11	*Papan Tawing* (Wall Board)	1,5/13 s/d 2/15	Some are *ulin*, some are not *ulin*	--	Nailed
12	*Sampaian* (Ringbalk)	10/10 s/d 20/20	Some are *ulin*, some are not *ulin*	Following Tihang's Position	Mortise & tenon joints
13	*Kuda-kuda* (Roof Frame)	5/10	Some are *ulin,* some are not *ulin*	2 m or According to Tihang Distance	Mortise & tenon joints
14	*Kalang Dada* (Gording)	5/10 s/d 10/10	Some are *ulin*, some are not *ulin*	1,5 m or According to Tihang Distance	Notch
15	*Kasau* (Rafters)	5/7 s/d 6/8	Not *ulin*	0,3 s/d 0,4	Nailed
16	*Ri-ing* (Battens)	3/4	Not *ulin*	0,15	Nailed
17	*Atap* (Roof Coverings)	Thick: 0,5 cm	Sirap (ulin)	--	Nailed

Source: Author.

From the summary of table 2, all samples have all parts of the structure, except bracing. The sample that uses bracing is only 3 samples found in Banjar Regency, namely Mrs. Mulya's house, Badiuzzaman's house, and Husnan's house.

All samples had tihangs (which also functioned as wall posts), *tongkat, susuk, gelagar, papan, belabat, papan dinding, sampaian, kuda-kuda, kalang dada, kasau, ri-ing* and *atap*. The shape of the structural elements is relatively the same, for example *tihang* and *tongkat* are rectangular in shape and arranged transversely to the front-back direction of the building.

The structural elements mentioned above have variations in dimensions and spacing. While the materials for the elements of *tihang, tongkat, watun, penampik, susuk, kasau, ri-ing,* and *atap* have the same type of material.

The existence of *watun* elements varies, there are some samples that have complete *watuns,* and some have only partial *watuns*. There are indications, that the older the building, the more complete the *watun* is and vice versa where there are buildings that do not have *watun* at all.

The presence of *penampik* elements also varies, where there are some samples that do not use penampik. Samples that do not use penampik are samples whose age is younger.

From the description above, it can be concluded that the structural system of traditional Banjar houses has similarities in terms of structural elements, types of wood, profile shape, arrangement, and types of connections. The difference that occurs is only in the *watun* and *penampik* elements, where there are a small number of samples that do not have complete watuns and a small number of samples that do not have penampik.

The structural system of the traditional Banjar house shown in section 3.3 is a structural system that has complete elements including *watun* and *penampik*, because the elements of *watun* and *penampik* are structural elements typical of traditional Banjar houses that are always present (Seman, 2001).

Banjar Traditional House Structure System

Structural Elements

The structural elements of a traditional Banjar house consist of:

1. Tihang, is a continuous column from the ground to the bottom of the roof. The material is always ulin wood with sizes ranging from 7/15 to 11/19, arranged transversely to the front-back direction of the building.
2. Tongkat, is a column element that only reaches the bottom surface of the floor. The material is always ulin wood with a size smaller than the tihang ranging from 4/11 to 7/11, arranged transversely to the front-back direction of the building.
3. Watun, is the main binder of the tongkat in an important position, namely at the boundary of the difference in 2 spaces or the difference in floor height. The material is always ulin wood with sizes between 5/14 to 8/26. Watun is perforated as a place for the tihang to enter, such as the knock-down system which in Banjar language is called berasuk system.
4. Penampik, is a fastener or side lock that is connected to the ends of the watun with a straight connection and a pen with a peg. The material is always ulin wood with sizes between 5/14 to 4/20.
5. Susuk, is the main floor beam that connects the tihangs and tongkats in the longitudinal direction of the front and rear of the building. The material is always ulin wood with an average size of 5/10.
6. Gelagar is a supporting beam for the floorboard which is arranged transversely to the susuk. The material is always ulin with a general size of 5/7.
7. Papan, which are floor coverings arranged on top of the gelagar. The general material is ulin wood, but there is a small portion that is not ironwood, such as meranti wood. The size varies from 15 cm to 20 cm wide, and 1.5 cm to 2 cm thick.
8. Suai, which functions as a bracing that connects tihangs and tongkats. However, only 3 samples used this suai. The material is always ulin wood with a size of about 5/10.
9. Belabat, is a horizontal wall frame. The vertical frame of the wall is the tihang. Some of the materials made from ulin wood and some are not ulin wood with sizes between 5/7 to 7/8.
10. Tiang Tawing, is a vertical wall truss, where the function of this wall pillar is carried out by tihang. The material and size are in accordance with the material and the size of the tihang.
11. Papan Tawing, is a building wall covering board that is arranged vertically. Some of the materials are ulin wood and some are not ulin wood, but the outer walls are generally made of ironwood. Generally 15 cm wide and 1 cm to 1.5 cm thick.

12. Sampaian, is a beam covering tihang or wall pole and also functions as a pedestal for the main roof frame. The material is ulin wood or not ulin wood, with size of 10/10 to 20/20.
13. Kuda-kuda, are the main frame of the roof whose material is generally ironwood with a size ranging from 5/10.
14. Kalang Dada, or gording that binds kuda-kuda as well as the pedestal of kasau. The material is ulin wood or not ulin wood, with an average size of 5/10 to 10/10.
15. Kasau, resting on the gording and as a support for ri-ing. The material is meranti wood with an average size of 5/7.
16. Ri-ing, or battens, rests on kasau and as a fastener for roof coverings or sirap. The material is meranti wood with an average size of 2/3 to 3/4.
17. Sirap, which is a roof covering made of thin sheets of ulin wood with an average thickness of 0.5 cm.

Structural System

The traditional Banjar house structure system is formed by the 17 structural elements mentioned above. There are several elements that have important and distinctive roles, namely: *Tihang, Watun, Susuk, Penampik*, and *Sampaian.*

Tihang which functions as a lower column as well as a wall pole is rectangular in shape arranged transversely to the longitudinal direction of the building. The number in the transverse direction is always 4 sticks, while in the longitudinal direction for the front room generally 6, 8 or even numbers. In anjung room, the longitudinal direction is generally 4 or even. The position of the Tihang and its number can be seen in Figure 3.

The roles and functions of Tihang and Tongkat in traditional Banjarese houses are similar to Jihi and Tungket in the Betang Toyoi Dayak house, where the main pillar (Jihi) is large and continues to the roof and the supporting pillar (Tungket) is smaller which only supports under the floor (Restyanto, 2012). It is also similar to Bugis Traditional House (Madeali, 2018). Not only in nusantara, one of the traditional Turkish houses also uses continuous poles like this (Zelen, 2015).

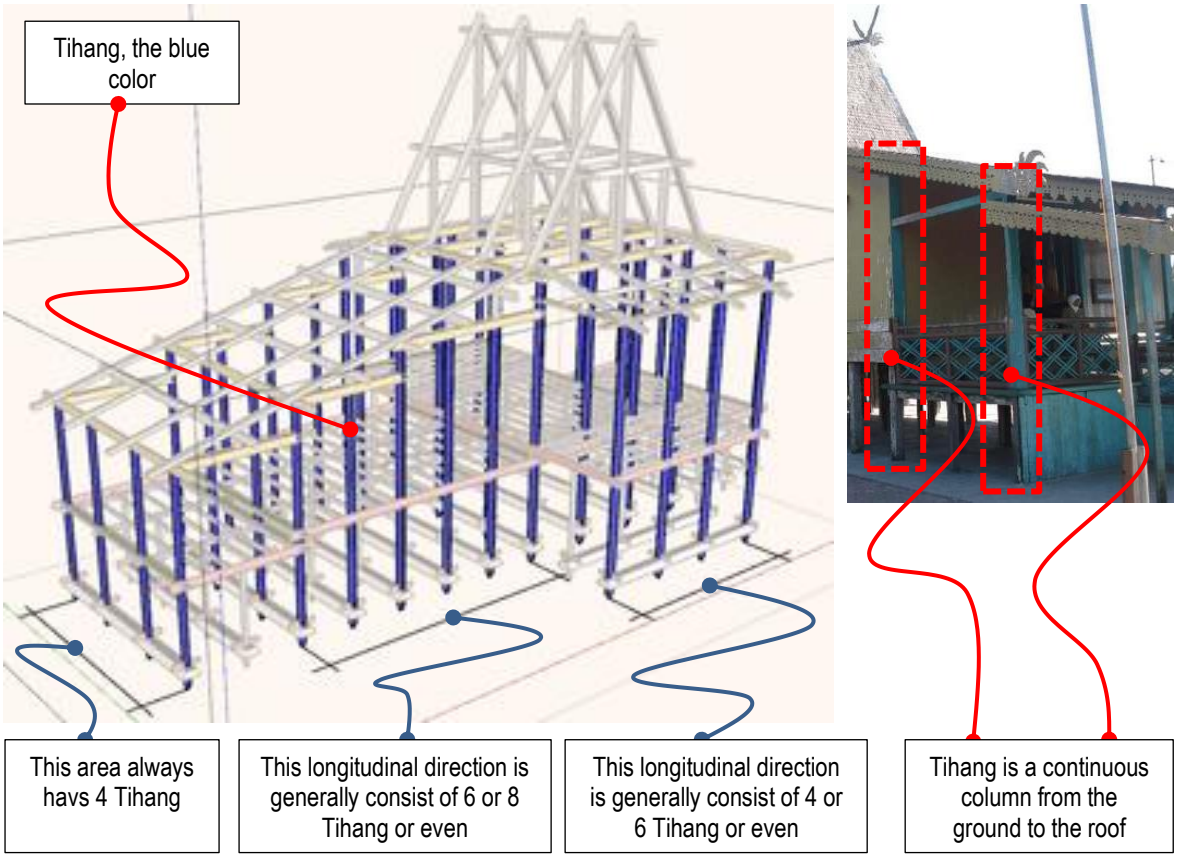

Figure 3: Position of Tihang in Banjar tradisional house.
Source: Author

Watun serves as a binder for Tihang in the transverse direction at certain places, namely: the outer part of the building, the boundary between spaces, and the height difference limit. Watun stabilizes the structure in the transverse direction. Watun's position can be seen in Figure 4, which also shows its posotion in one of the samples.

Watun has a function similar to transverse beams that are installed on the outermost parts and the meeting place between 2 spaces, both on conventional wooden structures (Sugihardjo, 1978; Subarkah, 1980; Winoto, 2014), as well as on traditional wooden structures (Restyanto, 2012; Manthani, 2019; Sahputra, 2020). However, the shape and method of installing the Watun with the berasuk system is different from the existing conventional and traditional systems.

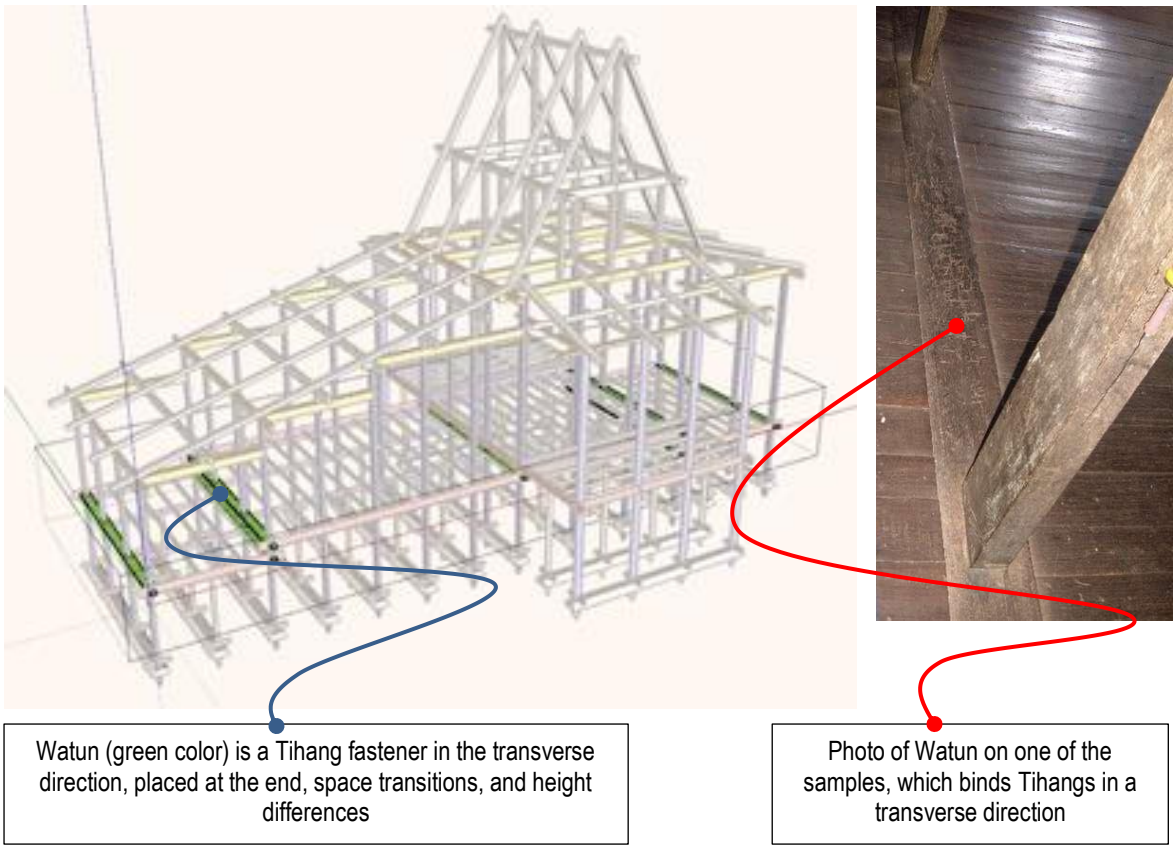

Figure 4: Position of Watun dan its photo in Banjar tradisional house.
Source: Author

Susuk has the same function as the main beam in a conventional wooden structural system, namely as a tie of Tihang and Tongkat in the longitudinal direction of the building. Susuk is also a place for the rafters to rest. Susuk stabilizes the structure in the longitudinal direction. The position of Susuk can be seen in Figure 5.

Susuk has a function, shape, connection and position similar to conventional wooden structures, vernacular wooden structures that are currently developing in the province of South Kalimantan, and are also similar to some traditional structures (Restyanto, 2012; Sahputra, 2020).

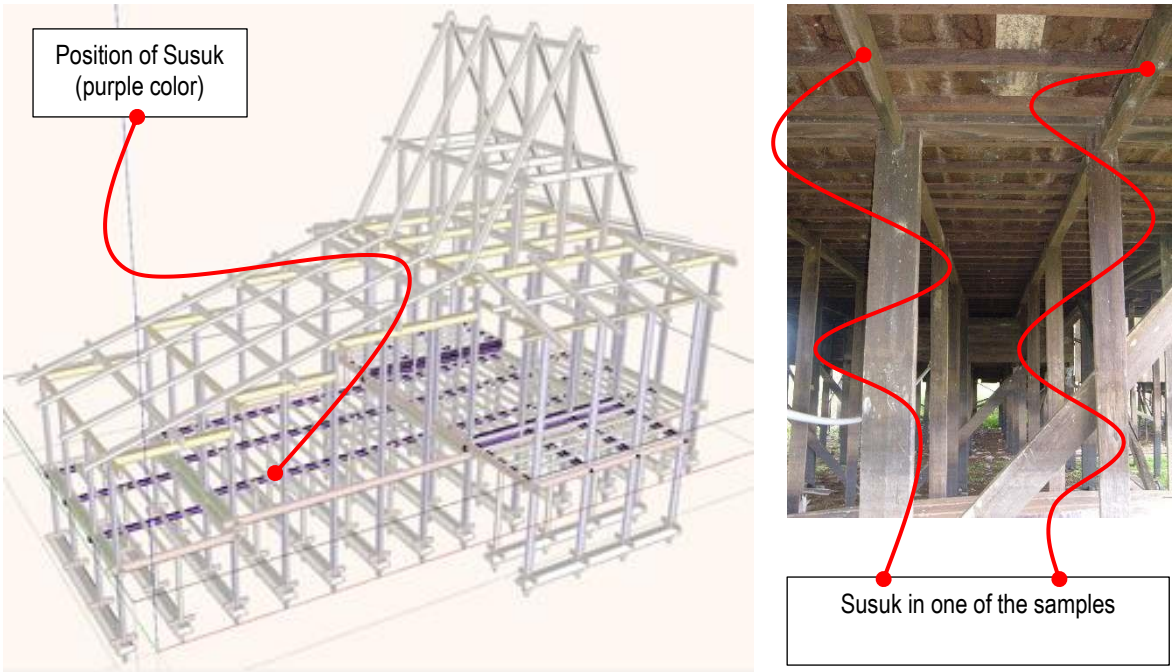

Figure 5: Position of Susuk and its photo in Banjar tradisional house.
Source: Author

Penampik has a dual function, where the first is as a clamp for the lower structure in the longitudinal direction, and the second is as an outer wall trim so that the shape of the building becomes better and neater. This Penampik is tied to Watun with a peg connection. The position of the Penampik can be seen in Figure 6, as well as the photo of the connection between Penampik and Watun.

Penampik is a typical structural element in traditional Banjar houses, which is not found in conventional or traditional structures.

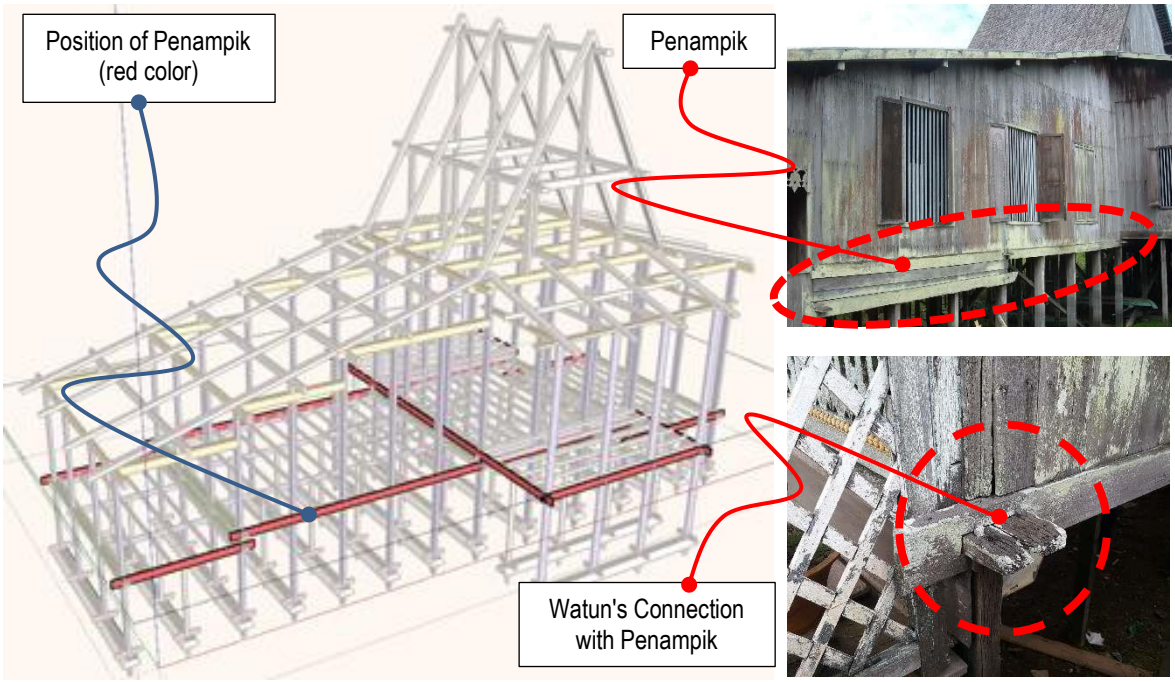

Figure 6: Penampik's position and its connection with Watun in a traditional Banjar house.
Source: Author

Sampaian serves to connect the Tihangs at the top, both in the longitudinal and transverse directions. Its existence strengthens the bonds between Tihang and strengthens the overall structure. The position of the Sampaian can be seen in Figure 7.

Sampaian is a wooden structural element that is commonly used in both conventional and traditional wooden structures. Sampaian in general is also called cover beam, beam circumference or ringbalk.

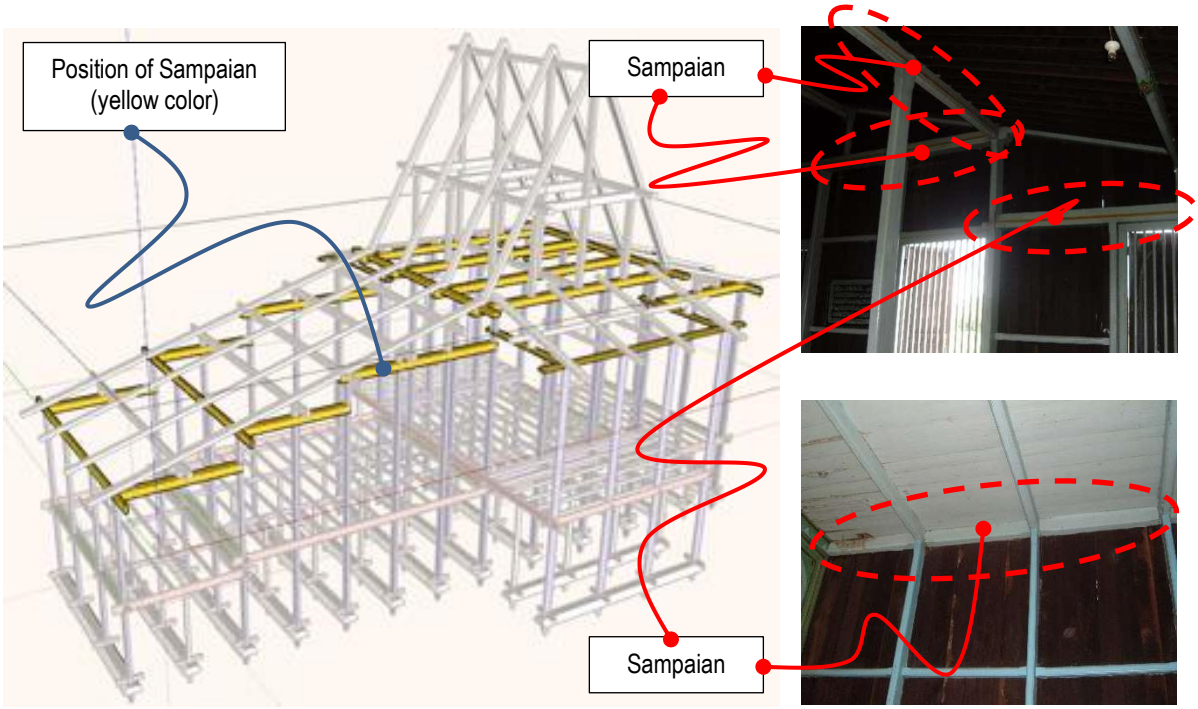

Figure 7: Position of Sampaian and its photo in Banjar tradisional house.
Source: Author

CONCLUSION

The wooden structure system in a traditional Banjar house has 17 structural elements. These structural elements are generally found in conventional and traditional wood structural systems.

Among the 17 wooden structural elements, there are several elements that have a major role in building the strength of the structural system of the traditional Banjar house, namely: Tihang, Watun, Penampik, Susuk, and Sampaian.

Of the 5 main wooden structural elements in the Banjar traditional house, there are 3 elements that are unique compared to elements in the existing conventional and traditional wooden structural systems, namely: Tihang, Watun, and Penampik.

Tihang is a pillar or column which is a complete beam that is continuous in length from the foundation to the bottom of the roof.

Watun acts as a main beam in the transverse direction and on the outer part of the building, but has a rectangular shape with a typical connection system in the form of holes that are directly attached to the Tihang or called the berasuk system.

Penampik is a structural element that is not found in the existing conventional and traditional wooden structural systems, where this element serves not only as a structural binder but also as a part that beautifies the shape of the outer wall at the bottom.

Altogether the 17 structural elements are arranged in such a way as to form a solid wooden structural system in a traditional Banjar house. Its resilience is reflected in the solid survival of the surviving traditional Banjar houses that are over 100 years old.

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