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COMPARATIVE STUDY OF VERNACULAR HOUSE TECTONICS IN GUBUGKLAKAH VILLAGE, TENGGER AND IN PEDAWA VILLAGE, BALI

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ABSTRACT

This article is a summary of research activities with a focus on comparative studies related to aspects of structural and construction systems applied in vernacular buildings in Gubugklakas Village, Tengger, East Java and in Pedawa Village, Buleleng, Bali. The aspects that are observed, are related to the structural system contained in the three segments of the building, namely in the substructure or building foundation, the superstructure or the building body, and the upper structure or roof of the building. This research was carried out using a comparative method which focus on the study regarding the structural system, loading logic, and construction system applied in the two vernacular buildings of residential houses in the two areas. The conclusions obtained are related to the characteristics of the loading logic, the construction system, the anticipation of loads and natural phenomena, as well as the building materials applied in the vernacular residential structure system in the two villages.

Keywords: ***Comparison, Gubugklakah, Pedawa, Structure, Vernacular House***

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INTRODUCTION

The archipelago, home to around 1,340 ethnic groups with diverse cultures, customs, artistic works, and regional languages, holds a unique advantage. These qualities make the Equatorial Emerald Country renowned as one of the richest countries in arts and culture. Historical, geographical, climatic and even belief system factors have caused the tribes of the archipelago to grow and develop to have their own characteristics in developing their cultural traditions. One of the noble cultural products that is also interesting to observe is related to the diversity of vernacular architectural forms that are characteristic of the form of residential buildings of each tribe in the archipelago. A dwelling serves as a symbol of the cultural development of the community itself. Such conditions can be found in both urban and rural areas (Sukowiyono, Susanti, and Istiqoma, 2021). Every region, island, even tribe, has a variety of forms of vernacular and traditional architecture, some of which also have similarities with buildings belonging to other tribes in Indonesia. These similarities are inseparable from the existence of historical background factors, belief systems, similarities in the character of the regional climate, and various other natural factors.

The Javanese, who inhabit eastern Java, and the Balinese, the native people of Bali, are neighboring tribes separated only by the narrow Bali Strait. These two tribes share many cultural similarities due to their common history, demographics, and past beliefs. The East Java region is known as one of the areas with various Hindu and Buddhist temple buildings from the classical period. This fact is also widely found in Bali Island area. Apart from that, the vernacular buildings in these two areas also have a lot in common in the principles of orientation, spatial planning, zoning, and even in terms of the building construction system. This reality certainly cannot be separated from the characteristics of these two areas, similarities of climate characteristics, and the geographical locations which are in the area of the volcanic range. Vernacular buildings in these regions have been adapted since ancient times to withstand frequent volcanic activity throughout the year (Angkasa Wazir, 2019). These structures are notably resilient, particularly in highland village settlements that endure extreme conditions compared to urban climates (Susanti and Sukowiyono, 2020). As noted by Hermawan and Švajlenka (2021), vernacular houses in mountainous areas typically feature saddle roofs, exposed wood, stone walls, and zinc roofing.

This article is one of the products of the 2023 Independent Learning Independent Campus Program activities which are jointly run by the Architecture Study Program, Udayana University, Balk and the Department of Architecture, Brawijaya University, Malang, East Java. On this occasion, through the results of direct observation in the field, there were some similarities in the structure and construction system of vernacular buildings in these two provinces. This picture further prompted the emergence of a desire to conduct a comparative study between structural and construction systems applied in both vernacular buildings. On this occasion, the two areas that became the focus and locus of this research activity were vernacular buildings in Gubuhklakah Village in Tengger, East Java and Pedawa Village in Buleleng, Bali. These two areas have relatively distant locations, but they both have similar geographical characteristics, climates, and seasonal

cycles. The form of vernacular residential buildings also has many similarities, especially in terms of the use of materials, and the logic of loading the structure.

This article is a summary of research activities with a focus on comparative studies between structural systems applied in vernacular buildings in Gubugklakas Village, Tengger, East Java and in Pelawa Village, Buleleng, Bali. The aspects that are observed, are related to the structural system in the three segments of the building, namely in the substructure or foundation of the building, the superstructure or the body of the building, and the upper structure or roof of the building. The comparative study also examined aspects of the construction system applied in vernacular buildings from these two regions.

METHODS

This study applies a comparative analysis method between vernacular buildings of residential houses in Gubugklakah Village, Tengger, East Java and vernacular buildings of residential houses in Pedawa Village, Buleleng, Bali. The Comparative Study Method is a method that is carried out by comparing similarities or differences from a research object. This method is used to compare two house objects from the objects used in the study. Qualitative research is used to explain the results of an analysis. (Giawa, Pakpahan, and Yulianto 2019). This study has an observational focus related to the structural system, loading logic, and construction system applied in the two vernacular buildings of residential houses in the two areas.

In researching a tectonic, the things that are considered in the building are from the legs, the body to the head (Rodriques; Rahadhian P. Herwindo 2020). In material processing, the structure of the construction, which makes the aspect of aesthetic value an affirmative, through ability and technology, can be referred to as tectonics (Frampton, K.1995; Kapilawi, Nday, and Wiras Hardi 2019). An artistic value consisting of the materials used, construction and arrangement along with formation is referred to as tectonics (Nugroho and Herwindo 2023). The existence of tectonics has an honest nature in terms of showing the distribution of the load, the nature of the materials used, as well as the correct interpretation, cosmology, and cultural character (Devi and Sombu 2022). The research conducted by Darma and Suryada (2023) regarding tectonics is analyzed through several stages starting from classification, definition and construction elements. Therefore, the structure and construction system that is observed is broadly divided into three segments of the building section, namely the *substructure* segment or building foundation section, the *superstructure* segment or building body part, and the *upper structure* segment or the roof of the building. In these three segments, the construction system applied in the two vernacular buildings that are the object of this study is also observed. The final results obtained show that there are similarities, differences, and forms of system variants found in the two residential vernacular buildings from these two areas.

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RESULTS AND DISCUSSION

Gubugklakah Village

Gubugklakah Village is one of the villages included in the Bromo Area. This village is inhabited by around 3,734 people. The majority of the inhabitants are Tengger tribes. Gubugklakah is precisely located in Poncokusumo District, Malang Regency and can be reached by driving for about an hour from Malang City. Like the villages in the Bromo area which are inhabited by the majority of the Tengger Tribe in general, Gubugklakah is also geographically surrounded by a stretch of hills around Mount Bromo. In terms of language and customs, the tengger people do have similarities with Javanese, but that does not mean that they are completely Javanese. Therefore, Novita (2020) said that the Tengger people are included in the Javanese sub-ethnic category (Novita Taniardi 2020). Gubugklakah Village is directly adjacent to several areas, namely Duwet Village to the north, Ngadas Village to the east, Poncokusumo Village to the south, and Wringinanom Village to the west.

Based on the information obtained, the name Gubugklakah which is the identity of this village comes from the word gubug meaning 'small house', and klakah which in the local language can be interpreted as 'bamboo stalks split in half'. Most of the people of Gubugklakah Village are engaged in plantations. There are several types of plantation products in this area, namely corn, vegetables, and several types of fruits. The people of Gubugklakah Village are trying to manage its potential to make it a tourist destination and a trail to Mount Bromo and Mount Semeru (Asikin et al. 2022). The conditions in the mountainous area are very different from the areas on land, both from the geographical conditions, and the climate in adapting the buildings where they live. Gubugklakah Village has a distinctive climate with high rainfall during the rainy season, cool mountain air temperatures, and high levels of air humidity that cause its vernacular residential buildings to be closed and monolithic. Residents usually carry out more activities in the house at night.

The vernacular residential buildings in this area are made of materials that are easily obtained around the village, such as wood, natural stone, and bamboo. Residential house buildings usually adhere to a structural system with the main columns of the house standing on the pillars. The construction system of columns and wooden beams also uses a lot of peg systems, as an effort to anticipate the load and shift in the position of structural elements as a result of the load of wind, rain, and even volcanic movements. The roof shape of the vernacular building in Gubugklakah Village has a resemblance to a traditional Javanese house. This can be seen from the shape of the roof. Rural communities in Java, in general, have village-type houses (Sardjono et al., 2022). This is also strengthened by the opinion of Lelono (2019), by saying that the shape of the Tengger Tribe's house is not much different from the houses in the Javanese countryside, namely the architectural form with a limasan or *kampung* roof (Lelono, 2019). The shape of the roof is dominated by the roof of the pyramid, the basic shape of the building body is in the form of square and rectangular shapes, and the shape of the legs of the building

consisting of high stilts, low stilts and non-stilts are typologies owned by Javanese vernacular buildings as well (Hamka, and Winarni, 2023)

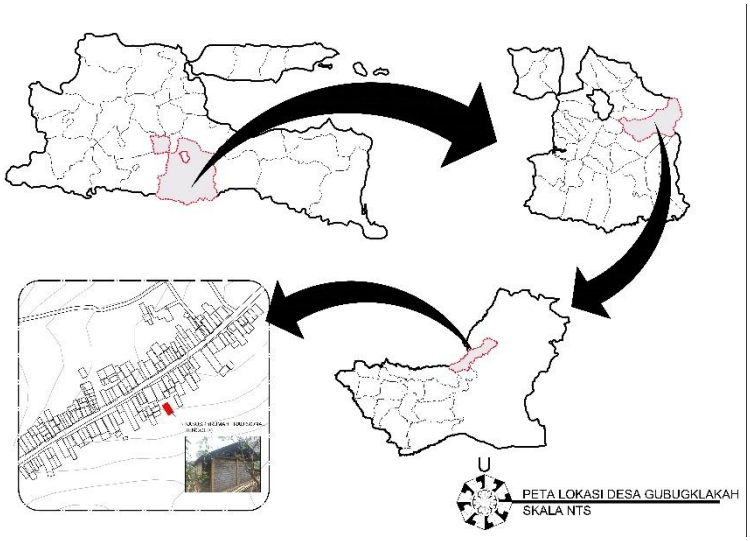
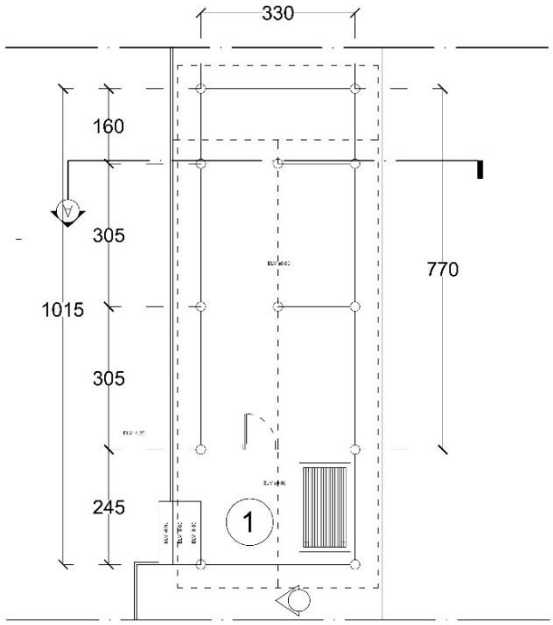


Figure 1. Location Map of Gubugklakah Village
Source: Author (2023).



LEGENDA

1. RUANG TAMU
2. KAMAR
3. PAWON

DENAH RUMAH GUBUGKLAKAH
SKALA 1:50

Figure 2. Gubugklakah Village House Plan
Source: Author (2023).

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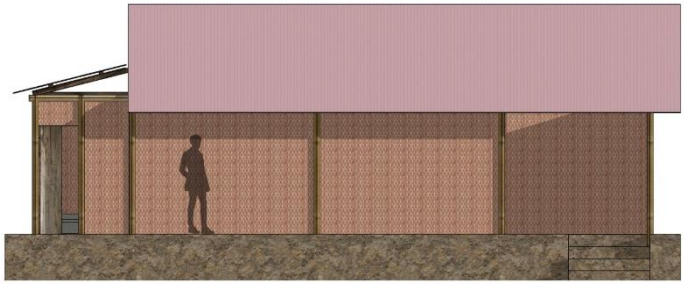

Figure 3. Gubugklakah Village House
Source: Author (2023).

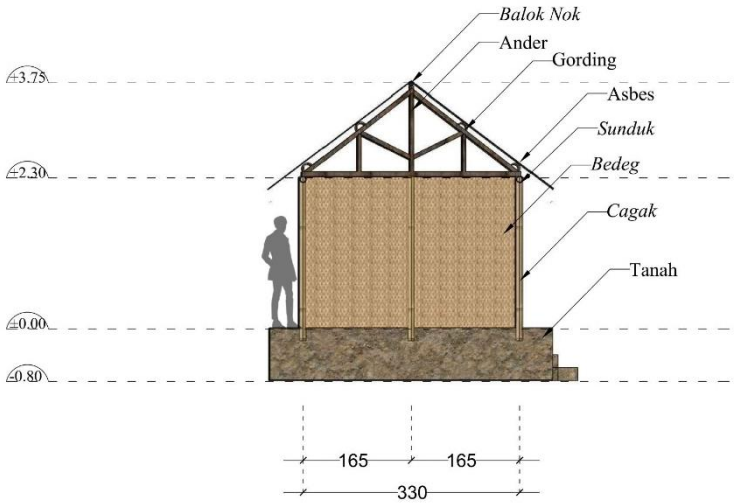

Figure 4. Pieces of Gubugklakah Village Houses
Source: Author (2023).

Pedawa Village

Pedawa Village is included in the group of Bali Aga Villages or villages that have existed for a long time, before the arrival of the Hindu community from Majapahit to Bali (Prajnawrdhi 2020). Pedawa is located in Banjar District, Buleleng Regency, Bali, and can be reached by car for about an hour from Singaraja City. Geographically, Pedawa Village is located in a hilly area surrounded by a fairly large expanse of forest. The Pedawa area is directly adjacent to several neighboring villages as follows. Tigawasa Village, Cempaga Village, and Straits Village to the north, Gobleg Village to the east, Gobleg Village, Tirtasari Village and Kayuputih Village to the south, and Banyuseri Village, and Banjar Village to the west.

Pedawa Village is one of the oldest traditional village groups in Bali. This village was previously known as Gunung Tambleg Village since the ancestors came from the Tamblingan area. Most of the residents of Pedawa Village are engaged in plantations with the main products of palm oil, coffee, cloves, vegetables, and fruits. Pedawa, which is located in a hilly area, has a climate with cool temperatures, high rainfall, and has a fairly high level of air humidity.

Residential buildings that are still classified as vernacular architecture, have a rectangular plan. The dominant building materials are wood, bamboo, natural stones, and clay materials used to compose the walls and floors. The climate of Pedawa which is quite cold at night causes residents to be dominant in their homes at night. The residential building, sacred room, bedroom, and kitchen are designed to be integrated into one monolith house building equipped with a terrace in the front area. The use of wooden structures itself has various installation techniques, such as poles planted with stalks, tie techniques and purus-hole techniques, stacked beams and purus-holes. (Koesmartadi and Prijotomo 2020). Local techniques such as the sliding foundation technique in the form of wood by placing a stone on a flat surface with additions in the form of a lower, middle, and upper frame (Hariyanto, Triyadi, and Widyowijatnoko 2020). As stated earlier, the main structure of the house building uses a system of main structure columns known as *sesaka* which stands on *joints* or *umpak* made of stone. Inside the building there are *bale-bales* called couches made of bamboo slats and reinforced with *sunduk* wooden blocks that apply a construction system in the form of pegs made of wood.

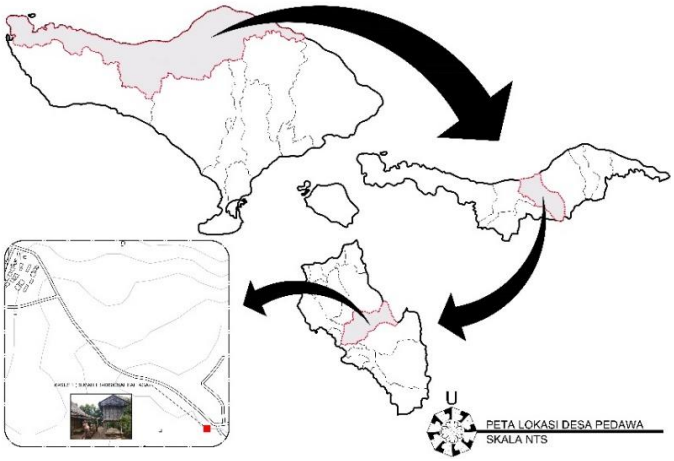

Figure 5. Map of Pedawa Village Location
Source: Author (2023).

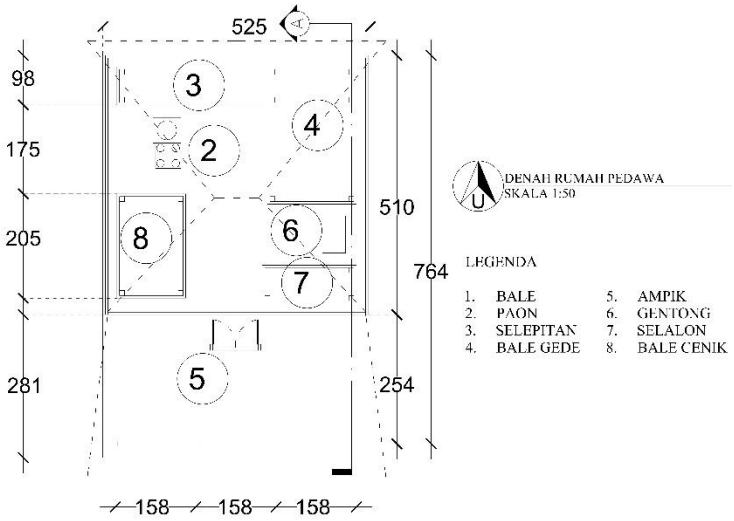

Figure 6. Pedawa Village House Plan
Source: Author (2023).

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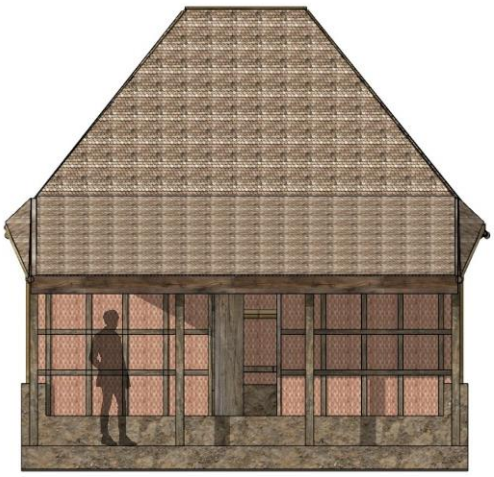

Figure 7. Pedawa Village House
Source: Author (2023)

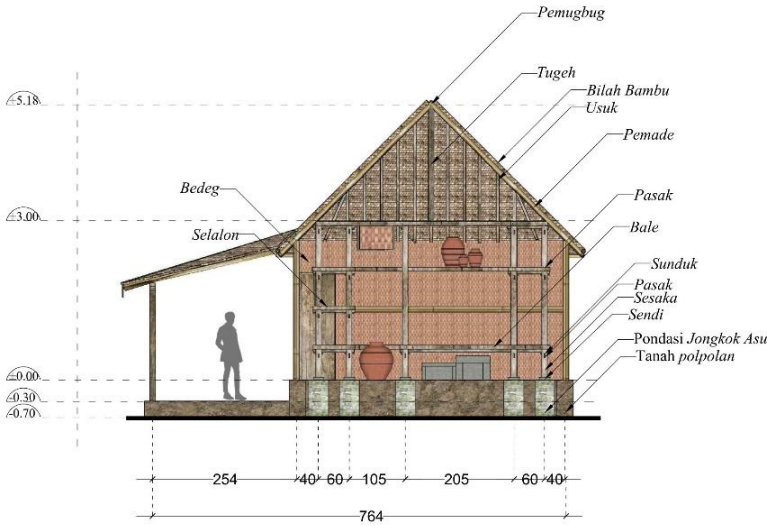

Figure 8. Pieces of Pedawa Village Houses
Source: Author (2023)

Tectonic in the Vernacular Buildings of the Tengger and Bali Aga Tribe

In the following section, an overview of the results of the comparison related to the aspects of tectonics that apply in vernacular buildings of community houses in Gubuklakah Village and Pelawa Village is presented. The aspects that are observed are related to (1.1) the logic of building loading in general, (1.2) the structural system applied in the substructure, superstructure, and superstructure segments, (1.3) the construction system.

1.1. *Building loading logic*

In general, the loads that work in the residential buildings of Gubuklakah Village, starting from the load of the roof both in the form of one's own load and due to the weight of wind and rain are channeled through a short wooden pole in the middle of the roof called *ander*, to then be channeled to the roof span beams. This load is then channeled to

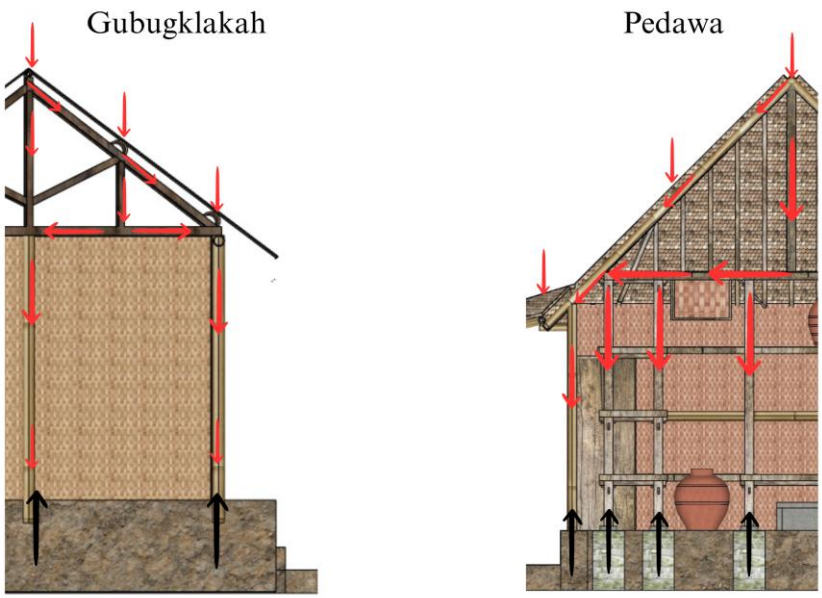

Figure 9. Loading Logic of Gubugklakah and Pedawa Village
Source: Author (2023).

the main columns of the building called *cagak guru/pinggir*. The load collected in the building columns is then channeled to the pillar foundation to the ground.

As for the logic of the levy that applies to residential buildings in Pelawa Village, broadly adhering to the same principle. The load on the roof is channeled through the bridge beams to be further united with the loads from other bridge beams through the connecting beams between the truss (ring beams) called *sineb-lambang*. This traditional block ring is made of wood. This accumulated load is then passed on to the columns of the main structure of the building called *sesaka*. The load received by s*esaka* is then channeled to the ground through joints or *umpak* that are above the floor surface of the building.

1.2. *Structure System*

Foundation structure system (substructure)

The vernacular building of the residential house in Gubugklakah Village applies a construction system with the foundation and floor parts that are designed to be integrated and made of an arrangement of soil and gravel materials. The vernacular building of the residential house in Gubugklakah Village implements a construction system with the foundation and floor parts that are designed to blend together and are made of an arrangement of soil and gravel materials. The foundation and at the same time the floor of this building are also the main footing of the main columns of the building made of intact bamboo stalks. The base or bamboo feet of the building are inserted into the foundation or floor of the building so that the columns can stand stably as a support for the building, as well as a load distribution from the top of the building. Thus, the substructure of the vernacular residential building in Gubugklakah Village is to apply the principle of building floors which are also the foundation of this residential building.

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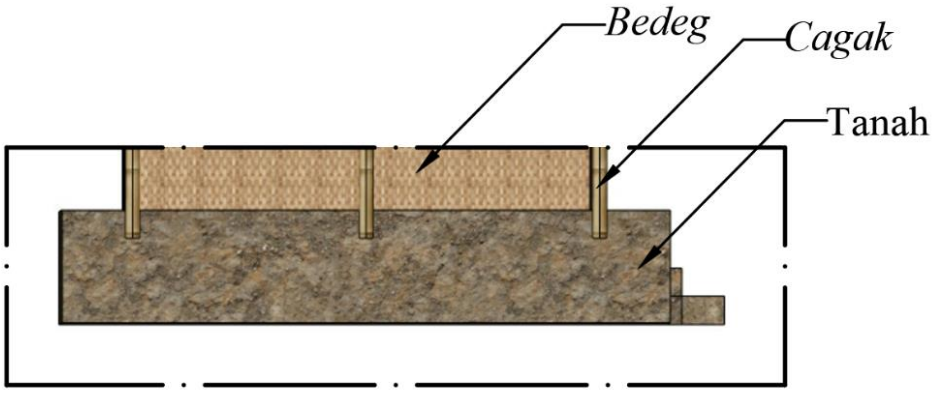

Figure 10. Foundation (substructure) of Gubugklakah Village
Source: Author (2023)

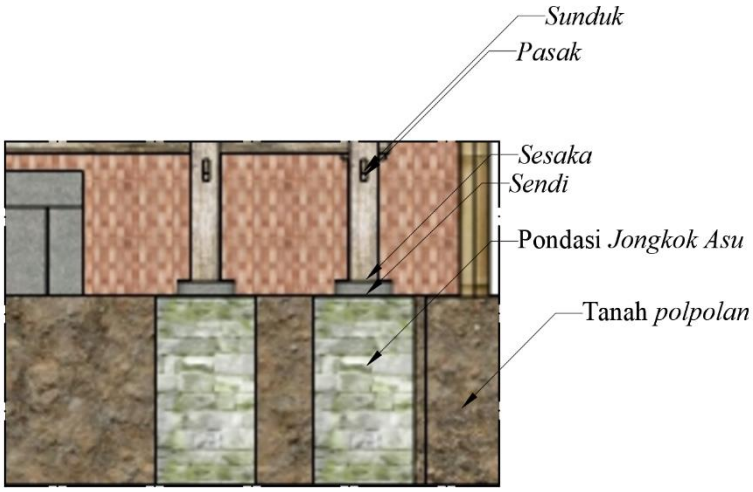

Figure 11. Foundation (substructure) of Pedawa Village
Source: Author (2023)

The vernacular residential house building in Pedawa Village uses a traditional type of foundation made of whole natural stone material known as *jongkok asu* ('sit dog'). Presumably, the naming of the traditional Balinese foundation like this is based on its resemblance to the posture of a dog when sitting. This foundation is placed right at the point where the main column of the building is located. The foundation of *the jongkok asu* becomes the base for the columns or *sesaka* of the building that stands right on it. To maintain the life of the building longer, the stone, which acts as a *umpak*, is placed a little higher with the aim of protecting the wood from water, because one of the factors is the damage to a building (Sagita Ari and Pradipto 2020). The floor of the house building is composed of a mixture of soil and gravel materials that are easy to obtain around the area where the house is located. Right on top of the *jongkok asu* foundation, the joints of the house building are placed with holes facing upwards as a place for the main columns of the building or *sesaka* with a square cross-section. Thus, it can be mentioned that the substructure system of the vernacular residential house building in Pedawa Village adheres to the principle of *umpak* as a burden bearer from the building pillars which will then be channeled to *the jongkok asu* with a wider cross-sectional area at the base of the

building. The overall load of the building is channeled through *the jongkok asu* and will then be channeled to the ground.

Building Superstructure System

The superstructure system of the residential house in Gubugklakah Village places the main column of the building made of whole bamboo stalks as the main structural column. This bamboo column is known as *cagak guru or cagak pinggir* which is the main pillar of the building which is a support as well as a place to distribute the load from the roof to the foundation of the building. The bamboo columns of this building are united with two wooden blocks placed stacked at the head of the column. This wooden block in local terms is known as *sunduk* which in principle is the link between the heads of bamboo columns. The beams above the head of these columns have the same role as the beam ring elements known in modern building structure systems. The bamboo column base of the house building is applied to the floor which also acts as the foundation of the building. The floor or foundation of this house building is made of clay and gravel mixed with water when the house construction stage is carried out. The floor of the house has a flat surface that becomes the footing of the residents in the house as a whole.

The superstructure system of vernacular buildings of residential houses in Pedawa Village uses the main columns of buildings made of wood materials cut into box sections. This wooden column is known as *sesaka*. Each sesaka column is connected by two blocks with a flat rectangular cross-section at the head of the column. These blocks are named *sineb* and *lambang*. *The lambang of the cylinder* also has a similar working principle to the beam ring in modern buildings. The *sesaka* base or building pillar is based on a joint

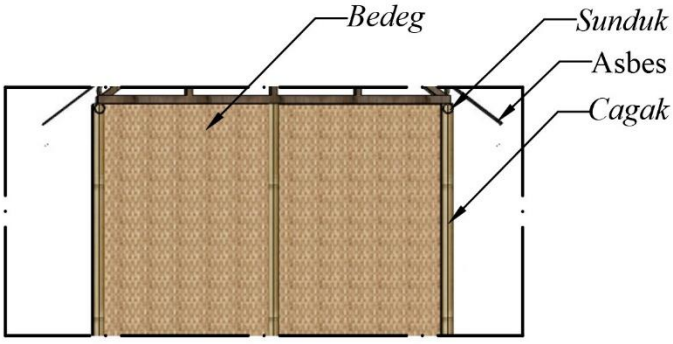

Figure 12. *Superstructure* of Gubugklakah Village
Source: Author (2023)

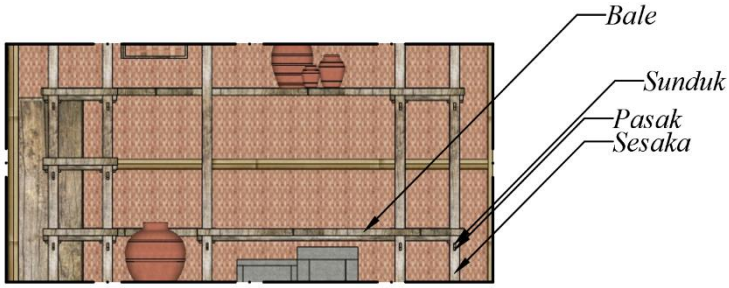

Figure 13. *Superstructure* of Pedawa Village
Source: Author (2023)

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or *umpak* that has a hole as a place for *sesaka* to enter the *umpak*. This *umpak* or *joint* is made of intact natural stone material. The base of the column is placed into the joint hole in such a way that in the event of horizontal force movement, the position of the *sesaka* pole will not change from the position point above *the joint* hole it occupies. In vernacular house buildings, Pedawa Village residences are usually also equipped with *bale-bale* as beds or places for residents' activities. These *bale-bale* are known as couches with their surface composed of bamboo slats. The construction of these *bale-bale* is formed from the presence of wooden beams placed connecting four columns that are close to each other so that they form rectangular *bale-bale*. At the bottom of the bed is a wooden block known as the connecting *sunduk* between the generations. This wooden beam implements a construction like pillars and pegs that can be removed, inserted, or re-tightened at any time.

Building Upperstructure System

The vernacular building of the residential house in Gubugklakah Village uses a structural system that combines wood and bamboo materials. The roof of this residential building takes the form of a gable roof that allows for the movement of wind crosswise from the front of the building roof to the back of the building's roof. In line with the shape of the plan of this building which tends to be rectangular, the vernacular building of a residential house in Gubugklakah Village has a nook beam placed lengthwise as the main structural element at the top of the roof of the building. This wooden nook beam is supported by two roof truss legs, both of which are supported by roof beam rings. The block ring is called *sunduk* in local terms. The nook block at the top of the roof of the house building is also supported by a vertical log named *ander*. The vertical wooden block is then supported by a wooden block named *sunduk*. The meeting area between the ends of the balustrades and the legs of the easels will be placed directly above the head of the main structural column of the building made of intact bamboo stalks. The roof material of residential buildings in Gubugklakah Village is usually made of bamboo blades or tiles.

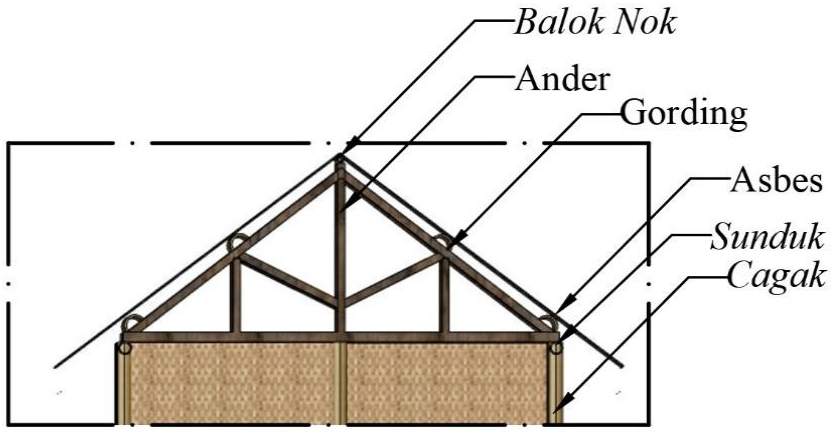

Figure 14. *Upperstructure* of Gubugklakah Village
Source: Author (2023)

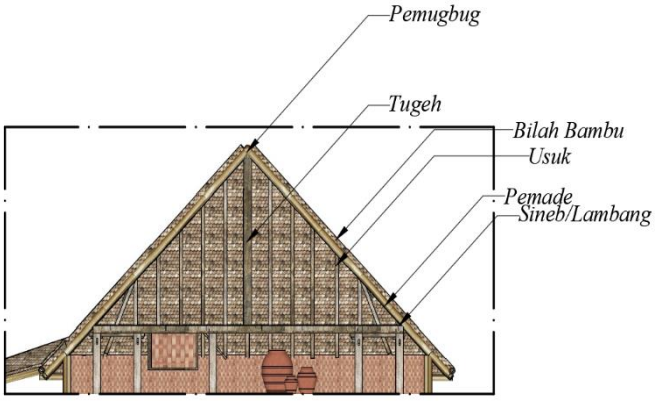

Figure 15. *Upperstructure* of Pedawa Village
Source: Author (2023)

The vernacular house in Pedawa Village also has a rectangular plan in sections. In the top structure of the roof of the building there is a nook beam which in local terms is known *pamugbug.* The wood is supported by wooden ribs which are the most important roof support structural elements in the construction of vernacular residential buildings in Pedawa Village. The entire lower end of the roof rib rod is then placed on the *lambang sineb* wood which acts as a beam ring for the roof of the building. The *lambang* wooden beams are then placed on top of the heads of *the sesaka* columns as a load distribution rod from the roof, body, to the foundation of the building. The roof of a vernacular house in Pedawa Village usually uses covering materials made of bamboo or tiles. Broadly speaking, a comparative overview of the structural aspects of vernacular buildings in Gubugklakah and Bali Aga Villages can be seen through the following table.

Table 1. Comparison of aspects of vernacular house structure in Gubugklakah Village with Pedawa Village

No	Comparative Aspects	Vernacular House of Gubugklakah Village	Vernacular House of Pedawa Village
1	*Substructure*		
	• Foundation	Applying the principle of building floors which are also the foundation of residential buildings.	Adhering to the *umpak* system called *jongkok asu*
	• Umpak	-	Using *umpak* called joints.
	• Floor	Using soil material mixed with gravel and watered.	Using clay called polpolan soil
2	*Superstructure*		
	• Column	There is a column with materials derived from Bamboo	There is a column called *sesaka* which is connected to a *sunduk* that is reinforced by wooden peg elements.
	• Bale-bale locking beam	Bales detached with columns	Bales connected with columns
	• Column locking beam	There is a *sundrum* that is reinforced with a peg system.	There is a *sundrum* that is reinforced with a peg system.
3	*Upperstructure*		
	• Nok beam	There is a nook block with the name *of the rib stand*	There is a nook block with the term *pemugbug* which is supported by roof ribs with wooden material.
	• Easel beam	It has a wooden vertical beam as a support for the easel called *Ander*	It has a vertical wooden beam as a support for the truss called *Tugeh.*
	• Ribs	There are wooden ribs as a load bearer from the roof covering.	There are wooden ribs as a load bearer from the roof covering.

No	Comparative Aspects	Vernacular House of Gubugklakah Village	Vernacular House of Pedawa Village
	• Beam Ring	There are *Blandar Panitih* and *Blandar Pamanjang* made of wood	There is a *Sineb* and a *Lambang* of wood
	• Roof coverings	. Using roofing materials from bamboo slats and tiles.	For roof covering materials, use reeds or bamboo slats.

Source: Author (2023)

1.3.*Building Construction System*

The construction system for the main structural elements of the vernacular residential building in Gubugklakah Village is a bonding construction system with ropes made of peeling the inner bark of bamboo stalks. This construction element is most widely used to tie the head of the main column of the building, the roof support beam, and the legs of the building easels. This construction system with bamboo rope ties is also used to tie the elements of building easels and roof timbers of buildings in the past. Nowadays, the construction system with the use of bamboo rope has begun to be replaced by the use of construction elements in the form of nails made of metal.

The construction system for the main structure of vernacular residential buildings in Pedawa Village uses a pits and pegs construction system. This kind of construction structure system is very possible to use considering that the main structural elements of residential buildings in this village are more dominant using wood materials. Wood is an element of nature that has a solid character so that it is relatively easy to perforate and solid enough to include other structural elements. Wooden columns that have been perforated and inserted with wooden blocks, after which they can also be locked using wooden peg elements. The value of the superiority of the use of peg elements in the construction system of residential buildings in Pedawa Village can be proven when the main structural components of the building change their position or shape due to the force or load acting on the building. In this case, the change in the position of the structural element can be restored to its original condition by reassuring the peg element into the *puru* hole made. After that, the structural components of the building will return to stability and return to their original shape and position. The use of joints such as laying, notches, and ties are joints that are able to adapt to external forces, such as earthquakes (Ibn 2018).

CONCLUSION

The results of the comparison that have been carried out related to the structural and construction system aspects applied in vernacular buildings, community houses in Gubugklakah Village and in Pedawa Village can be concluded as follows.

1. The loading logic that applies in these two systems of vernacular residential house structures is essentially that the load from the roof is channeled through the legs of the easel to be transferred then to the columns of the building to the ground through the building foundation.
2. The construction system used in both buildings has been applied for generations as an effort to anticipate various load forces working in the building, as well as other existing loads as a result of natural phenomena of rain, wind, and earthquakes.

3. The building materials used in these two residential vernacular buildings are materials that are easy to obtain in the surrounding area, namely around natural stone, gravel, clay, wood, and bamboo.
4. In terms of the building construction system, there is a fairly significant difference between the main column construction system in the two-house buildings. The main column of residential buildings in Gubugklakah Village uses a tie construction system with bamboo rope, while the main column construction system of residential buildings in Pedawa Village uses a wooden peg system.

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