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Safe, Simple and Comfortable House with Bamboo Reinforced Concrete Structure

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Abstract

Development of a livable housing in the form of a simple home is indispensable for poor families. Simple houses built with brick or concrete block walls and a frame of bamboo reinforced concrete structures are resistant to earthquake and wind as well as convenient. The construction method to consider the application of the six criteria for appropriate technology (technical, economical, ergonomic, social cultural, energy-saving, and environmentally friendly) and the systemic, holistic, interdisciplinary and participatory (SHIP) approach are applied starting from when a house is planned, constructed, and maintained. The conclusions of this research are as follows: (1) compressive strength of concrete, $f'_c = 20.75$ MPa and the tensile strength of bamboo $f_y = 129.17$ Mpa; (2) the simple house with the bamboo reinforced concrete structure can fulfill the requirement of being safe prevailing in Indonesia; (3) it can fulfill the requirement of physical comfort, which includes the temperature, humidity, the wind speed, noise, and illumination; (4) based on the information obtained through the questionnaire, such a house can also make the dweller feel highly safe, comfortable, and satisfied.

Keywords: simple house, bamboo reinforced concrete, safe, comfortable

1. Introduction

Housing is one of the human basic needs apart from food and clothing. Everybody has the right to occupy a comfortable house. The reason is that house plays an essential role in human life. Without house humans cannot live comfortably as it importantly contributes to the daily human health, meaning that the indoor and outdoor human activities are also determined that their houses are comfortable [22].

A livable house should be safe, healthy, comfortable, and adequately equipped, as prescribed in the Act of Building Construction Number 28/2002 and the Regulation of the Ministry of Public Works Number 25/PRT/M/2007 dated on August 9, 2007 concerning “Pedoman Sertifikasi Laik Fungsi Bangunan Gedung” (Guideline for Functionally Comfortable Building Construction) [2].

It is highly possible for the natural disasters such as the earthquake and wind to take place in Bali as an island which is densely populated enough [4, 20]. It is recorded that the earthquake referred to as “Gejer Bali” which took place in 1815 cost 1500 lives; the earthquake referred to as “Gempa Buleleng” which took place in 1862; the Negara earthquake took place in 1890, the Gejer Bali earthquake occurred again in 1917 and cost 1500 lives, the Seririt earthquake occurred in 1976 and cost 560 lives, the Karangasem earthquake took place in 1979 and cost 24 lives. Several other earthquakes that were responsible for the material loss have also been recorded.

The bamboo has a high strain force and available almost everywhere in Indonesia, especially in Bali. Therefore, it is necessary to construct simple livable houses with bamboo reinforced concrete structure, which are resistant to the earthquake and wind. The reason is that they can be constructed using the cheap local building materials [5]. In addition, such houses are functionally feasible. However, it was necessary to test them to identify how reliable and comfortable they were and to what extent they could satisfy the dwellers. The test was done by building two types of simple houses; one is the simple traditional Bali age house and the simple modern Balinese house.

The six criteria of the appropriate technology (technical, economic, ergonomic, socio cultural, energy saving, and environmentally friendly) with the systemic, holistic, interdisciplinary and participatory (SHIP) approach are relevantly applied starting from when a house is planned, constructed, and maintained. The design of a house should develop and grow based on what is needed by people; it should not be designed by other parties with particular objectives [1]. The designer should pay attention to the human dimensions (the human ability and limitedness) [25]. A house should be designed based on the user; it should be constructed in such a way that it can reduce the possible negative impact and improve the user’s comfort. If it is designed based on what is needed and expected by the user, it can improve the quality of his/her life [6].

As times go by, an idea has appeared recently that the local wisdom should be applied to overcoming the human problem and environment. The reason is that it is easily accepted by the local people. Exemplifies [18] the concept *Tri Hita Karana* especially the relationship between the user of a house with his/her ancestors and the relationship between him/her with his/her environment, the concept *Tri Mandala* which suggests that a compound should be divided into three zones: they are the highest “hulu” zone, the middle “tengah” zone, and the lowest “teben” zone; the concept *Tri Angga*; the house should be physically divided into three parts: they are the roof, the body (wall), and the foot (foundation).

2. Material and method

2.1. Material and research location

The test was done by building two types of simple houses: they are the simple traditional Bali age house and the simple modern one. The study was conducted in Bali Province, Indonesia,

where different types of bamboo can grow which can be used as concrete reinforcement. This present study gives a new opportunity that bamboo can be used as the reinforced concrete structure of the simple house resistant to the earthquake and wind.

2.1.1. The brick masonry

The brick masonry tested was made at Keramas village, Gianyar regency (one of the villages close to Pengotan village). The mortar space was made of Portland cement and sand with the proportion one to four. The testing process is described in **Figure 1** [23].

2.1.2. Result of the bamboo tensile strength test

The bamboo tensile strength was obtained using the procedure regulated in the prevailing material tensile strength test in the laboratory, as shown in **Figure 2** [22]

2.1.3. The nominal moment and ultimate moment

Based on the concrete compressive strength and bamboo tensile strength, the nominal moment of the beam could be analyzed. Beam dimensions were 110 mm width and 250 mm height. The bamboo reinforcement area of 400 mm² was used for beam 1a, 1b, 1c, and 1d while for beam 2a, 2b, 2c, and 2d was used bamboo reinforcement area of 1200 mm². **Figure 3** [22] shows the process of how the bamboo reinforcement was assembled. **Figure 4** [22] shows the loading test of the bamboo reinforced concrete beam.

2.2. Research design

This present study is an experimental one with the treatment by subject design. This method was chosen in order to be able to analyze the four factors of life quality, such as safety, thermal comfort, subjective comfort, and the life satisfaction of the user, after the simple houses with the bamboo reinforced concrete structure were constructed.



Figure 1. The brick masonry compressive strength test.



Figure 2. Standard machine used to test the bamboo tensile strength [22].



Figure 3. The bamboo reinforced concrete beam assembled was 120 mm \times 250 mm. The reinforcement area were 400 and 1200 mm² [22].



Figure 4. The loading test of concrete beam which 120 mm \times 250 mm with the reinforcement area were 400 and 1200 mm² [22].

2.3. The house construction

The diagram of the house construction to which the six criteria of the appropriate technology with the systemic, holistic, interdisciplinary and participatory (SHIP) approach is applied can be described as follows (**Figure 5**) [23]. Such a house construction gives emphasis on the local wisdom-based people's participation.

The simple house construction using the people's participatory approach can definitely and gradually improve the people's capacity due to the following reasons:

1. Promoting job opportunities: opportunities are made available for people to participate in developing their economy justly and equally, meaning that poverty can be reduced.
2. Community empowerment: the quality of human resources becomes improved, meaning that people can have access to and participate in the decision making.
3. Capacity building: the poor people can increase their income by improving their health, education, skill, technology, and information using the on the job training (OJT) method.
4. Social protection: the poor people become protected and feel safe from the natural disaster, social conflict, and so forth.

The simple house construction using the participatory approach takes the following principles into consideration:

1. The top-down way of thinking changes into the bottom-up way of thinking
2. Priority is given to the simple technology
3. The user is made to have the sense of belonging and maintaining
4. Technologically, people are made to improve their technical and administrative expertise.
5. No environmental degradation takes place.

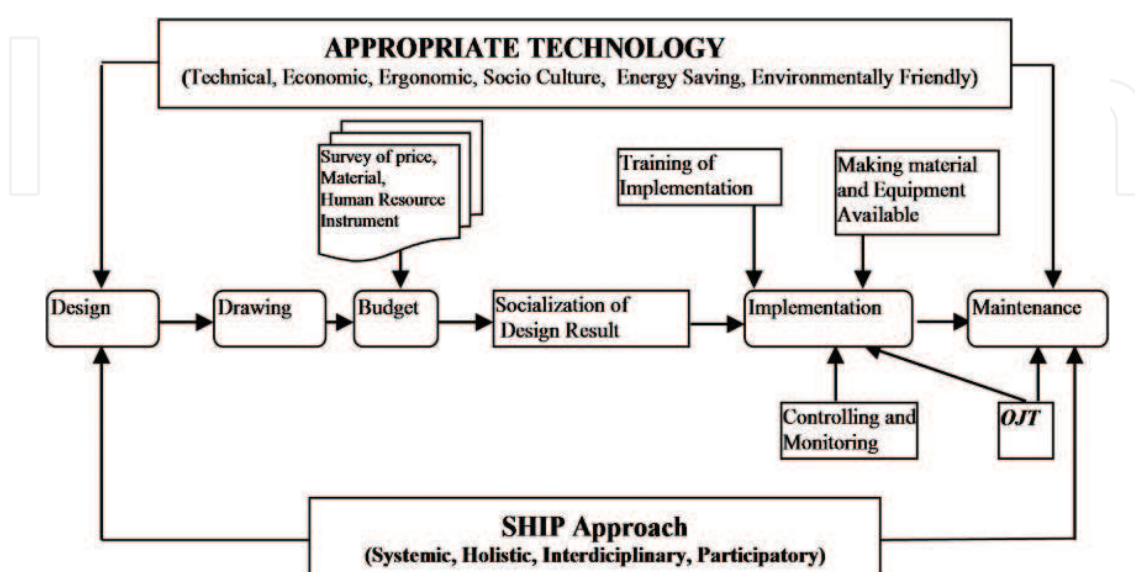


Figure 5. Diagram of the house construction using the participatory approach [23]. Note: OJT = on the job training.

2.4. Data analysis

The data analyzed to determine whether the simple houses were livable or not are as follows:

1. The building physical data: the dimension and the material strength were analyzed to know whether the houses were resistant to the earthquake and wind or not. The finite element method assisted with the SAP-2000 program.
2. The level of thermal and physical feasibility: it was measured using the environment meter (reliable testing & measuring equipment—KRISBOW-kw06-291).
3. The extent to which the dweller feels satisfied and subjective comfortable was measured through questionnaire.

3. Result and discussion

3.1. Characteristic of the construction material

For, the construction of simple house with either brick or concrete block and the bamboo reinforced concrete structure characteristics of the materials are need be determined. To this end, the characteristics of the materials used were tested in the laboratory. The material tests are as follows: compressive strength of brick masonry, compressive strength of concrete block wall, compressive strength of concrete, tensile strength of bamboo, and flexural test on concrete beam with bamboo reinforcement.

3.1.1. The brick masonry compressive strength

Figure 1 shows the four samples of brick masonry used in the test: the length averaged 470 mm, width averaged 112 mm, and the height averaged 377 mm. The average compressive strength obtained was 2.04 MPa.

3.1.2. The concrete block wall compressive strength

The mortar space of concrete block wall was made of Portland cement and sand with the ratio 1 to 4. The compressive strength averaged 4.96 Mpa, which, according to SNI 03-0348-1989, can be classified as having the quality of B40. **Figure 6** [3] shows a failure/collapse model of



Figure 6. Collapse of concrete block wall sample after being tested [3].

concrete block for wall system in Indonesia under compressive test. The concrete block wall used to apply as a typical masonry wall in semimodern residential houses.

3.1.3. Result of the bamboo tensile strength test

The bamboo tensile strength was obtained at the laboratory of the Mechanical Engineering Department of Udayana University, as shown in **Figure 7** [22] and **Table 1** [22].

It can be seen from **Table 1** that the average yield strength was 129.17 MPa and the average elongation was 8.99%. The results were used to analyze the nominal flexural strength or the nominal moment of the bamboo reinforced concrete. Viewed from the tensile strength, it can be stated that bamboo can be used as an alternative concrete reinforcement, especially the light and moderate structure.

3.1.4. The result of compressive strength of concrete cylinder

Three concrete cylinders were tested in order to identity the concrete strength. The diameter of each cylinder was 150 mm and the height was 300 mm. The results were that the compressive



Figure 7. The bamboo was tested until it was Fracture [21].

0.2 Y.S.	Yield strength	Rupture strength	Elongation
(MPa)	(MPa)	(MPa)	(%)
130.67	130.67	180.00	8.865
127.67	127.67	201.00	9.128

Table 1. The result of the bamboo tensile strength test.

strength of cylinder 1 was 21.07 MPa, cylinder 2 was 20.35 MPa, and cylinder 3 was 21.94 MPa, meaning that the average compressive strength was 21.12 MPa.

3.1.5. *The nominal moment and ultimate moment*

Figure 8 shows the crack pattern of the concrete beam after being tested [21].

Table 2 [22] presents the result of the nominal moment analysis of the beam and ultimate moment analysis. All the blocks were collapsed beyond to the nominal strength; the average ultimate strength was 22.46% greater than the nominal strength.

3.1.6. *The structural system of bamboo reinforced concrete*

The Bali age traditional house and the modern Balinese house constructed for this study used the structural system of bamboo reinforced concrete. The bamboo was splitted in dimension 10 mm × 30 mm. The bamboo was tied to steel stirrup with an 8-mm diameter, as shown in **Figure 9** [24]. The walls of the traditional Bali age house were made of brick masonry which spacing made of mortar with proportion of 1 Portland cement to 4 sand, whereas the walls of the modern Balinese house were made of concrete block.

3.2. The traditional Bali age house

3.2.1. *The characteristics of the house used as the sample*

The characteristics of the Bali age traditional house used as the sample in this present study included the total area of the building, the area of the room, the area of the terrace, the height

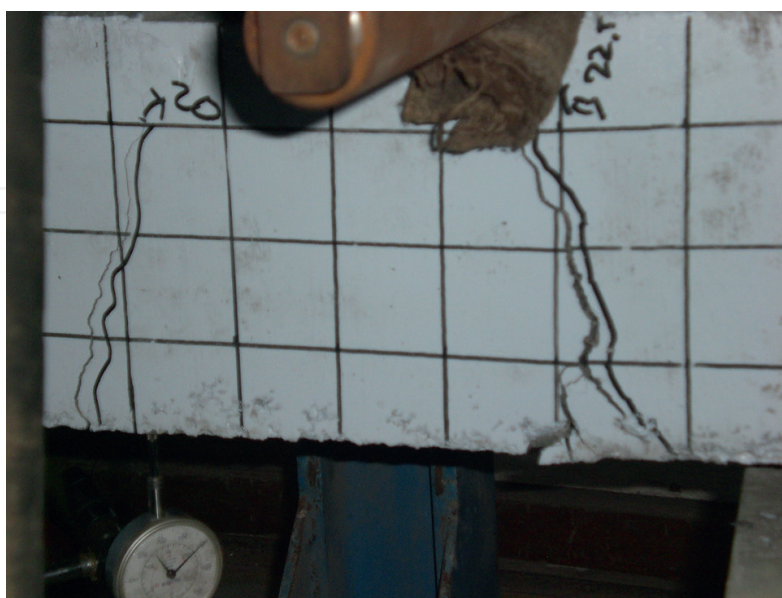


Figure 8. The crack pattern of the bamboo reinforced concrete beam after being tested [22].

No.	Number of tested items	Nominal moment (kNm)	Ultimate moment (kNm)
1	1a	10.47	13.2
2	1b	10.47	13.0
3	1c	10.47	10.8
4	1d	10.47	19.2
5	2a	27.42	29.2
6	2b	27.42	35.2
7	2c	27.42	30.4
8	2d	27.42	25.2

Note: The nominal moment was analyzed based on the formulation proposed by Ghavani [5].

Table 2. Presents the nominal moment and the ultimate moment.



Figure 9. The bamboo reinforcement was assembled before concrete was casted [24].

of the walls, the number, height, and width of the doors. Four units of the traditional house were used as the sample in the present study with the characteristics presented in **Table 3**. The componential dimension of one unit was different from that of another, as it should be adjusted to the dweller’s anthropometry. **Figure 10** [23] shows a residential house-1 built by using brick wall and bamboo reinforced concrete structure system.

In order to find out the displacement of the top of the building under seismic load, traditional residential houses were analyzed by using three-dimensional configuration, as shown in **Figure 11** [23]. From the result of the three-dimensional analysis of the four traditional houses, the average maximum horizontal displacement was 0.193 cm with the building height was 3750 cm, thus displacement ratio was 0.0005 or 0.05%.

Characteristics	House-1	House-2	House-3	House-4
The building area (m ²)	36.00	40.95	29.00	22.50
The room area (m ²)	25.80	30.87	20.30	15.00
The terrace area (m ²)	10.20	9.10	8.70	7.50
The door height (m')	1.95	2.20	2.10	1.95
The number of doors	1	1	1	1
The door size (W × H)	1.80 × 0.70	1.85 × 0.70	1.75 × 0.70	1.70 × 0.70
The number of windows	2	2	2	2
The door size (W × H)	1	1	1	1
The roof material	Tile	Tile	Tile	Tile
The walls material	Brick	Brick	Brick	Brick
The floors material	Cement	Cement	Cement	Cement
The terrace floors material	Ceramic	Ceramic	Ceramic	Ceramic

Table 3. The characteristics of the traditional Bali age house.



Figure 10. The simple traditional Bali age house with the bamboo reinforced concrete structure and brick walls [23].

3.2.2. Thermal comfort

In this present study, the environmental condition included the dry temperature, the relative humidity (RH), the wind speed, illumination, and noise, which contributes to the physical comfort. The environmental condition, after and before the internal and external parts of the house were redesigned, is presented in **Table 4**.

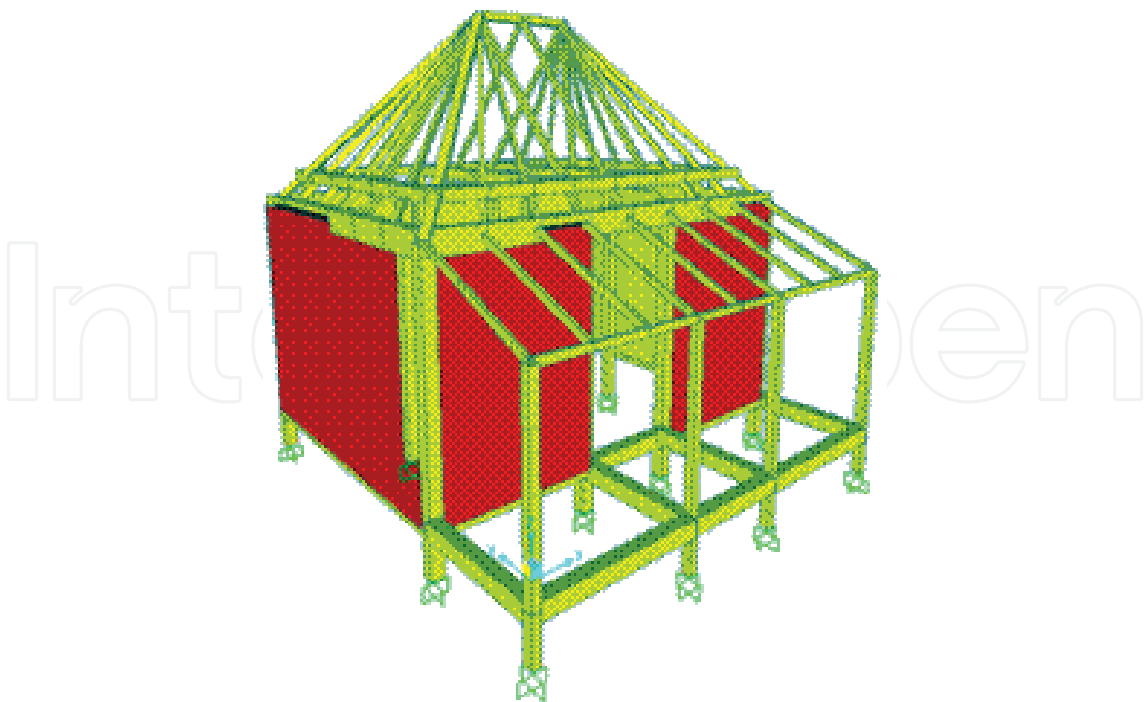


Figure 11. Three-dimensional model of structural system (example of model house 1 [23]).

Nbr.	Description	Time when it was measured			
		06.00	12.00	18.00	24.00
1	The temperature in the room (°C)	21	27	24	22
2	Humidity (%)	78	72	79	82
3	Noise (dBA)	39	42	40	35
4	Natural illumination (Lux)	135	245	215	–
5	The wind speed (m/second)	0.1	0.3	0.2	–

Table 4. The physical comfort of the traditional Bali age house.

The temperature within the room ranged from 21 to 27°C or it averaged $23.50 \pm 2.65^{\circ}\text{C}$. The relative humidity (RH) within the room averaged $77.75 \pm 4.19\%$. The maximum noise during daytime was 42 dBA and at night it was 35 dBA, and averaged 39.00 dBA. The average natural illumination within the room during daytime ranged from 135 to 245 Lux, higher than 115 Lux, the minimum natural illumination required for doing activities within the bed room [7]. The wind speed within the room during daytime ranged from 0.1 to 0.3 m/second. The natural illumination and wind speed within the room were not measured as the window and ventilation were closed.

3.3. The modern Balinese house

3.3.1. The characteristics of the house used as the sample

The characteristics of the modern house used as the sample in this present study included the whole area of the house, the area of the room, the area of the terrace, the height of the wall, the number, height and width of the door. All the componential dimensions were adjusted to the dweller’s anthropometry as presented in **Tables 5** and **6** [24]. **Figure 12** [24] shows a modern Balinese house which built of concrete block wall with a bamboo-reinforced concrete system.

3.3.2. Structural performance of the house

The structural performance is defined as a ratio of the most maximum horizontal displacement to the height of the building. The building was analyzed in three-dimensional model as

Nbr.	The house characteristics	Volume	Unit
1	Area of the building	35	m ²
2	Area of the room	2 × 12.5	m ²
3	Area of the terrace	1 × 10.5	m ²
4	Height of the wall	3.1	m'
5	Number of the doors	2	pieces
6	Number of the windows	2	pieces
7	Foundation material	Stone	–
8	Wall material	Concrete block	–
9	The hood	Hood	–
10	Roof material	Pressed tile	–
11	Floor material	Ceramic	–

Table 5. The house characteristics.

Nbr.	Description	Width (cm)	Height (cm)	Reinforcement area (cm ²)
1	Sloof (concrete)	20	25	8.40
2	Column (concrete)	20	20	11.20
3	Beam (concrete)	18	30	7.00 + 2.80
4	Gording (wood)	6	12	–
5	Rafter	5	6	–
6	Lisplank (wood)	2	20	–

Table 6. The characteristics of the house structural component.

the consequence of the load assigned. After that the maximum horizontal displacement could be determined.

Figure 13 [24] shows a typically modern three-dimensional model of simple Balinese houses which has been analyzed to define deformation at the top of the structures under earthquake load. From the result of the three-dimensional analysis of the house, the maximum horizontal displacement was 1.71 cm with the building height was 5500 cm, thus the displacement ratio was 0.031%.

3.3.3. The building physical comfort

The measured building physical comfort included the temperature, humidity, noise, and the natural illumination. It was measured at 6 a.m., 12 a.m., 6 p.m., and 12 p.m. The results of the measurement are presented in **Table 7** [24].



Figure 12. The simple modern Balinese house with the bamboo reinforced concrete structure and concrete block wall [24].

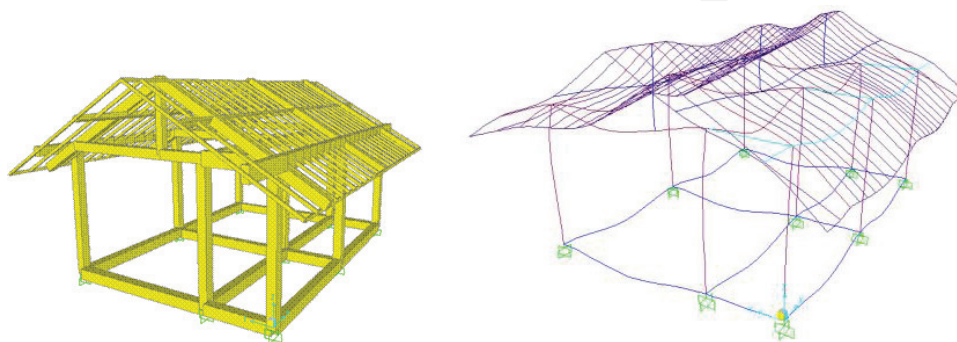


Figure 13. Model and deformation of house structure [24].

Nbr.	Description	Time of measurement			
		06 a.m.	12.00 a.m.	06 p.m.	12.p.m.
1	The temperature within the room (°C)	26	32	31	28
2	Humidity (%)	79	67	77	80
3	Noise (dBA)	41	41.8	44.74	41.47
4	Natural illumination (Lux)	145	255	235	–
5	Speed of wind (m/second)	0.1	0.4	0.25	–

Table 7. The physical comfort of the modern Balinese house.

3.4. Discussion

3.4.1. Construction material

The construction forming materials tested in the laboratory included the compressive strength of the concrete block, the compressive strength of the brick, the compressive strength of the concrete, and the tensile strength of the bamboo. The materials were tested as the data used to analyze the performance of the house structure. The results showed that the compressive strength of the concrete block averaged 4.96 MPa and the compressive strength of the brick averaged 2.04 MPa. The compressive strength of the concrete cylinder with a diameter of 150 mm and a height of 300 mm averaged 21.12 MPa or equal to K-260 kg/cm², meaning that the standard SNI – 213 for concrete was already fulfilled which requires that the minimum strength of the concrete structure in an area which is sensitive to the earthquake such as Bali should be 20.75 MPa and equal to K-250 kg/cm².

Bamboo test results show in **Table 1**, in which the tensile strength of the bamboo averaged 129.17 MPa and the rupture strength averaged 191 MPa, so the over strength was 47.86%. The melting and tensile strength $f_y = 129$ MPa was used to design and analyze the diameter of the item tested. Bamboo can be used as the alternative reinforced concrete structure in the construction of a simple house. In addition, it is cheap and can be found anywhere in Bali. This is supported by the result of the study conducted in Ref. [5], stating that bamboo can be used as an alternative material of construction because it is cheap and saves energy. According to Ref. [9], the tensile strength of the bamboo ranges from 200 to 300 MPa, its flexibility averages 84 MPa and its elastic modulus is 200.000 MPa. Viewed from its tensile strength, it is feasible enough to use as the concrete reinforcement, at least for the light and medium structure. Furthermore, according to Ref. [14], bamboo can be used as the reinforcement of the concrete structure as its rupture strength is high enough [16].

3.4.2. Safety and performance of construction

Based on the compressive strength of the concrete and the tensile strength of the bamboo, it can be stated that the bamboo-reinforced concrete structure with brick walls used to construct the traditional Bali age house is resistant enough to load assigned (dead load, live load, earthquake

load, and wind load), and bamboo reinforced concrete structure could be used to construct the simple modern Balinese house. It can be stated that the two types of the houses are safe enough for the dwellers. The bamboo reinforced concrete structure was already applied to constructing two storied houses. It was stated in the study conducted by Virgyan [26] that the multiple bamboo reinforced portal concrete structure that was bridled at the construction location with plastic joints can be used in the construction of a simple house, which is resistant to the earthquake. Based on the result of the three-dimensional analysis, it can be stated that the performance of the structural system is highly good, making the dwellers feel so safe. The performance of the structural system when planning to construct a building, which is resistant to the earthquake in Indonesia, is highly important as it is highly possible for the earthquake to take place in almost every part of Indonesia [28].

3.4.3. *Thermal comfort*

The thermal comfort or the house physical environment is affected by the temperature, relative humidity, speed of the wind, illumination, and noise. The temperature within the room in the traditional Bali age house ranges from 21 to 27°C, and the temperature within the room in the modern Balinese house ranges from 26 to 32°C. At certain hours, it is higher than what is required. In the equatorial region, the comfortable temperature ranges from 22.5 to 29.5°C [12], from 21.37 to 28.37°C (ASHRAE), and from 22.8 to 30.2°C [21].

The relative humidity both within and outside the room is almost the same, namely 60% during daytime and 80% at night. It will be better if the relative humidity is higher than 20% all the year round, and lower than 60% during the summer and lower than 80% during the winter [11]. If the relative humidity is higher than 80%, there will be water vapor on the human skin, making the body uncomfortable [17, 19]. In addition, the dweller will not be in good health and, for example, there will be fungus on the skin.

The speed of the wind within the room ranges from 0.1 to 0.4 m/second during daytime. At night, it is 0 m/second as the window and ventilation are closed. The speed of the wind can contribute to the speed of the missing heat due to convection and evaporation. Therefore, the speed of the wind ranging from 0.1 to 0.3 m/second can fulfill what is required for being comfortable [11, 13]. It should not be faster than 0.2 m/second [10]. As the speed of the wind is in accordance with what is required by the experts mentioned above, the weather within the room circulates well, causing the dweller's health to improve and the eyes to be less irritated. The front window and the ventilation at the rear wall affect the speed of the wind and cause the cross-weather circulation to take place. This is supported by the result of the study conducted in Ref. [15], in which it is stated that the cross-weather circulation can improve the comfort of those who stay at the simple houses located in Cemara Giri area, Dalung, Bali.

The natural illumination within the room ranges from 145 to 255 Lux during daytime, higher than what is required, namely 115 Lux [27]. The intensity of the natural illumination within the room is affected by how wide the window is open and how wide the ventilation is. The window or ventilation is installed at the front and rear walls, causing the fresh weather to circulate from the front window and the dirty weather to get out from the rear ventilation. The dweller becomes comfortable and the electric energy can be saved. The maximum use of the natural illumination does not only positively contribute to the dweller's health but also saves the electric

energy. Before the house was redesigned, the electric lamp was always turned on when there was an activity within the room. The good natural illumination can make the room brighter and healthier. Indra [8] stated that the maximum penetration of the sunlight into the house reduce the lamp use, causing the costs needed to be reduced. It is proved that the sunlight can also kill the bacteria which can grow well in the humid environment. Vitamin D which is obtained from the sunlight is highly useful to the bones and skin [27].

The maximum noise within the room is 44.74 during daytime and 41.47 dBA at night. It is still under the limit determined by the government of Bali province, namely 50 dBA during daytime and 45 dBA at night. The noise taking place in the residential environment is more frequently caused by the agricultural equipment such as tractor. The acoustic safety such as noise cannot be separated from the dweller's health; however, as its effect cannot be identified at once, the impact cannot be felt at once either. Therefore, the acoustic safety is still neglected. The dweller does not only feel uncomfortable but his/her health will also be indirectly getting worse. As an illustration, he/she cannot take a rest well due to noise. As a consequence, he/she will get tired, angry, cannot concentrate well, and so forth. If this takes place continuously, it is highly possible that his/her health will be getting worse.

3.4.4. The dweller's safety, comfort, and satisfaction

The houses that had been constructed were directly occupied by the dwellers. Their subjective response to safety, comfort, and satisfaction was measured using questionnaire. It was measured after the houses were occupied for 30 days. On the average, they felt highly comfortable, safe, and satisfied. The participatory approach to the construction caused the dwellers to feel highly satisfied. They were directly involved from the planning to the construction.

3.4.5. The dweller's life quality

The people's dynamic human life always interacts with the environment where they live, the facilities and infrastructure they use, the organization they belong to, the activities they do and the houses where they can take a rest. The house that is constructed using the concrete block as the walls with the bamboo reinforced concrete structure can make the environmental condition safe and comfortable for its dwellers. This can improve their health quality as they can do their activities in the healthy, comfortable, and safe environment [1].

The anthropometry that is adjusted to the facilities and infrastructure available leads to an easier access [25]. Similarly, the maximum natural illumination contributes to the dweller's safety. It saves the electric energy that then can reduce the household costs. In addition, it can also hamper the global warming and delay the natural sources such as the coal from being used up [8].

The SHIP approach, which gives emphasis on the dweller's participation from the planning, during the construction and in the maintenance of the house can make the dweller more satisfied, as what he/she suggests can be accommodated [1]. In short, the simple house with the bamboo reinforced concrete structure fulfills the requirements of being healthy and safe and this positively contributes to the dweller's life quality. If a house is constructed based on

what is needed and expected by the dweller, it can function as a means of improving his/her life quality [6].

4. Conclusion and suggestion

Based on the results of the study, analysis and discussion, several conclusions can be drawn as follows:

1. The simple house with the bamboo reinforced concrete structure can fulfill the requirement of being safe prevailing in Indonesia.
2. It can fulfill the requirement of physical comfort, which includes the temperature, humidity, the wind speed, noise, and illumination.
3. Based on the information obtained through the questionnaire, such a house can also make the dweller feel highly safe, comfortable, and satisfied.

This is suggested that the bamboo reinforced concrete structure should be taken into consideration in the simple house construction.

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