Simple House with Brick Walls and Structure System of Bamboo Reinforced Concrete, Safe and Comfortable

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Abstract Development of appropriate housing, in the form of a simple house with concrete block walls and system of reinforced concrete structures bamboo withstand earthquakes and wind and comfortable, very necessary, because it can be built with local materials and low cost, environmentally friendly and meet the requirements are eligible to building functions, namely reliability and comfort. The construction method considers the application of six criteria for Appropriate Technology (technical, economical, ergonomic, social, cultural, energy-saving and environmentally friendly), the Systemic approach, Holistic, interdisciplinary and Participatory (SHIP), from planning to implementation to maintenance. The conclusions of this research are: 1) the material used for the structural system is concrete with a simple house f'c 20.75 MPa and a tensile strength of bamboo with a reinforcement fy amounted to 129.17 MPa, 2) application of the system of reinforced concrete structures of bamboo and walls the modest brick house technically meet the safety requirements, and 3) .development simple house with concrete block walls and bamboo reinforced structural systems meet health and safety requirements that will positively affect the quality of life of its inhabitants

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

I. INTRODUCTION

A house is one of basic need of human being and the right of every people to live in the habitable houses. The habitable house should fulfill reability that comply the safety, health, comfort, and accesibility as it is regulated in the Building Constitution No. 28/2002 and Public Work Regulation No. 25/PRT/M/2007, 9 Agust 2007 that concern about Certification Guidelines of Eligible Building Function.

The density of population in Bali tends to have risk of natural disaster such as earthquake and tornadoes. There are several earthquake have been happened including Gejer Bali in 1815 with 15,000 people died; Buleleng earthquake in 1862; Negara earthquake in 1890; Gejer Bali in 1917 with 1,500 people decease; Seririt earthquake was having 560 people died; Karangasem earthquake was having 24 people died and others.

The development of habitable hoausing for low income people, simple house with reinforced concrete bamboo withstand to earthquake and wind, comfort. It is needed due to it easily to build with local material and affordable, environmentally friendly, and fulfills the requirement of building function there are reliability and comforts.

II. RESEARCH METHODS

Method of research examines the application of six criteria of appropriate technologies including technical, economic, ergonomic, socio-culture, energy saving, and environmentally friendly. The research approach uses Systemic, Holistic, Interdisciplinary, and Participatory (SHIP) begin from planning, implementation to maintenance.

The simple house with reinforced concrete bamboo system analyzed through three dimensional to determine its safety level. The safety of physical building measures directly including temperature, humidity, noise, wind speed and lighting. The householders were given the questioners to determine the sense of safety, comfort and occupant satisfaction.

III. RESULT AND DISCUSSION

A. Result

A.1. the Compressive Strength of Concrete

To determine the quality of concrete, there is a testing of three concrete cylinders with diameter of 150 mm and 300 mm high. The test result shows that compressive strength of cylinder 1 is 21.07 MPa, cylinder 2 is 20.35 MPA, and cylinder 3 is 21.94 MPa or the average is about 21.12 MPa. The qualities of these concrete were functioned to specify performance of house structure system that has been built.

A.2. Bamboo Pull Strength

Bamboo pull strength is determined by bamboo pull test through procedure in accordance with the regulation of material pull test that still prevail. The bamboo pull test result can be seen in the Table 3.1.

TABLE 1
BAMBOO PULL TEST RESULTS

0.2% YS MPa	Dilute Tension MPa	Break Tension MPa	Extension (%)
130.67	130.67	180.00	8.865
127.67	127.67	202.00	9.128

A.3. the Characteristic of Housing Sample

The characteristic of simple houses that have been built were documented as sample in this research, including total area of building, wide of rooms, terrace total area, walls high, number of doors, and width of the door. Characteristic data shows in the Table 3.2 and Table 3.3.

TABLE 2
HOUSE CHARACTERISTICS

No	House Characteristic	Volume	Unit
1	Total are of building	35	m²
2	Wide of rooms	2 x 12.5	m²
3	Wide of terrace	1 x 10.5	m²
4	High of walls	3.1	m
5	Total of doors	2	unit
6	Number of windows	2	unit
7	Foundation material	River stone	-
8	Wall material	Concrete block	-
9	Roof construction material	Wood	-
10	Roofing materials	Press tile	-
11	Floor materials	Ceramic	-

TABLE 3
CHARACTERISTIC OF HOUSE STRUCTURE COMPONENT

No.	Item	Width (cm)	Height (cm)	Width of reinforcement (cm2)
1	Sloop (concrete)	20	25	8,40
2	Column (concrete)	20	20	11,20
3	Ring beam (concrete)	18	30	7,00 + 2,80
4	Supporting roof beam (wood)	6	12	-
5	Rafter (wood)	5	6	-
6	List plank (wood)	2	20	-

a. Foundation construction and bamboo reinforcement

b. The housing appearance

Fig. 1. Result of Housing Development

Figure 1 shows the construction of bamboo for simple housing with system of reinforced concrete bamboo structure.

A.3. Performance of Building Structure

Performance of structure defines as comparison or ratio between the peaks of maximum horizontal deviation with the building height. The building was analyzed through three dimensions that caused by load work of earthquake, and then determine the maximum of horizontal deviation.

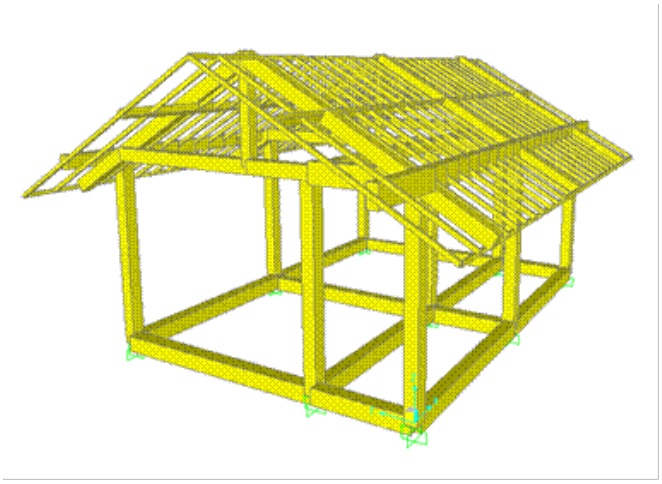

Fig. 2. the Three Dimension Model of System of House Structure

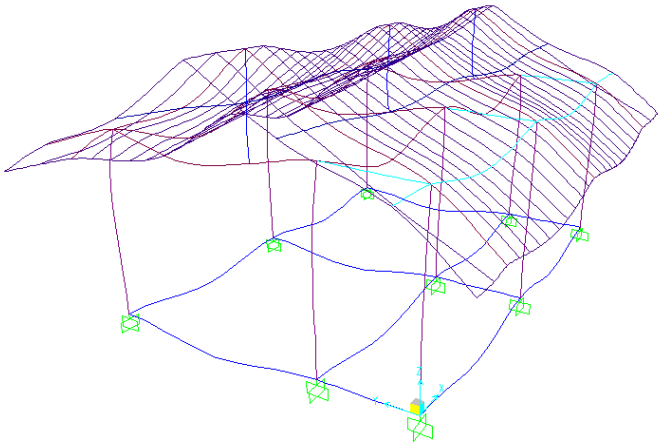

Fig. 3. Deformation of House Structure Model

From the analysis result of three dimensional, it is obtained the maximum horizontal deviation of the peak of the building of 1.71 centimeter with building height of 5,500 centimeter, which it is similar to its performance of the building about 0.031%.

A.4. Physical Comfort of the Building

The building physical comfort elements were measured including temperature, humidity, noise and natural lighting. The measurement time is done at 6.00 o'clock, 12.00 o'clock, 18.00 o'clock, and 24.00 o'clock. The result can be seen in the Table 3.4.

TABLE 4 PHYSICAL COMFORT OF THE HOUSE

No.	Item	Measurement Time (WITA)			
		06.00	12.00	18.00	24.00
1	Temperature (°C)	29	35	31	30
2	Humidity (%)	79	67	77	80
3	Noise (dBA)	41	41.8	44.74	41.47
4	Natural Lighting (Lux)	145	255	235	-
5	Wind Speed (m/sec)	0.1	0.4	0.25	-

B. Discussion

B.1 Construction Material

The materials of construction that are tested in the laboratory are the characteristic of the concrete blocks, concrete compressive strength and tensile strength of bamboo. This material test is done as data to analysis the structure performance of house building. The test result of compressive strength of concrete blocks showed that the average of concrete blocks strength is 4.96 MPa, which is according to SNI 03-0348-1989 including in quality concrete blocks of B40. The average of the compressive strength of the concrete cylinder is 150 mm in diameter; the high of 300 mm is 21.12 MPa or equivalent to concrete quality of K-260 kg/cm2. These are fulfill the requirement of SNI-2013 for concrete, that requires the minimum strength of structure concrete for earthquake area such as Bali Island is about 20.75 MPa or equivalent to K-250 kg/cm².

Based on test results of bamboo tensile on Table 5.1, the average melting strength is 129.17 MPa and the average breaking voltage is 191 MPa or having over strength of 47.86%. The design and analysis of the cross section of the test specimen use the melt tensile strength; fy is equal to 129 MPa. Bamboo can be used as alternative of reinforced concrete reinforcement for simple house construction, have lower price because it is widely available in Bali. This is in accordance with research result of Ghavani (2008), which stated that bamboo can be used as alternative construction material (reinforcement) which is cheap and energy saving [1]. According to Jansen (1987), the tensile strength of bamboo parallel fiber is between 200-300 MPa, the average bending strength is 84 MPa and the elastic modulus is 200,000 MPa, and it can be seen from the tensile strength of bamboo is quite feasible to be used as concrete reinforcement, minimal for light and medium structure [2]. Similarly, according to Morisco (1999), bamboo can be used as a concrete reinforcement structure because it has a high break tensile tension [3].

B.2 Security of Construction

Based on the comprehensive strength of concrete and tensile strength of bamboo, it is found that the reinforcement of columns and beams installed in accordance with Table 5.3 has met the requirements to bear all the loads (dead load, live load, and earthquake load and wind load), therefore the house safe for the residents. The application of bamboo reinforced concrete framework system for 2 story building has been implemented by Nino and Aditya (2008), and the research result of Virgyan (2009), concluded that the model of double reinforced concrete bamboo portal structure which is restricted to plastic joints can be used as material for the construction of concrete structures for simple earthquake resistant houses.

B.3 System Performance of Structure

The result of 3-dimensional analysis, obtained the maximum horizontal deviation from the top of the building

is 1.71 cm with the building height of 5,500 cm, or the performance is 0,031%. The structural system has a very good performance, so the residents are very safe to live in their houses. Yosafat (2006) suggested that the evaluation of structural system performance in earthquake resistant building planning in Indonesia is very important because most of its area is an earthquake area with moderate to high intensity.

B.4 Thermal Comfort

The thermal comfort or physical of a house environment is affected by temperature, relative humidity, wind speed, lighting and noise. From Table 5.4, it shows that the indoor temperature ranges from 29oC to 35oC. Temperatures in the afternoon, evening and morning, at 18:00 to 06:00 ranged from 29°C to31°C and at noon at 12:00 pm, the temperature in the room is 35°C. This is above the required temperature, that the equilateral comfort limit is between 22.5°C and 29.5°C [4], with a range from 21.37°C to 28.37°C (ASHRAE), and a range from 22.8° C to 30.2°C (Sujatmiko, 2007).

The humidity or Relative Humidity (RH), for indoor and outdoor is almost the same, between 67% during the day time and 80% at night time. For convenience purpose, RH should be above 20% year-round, below 60% during summer, and below 80% during winter [5]. Above 80% of high humidity can cause the formation of water vapor on human skin that makes the body less comfortable (Satwiko 2009, Rahman 2010), and disruption of occupant health such as the growth of mold on the skin.

The indoor wind speed during the day time ranges from 0.1 m/sec to 0.4 m/sec. At night the wind speed in the room is 0 m/sec, because the windows and vents are closed. Wind motion can affect the heat velocity lost either by convection or evaporation. Therefore, wind speeds range from 0.1 to 0.3 m/sec can meet the convenience requirements [5], [6], and should not exceed 0.2 m/sec [7]. Further, the air movement as required by some experts mentioned above, and then the air circulation in the room flows better, which this impact on improving occupant health, and stinginess or eye irritation is decreased. The air velocity in the room is caused by the installation of windows on the front wall and ventilation on the back wall that resulting in cross circulation. This is supported by the research results of Nitiyasa (2009) which states that the cross air circulation can increase the comfort of residents of simple housing in the area of Giri Dalung Cemara Bali.

The indoor natural lighting in the day time ranges from 145 Lux, up to 255 Lux, which is greater than 115 Lux which is required for indoor natural lighting (Wibisono, 2010). The intensity of natural light in the room is strongly influenced by the width and type of window openings and ventilation. Window or ventilation mounted on the front and rear wall so that the flow of fresh air from the front and dirty air out through the back ventilation. Hindarto (2011) mentions a window for natural lighting more evenly and cross ventilation for air circulation that can provide comfort for the residents, as well as saving the use of electricity. The optimal use of natural lighting does not only has a positive effect to the health of the occupants, but also decreases the use of electrical energy, which before the electrical redesign is always lit when there is indoor activity.

Good natural lighting makes the room brighter and healthier. Indra (2011) explains the maximum penetration of sunlight into the house reduces the use of lights and ultimately save the cost of living that must be spent. Sunlight is also proven to kill germs or bacteria that usually thrive in a humid environment. Vitamin D contained in the morning sun is good for bone and skin (Wibisono, 2010).

The maximum noise inside the room during the day time is 44.74 dBA and at night time is 41.47dBa. This noise is still below the threshold that regulated by the government of Bali Province, it is maximum of 50 dBA during day time and 45dBA at night. The noise occurs in the neighborhood is more affected by the sound of agricultural equipment such as tractors. The acoustic comfort factor, such as the actual noise is also related to the inhabitant's health. However the effects are not immediately felt, thus it is often to be ignored.

The inhabitants in the house do not only feel uncomfortable, yet it will reduce their health indirectly. For instance to this, the noisy will affect the residents which they do not have good rest and they will feel tired easily, easy to get angry, less able to concentrate, and so forth. If this is faced throughout the day and continuously, it is not impossible that the health of residents will gradually decrease (Anonymous, 2011).

B.5 the Life Quality of the Residents

The dynamic of human life always interacts to the environment, to the equipment or facilities, and to the organization during they are active as well as they are having rest. The construction of simple house with concrete blocks and bamboo reinforced structure system can make the environment condition become optimal that is fulfillment of the security requirement and occupant comfort. This will improve the quality of health, it is because of the occupants are active in a safe, comfortable and healthy environment (Primayatna, 2001). The compatibility between anthropometry to facilities and infrastructure will facilitate the accessibility [8], likewise to the optimal natural lighting will affect to the safety of occupants. Natural lighting has an impact on electricity savings, and saving of electricity usage, which does not only affect to the household finances; it can also obstruct global warming and retard the depletion of natural resources such as coal (Indra, 2011).

The SHIP approach that focuses on participation patterns by actively involving the occupants from the beginning of the planning, implementation and maintenance process that can improve the satisfaction of the residents, it's because of most of the proposal and ideas can be accommodated [9].

Therefore, the construction of simple house with concrete blocks and bamboo reinforced structure system meet to the health and safety requirements that will positively affect the quality of life of the inhabitants. Similar to Hartatik and Nastiti (2010) that states, if a house is in accordance with the needs and residents expectation, thus the house can be a means to improve the quality of live [10].

IV. CONCLUSION AND SUGGESTION

A. Conclusion

Based on the results of research that has been done, analysis, and discussion, it can be concluded as follows:

1. Material used for simple house structure is concrete f”c of 20.75 MPa and bamboo reinforced with tensile strength fy of 129.17 MPa.
2. The application of structure system of bamboo reinforced concrete and brick walls in the simple house are fulfill the security requirement technically.
3. The constructions of simple houses with brick wall and bamboo structure system meet the health and safety requirements that positively affect the quality of the residents.

B. Suggestion

The development of simple house that safe and comfort, the use of its structure system can be considered by using of bamboo reinforced concrete.

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