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RESEARCH ARTICLE OPEN ACCESS

Innovation in the Manufacture of Wood Pow Panel And Bricks As The Walls Of Simple House Earthquake Resistant

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ABSTRACT
The number of poor people in Indonesia in March 2021 was 27.54 million people. One indicator is that people do not yet have decent homes. The income of the poor is generally below average, resulting in difficulties in accessing housing loans from banks. All parties must contribute in helping the poor to have livable houses. Researchers innovate to make simple houses livable based on Appropriate Technology, namely technically meeting safety, economical and affordable, ergonomic according to occupant anthropometry, fulfilling socio-cultural standards so that they can be accepted by the community and are energy efficient and sustainable. The innovation of using panels or bricks from sawdust for the walls of a simple house with a size of 3 m x 6 m that was built according to Appropriate Technology methods meets feasibility. The maximum stress ratio of 0.534 occurs in the column and is smaller than the required 1.0. The maximum deviation that occurs at the top of the building is 5.91 mm and is smaller than 0.02 times the total height of the building, namely 0.02 times 4000 is 80 mm. Measurement of the intensity of natural lighting during the day obtained 338 Lux, room temperature obtained 25.56ºC, air humidity (RH) 71.62%, and air movement 0.15 m/sec and noise 36.82 dB. The price of the building is forty million rupiah with 14 days of implementation.
Keywords: innovation, panels, sawdust, walls, simple houses.

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I. INTRODUCTION

A house or shelter is a basic human need and everyone's right to live in a decent house, in addition to the need for food and clothing. Because in essence the function of the house for human life is very vital. Without a house to live in, humans will not be able to live properly, because the house is also a very important factor for everyday human health. The feasibility of the house will affect human life in the house itself and in order to prepare for activities outside the home. (Sutarja,2018)

Ergonomic or livable house rules must meet reliability, that is, meet safety, health, comfort, and convenience as stipulated in Undang-undang Bangunan Gedung Nomor: 28/2002 (Arief, 2012) and Peraturan Menteri Pekerjaan Umum Nomor: 25/PRT/M/2007, Tanggal 9 Agustus 2007, tentang Pedoman Sertifikasi Laik Fungsi Bangunan Gedung.

Badan Pusat Statistik (BPS, 2021) stated that the number of poor people in Indonesia in March 2021 was 27.54 million people. There are fourteen indicators to determine the category of poor people, one of the indicators is that people do not yet have decent housing. The income of the poor is generally below average, resulting in difficulties in accessing housing loans from banks. All parties must contribute in helping the poor to have livable houses (Winarno, 2018).

Researchers innovate to make simple houses livable based on Appropriate Technology, namely technically fulfilling security, economical and affordable, ergonomic according to occupant anthropometry [3], meet social and cultural methods so that they can be accepted by the community and save energy and be sustainable (Ocky, 2020 and Nekky et al, 2015). The innovation of using panels and bricks from wood sawdust for the walls of a simple house with a size of 3 m x 6 m built according to the Right Use Technology method.

Referring to research conducted by Jeni P., and

Hairulla, make a mixture of bricks for wall materials 1 Portland cement : 5 sand : 5% husk ash to get a compressive strength of 4.92 MPa. Researchers made panel walls and sawdust bricks with a mixture of 1 Portland cement : 2 sand : 3 sawdust. Sawdust is taken from sawmill waste in wood processing factories. This mixture is then printed as needed. Wood panels must be tested in a laboratory before being used(Siswanti and Sastika, 2020).The characteristic properties of the panels tested include density or volume weight and compressive strength. To measure the strength of the sawdust panels that have been made, laboratory tests were carried out. For this laboratory test, three test cubes measuring 15 cm x 15 cm x 15 cm were made.

II. MATERIALS AND METHODS

2.1 Place of research

The research was conducted in Selemadeg Village, Tabanan Regency, Bali Province, Indonesia.

2.2 Panels and Sawdust Bricks

Wood Powder Panels are made with a mixture of 1 Portland cement : 2 sand : 3 sawdust. Sawdust is taken from sawmill waste in wood processing factories. For laboratory tests which include volumetric weight and compressive strength, three test cubes measuring 15 cm x 15 cm x 15 cm are made.

2.2.1 Volume Weight

Volume weight is measured by: $\mu = M/V$ ………………………………………………………(1)

where: μ is the unit weight
M is the mass of the cube
V is the volume of the cube

2.2.2 Compressive Strength

Concrete compressive strength $fc' = fc'r - k\ S_d$ ………………………………………………………(2)

with: fc' is the compressive strength of the plan
fc'r is the average compressive strength of the specimen
k is the constant value of the defect factor
S_d is the standard deviation

2.3 Panel Application as a Simple House Wall

Wood Sawdust Panels are applied to the walls of a simple house with a building area of 18 m^2 or floor size 3 m x 6 m. House construction follows the principles of Appropriate Technology. The building structure is analyzed with the help of the SAP-2000 program to measure the physical safety of the building. The physical safety of the building seen from the stress ratio that occurs must be less than one and the maximum deviation at the top of the building must be less than 0.02 times the height of the building. The loading is adjusted to the applicable Indonesian National Standard (BSN, 2018 and 2019). Indoor physical comfort is measured with an Environment Meter made by Krisbow.

2.4 Panel and Brick Making Training

This research was continued by providing training to the people of Selemadeg Village through the Village Unit Business, namely MSME. This training was conducted to increase the types of MSME products during the Covid-19 Pandemic. The important thing is that it will also be able to help maintain environmental cleanliness, by utilizing sawdust waste.

III. RESULTS AND DISCUSSION

3.1 Panels and Sawdust Bricks

Local sawdust panels and bricks are made from a mixture of portland type cement, fine sand and sawdust from sawdust from wood processing factories. The mixture ratio is 1 cement: 2 fine sand: 3 sawdust. The process and results are as shown in Figure 1 and Figure 2 and Figure 3.

a. Mix 1 cement : 2 sand : 3 sawdust b. Print panels/boards

Figure 1, Local Sawdust Panel manufacture

a. Manufacturing result of panel b. Panels are installed

Figure 2, Manufacturing Results of Local Sawdust Panels

Figure 3, Process and Results of Manufacturing Panels and Local Sawdust Bricks

The test results for the three cubes were an average weight of 4.72 kg or a volume weight of 1398.52 kg/m3 (Figure 3a). The weight of these panels is lighter than the masonry wall which has a volume weight of 1675 kg/m3, this provides an advantage for the safety of the building structure due to reduced self-weight and earthquake loads. The compressive strength fc' achieved was 5.26 MPa (Figure 3b). The compressive strength fc' of this panel is greater than the compressive strength of the bricks examined by Jeni P., and Hairulla[6] who made a mixture of bricks for wall materials 1 Portland cement : 5 sand : 5% husk ash to get a compressive strength of 4.92 MPa. The condition of the three cubes after the maximum pressure test looks intact, because sawdust also functions as fiber (Figure 3c), this will not cause sudden collapse of the wall if there is an excess load.

According to local traditions, the utilization of sawdust has several views as a basis for consideration. Waste sawdust that is processed into wall panel material is a very noble ethic and a creative idea to reduce waste and "dirty" by reducing the amount of waste and saving the use of natural resources. In the philosophy of the local community, wood means *kayun* (mind), with the human mind can change and create something good. Therefore, traditionally, wood has been the main material in traditional buildings and has been used with great care by the Balinese since ancient times

Wood as a material that is environmentally friendly, sustainable and easily available in the local environment. In terms of construction, local people can easily work on wood materials with simple traditional technology so that they can be recycled and reused when they are no longer used. Traditional knowledge about procedures for procuring, processing and ethical use of wood was inherited in a sustainable manner in various lontars such as Asta Kosala Kosali, Swakarma, Prabu Janantaka, Taru Permana, Bama Kertih, and others.

a. Weight Test b. Compression Test c. Cube Condition After Compression Test
Figure 4, Manufacturing Results of Local Sawdust Panels

3.2 Application of Panels and Bricks as Simple House Walls

3.2.1 Development Process Oriented to Appropriate Technology

The application of sawdust panels as a simple house wall starts with the manufacture of adobe foundations and reinforced concrete coverings (Figure 5a). The construction continued with light steel structure pairs (Figure 5b), local tiled roofs (Figure 6a). Installation of walls and finishing with installation of ceramics, installation of frames and painting Figure 6b). The development process always considers aspects of Appropriate Technology, namely the selection of materials that meet the technical aspects, namely strength, rigidity and stability. The economical aspect is choosing cheaper materials such as adobe foundations, light steel frames and panel walls. The ergonomic aspect is making the size of doors, windows and building height adjusted to the anthropometry of the occupants. The aspect of saving energy is by making the size and position of the windows in such a way that natural lighting and air movement into the room can be maximized. The socio-cultural aspect of the appearance of the house is in accordance with the principles of Balinese architecture with local materials so that it is in harmony with the environment. The aspect of sustainability with the use of panel walls from sawdust from wood processing factory waste will be able to reduce environmental damage.

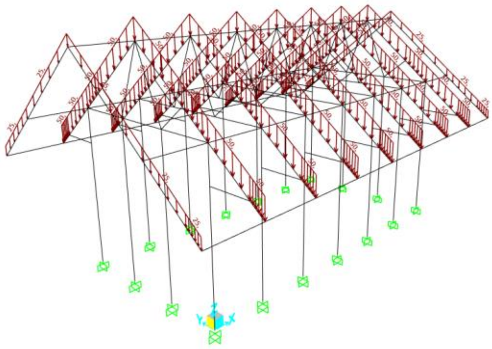
a. Brick Foundation Work b. Light Steel Structure
Figure 5, Foundation and Building Structural Work.

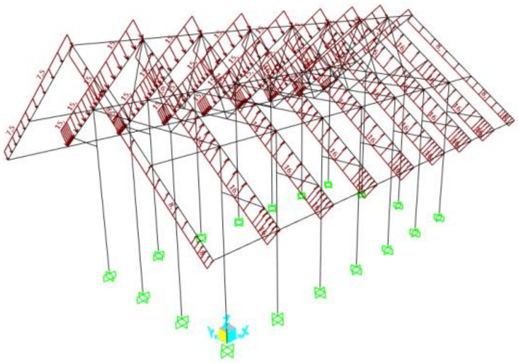
a. Roof installation work b. Finish House (Physical 100%)

Figure 6, Roof Pairing Work and Front View of a Light and Bressing Steel Structure System House with Local Sawdust Panel Walls
(Building Size 3m Width and 6m Length)

3.2 Safety of Structural Systems

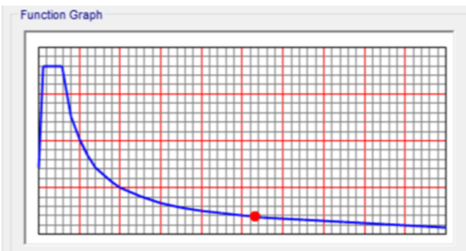
Safety was analyzed from the stress ratio and deviation of the light steel structure system due to dead loads (Figure 7a) and wind loads (Figure 7b) as well as the seismic load Response Spectrum (Figure 8a). Evaluation of the performance of building structural systems needs to be carried out to ensure the safety of occupants, because Indonesia is very prone to hazards such as earthquakes, tornadoes (Christy et al, 2014 and Sutarja et al, 2021). Evaluation of the performance of building structures is obtained through a three-dimensional structural system analysis method with the SAP 2000 program.

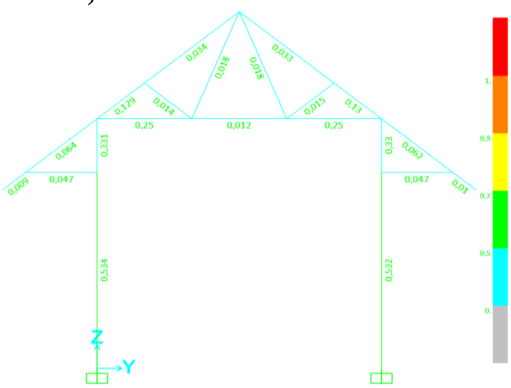




a. Dead load b. Wind load

Figure 7, Loading of the structure, namely dead load and wind load according to standards in Indonesia (BSN, 2018 and 2019).





a. Response Spectrum Curve b. Stress Ratio

Figure 8, Response Spectrum Curve for Earthquake Loading [19] And Stress Ratio In Light Steel Frame Structure.

3.2.1 Basic Shear Force

In SNI Gempa 03-1726-2002 Article 7.1.3, it is stated that the final value of the dynamic response building structure against nominal earthquake loading due to the influence of the internal design earthquake a certain direction, cannot be taken less than 100% of the response value of the first variety.

Table 3. 3 Basic Shear Forces

Earthquake Force Direction	Dynamic Earthquake	Static Earthquake
X direction	3065,74	2211,22
Y direction	3076.12	2211,22

3.2.2 Period Fundamental Structure (T)

According to SNI 1726-2019[19], the fundamental period of the structure, T, shall not exceed the resulting coefficients for the upper bounds on the calculated period (Cu) and the approximation fundamental period, Ta, determined in accordance with 7.8.2.1. and SD1 is determined based on the official site application
the ministry of public works (PU) http:puskim.pu.go.id obtained acceleration parameters
SD1 design spectra. Here is the calculation
$T_a = C_t h_n^x$
Where hn , is the height of the inner structure (m), above the base to the highest level
structure and Ct and x determined from SNI 1726-2019
$T_a = 0{,}0724 \times 4^{0{,}8}$
$T_a = 0.307$ seconds
$T_{max} > T$
$Ta\ C_u > T$
0.307 x 1.4 = 0.429 seconds > T = 0.377 seconds
Cu is obtained from SNI 1726-2019 and T is the fundamental time structure of the analysis results.

3.2.3 Stress Ratio and Deviation

The maximum stress ratio of 0.534 occurs in the structural column and is smaller than the required 1.0 (Figure 8.b). The maximum deviation that occurs at the top of the building is 5.91 mm and is smaller than 0.02 times the total height of the building, namely 0.02 times 4000 is 80 mm (BSN, 2019).

3.2.4 Conditions of the Physical Environment

Physical environmental conditions seen from temperature, noise, natural lighting, wind speed and humidity. From the measurements that have been made, the intensity of natural lighting during the day is 338 Lux, the room temperature is 25.56ºC, air humidity (RH) 71.62%, and air movement 0.15 m/sec and noise 36.82 dB. A good objective comfort level at home based on lighting intensity according to Kroemer and Grandjean, 2000 and Mangunwijaya, 1981 is 300 lux – 700 lux. Good objective comfort level at home based on air temperature according to Meijs, 1983; Kroemer and Grandjean, 2000; Pheasant, 1991; Lippsmeier, 1994; Suma'mur, 1996 and Mangunwijaya, 1981 is 24ºC – 28ºC. A good level of objective comfort at home based on air humidity according to Meijs, 1983; is 40% - 70%. Kroemer and Grandjean, 2000 decisive Relative Humidity (RH) 80% temperature 18ºC, RH 70% temperature 19ºC, RH 60% temperature 20ºC, RH 50% temperature 20.5ºC and RH 30% temperature 21ºC. A good objective comfort level based on air movement according to Kroemer and Grandjean, 2000 should not be more than 0.2 m/s. Mangunwijaya, 1981 states that good air movement is between 0.1 – 0.3 m/sec. A good objective comfort level based on noise according to the Bali Governor's Rules should not be more than 55 dB. Physical environmental conditions in terms of temperature, noise, natural lighting, wind speed and humidity also meet the standards that apply in Indonesia.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

1. Panels and sawdust bricks with a mixture of 1 portland cement: 2 sand: 3 sawdust, can reduce weight and provide strength for the walls of house buildings and is a new finding.
2. Simple house buildings that have been built using the Appropriate Technology Approach are Livable Houses, because they have fulfilled the aspects of safety and comfort.

4.2 Suggestions

It is necessary to further investigate the use of bricks mixed with 1 portlang cement : 2 sand : 3 sawdust for walls of simple buildings and are calculated to carry earthquake loads, with the approach as struts or shells.

5. THANK YOU

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