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Non-Burning Bricks with Natural Materials Environmentally Friendly

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Abstract: The city of Bima is an area that produces quite a lot of bricks with favorable natural conditions, most of the area consists of rice fields and has a soil texture suitable for making bricks. Red brick is the most widely produced type of brick with a total of 20,000 bricks per month and its use has a negative impact on the environment because it produces carbon dioxide (CO2) emissions which pollute the air and contribute to the greenhouse effect which causes global warming, also as a result of burning bricks. Based on this, researchers are trying to conduct research related to building materials in Bima City in the form of brick innovations with more environmentally friendly basic materials. The research was carried out using a true experiment and cross sectional approach using conventional bricks as a standard for quality comparison. Descriptive analysis was chosen as the method of analysis in this study. From the results of brick quality tests, all brick formulas met the requirements for water content (<15%), four of the six formulas met the compressive strength requirements based on SNI. The average compressive strength of the four formulas is >5 MPa and meets the Indonesian national brick breaking strength standard (SNI-0021-78). The most significant advantage seen from brick products without burning is the lower water content than conventional bricks and is more environmentally friendly because it uses natural materials and is obtained at competitive prices.

Keywords: Bricks; Compressive strength; Economical; Environmentally friendly; No burning

Introduction

Bricks are one of the materials for the physical construction of buildings (Vijayan et al., 2021). The bricks themselves are conventionally made of clay which is fired until it is reddish in color. As technology develops, the use of bricks decreases (Eliche-Quesada et al., 2017). The emergence of new materials such as gypsum, treated bamboo tend to be preferred because they are cheaper, lighter and architecturally more beautiful (Kaminski et al., 2016).

Kota Bima is one of the brick-producing areas spread across several regions (Fauzan, 2019). This is supported by the natural conditions in some of these areas which are mostly rice fields and the soil texture which is suitable as a base material for making bricks (Singh et al., 2021). Most of the brick production in Kota Bima is red brick by the burning process with an abundant amount of production, even reaching 20,000 bricks in one month.

Red bricks with kiln have many advantages compared to other bricks, especially lighter weight (Almssad et al., 2022). However, red bricks, which are mostly made by burning, have a negative impact on the ecology and the environment because they produce carbon dioxide (CO2) pollution which pollutes the air, thereby contributing to Greenhouse Gases (GHG) into the atmosphere. Greenhouse gases are gases in the atmosphere that cause the greenhouse effect (Kweku et al., 2018; Shen et al., 2020). These gases actually appear naturally in the environment, but can also arise due to human activities, one of which is the burning of bricks

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(Irwansyah et al., 2018; K. D. Miller et al., 2021; S. A. Miller et al., 2021).

To burn 5,000 bricks measuring 20cm x 10cm x 5cm, no less than 100kg of CO2 will be released into the air. Increasing the temperature of the earth's surface will result in extreme climate change on earth, this can result in disruption of forests and other ecosystems, thereby reducing their ability to absorb CO2 in the atmosphere. Global warming causes the melting of icebergs in the polar regions which can cause sea levels to rise and increase the temperature of the earth's surface (Khan et al., 2020; Rignot, 2021). Based on this, the researchers tried to make a new design related to building materials in the city of Bima in the form of an innovation without burning bricks with the research title Non-combustion Bricks with Environmentally Friendly Natural Materials.

The research process was carried out by mixing certain materials such as cement, sand, rice husk, water and rice husk ash with the raw material in the form of clay with the percentage of the mixture determined by the researcher as has been done in previous studies. However, a significant difference can be seen from the change in the percentage proportion of the mixture of brick materials without burning.

The need for commodities and materials at lower prices but with high quality is one of the important issues that are urgently needed by the people of Bima City. The existence of alternative non-combustion bricks with good quality and fulfilling the requirements can be a good and useful input for the needs of the community and in line with the objectives to be achieved in this study, namely to obtain a proportion of a mixture of quality non-combustible bricks that meet the standards with a value production is lower and more economical in use and can create a healthier environment from the brick formula which is environmentally friendly.

Method

This study used the true experiment method and a cross sectional approach using conventional fired bricks produced by a brick manufacturer in Bima City as a standard for comparing the quality of innovative bricks. Data analysis of the results of the research was carried out in the form of descriptive data analysis from the output of each formula based on the results of measuring the quality of bricks without burning. These measurements include: Measurement of the water content by calculating the percentage difference in the water content of the bricks before and after they are heated; brick weighing; Surface area measurement; Measurement of compressive load; and Measurement of compressive strength. Then determined the best non-combustion brick formula sample.

Tools and Materials

Tool is an important supporting factor in the manufacture of specimens. Completeness of equipment used in the process of making test specimens can contribute to optimal results and ease of process. Some of the tools you need to prepare include paper, pen, brick mold, plastic bucket, balance, oven (temperature 40^0C), wooden pallet, ruler, filter, and clear plastic. Meanwhile, various basic materials used in this study were clay, cement, sand, rice husks, and rice husk ash.

Bricks Formula without Burning

Mixed proportions or formulas are made into six sample codes, namely WS 1 (Widodo Sample 1), WS 2 (Widodo Sample 2), RS 1 (Research Sample 1), RS 2 (Research Sample 2), RS 3 (Research Sample 3), and RS 4 (Research Sample 4) with materials such as clay, cement, sand, rice husk ash, and rice husks. The selected materials are used to produce environmentally friendly products according to research objectives. The time of the research was conducted from January to February 2023 which was carried out in the workshop room of the Regional Research and Innovation Agency for the City of Bima and at the UPT. Regional Health Laboratory and Maintenance of Medical Devices in the City of Bima. The formulation of a mixture of brick materials without burning from six sample code formulas includes: WS1: 80% clay, 20% cement; WS 2: clay (90%), cement (10%); RS1: clay (60%), cement (20%), and sand (20%); RS 2: clay (60%), cement (30%), and ASP (10%); RS 3: clay (60%), cement (30%), and rice husk (10%); RS 4: clay (40%), cement (20%), sand (20%), 10% ASP, and rice husk (10%).

Making Bricks without Burning

The flow or stages of making bricks without burning are carried out with stages starting with: (1) literature review; (2) Determination and calculation of the brick material formula, calculation of the research sample formula is carried out by calculating the composition or dosage of each material that has been prepared using a balance; (3) Collection and preparation of tools and materials, preparation of research tools and materials is carried out by reassuring that each tool and material collected is in accordance with research needs; (4) Preparation of dough according to the specified formula; (5) Drying bricks without burning, drying is done in two ways, namely drying in the sun for a minimum of 7x24 hours and drying using an oven at 40ºC for 1x24 hours; (6) Measurement of water content; (7) Testing the quality of bricks and determining the best formula for bricks without burning.

Result and Discussion

Product Performance of Non-Burning Bricks

Bricks without burning is an appropriate technological innovation that was first carried out in Bima City using two types of treatment, namely direct sunlight for a minimum of 7x24 hours and heating to 40ºC for 1x24 hours using an oven.

The innovative bricks have been tested using conventional bricks with burning as a comparison. Several quality tests were carried out, namely: brick weight measurement, surface area measurement, water content measurement, surface tension measurement, endurance test, compressive load test and compressive strength test. The results of the brick quality test can be seen in Table 1.

Table 1. Results of Brick Quality Tests without Burning

No	Sample Code	Test Object Size (Cm)	Color	Press Area (Cm^2)	Heavy (Gram)	Maximum Load (KN)	Voltage (Kg/Cm^2)	Strong Press		Average Compressive Strength	
								$Kg/(Cm^2)$	Mpa.	$Kg/(Cm^2)$	Mpa.
1	WS 1-b (1)	11 x 11 x 4	Light brown	121	873.8	70	59.01	59.01	4.90	61.12	5.07
	WS 1-b (2)	11 x 11 x 4	Light brown	121	824.7	75	63.22	63.22	5.25		
2	WS 2-a (1)	11 x 11 x 4	Light brown	121	759.5	45	37.93	37.93	3.15	35.83	2.97
	WS 2-a (2)	11 x 11 x 4	Light brown	121	703.6	40	33.72	33.72	2.80		
3	RS 1-b (1)	11 x 11 x 4	Light brown	121	905.2	100	84.30	84.30	7.00	88.51	7.35
	RS 1-b (2)	11 x 11 x 4	Light brown	121	950.2	110	92.73	92.73	7.70		
4	RS 2-b (1)	11 x 11 x 4	Light brown	121	890.8	95	80.08	80.08	6.65	90.62	7.52
	RS 2-b (2)	11 x 11 x 4	Light brown	121	814.3	120	101.16	101.16	8.40		
5	RS 3-a (1)	11 x 11 x 4	Light brown	121	782.1	110	92.73	92.73	7.70	92.73	7.70
	RS 3-a (2)	11 x 11 x 4	Light brown	121	753.9	110	92.73	92.73	7.70		
6	RS 4-a (1)	11 x 11 x 4	Light brown	121	795.9	70	59.01	59.01	4.90	56.90	4.72
	RS 4-a (2)	11 x 11 x 4	Light brown	121	753	65	54.79	54.79	4.55		
7	Bata Merah (K)	10 x 10 x 4	Reddish brown	100	543.1	55	56.10	56.10	4.66	51.00	4.23
	Bata Merah (K)	10 x 10 x 4	Reddish brown	100	532.3	45	45.90	45.90	3.81		

Based on the results of brick quality tests, all brick formulas met the requirements for moisture content (<15%) and the four formulas (WS1, RS1, RS2, RS3) that were tested met the compressive strength requirements and other criteria based on SNI standards compared to conventional bricks as controls. Based on the quality test results, the four best brick component formulas were obtained in terms of the quality of the test results, namely bricks without burning with sample code "WS1" with the composition: clay (80%), cement (20%); "RS2" with composition: clay (60%), cement (30%) and rice husk ash (10%); sample code "RS3" with composition: clay soil (60%), cement (30%) and rice husk (10%) and sample code "RS1" with composition: clay soil (60%), sand (20%) and cement (20%).

The average compressive strength of the four formulas is >5 MPa and meets the provisions of the Indonesian national standard for brick fracture strength, which is >5 MPa (SNI-0021-78) (SNI, 2002). Physically, when viewed from the outside, the printed bricks comply with the requirements of SNI 15-2094-2000 (SNI, 2000) entered in Module M-6a, in terms of color, the seven compositions have color variations from light brown, dark brown, and dark red (Naufal, 2018).

Specifications of Bricks without Burning

a) Product Dimensions

Figure 1. Display of brick products without burning

b) Product Weight

The results of brick products without burning from this study obtained the weights as shown in Table 2.

Table 2. Weight of Bricks without Burning

Sample Code Trials	Average Weight (gr)	Average Weight (gr) conversion x2
WS1	849.3	1.699
WS2	731.6	1.463
RS1	927.7	1.855
RS2	852.6	1.705
RS3	774.5	1.549
RS4	774.5	1.549
Bata konvensional (K)	537.7	1.075

c) Output Capacity and Product Components

The use of brick formula components without burning in the six trial samples can be seen in Table 3**.**

Table 3. Output Capacity of Bricks without Burning

Sample Code	Clay (gr)	Cement (gr)	Sand (gr)	ASP (gr)	Rice Husk (gr)	Water
WS 1	1358.8	339.6	-	-	-	Adapt
WS 2	1316.8	146.4	-	-	-	Adapt
RS 1	1113.24	371	371	-	-	Adapt
RS 2	1023.2	511.6	-	171.4	-	Adapt
RS 3	929.4	464.8	-	-	155	Adapt
RS 4	430.2	215	215	107.6	107.6	Adapt

d) Product Strength

The strength of brick products without burning can be seen in Table 4.

Table 4. Average Strength of Bricks without Burning Based on Quality Test Results

Sample Code	Size (cm)	Color	Max Load (KN)	Voltage (Kg/Cm²)	Press hard (MPa)	Water Content (%)
WS 1	11 x 22 x 4	Light brown	72.5	61.1	5.07	5.63
WS 2	11 x 22 x 4	Light brown	42.5	35.8	2.97	7.20
RS 1	11 x 22 x 4	Light brown	105	88.5	7.35	4.50
RS 2	11 x 22 x 4	Light brown	107.5	90.6	7.70	2.77
RS 3	11 x 22 x 4	Light brown	110	92.7	7.52	7.11
RS 4	11 x 22 x 4	Light brown	67.5	56.9	4.72	8.29
Conv. brick (control)	10 x 20 x 4	Reddish brown	47.5	51	4.23	8.9

e) Product Excellence

Non-combustible bricks with natural materials that have been produced have several , including: (1) Lower water content than conventional bricks; (2) Using natural b materials and reducing waste; (3) More environmentally friendly; (4) Better quality; (5) Competitive price.

f) Economic Value

Based on the use of brick raw materials without burning, the estimated selling price of the product can be seen in Table 5 which previously took into account the calculation of the estimated price of basic materials written in point a as follows:

1) Calculation of the estimated price per component
   - Tanah Lempung: Rp. 250.000,00- /*Dump truck* (± 4 Ton) (Rp. 0.05/gram).
   - Sand: Rp. 600.000,00- /*Dump truck* (± 2 Ton) (Rp.0.3/gram).
   - Rice Husk: Rp. 20.000,00- /Sak (± 10 Kg) (Rp. 0,5/gram).
   - Rice Husk Abu: Rp. 20.000,00- /Sak (± 10 Kg) (Rp. 0.5/gram).
   - Cement : Rp. 65.000,00- /Sak (±50 Kg) (Rp. 1.3/gram).
2) Calculation of the estimated selling price of each brick formula without burning.

Table 5. Estimated Selling Price of Each Brick Formula without Burning

Sample Code	Lempung (Rp)	Cement (Rp)	Sand (Rp)	ASP (Rp)	Rice Husk (Rp)	Water (Rp)	Estimated selling price (Rp)
WS 1	67.94	475.44	0	0	0	0	543.38
WS 2	65.84	204.96	0	0	0	0	270.8
RS 1	55.662	519.4	278.25	0	0	0	853.312
RS 2	51.16	716.24	0	85.7	0	0	853.1
RS 3	46.47	650.72	0	0	77.5	0	774.69
RS 4	21.51	301	161.25	53.8	53.8	0	591.36

Technical Feasibility

The need for bricks as the main component of physical development is still the main commodity and the main job field for some people (Haris et al., 2020; Milanie et al., 2022). The activity continued with the collection of references and literature review related to the idea of innovation, followed by the determination of several brick component formulas (Zaifuddin, 2022).

Collection of raw materials, dough making followed by the first treatment, namely drying brick samples for a minimum of 7x24 hours which was carried out in the BRIDA workshop room, Bima City. The second treatment was heating brick samples at 40^{0}C using an oven in the UPT environmental chemistry laboratory. Labkesda and Maintenance of Health Devices for the City of Bima.

To test the quality of brick samples without burning, measurements of water content were carried out in the BRIDA workshop room, Bima City, while weight measurements, surface area measurements, surface tension measurements, endurance tests, compressive load tests and compressive strength tests were carried out in the BPMKP workshop room, City PUPR Office. Bima.

Economical Feasibility

Research with product results in the form of bricks without burning was carried out with the hope of introducing alternative types of bricks which besides being environmentally friendly also have high economic value so that they can compete with conventional brick products but with better quality based on several quality test results that have been carried out.

The economic value of this product is due to: (1) Not using wood for the combustion process; (2) The compressive load strength is better than conventional bricks so that the bricks are more durable and long lasting; (3) Competitive price with conventional bricks. This product is expected to be one of the brick formula references used by brick manufacturers.

In general, when compared to the price of conventional fired bricks, it is currently around Rp. 600,- to Rp. 800, -, the estimated selling price of bricks without burning is calculated based on the weight of component requirements in each sample formula tested and can be seen in table 5. The three formulas for bricks without burning with the best compressive strength value are code "RS1"; "RS2" and "RS3" have a tendency for higher selling prices but in the sample formula with code "WS1" even though the compressive strength values are not as good as the three formulas above, they still meet the standards and have a lower estimated selling price. Likewise, the brick formula with the sample code "RS1" can be considered, because even though the price is slightly higher, it has a much better test quality than conventional bricks. The calculation of the estimated selling price is also influenced by the weight of the brick sample being tested, so further experiments are needed.

Conclusion

Based on the research results, it can be concluded that: (1) A more economical/competitive price and environmentally friendly brick formula is obtained. (2) An environmentally friendly non-burning brick formula is obtained at competitive prices. (3) Creating a healthier environment by reducing the formation of the greenhouse effect due to CO2 contamination due to burning bricks.

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Author Contributions

Adhi Aqwan, Asryadin, Muhammad Ichwanul Muslimin and Rizka Khairunnisa: preparation of the original text, results, discussion, methodology, conclusions; Hetti Koes Endang, Rosita, Fahrul Annas, Hasan Muhammad Rahadian did analysis, proofreading, reviewing and editing.

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Conflicts of Interest

Conflicts of interest related to the environment and the economy

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