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Technology Of Light Brick Production Using Lamongan Sand

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Abstract
Light brick is now starting to be widely used for wall construction to replace red brick or bricks. It is more water- and fire-resistant and lighter, making it one of the most popular types of concrete. This precast is in great demand in many construction circles. The light brick is also relatively stronger than the red brick, which is more brittle. The light material also makes work more efficient and faster. This research method uses experimental research methods. The purpose of this research is to determine the effect of Lamongan sand through light brick-making tests, where light brick composition with a ratio of 25.65% cement, 51.31% fine sand, and stone ash 2.85% and 10.01% fly ash and foam agent mixed evenly and dissolved in water, adjusted to materials.
Testing the comparison of light bricks using Lamongan sand through compressive strength tests, bulk density tests on light bricks, and a water absorption test on light bricks. Results testing for an average compressive strength of 595.84 Newton and a standard deviation of 233.53 Newton and testing water resistance on flat concrete roof tiles made of iron sand, it turns out that water does not penetrate and there are no drops on their surface brick bottom. In addition, this light brick is also used for concrete dak with reinforced elbow iron, or mild steel with a thickness of 1 mm. For the water absorption test, the average is 8.4%.

Keywords: *light brick, Lamongan Sand, compressive strength test, absorption test*

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I. INTRODUCTION

In Indonesia, especially in big cities such as Jakarta, Surabaya, Gresik, Lamongan, Bandung, Medan, Makassar, and Bali, the need for settlements and houses has become a primary basic need in society. It should be noted that at this time, the technology of building materials used red bricks, adobe, and white adobe, the workers wanted lighter materials which are used for building.

Light brick is now starting to be widely used for wall construction to replace red brick or bricks. It is more water- and fire-resistant and lighter, making it one of the most popular types of concrete. This precast is in great demand in many construction circles. The light brick is also relatively stronger than the red brick, which is more brittle. The light material also makes work more efficient and faster.

One of the ways to make light foam bricks is to use chemicals as ingredients to create fine air bubbles in the cement paste. The chemicals are used as foam agents. This substance will produce light bricks, but two with a half composition than it should. Because this substance will multiply the volume up to two times. Nonetheless, the value of the physical strength it has does not decrease and it even exceeds that of conventional bricks.

The problem of concern in this research is how the light brick-making technology by using Lamongan sand with the utilization of Lamongan sand as a mixture of light bricks-making. This light brick research is related to the utilization of Lamongan sand as an alternative material for the manufacture of light bricks based on mechanical properties or quality produced better than light bricks using other sands.

This study aims to develop light brick manufacturing technology for its mechanical properties. In addition, it aims to determine the effect of Lamongan sand through the test of light brick-making, the composition of light brick-making with a cement ratio of (25.65%), fine sand (51.31%), rock ash (2.85%), and fly ash (10.01%), and foam agent mixed evenly and dissolved in water, according to the material.

This research is expected to provide information to light brick entrepreneurs that Lamongan sand can be used as a mixture for making light bricks, broadening horizons, and mindset in material science development, and provide references on light brick performance in the building materials industry.

II. LITERATURE REVIEW

Light concrete technology has become the right solution in the construction industry. Concrete bricks Foam can replace ordinary bricks fired from clay, but bricks cost much more energy and carbon. Light brick is a building material that resembles concrete in its strong and resistant properties to water and fire which are made using machines in factory [1]. Type of light bricks have a light and smoother surface, as well as a level higher flatness compared to ordinary red brick. One of the benefits of this light brick is a lighter load for building construction structures, saving the rest of the material during the construction of building walls project, and speeding up processing time [2].

Light Brick

Light brick is a building material produced by modern technology to produce higher-quality buildings or houses [3]. In the world of construction, there are two types of light bricks, *Autoclaved Aerated Concrete* or AAC light bricks, and light bricks type of *Cellular Lightweight Concrete* or CLC. Whereas the difference between both is the drying process in which the AAC type is processed by drying in a device called a high-pressure autoclave oven. Whereas CLC light brick which drying process is carried out naturally, so CLC is often also called non-AAC light brick.[4]

AAC light concrete was first developed in Sweden in 1923 as an alternative building material to reduce deforestation. AAC light concrete was then developed again by Joseph Hebel in West Germany in 1943. He decided to develop a system of buildings better at a more economical cost. His brilliant innovation in such a process of cutting with wire opens new possibilities for the development of this product. As a result, aerated light concrete is considered perfect, including as an environmentally friendly building material because it is made from abundant natural resources. It is strong, durable, malleable, efficient, and very efficient. [5]

Since 1980, the type of AAC block has been increasingly used in the construction industry in various parts of the world because of the characteristics of AAC, which are light but strong, so it can suppress building structure costs. The use of natural materials in the production of building materials such as Quartz sand and limestone has been known since the late 19th century; their development began at the beginning of the 20th century production processes were improved with the introduction of an additional deep water vapor pressure system treatment (steam curing) [5].

The compressive strength test in the laboratory shows that red brick and light brick have different compressive strengths, the light bricks heated from the sun for 7 days have the compressive value was 58.916 kg/cm^2, while those soaked in water for 4 days had a compressive value of 36.256 kg/cm^{2,} and aired for 28 days, had a compressive value of 45.32 kg/cm^2. For the red bricks that are sun-dried for 5 days and then burned for 1 day after being red. The baked bricks are then heated in the sun for 7 days and have a compressive strength value of 33.709 kg/cm^2 after being soaked for 4 days has a compressive strength value of 29.495 kg/cm^2 and in the wind for 28 days has a compressive strength value of 25.281 kg/cm^2 [6].

Some efforts are conducted to develop solid, hollow, and interlocking beams that are light. In foam concrete, macroscopic air bubbles are produced mechanically and added to the base-mix mortar during mixing. This type of foam concrete technique is called concrete preformed foam. The foam material needed to produce a stable foam can come from natural or synthetic. The foamed concrete is very easy to flow and compact. Because foam concrete contains air bubbles; it cannot be bumped and vibrated in the engine to produce beams. The stiffness of foam concrete depends mainly on the porosity added [7].

Normal foam concrete, when cast in molds, can be dismantled only after 24 hours. This has constraints on the productivity of block-making. Problems faced in buildings and structure has a larger dead load than ordinary brick and concrete. In foam concrete, the distribution of uniform air bubbles through the concrete mass, resulting in 20% entrapped air, making it very light in comparison to conventional concrete [8, 9].

Sand

Sand is widely used from the lowest structure to the top of the building. Good As you pile sand, mix it until the concrete mixes. Besides, there is still a lot of use for sand. building materials used as a mixture of materials for the manufacture of printed materials such as making paving blocks, *kansteen*, bricks, and others. Sand is one of the materials in the form of granules. Range of grains in sand, generally measuring between 0.0625 and 2 millimeters. From many classifications of types of sand, sand is a very variable material, and therefore, it is possible to made efforts to classify it into a separate category. [10]

Cement

Cement is a hydraulic adhesive produced by grinding clinker. consists of the main ingredients of calcium silicates and additional ingredients of gypsum stone, where these compounds can react with water and form new substances that are adhesive to rocks. Cement comes from *Caementum* (Latin word), which means to cut into irregular small pieces. Meanwhile, in the everyday sense, cement is a substance that is used for gluing bricks and other building materials [11].

Portland Cement (PC) is a type of hydraulic cement produced by fine grinding clinker consisting mainly of hydraulic calcium silicates and gypsum as a supporting ingredient. (PUBI-1985) [12].

Fly Ash

Fly ash is a material used to increase durability and durability against chemicals. Based on the foregoing, it is necessary to conduct research on whether bottom ash can also act as a substitute for cement like fly ash.

The effect of fly ash on the compressive strength of light bricks after 28 days of curing in water shows that the optimum percentage of fly ash was found to be 10%, which gives a strength of about 9.1 MPa. The strength of light foam concrete with 5% and 15% fly ash was 8.4 and 8.1 MPa, respectively [13].

Stone Ash

Stone ash is a material resembling coarse sand with small, dense, and hard sizes which is produced from the grinding of rocks taken from rivers in mountainous areas, for East Java, these materials are mostly found in the Lumajang area or Semeru Mount, Blitar (Kelud Mountain). Stone ash is a by-product of the cement industry and stone processing. This stone's ash is included in the category of artificial aggregate construction material, which is widely used as a mixture in the paving and sand pairing process. In addition, the brick industry press also uses a lot of stone ash as the main composition for making pressed bricks.

In addition, stone ash is a fine aggregate that passes through a 4.75-mm-diameter sieve and is retained in size. 0.075mm. Therefore, stone ash is a useful waste as a mixture of materials in construction buildings because rock ash can function as a filler in the production of SCC and asphalt mixtures, as well as fine aggregate as a substitute for sand in concrete or asphalt mixtures. [14]

Aluminum Paste

Aluminum paste is one of the most important material elements in manufacturing light brick AAC and AAC non-block. The aluminum paste used in the dough, apart from being functional as a developer it is also plays a role in influencing the hardness of concrete. Each component or material in the manufacture of light bricks has a very important role in producing light bricks of good quality required the right measurements for each ingredient and

proper processing so that the results are maximized and the level of loss to the company will be thinning.[15]

Foam Agent

Foam agents are used to obtain foam concrete. It is defined as a water-entraining agent. Foam agents have an important influence on foam concrete. There are two types of foam materials: foam protein-based and synthetic-based foams. Protein-based foaming agents are easier to obtain and cheaper, and it has lower consistency and strength than synthetic foaming agents. Foam Synthetic is suitable for densities of 1000kg/m^3 and above, and foam protein is suitable for densities of 400 kg/m^3 up to 1600 kg/m^3. Preliminary observations of foam indicate that it is a liquid with a dark brown color and oily form. To produce stable foam from aqueous foam, one liter of protein foam is thoroughly mixed with 30 liters of water with a mixing machine. [16].

III. RESEARCH METHOD

Time and Place

Research on the manufacture of light bricks was carried out at PT Abadi Utama Genteng, which is located at Karangpandan Highway 265, Bendo T-junction, Pakisaji, Kepanjen, Malang Regency, East Java. This company is a home industry company engaged in the production of building material products.

Equipment and Materials

Some of the equipment needed to produce light bricks includes a molen machine to mix the ingredients into a homogeneous dough; Hydraulic presses and master light brick mold to form or print light bricks Also needed is an open space protected from rain and heat used for temporary storage and a light brick drying process. All facilities and infrastructure needed for this research are available at PT Abadi Utama Genteng.

The materials needed in the manufacture of light bricks in this study are divided into: two categories, namely main materials and supporting materials. This main ingredient is the basic ingredient needed to produce light bricks. The main materials used are cement, fine sand, and fly ash, rock ash, and foam

agents. The cement used is Gresik cement, which is a type of PCC cement (Portland Composite Cement). The supporting materials that need to be prepared are biodiesel and wax, which are used as lubricants in the mold.

Light Brick Production Process

The steps involved in the process of making light bricks are as follows:

1. Selection of main raw materials

All raw materials contained in the production area will be subject to a Quality Control (QC) process to ensure that the raw materials to be used are still suitable for use and appropriate. The main raw material used in the production of light bricks is fine sand, which is a solid material taken from the Bengawan Solo rivers in Lamongan for the East Java region it is easy to find in the Lamongan area and the coastal area of the north coast of the Lamongan area.

Measurement of the main raw materials

After going through the raw material selection process, the next step is measuring the amount of material to be used in accordance with the desired composition. Composition dosing What is done is to use the ratio of the volume of raw materials. The main ingredients needed measured, namely fine sand (51.31%), rock ash (2.85%), fly ash (10.01%), cement (26.5%), and foam agent.

Mixing of the main raw materials

In this process, all the main raw materials will be mixed with the addition of water into a homogeneous and ready-to-print mixture of light brick material. This mixing process done using a molen. This is very influential on the quality of light bricks resulting. If the mixture is not homogeneous, it can cause light brick strength to not flat and easy to crack.

Mixing supporting materials

The supporting materials mixed in this process are biodiesel or palm oil frozen night or batik night. The composition used is 75% biodiesel or palm oil and 25% frozen thawed wax. This mixture will be used as a lubricant for mold mattress or mold master.

Light brick molding

The procedure for making light bricks is to take the dough from a molen machine that has been used mix it evenly into the measuring cup then pour the mixture into the master steel mold and level the entire surface. The next process is to open the brick mold which must be done carefully, then move to the drying area.

Light brick drying

During the drying process, light bricks only need to be watered for 10 consecutive days. This is intended so that the drying process takes place slowly and light bricks do not suffer cracks or damage.

Light brick storage

After the 15^{th} day, the light bricks are ready to be stored in the storage warehouse. New light brick can be used after reaching the age of 20 days at the start of manufacture. Light brick in less than 20 days, can be used for building wall structures or *dak* of the light brick floor in this research.

Testing Method

Mechanical testing of light bricks was carried out at the Civil Engineering Laboratory, Brawijaya University, Malang. In general, light brick testing must refer to the Indonesian National Standard (SNI) 8640:2018, there are 3 tests that need to be carried out on light bricks, where the test parameters are required in accordance with these standards, namely as follows: [17]

1. Compressive strength test

The compressive strength test is a mechanical test tool that is useful for measuring and determining the strength of an object to pressure. This compressive strength test has good performance and quality for knowing the power of things. In general, this compression test is used on brittle metals because this pressure test tool has a breaking point that is clearly visible when testing the objects.

2. Test the weight of the contents

The unit weight test aims to determine the density of light bricks that have been produced so that they can be known whether the material produced fits the light brick criteria or not.

3. Water absorption test

This water absorption test aims to determine the light brick body cavity that can cause additional weight when hit by rainwater resulting in additional problems in building a strong structure.

IV. RESULT AND DISCUSSION

Light Brick Compressive Strength Testing

Table 1, the results of the compressive strength of 20 samples of light bricks made of Lumajang sand, which was carried out on February 27 - March 2, 2023, with testing number 3010/UN/10. F.07.40/III/2023.

Table 1. The result of the light brick compressive strength test

No.	Types of Light Brick Construction (Cm)	Weight (Gram)	Crushing Pressure (KN)	Breakdown Stress (Kg/Cm^2)	Corrected Crushing Stress (Kg/Cm^2)	Average Crushing Stress (Kg/Cm^2)
1	9.9×9.9×9.8	635.00	12	12.49	12.49	17.54 kg/cm^2
2	9.9×9.9×9.8	602.00	20	20.82	20.82	
3	9.9×9.9×9.8	635.00	14	14.58	14.58	
4	9.9×9.9×9.8	539.00	14	14.58	14.58	
5	9.9×9.9×9.8	727.00	23	23.95	23.95	
`6	9.9×9.9×9.8	664.00	18	18.74	18.74	
7	9.9×9.9×9.8	662.00	19	19.78	19.78	
8	9.9×9.9×9.8	631.00	16	16.66	16.66	
9	9.9×9.9×9.8	642.00	16	16.66	16.66	
10	9.9×9.9×9.8	662.00	14	14.58	14.58	
11	9.9×9.9×9.8	654.50	15	15.62	15.62	
12	9.9×9.9×9.8	650.50	17	17.70	17.70	
13	9.9×9.9×9.8	567.50	18	18.74	18.74	
14	9.9×9.9×9.8	604.50	14	14.58	14.58	
15	9.9×9.9×9.8	611.00	23	23.95	23.95	
16	9.9×9.9×9.8	633.50	20	20.82	20.82	
17	9.9×9.9×9.8	594.00	14	14.58	14.58	
18	9.9×9.9×9.8	582.50	9	9.37	9.37	
19	9.9×9.9×9.8	581.50	21	21.86	21.86	
20	9.9×9.9×9.8	602.00	20	20.82	20.82	

The compressive strength test on light bricks, after the 20-day age test, started from the process of light brick manufacturing from the beginning of the material by mixing light brick materials with the appropriate composition, pouring water into the light brick mortar, the mixing process is carried out until the composition mixed well, after a light brick mortar, which then forms it with special molds; after one day, the light bricks were carefully unwrapped and then dried but dried bricks must be protected from direct sunlight and light brick care by watering the light bricks for 10 days, and 15 days later, the light bricks are placed in storage, and 20 days later, the light brick material can be used or wore then the light brick test object was held.

Testing in the Laboratory of Structures and Construction Materials, Faculty of Engineering, Department of Engineering Civil University of Brawijaya. The first time, a compressive strength test of light brick workpieces of this size was carried out 60 x 20 x 10 cm was first cut or sawed with a light brick saw from one light brick divided into 6 parts with the size after being sawed according to the size of 9.9 × 9.9 × 9.8 cm as shown in Table 1: Compressive strength test of light bricks from 20 samples tested as a whole as an example in Table 1 samples of the five types of light brick construction with a size of 9.9 x 9.9 x 9.8 cm, weight of 727 grams, pressure crushing force of 23 KN, crushing stress of 23.95 kg/cm^2, corrected crushing stress of 23.95 kg/cm^2, and strength test press for successive workpieces according to the drawing up to the 20^{th} (twentieth) sample, then the average yield of the samples from the first to the twentieth sample averages 17.54 kg/cm^2. So according to the test, compressive strength, so that it meets the requirements of SNI 8640:2018. [18]

Light Brick Content Weight Testing

Table 2, it can be seen the results of the content weight of light bricks in 20 samples carried out on dates 27 February – 2 March 2023 with the testing number of 3010/UN/10. F.07.40/III/2023.

Table 2. The result of the Measurement of the Content Weight of Light Bricks

No.	Types of Light Brick Construction (Cm)	Wet Weight (Gram)	Dry Weight (Gram)	Water Weight (Gram)	Wet Content Weight (Kg/m^3)	Dry Content Weight (Kg/m^3)
1	9.9×9.9×9.8	854.00	635.00	219.00	889.12	661.12
2	9.9×9.9×9.8	831.50	602.00	229.50	865.70	626.76
3	9.9×9.9×9.8	863.00	635.00	228.00	898.49	661.12
4	9.9×9.9×9.8	822.00	539.00	283.00	855.81	561.17
5	9.9×9.9×9.8	911.50	727.00	184.50	948.99	756.90
`6	9.9×9.9×9.8	905.50	664.00	241.50	942.74	691.31
7	9.9×9.9×9.8	881.50	662.00	219.50	917.75	689.23
8	9.9×9.9×9.8	852.00	631.00	221.00	887.04	656.95
9	9.9×9.9×9.8	864.50	642.00	222.50	900.05	668.40
10	9.9×9.9×9.8	884.50	662.00	222.50	920.88	689.23
11	9.9×9.9×9.8	879.50	654.50	225.00	915.67	681.42
12	9.9×9.9×9.8	879.50	650.50	229.00	915.67	677.25
13	9.9×9.9×9.8	824.00	567.50	256.50	867.89	590.84
14	9.9×9.9×9.8	839.50	604.50	235.00	874.03	629.36
15	9.9×9.9×9.8	845.50	611.00	324.50	880.27	636.13
16	9.9×9.9×9.8	853.50	633.50	220.00	888.60	659.56
17	9.9×9.9×9.8	828.50	594.00	234.50	862.57	618.43
18	9.9×9.9×9.8	827.00	582.50	244.50	861.01	606.46
19	9.9×9.9×9.8	826.50	581.50	246.00	860.49	606.42
20	9.9×9.9×9.8	828.50	602.00	226.50	862.57	626.76

Based on the light brick fill weight test using light brick workpieces of the same size 60 × 20 × 10 cm was first cut or sawed specifically for light brick saws from one light brick it is divided into 6 parts with the size after being sawed according to the size of 9.9 × 9.9 × 9.8 cm as shown in Table 4.2: The test for bulk density of light bricks is obtained as follows, among others: the first sample of this type of light construction brick with a size of 9.9 x 9.9 x 9.8 cm, wet weight of 854 grams, a dry weight of 635 grams, and water weight of 219 gram, the wet density is 889.12 kg/m^3, and the dry density is 661.12 kg/m^3.

The light brick workpiece density test is then continued for successive workpieces according to Table 2 to the 20^{th} (twentieth) sample, then the average sample results from the first sample to the twentieth, the average yield was 649.741 kg/m^3. In addition, the fifth sample, with a size of 9.9 x 9.9 x 9.8 cm for a wet weight of 911.50 grams, a dry weight of 727 grams, a water weight of 184.5 grams, a wet content weight of 948.99 Kg/m^3, and a dry content weight of 756.9 Kg/m^3. So, among the 20 largest samples is number 5 in terms of wet weight, dry weight, wet content weight, and dry content weight is the biggest, but in terms of water weight, the smallest of the 20 (twenty) samples.

Figure 1. Test Sample and weighing of weight and water absorption testing of light brick

The Water Absorption Testing

Table 3, It can be seen the results of the water absorption test conducted on 20 light brick samples with a mixture of Lamongan sand. This test was carried out on February 27, 2023, with a testing number of 3012/UN/10. F.7.40/III/2023.

Table 3. Light Brick Water Absorption Test

No.	Kinds of Construction	Wet Weight (Gram)	Dry Weight (Gram)	Water Weight (Gram)	Water Absorption (%)	Average Water Absorption (%)
1	Size of Light Brick 9.9x9.9x9.8 cm	854.00	635.00	219.00	34.49	37.38
2		831.50	602.00	229.50	38.12	
3		883.00	635.00	228.00	52.50	
4		822.00	539.00	283.00	52.50	
5		911.50	727.00	184.50	25.38	
`6		905.50	664.00	241.50	36.37	
7		881.50	662.00	219.50	33.16	
8		852.00	631.00	221.00	35.02	
9		864.50	642.00	222.50	34.66	
10		884.50	662.00	222.50	33.61	
11		879.50	654.50	225.00	34.38	
12		879.50	650.50	229.00	35.20	
13		824.00	567.50	258.50	45.20	
14		839.50	604.50	235.00	38.88	
15		845.50	611.00	234.00	36.38	
16		853.50	633.50	220.00	34.73	
17		828.50	594.00	234.50	39.48	
18		827.00	582.50	244.50	41.97	
19		826.50	581.50	245.00	42.13	
20		828.50	602.00	226.50	37.62	

Based on Table 3: Light Brick Water Absorption Test, in the above test, the initial light brick sample is soaked in water until saturated, then its mass is weighed (SDD). After that light brick is dried until the water content is gone using an oven, and then the mass is weighed again. The difference between the mass of saturated water and the oven is used as a reference to determine the absorption capacity of light bricks to water, and the result of average water absorption is 37.36%. Apart from that, out of 20 (twenty) samples, number 5 has the lowest absorption at 25.38%.

These results were then calculated as a percentage of the dry mass. For that complete data result, water absorption testing can be seen in Table 3. From the results of the three tests mentioned above generally, Lamongan sand light brick has the lowest absorption power, which causes damage to light bricks, which makes the quality of light bricks become good, while the strong compression test has the highest crushed stress.

V. CONCLUSIONS AND SUGGESTIONS

Based on the research that has been done, it can be concluded as follows:

1) The compressive strength test of light bricks was carried out on 20 samples measuring 9.9 x 9.9 x 9.8 cm, weight at 727 grams, crushed pressure at 23 kN, crushed stress at 23.95 kg/cm^2, corrected crushed stress 23.95kg/cm^2 and compressive strength test for workpieces according to the drawing up to the 20th sample (twenty), then the average result of the sample from the first sample to the twentieth is the average result at 17.54 kg/cm^2. So, according to the compressive strength test, it meets the requirements of SNI 2018: 8640.
2) The weight content testing for 20 light brick samples gave an average value of 649.741 kg/m^3.
3) The water absorption testing for light bricks using Lamongan sand of the testing above, 20 samples of light bricks were soaked in water until saturated, and then their mass was weighed (SDD). After that, the light bricks are dried until the water content is gone using an oven then it is weighed again. The difference between the mass of saturated water and the oven is used as a reference to determine the absorption capacity of light bricks in water, and the average water absorption results are 37.36%. In addition, of the 20 (twenty) samples in number 5, the lowest absorption was at 25.38%.

Some suggestions that can be submitted based on research results include:

1) Follow-up research, that it is better to use other materials that are softer and smoother.
2) Besides that, further research uses other materials with varied percentages.

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