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Effect of Bamboo & Ficus Alestica's leaves Addition on properties Fired Clay Bricks

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ABSTRACT: *Organic waste from leaves contributes to the increase in the amount of organic waste that is piled up in open fields, if this is not handled properly it will provide the potential for environmental pollution. The purpose of this study was to obtain the characteristics of bricks by utilizing an additional mixture of 70% bamboo leaf waste and 30% ficus alestica (B-Fa). The composition of additives made 1, 3, 5, 7 and 9% w / w by weight of clay. After mixing organic matter, clay and water and formed a cube of 5 cm x 5 cm x 10 cm, the sun is drained for 3 days. raw coal is burned using an electric furnace for 5 hours at a temperature of 1000 ^oC. The clay brick test results are as follows: The characteristics of clay bricks with 70% bamboo leaves and 30% ficus elastica waste additives obtained compressive strength, drying shrinkage, porosity, and density were 25.61-50.78 kg/cm^2; 1.04-2.21%; 14.81-19.61%; and 1.73 to 2.50 g/cm^3, respectively*

KEYWORDS:- *brick, compressive strength, drying shrinkage, apparent porosity, bulk density*

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I. INTRODUCTION

Garbage in Malang City Indonesia continues to increase in number from year to year, if this increase is not balanced with good handling it will become a problem for the environment and can disturb living things. The amount of waste is usually dominated by food scraps, shredded leaves, plastic bags, used cloth, paper, cardboard, rubber, broken household appliances and so on. Disposal of waste by stacking (landfill) will cause odors and gases that are harmful to human health and the occupancy around the disposal site becomes uncomfortable (Lichovníková et al., 2015; Gębicki et al., 2017; M. D. Vaverková et al., 2019; M. D.. Vaverková, 2019)

Combustion of organic waste generally often leads to air pollution (Lemieux et al., 2004; Estrellan & Iino, 2010; Solorzano-Ochoa et al., 2012), this burning behavior is often carried out if besides the tradition of throwing garbage in the river can cause biota in the river disrupted and blockage of the river flow can cause flooding, and can cause unpleasant odors due to the decay of the garbage (Pieters, 1991; Knussen & Yule, 2008; Liu & Huang, 2014)

The processing of organic waste that is often done include composting, the end result of which is compost, which can be useful for fertilizing agricultural crops. The compost produced from this organic wastes is widely used in the rural community, but to process organic waste in large quantities requires extensive land, the process of making and storing products and requires time (Adekunle et al., 2011; Oberlin & Szántó, 2011; Alvarenga et al., 2015; Kadir et al., 2016). Another treatment process that is often carried out by the community that is most effective and quick is to do open burning, but this treatment often causes air pollution problems resulting from the combustion and the heat energy released is often not utilized properly (Estrellan & Iino, 2010).

In the previous research, it was obtained the characteristics of clay brick using rice husk additives (Tonnayopas et al., 2008; Agbede & Joel, 2011; Görhan & Şimşek, 2013; Kizinievič et al., 2018; Phonphuak et al., 2019), but the selling price of rice husk has recently increased in price because it can be used as a medium for ornamental plants or as a mixture of chicken feed (Giddel & Jivan, 2017; El Sharkawi et al., 2014; Panj et al., 2014)

Based on the description above, a study was carried out on the utilization of bamboo and ficus elestica leaves waste mixture as an additional material in the manufacture of environmentally friendly clay bricks while also primarily to reduce the impact of these wastes on health when landfills were carried out on open land. From this research, it is expected to obtain brick characteristics that meet Indonesian industry standards.

II. MATERIAL AND METHODS

Materials

waste mix of Bamboo leaf- ficus elastica leaf and clay were from Malang, East Java, Indonesia. Chemical compositions were shown in Table 1. X-Ray florescence analysis of clay and organic waste were shown in Table.1.

Table 1. elements of the clay and organic waste(mix of 70% bamboo & 30 % Ficus Alestica's leaves).

Name of element	Composition (%)	
	Clay	B-Fa
Fe	47.69	7.73
Si	27.30	42.20
Al	11.00	0
Ca	6.32	30.00
Ti	2.16	0.56
K	1.85	11.40
Mn	1.00	0.43
P	0.66	1.60
Eu	0.59	0.10
Sr	0.56	0.00
Re	0.30	0.50
Cu	0.22	0.32
Ba	0.20	0.30
V	0.15	S
Cr	0.08	0.00
S	0.00	2.70

Three different types of secondary materials are used in the composition of the brick matrix, in order to produce products that meet regulatory requirements and have characteristics comparable to traditional bricks.

1) Clay
2) Organic waste was obtained by mixing 70% bamboo leaves with 30% ficus alestica leaves. This organic waste mixture was crushed to reduce its size using a crusher then grinding tools. Figure 2. (a) (b)
3) Water

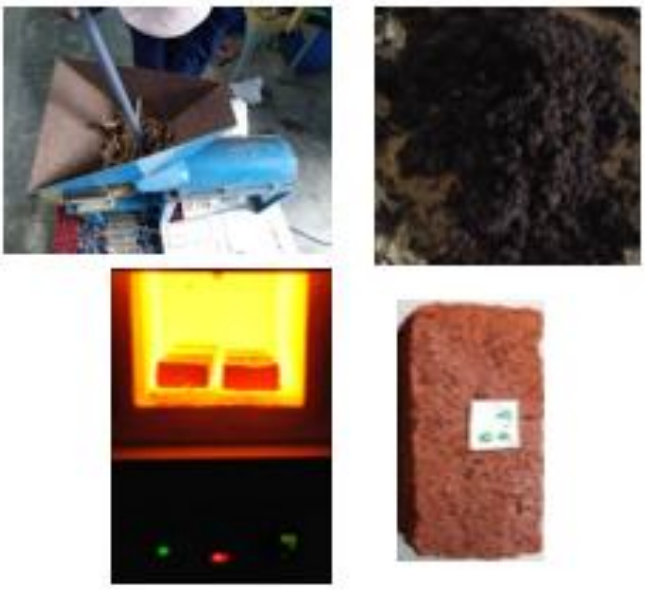

Figure 1: Raw materials (crushed mix of bamboo and ficus Alestica's leaves, clay) and shaped samples (fired brick in electric furnace left, fired brick right).

Equipment

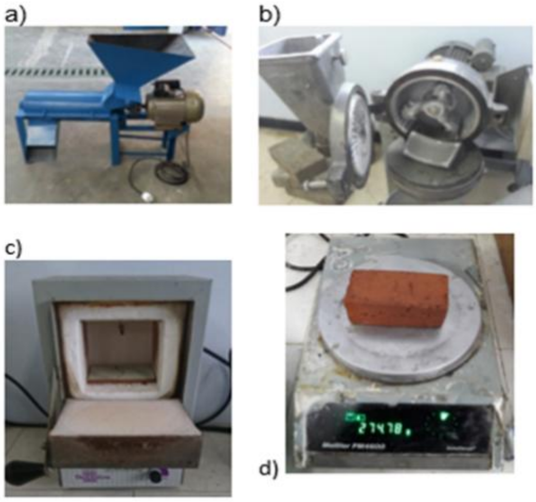

Figure 2: Equipments: a)Coarse Crusher, b) Hammer crusher, c) electric furnace, and d)analytical balance)

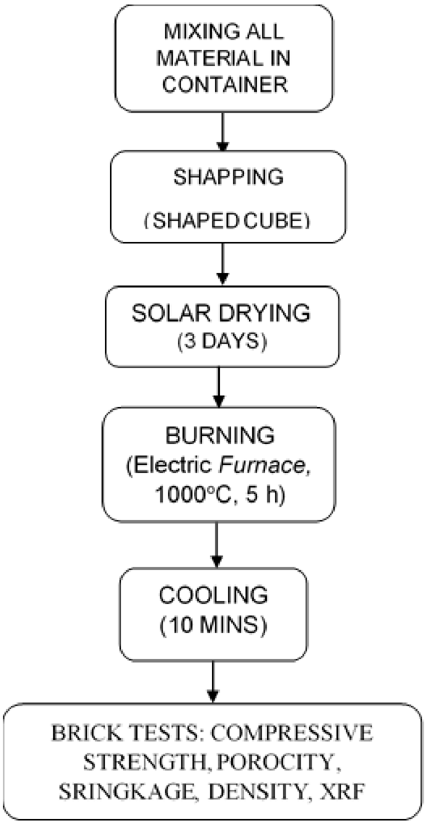

Figure 3: Flow of Fired Clay Brick Making

Clay bricks are artificial materials produced by humans for building purposes that have proven to be easy to produce, resistant and durable, as evidenced by many examples found in various parts of the world that have experienced various climacteric conditions for centuries. This clay brick is produced by mixing clay with water. Hardening methods evolved from solar drying to industrial ovens, which allowed the strength and durability of bricks to increase. Meanwhile, the durability of clay bricks was initially affected by inadequate raw materials and contamination in their use, but at present, urban pollution and improper use of materials increase brick damage more quickly, adding to the lack of maintenance that occurs in most buildings. By understanding how bricks are damaged, a series of manufacturing methods and raw materials used can be improved to improve clay brick odor quality.

Clay bricks are made by forming "clay dough" in molds of standard size, which are then burned at a temperature of 900-1150 ° C for 8-15 hours. Burnt products in the form of ceramics consisting mainly of silica (55-65%) and alumina (10-25%) combined with as much as 25% of other constituents. Quartz sand is a common and desirable mixture of clay bricks because it reduces shrinkage, helps demoulding, and encourages the drying process by creating an open texture. This additional sand is sometimes added to clay as an "inert filler", and other fillers commonly used are crushed stone, burned household waste, and used bricks. A common practice is to add a certain amount of fuel to the bricks to produce more even combustion, such as coking coal or powder.

Color is an important characteristic of clay bricks which depends on the chemical composition of raw materials and the nature of the combustion process. As a general rule, the color of a brick is determined by the iron content and calcium carbonate content of the raw material, combined with the amount of oxygen in its combustion. The color of bricks is not always uniform and bricks with mixed colors can be produced from variations in raw materials, or from thermal gradients that develop in bricks during the combustion process. Black spots and black cores can be produced from the inclusion of carbonaceous and flammable materials which create reduction conditions in bricks. The superficial color of the bricks can be controlled by treating the outer surface with sand or pigment before burning.

Apparent Porosity of bricks depends on the composition of clay raw materials and the temperature / duration of combustion and can range from 1-50%. The vitrification matrix usually contains several micropores (<1 µm) but there is usually continuous tissue from a larger pore cavity.

To make clay bricks as sustainable building materials, the use of agricultural and industrial waste materials is one practical solution. Researchers have examined various waste materials in different compositions as additional raw materials at different dosage levels for making clay bricks. The main function of this waste material is to act as pore formers in the clay body. Types of waste, properties, and durability of bricks that use waste as pore forming have been reported in several research results (Gadioli et al., 2006; Okunade, 2008; Pawar & Garud, 2014; Sultana et al., 2014; Coronado et al., 2015; Phonphuak & Chindaprasirt, 2015; Korah et al., 2016; Mendívil et al., 2017).

III. RESULTS

The abundance of bamboo ficus and ficus alestica leaves (a type of banyan tree) makes the environmental impact due to the leaf fall contribute significantly to the amount of organic waste every day, the use of waste as raw material for clay brick can provide an alternative as a substitute for rice husk which has been used as material raw or clay brick fuel. Tests carried out include: compressive strength test, drying shrinkage, apparent porosity, and bulk density of bricks with additional raw materials of rice husk or a mixture of bamboo-ficus alestica leaves waste shown in tables 5.1 to table 5.2. The results obtained have similarities between the two types of additives, and the percentage of the addition of these additives as shown in Tables 5.1 to 5.2 of the use of a mixture of bamboo-ficus alestica leaves waste additives (70; 30) with the largest percentage of 9% w/w of clay weight still meets the Indonesian National Standard from all aspects of testing. This shows that bamboo and Ficus alestica leaves waste can be used as an additional raw material in making clay brick, in the largest composition in this study, 9% w / w mixture of bamboo-ficus alestica leaves waste can replace the role of rice husk which has been the craftsmen brick making uses it as an additive which functions as an assistant in combustion and also as a pore maker in the bricks produced. This substitution provides a solution to reduce the volume of waste from bamboo and ficus elastica leaves which has been collected / disposed of at a temporary disposal site (TPS) or at a landfill site.

Compressive Strength Analysis

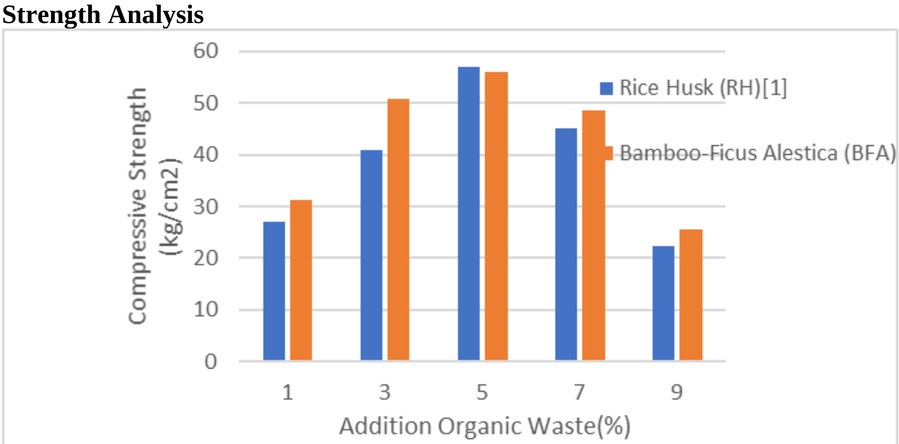

Figure 4: Comparison of Compressive Strength for different % of RH and B-Fa

This compressive strength test is intended to determine the extent of the role of additives both rice husks and 70% bamboo leaf waste mix - 30% ficus alestica leaf (B-Fa) with a percentage of 1; 3; 5; 7; and 9% w / w to clay to determine the effectiveness of the use of the proportion of rice husks and bamboo leaves + ficus alestica as additives in clay bricks. The results of compressive strength analysis are presented in Fig.1.

The compressive strength test results show that the strength of the bricks depends significantly on the amount of rice husk additives as well as the bamboo-ficus alestica leaves waste mixture added to the bricks, from table 5.1 showing that the amount of 5% mass added material provides optimum compressive strength. However, the strength of this clay brick is decreased by the addition of additional materials 7% and 9% by weight, the decrease in strength is due to the increasing number of organic additives, the more additives undergo combustion so that the shrinkage is also greater, the decrease in the value of this shrinkage is also causes the bonding of particles in clay to decrease and the rate of shrinkage usually depends on several factors including the characteristics of the material, the proportion of the material, the way of processing, the amount of water content and dry conditions (Nwoye et al., 2014;(Suwardono, 2002)

In general, the percentage of the use of bamboo and Ficus elestica leaves waste as an additional clay brick material as in table 5.1 above shows that it has a higher compressive strength than using rice husk additives, although at a composition of 5% by weight it produces optimum compressive strength at the range of 50 kg/cm^2 is slightly smaller than using additional rice husks 56.95 kg/cm^2. The greater compressive strength can be made possible by the composition of the waste elements of bamboo leaves and ficus alestica (Ca 30%; Fe 7.73%; K 11.4%; P 1.6%; S 2.7; Si 42.2 %) which has a more complete elemental composition than rice husk (Ca 0.54%; Fe 0.03%; K 0.94%; Si 82%), the elemental components, especially calcium and iron, can influence the compressive strength slightly higher compared to using additional ingredients of rice husk.

The addition of rice husk additives (Zamrudy et al., 2019) or a mixture of bamboo-ficus alestica leaves waste of more than 5% (additional ingredients 7% and 9% w / w) causes a decrease in compressive strength but still meets minimum standards. The decrease in compressive strength is very much related to the volume of the organic mass undergoing an oxidation (combustion) reaction, where the organic material evaporates during combustion. As a result the empty space resulting from combustion causes a decrease in the compressive strength of clay brick.

Drying Shrinkage analysis

Long dimension drying shrinkage in bricks caused by loss of water forming from the rest of the drying bricks experiences more evaporation with increasing burning time. Drying is the most important stage of the brick manufac-turing process. Small cracks may develop during drying, causing a failure during firing. The drying stress increases as the shrinkage increases and the clay body is more suscep-tible to cracking (Demir, 2008). Clay particles combine with ash originating from organic material additives in both rice husks and bamboo and ficus elastica leaves waste mixture which are burned from burning furnaces which causes bonding between clay particles to become denser so that the long dimensions of the bricks make the shrinkage of the burn bigger. From the results of drying shrinkage analysis, the more the composition of rice husk and bamboo-ficus alestica leaves mixture added, the greater the shrinkage, except for variations in the composition of rice husk 7% which experienced a slight decrease with the percentage of the value of drying shrinkage of 1.99%. The minimum brick drying shrinkage is obtained with a composition of 1% with a percentage of the value of the drying shrinkage in the range of 1.05% and the maximum occurring at the composition of 9% produces shrinkage in the range of 2.21-2.44%. The results of this test indicate that the more organic material added to either rice husks or a mixture of bamboo-ficus alestica leaves, the greater the value of drying shrinkage that can be shown in Figure 5. The greater the shrinkage is due to additional material that is mixed with clay bricks undergo chemical reactions (oxidation) of organic material both rice husks and a mixture of waste bamboo-ficus alestica produce carbon dioxide. Overall yields of rice husk shrinkage and bamboo-ficus alestica leaves waste mixtures with composition (1, 3, 5, 7, and 9% w/w) are included in the established standards (<2.5%) all of them meet the provisions with no more than 2.5% value (Suwardono, 2002)

Experiments for making bricks from clay mixed with bamboo and ficus elastica leaves waste additives produce increased shrinkage with increasing magnitude of additives. The minimum drying shrinkage value is obtained at the composition of 1% with a percentage of 1.04% while the maximum drying shrinkage is obtained at the composition of 9% with a percentage of 2.21%. However, compared to burnt rice husk, the waste of bamboo & ficus elastica leaves was lower in all added additive compositions.

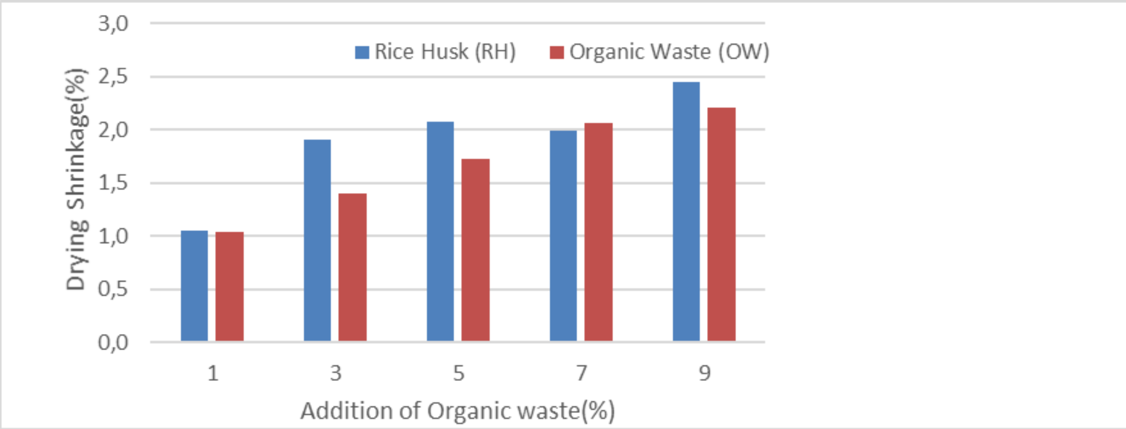

Figure 5: Comparison of drying shrinkage for different % of RH and B-Fa

Apparent Porosity Analysis

The porosity or absorption test aims to determine the ability of bricks to absorb water in each variation of the percentage of additional material added to the brick making. Based on the reference porosity of the maximum brick is 20%. Experiments with the addition of rice husk additives show the results of testing the higher the percentage of rice husk, the greater the porosity, this porosity is the pores resulting from the combustion of organic material CxHyOz + O_2 -> CO_2 + H_2O so that from chemical reactions (oxidation) produce carbon dioxide gas and water that can cause cavities that we recognize as pores.

The use of a mixture of bamboo & ficus elastica leaves (B-Fa) additives gives results similar to rice husk additives, which increases porosity as the composition of the additives increases, because the main function of the waste mixture is to act as a pore forming agent in the soil body see. When compared to rice husk additives, the absorption capacity of organic waste is slightly higher and this can be seen in table 1. This increase in porosity can be due to the increasing percentage of rice husk additives or bamboo & ficus elastica leaves mixture, the greater the ash loss due to combustion leaving cavities in the clay causing the value of porosity to increase, thereby increasing the insulation properties. (Demir, 2008).

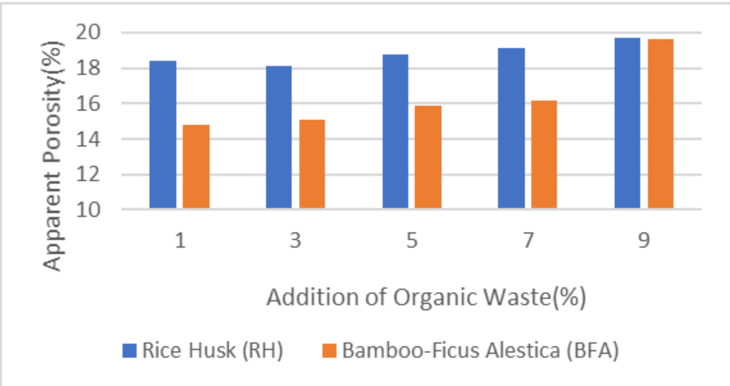

Figure 6: Comparison of apparent porosity for different % of RH and B-Fa

Bulk Density analysis

Density testing is carried out to determine the density of each brick sample. The value of good brick density has a standard 1.60 - 2.50 g/cm^3 (SNI-03-4164-1996). The results of testing the density of bricks with the addition of husks or a mixture of bamboo-ficus alestica leaves waste all meet SNI-03-4164-1996 standard (Standar Nasional Indonesia, 1996), ranging from 1.60 - 2.50 g/cm^3. The density value as shown in Fig. 6 that the more the composition of rice husk additives and the additive mixture of bamboo-ficus alestica leaves waste added to clay bricks the density value decreases this is due to the increasing occurrence of evaporation of rice husk and leaf waste mixture bamboo-ficus alestica when burning. The density characteristics of bricks using bamboo - ficus elastica leaves waste have a similar tendency to the use of rice husk additives that is decreasing with increasing composition added, but when viewed from the density values shown in table 5.8 there is an increase in all additional ingredients composition added which means the density of bricks using a mixture of bamboo leaves and ficus eleastica waste has a higher density than using rice husk additives.

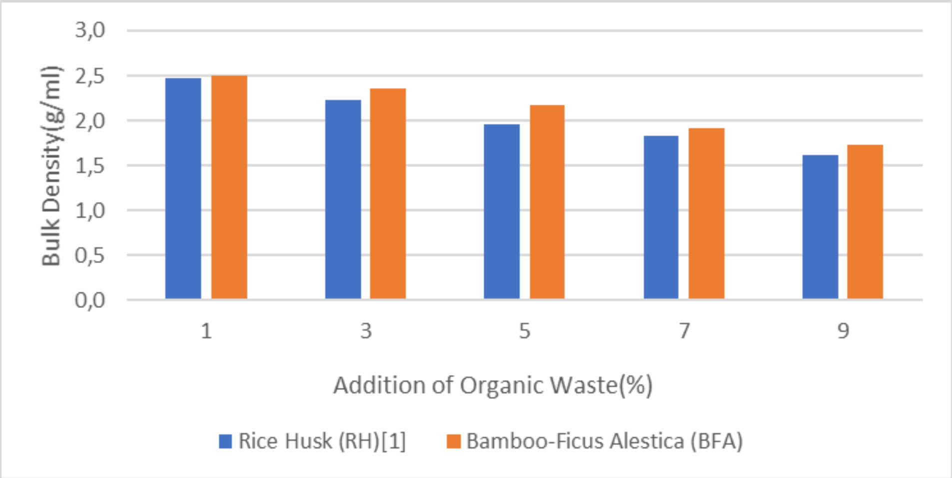

Figure 6: Comparison of bulk density for different % of RH and B-Fa

XRF analysis

The use of raw materials in the manufacture of these bricks consisting of clay, rice husk, bamboo leaf waste and ficus elastica. The raw material is analyzed using XRF (X-Ray Fluoresence) to determine the elemental oxides in the raw material.

In clay, the highest elemental oxide composition was 33.79% Fe_2O_3 and 29.01% SiO_2. Whereas the largest oxide content of rice husk is SiO_2, which is 98.49%, while the mixture of bamboo leaves and ficus elastica waste is the largest content of SiO_2 52.91% and CaO 24.57%.

The linkage of elemental oxides to the raw material has an effect on the results of the bricks in all tests carried out such as the compressive strength test, porosity test, drying shrinkage test, and the density test of the product. High silica element oxide in rice husk produces optimum bricks products in the composition of additional ingredients of rice husk 5% with compressive strength value of 56.95 kg/cm^2 meets SNI 15-2094-2000 (Anonim, 2000) (> 50 kg/cm^2), the value of drying shrinkage 2.07% (<2.5%), porosity test 18.79% (<20%), density 1.96 g/cm^3 (1.6-2.50 g/cm^3).

IV DISCUSSION AND CONCLUSION

A mixture of bamboo and Ficus alestica leaves waste can be used as additives in clay bricks with physical properties obtained by compressive strength, drying shrinkage, porosity, and density were 25.61-50.78 kg/cm^2; 1.04-2.21%; 14.81-19.61%; and 1.73 to 2.50 g/cm^3, respectively.

The use of bamboo-ficus alestica leaves waste mixture as an additional material in this clay brick has a fairly high innovation value in terms of economic value, there are several advantages, including: additional raw materials are available and not valuable (can be obtained free of charge) and problems pollution to the environment can be handled and minimized.

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