PERFORMANCE OF MODIFIED FLY ASH-BRICKS WITH SAGO HUSK AS FILLER FOR NON-STRUCTURAL ELEMENT IN HOUSING

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Abstract: - This paper scrutinizes the effect of additive material, fly ash, to modified bricks with sago husk as filler to be utilized as non-structural element of building. This innovation is expected to improve productivity and efficiency of brick production since without fly ash, the brick production takes 1-2 weeks with approximately 70% efficiency. The laboratory test was conducted in this research. It can be seen from the result that the duration of brick production can be reduced to merely 2–3 days. The compressive strength shows better result than bricks without fly ash, with 19 MPa in average. However, increase of sago husk content in fly ash – brick will decrease the compressive strength that still meet code's requirements.

Key-Words: - sago husk content, modified fly ash-bricks, productivity, initial rate of suction**,** compressive strength.

1 Introduction

Utilization of modified materials in green construction has been one of which attracts assiduousness of researchers, particularly utilization of recycled material in general parts of building, due to the efforts in diminishing inadequate impact to environment as a result of human activities. In terms of building construction, they should meet the minimum requirements or standards i.e. strength and serviceability. Numerous findings denotes reliable results on this regard, including modified bricks e.g. modified bricks with sawdust as filler [1], modified bricks with husk as filler [2], and modified bricks with reed as filler [3,4,5].

In recent development, various efforts have been accomplished in obtaining advantage in economic aspect. Productivity and efficiency will always be the challenge for those involved in home industry scale, e.g. local ward production in Kendari, Indonesia. Conservative techniques that they are using to carry out do not ameliorate what should be done to be competitive in terms of market price, not to mention that should suddenly high demand occur due to the inexorable rise of housing needs. Normally, it needs 1-2 weeks of brick production in local ward, and approximately 60 to 70% that could be vended. Therefore, there must be enhanced methods in improving the quality, productivity, and efficiency [1,3,4,5,6].

There are at least 5 (five) steps of conventional bricks prodution prior to be put into the market i.e. collecting raw materials (clay and water), molding, drying, burning and unloading. Based on previous research that used waste for bricks filler, there is improvement in burning duration, since those fillers operate as inner burning that might accelerate the process. In addition, there are approximately 80% efficiency which could be achieved and the strength, i.e. compressive strength, increased about 20 to 30% [1,3,4,5].

Sago husk as filler is expected to yield similar performance as sawdust and sago husk did on previous research since it also has hygroscopic properties. In its sago production ward, in Konawe – South East Sulawesi, Indonesia, utilization of sago husk will be very beneficial for the environment since the waste is always uncontrolled and causes bad impact to the river stream [7]. This has been ensuing continuously since sago is mainly traditional food of local people. On the other hand, another additive free waste material might be used for bricks. Fly ash might result on hydration in brick mixtures since it has properties like cementitious material. Fly ash is expected to accelerate the drying process, and increase the strength of the bricks. [8,9,10].

Fig.1 Modified Fly Ash-Bricks with Sago Husk

2. Method

This research was performed in laboratory testing. Two laboratories were facilitated to perform this research i.e. Soil Mechanics Laboratory and Construction Material Laboratory of Faculty of Engineering, Halu Oleo University. Laboratory test included testing on soil and sago husk i.e.sieve analysis, atterberg limit, water absorption, initial rate of suction (IRS) and compressive strength of modified brick. Measured production of modified brick was also carried out from mixing, molding, drying and drying, burning and storage.

Prior to laboratory works, fresh sago husk was first obtained then dried in the open space to gain direct sunlight until its color changed to amber. After that, the sago husk was then severed to the smallest size (± 7 mm), followed by arranging the composition of the water –clay ratio that meets the ASTM standard C216-15 (2015) [12-17], and SNI 15-2094 (2000) i.e. 8 : 1 [18]. Furthermore, the composition of the soil and sago husk was also determined where the average weight of soil was 1.8 kg while the sago husk varied in 8 (eight) composition between 1.3% and 3.2% . Weight measurement of soil and sago husk was performed by digital measuring scales. In addition, soil testing was conducted in laboratory to determine soil classification in accordance with ASTM C216-15 (2015) [12-17], and SNI 15-2094 (2000) [18],. Moreover, the fly ash composition is approximately 7% from the soil weight.

Next, production process was performed by mixing the clay, fly ash with sago husk and water in accordance with the predetermined composition, where 24 pieces of brick for each composition were produced. Each composition was separately and evenly stirred by trampling it until the mixture was not adhere and might be molded. Bricks were molded by rectangular wood with 21 cm length, 11 cm width and 5 cm thickness. Once bricks were completely molded, they were arranged for drying purpose in the outer side of the ward to obtain direct sunlight for ± 2 days. After that, the bricks were burned on a stove with average fire temperature of 550 ^{o}C (measured by fire thermometer). To achieve an entirely heat transfer, bricks were wrapped in aluminum foil and baked for 2 hours. Conventional fly ash-bricks were also produced with similar size and method to be compared with modified bricks in the analysis. Following the burning process, bricks were unloaded and prepared for examination in laboratory that covers density, color, dimension, textures and shapes, compressive strength, water absorption, initial rate of suction and salt content. After examination and laboratory tests, analysis was performed to examine the effect of sago husk on fly ash bricks mixture compared to conventional fly ash - brick as building material.

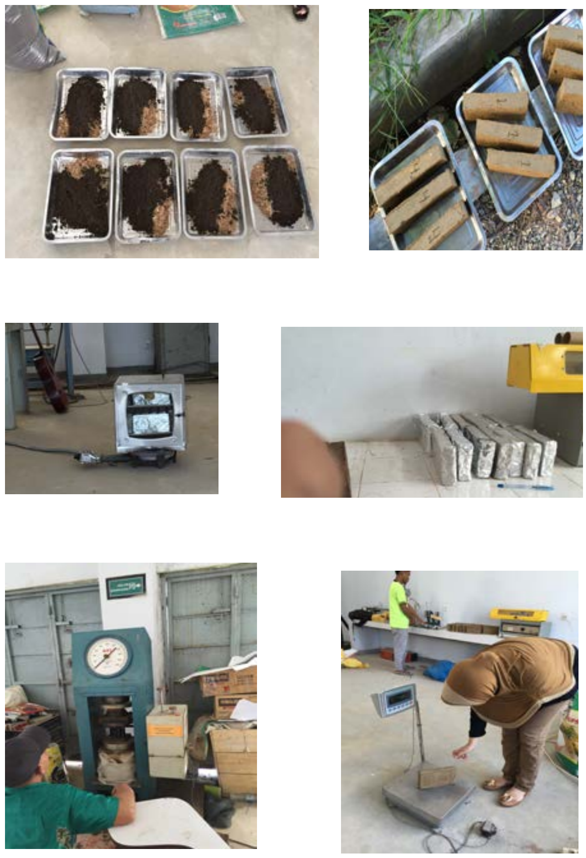

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Fig. 2 Laboratory Works

3. Result & Discussion

As shown on table 1,2 and 3, there were reduction in dimension and volume in comparison of modified bricks to conventional bricks. Dimensions of conventional bricks after burning were reduced with 19.5 cm length, 10.5 cm width, 3.5 cm thickness and 1.2 kg weight in average similar with shrinkage dimension of modified bricks. This uniform reduction of dimension agrees with the presumption that the water should have hydrostatic pressure that is similar to every direction. Moreover, this was generated by the influence of mixture of sago husk, where the sago husk was also burned as inner burning that their dimensions and volume decreased. The lighter brick will provide the better quality of the bricks, as it also consequently reduces the distribution or delivery cost.

Table 1 Brick's Dimension after Drying

Sago husk content	After Drying			
	Length (cm)	Width (cm)	Thickness (cm)	Weight (Kg)
Conv. brick	19,5	10,5	3,5	1,39
1.3% (A)	19,5	10,5	3,5	1,29
1.7% (B)	19,5	10,5	3,5	1,29
2.0% (C)	19,5	10,5	3,5	1,28
2.3% (D)	19,5	10,5	3,5	1,31
2.6% (E)	19,5	10,5	3,5	1,3
2.7% (F)	19,5	10,5	3,5	1,24
3.1% (G)	19,5	10,5	3,5	1,29
3.3% (H)	19,5	10,5	3,5	1,28

Table 2 Brick's Dimension after Burning

Sago husk content	After Burning			
	Length (cm)	Width (cm)	Thickness (cm)	Weight (Kg)
Conv. Brick	19,3	10,3	3,3	1,32
1.3% (A)	19,3	10,3	3,3	1,22
1.7% (B)	19,3	10,3	3,3	1,23
2.0% (C)	19,3	10,3	3,3	1,22
2.3% (D)	19,3	10,3	3,3	1,23
2.6% (E)	19,3	10,3	3,3	1,19
2.7% (F)	19,3	10,3	3,3	1,19
3.1% (G)	19,3	10,3	3,3	1,19
3.3% (H)	19,3	10,3	3,3	1,22

Although the percentage of shrinkage is different, but the actual shrinkage is similar for every composition. A rigorous quality control of the brick production engendered this e.g. using alluminium foil to spread the heat uniformly.

Table 3 Shrinkage Modified Brick with Filler Sago Husk

Sago husk Content	Shrinkage Length	Width	Thickness
Conventional Brick	3.5%	6.4%	17.5%
1.3%	3.5%	6.4%	17.5%
1.7%	3.5%	6.4%	17.5%
2%	3.5%	6.4%	17.5%
2.3%	3.5%	6.4%	17.5%
2.6%	3.5%	6.4%	17.5%
2.9%	3.5%	6.4%	17.5%
3.1%	3.5%	6.4%	17.5%
3.3%	3.5%	6.4%	17.5%

However, modified fly ash – brick has advantage in terms of duration of drying. It only took 1 to 2 days for drying process. On the other hand, without fly ash, modified bricks need at least 1 week for drying process. Due to cementitious properties of fly ash, it absorbs water for hydration process. It also resulted in the weight of the bricks that it is relatively heavier than those without fly ash.

Table 4 IRS and Salt

Sago husk content	Initial rate of Suction (gr/mm^2/minute)	Salt Content
Conventional brick	0,02	< 50%
1.3% (Type A)	0,02	< 50%
1.7% (Type B)	0,03	< 50%
2.0% (Type C)	0,03	< 50%
2.3% (Type D)	0,03	< 50%
2.6% (Type E)	0,02	< 50%
2.9% (Type F)	0,02	< 50%
3.1% (Type G)	0,02	< 50%
3.3% (Type H)	0,02	< 50%

Evaluation of initial rate of suction (IRS) and salt content is presented on table 3 both for conventional bricks and modified bricks. In terms of IRS, both conventional and modified bricks meet the requirement. However, their salt content met the requirement as specified in ASTM C216-15, ASTM C652- 14, ASTM C67-14, C62-10 ASTM, and SNI 15-2094. Furthermore, at the immersion, it was captured that the white crystal did not cover most of the surface of the bricks. Lesser percentage of crystalization will increase the durability of the brick itself. Bricks immersion over 24 hours with cold water (cold water absorption) was intended to look at the maximum capability of brick to absorb cold water (at room temperature) to saturation. Absorption value of bricks indicate less dense composition of bricks so that water can fill cavities in them. it affects on the strength or durability of bricks on bad weather.

In terms of bricks density, all bricks meet the requirement i.e. 1,60 – 2,00 gr/cm^3. Density of bricks is influenced by the composition of the raw materials, mixing process either manual or using blender, and the duration of drying and burning process.

However, as can be seen on table 5, conventional brick reaches 24 Mpa for compressive strength, and classified as first grade based on ASTM C216-15, ASTM C652-14, ASTM C67-14, ASTM C62-10, and SNI 15-2094. On the other hand, in average, modifid brick shows lesser performance than conventional brick. All types are included in first grade, with maximum compressive strength on type A (1.3) for 21.4 Mpa. Brick's compressive strength is influenced by the density and color of the bricks. Should the density is larger, then compressive strength will increase as well. There is a downward trendline. It can be concluded that addition of sago husk in fly ash-brick does not yield similar performance with conventional brick.

Table 5 Compressive Strength of Modified Brick

Sago husk content	Compressive Strength (N/mm^2)
Conventional brick	24
1.3% (Type A)	21,4
1.7% (Type B)	20,5
2% (Type C)	18,8
2.3% (Type D)	17,5
2.6% (Type E)	17,2
2.9% (Type F)	16,4
3.1% (Type G)	16,2
3.3% (Type H)	16,0

4. Conclusion

Test results indicate that the effect of sago husk in a mixture of brick with certain composition show lesser quality compared with conventional fly ash - brick as a building material based on ASTM C216-15, ASTM C652-14, ASTM C67-14 , C62-10 ASTM, and SNI 15-2094. Increase of brick's density at the beginning will not share similar distribution after burning due to insulator's properties of sago husk, modified brick filled improves the quality and quantity of produced bricks.

From the economic and sustainability aspect, it can be concluded that modified fly ash bricks will contribute in time reduction in drying and burning process significantly. Therefore, the production cost can be reduced.

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