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PERFORMANCE OF BRICK WITH SAGO HUSK AS FILLER ON GREEN BUILDING MATERIALS

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ABSTRACT

Sago, acknowledged as one of traditional food of local society in South East Sulawesi, Indonesia, influences the environment in terms of its waste management. This paper assesses performance of sago husk as additive material on bricks beside clay as raw material. 8 (eight) compositions of sago content, varying from 1.30% to 3.30%, were examined on their physical and mechanical properties as building material. Variation on initial rate of suction was also evaluated to obtain the subjected value to the compressive strength. The result shows that all types meet ASTM C216-15, ASTM C652-14, ASTM C67-14, ASTM C62-10 and SNI 15-2094, both the physical and mechanical properties. In average, 0,2% of IRR yields subjected result in acquiring compressive strength for 9,5 Mpa in average. Therefore, utilization of this filler for bricks material might contribute to the criteria of green building since 11 of 14 point maximum is potentially provided by this modified green material based on greenship rating tools.

Keywords: Brick; Sago; Shrinkage; Compressive strength; Green material.

1. INTRODUCTION

Sago (*Metroxylonsp*) is one potential source of food and energy. The area of sago palms in the world is approximately 2 million hectares and about 60% of which in Indonesia is spread across Papua, Maluku, North Sulawesi, Central Sulawesi, Southeast Sulawesi and Riau in 2011 (Novarianto, 2012). Its raw material is obtained from extraction of 5-8 years sago, resulting in wasted water and containing starch (Rumalatu, 1981). In sago processing, it is found that waste i.e. bagasseclanelod is 14% of total weight of wet sago (Flach, 1997), with ratio of starch and bagasse at1:6 (Rumalatu 1981). Since the large amount of the waste is not used as it should be, there is environmental pollution around the production ward.

In Souteast Sulawesi, sago is one of main food for Tolaki tribe, called *sinonggi*. Its production is considered conventional in home industry located near riverbank or tributary. Hence, without proper control, the bagasse with high fiber content is carried away by the stream that will have impact on the environment, not to mention its nomadic nature of production depended on the availability of sago palms.

As shown on previous research (ornam et al, 2015), utilization of sawdust and reed in brick material provides better performance in terms of heat transfer. Heat transfer performs acceptable in this model where it spreads more quickly and evenly in brick structures than on conventional model and hence minimizes the possibility of crack following unloading phase. On the other hand, the use of sawdust as inner burning,

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accelerates burning time twice and it also can reduce the use of firewood for about 50% (ornam et al, 2015).On those basis, as an organic material that has most similar characteristics to sawdust and reed, sago husk (*Metroxylon Sago*) is then developed to be engineered materials as a mixture for bricks.

Furthermore, based on criteria of green building as required by greenship rating tools, material resource and cycle is among other five criteria i.e. appropriate site development, energy efficiency and refrigent, water concervation, indoor health and comfort, and building environment management. Utilization of this material definitely meets the criterion and might yield significant result to environment in terms of housing group since bricks are still mainly non-structural wall material for housing.

2. METHODOLOGY/EXPERIMENT

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 and compressive strength of modified brick. Measured production of modified brick was also carried out from mixing, molding, drying and cooling, and burning.

2.1. Procurement of Raw Material

The wet bagasse of sago was obtained from one of biggest production center of sago i.e. Abeli Sawah village, Konawe, Southeast Sulawesi. In the beginning, tha baggase was dried in open air for one week, then it is put into oven to obtain uniform drying due to its high water content.The husk was also cut into uniform size with length of 1-2 cm. Meanwhile, the soil, as main raw material was seized from area surrounding the local production shed of bricks in Punggolaka, Kendari City, South East Sulawesi, Indonesia.

2.2. Production process

The composition of the water –clay ratio should meet the ASTM standard C216-15 (2015), and SNI 15-2094 (2000) i.e. 8 : 1. 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), and SNI 15-2094 (2000).

Next, production process was performed by mixing the clay 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 ± 5 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 approximately 6 hours. Conventional 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.

2.3. Examination process

Soil test was performed prior to production process to determine the soil classification from sieve analysis and atterberg limit test.Following the burning process, there were physical tests conducted to verify the colour, shape, sound as required by the code. In addition, water absorption test was performed by immersing the brick in water with similar height as bricks. Then, compressive strength test was conducted to obtain mechanical properties of bricks. The whole test was then scrutinized to obtain the comparison between conventional and modified bricks with sago husk as filler.

2.4. Green building material assessment

The performance of the modified brick with regard to green building material, i.e. material recources and cycle, is evaluated on some criteria i.e. building and material reuse, environmentally process product, modular design, regional material and non ODS usage. Field process and all laboratory results were utilized to calculate every details of the factors used for measuring this by correlating some to costs and then comparing them with the conventional bricks. Those criteria then were assessed to obtain total point that might be contributed by those bricks on building.

3. RESULT& DISCUSSION

3.1. Laboratory results

As shown on table 1 and 2, there were reduction in dimension and volume for both modified bricks and 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

Sago husk content	After drying				After burning			
	Length [cm]	Width [cm]	Thickness [cm]	Weight [Kg]	Length [cm]	Width [cm]	Thickness [cm]	Weight [Kg]
Conventional brick	19,5	10,5	3,5	1,39	19,3	10,3	3,3	1,31
1,30% (Type A)	19,5	10,5	3,5	1,29	19,3	10,3	3,3	1,12
1,70% (Type B)	19,5	10,5	3,5	1,29	19,3	10,3	3,3	1,21
2,00% (Type C)	19,5	10,5	3,5	1,28	19,3	10,3	3,3	1,15
2,30% (Type D)	19,5	10,5	3,5	1,31	19,3	10,3	3,3	1,14
2,60% (Type E)	19,5	10,5	3,5	1,3	19,3	10,3	3,3	1,12
2,90% (Type F)	19,5	10,5	3,5	1,24	19,3	10,3	3,3	1,11
3,10% (Type G)	19,5	10,5	3,5	1,29	19,3	10,3	3,3	1,12
3,30% (Type H)	19,5	10,5	3,5	1,28	19,3	10,3	3,3	1,11

Table 2 Shrinkage modified brick with sago husk

Sago husk Content	Shrinkage Length	Width	Thickness
Conventional brick	3,5%	6,4%	17,5%
1,30%	3,5%	6,4%	17,5%
1,70%	3,5%	6,4%	17,5%
2,00%	3,5%	6,4%	17,5%
2,30%	3,5%	6,4%	17,5%
2,60%	3,5%	6,4%	17,5%
2,90%	3,5%	6,4%	17,5%
3,10%	3,5%	6,4%	17,5%
3,30%	3,5%	6,4%	17,5%

Although the percentage of shrinkage is different, 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 IRS and Salt

Sago husk content	Initial rate of Suction ($gr/mm^2/minute$)	Salt Content
Conventional brick	0,015	< 50%
1.3% (Type A)	0,023	< 50%
1.7% (Type B)	0,022	< 50%
2.0% (Type C)	0,021	< 50%
2.3% (Type D)	0,015	< 50%
2.6% (Type E)	0,018	< 50%
2.9% (Type F)	0,021	< 50%
3.1% (Type G)	0,022	< 50%
3.3% (Type H)	0,024	< 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, ASTMC62-10,ASTM D2487-06 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.

Table 4 Brick's density of brick modified

Sago huskcontent	Brick density (gr/cm^3)
Conventional brick	2,00
1,30% (Type A)	1,71
1,70% (Type B)	1,84
2,00% (Type C)	1,75
2,30% (Type D)	1,73
2,60% (Type E)	1,71
2,90% (Type F)	1,70
3,10% (Type G)	1,71
3,30% (Type H)	1,70

In terms of bricks density, both conventional bricks and modified bricks meet the requirement i.e. 1,60 – 2,00 gr/cm^3 (table). Modified brick density is between 1,70 and 1,84 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 7,33 Mpa for compressive strength, and classified as third grade based onASTM C216-15, ASTM C652-14, ASTM C67-14, ASTM C62-10, ASTM D2487-06 and SNI 15-2094. On the other hand, on average, modifid brick shows better performance than conventional brick. All types are included in the first to third grade, with maximum compressive strength on type E (2,6%) for 11 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.

Table 5 Compressive Strength of Modified Brick

Sago husk content	Compressive Strength (N/mm^2)
Conventional brick	7,33
1.3% (Type A)	8,8
1.7% (Type B)	8,1
2% (Type C)	10,3
2.3% (Type D)	8,8
2.6% (Type E)	11,0
2.9% (Type F)	9,2
3.1% (Type G)	8,8
3.3% (Type H)	8,8

3.2. Material sources and cycle assessment

In terms of local housing in surrounding sago palm area, utilization of modified bricks as substitution for conventional bricks, economically, might reduce production cost until 50%, since the utilization of firewood in the ward is reduced by 50% compared to conventional bricks. By neglecting other factors that might increase, or decrease the material cost, the criterion building and material reuse could be considered as that reused all material, which can be used again at least or equal to 20% of total cost ceiling, floor, sills, and wall (2 point)

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Based on environmentally process product and modular design, this modified brick could obtain maximum value of every category, since there is husk as recycled material content and it could be classified as modular material (6 point). On regional material criterion, this recycled material is extracted within 1000 km of the local housing project site for a minimum of 50% based on cost of the total materials value (1 point). Additionally, this material does not use comosive ozone to the whole housing system and use non syntactic (2 point).

Hence, overall, from 14 point maximum there might be a contribution from this criterion.Utilization of modified bricks with husk as filler could provide 11 point, which is valuable in green building assessment.

4. CONCLUSION

Test results indicate that the effect of sago husk in a mixture of brick with certain composition show better quality compared with conventional brick as a building material based on ASTM C216-15, ASTM C652-14, ASTM C67-14 , ASTMC62-10, ASTM D2487-06 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. Due to the physical and mechanical properties of this modified brick, including its production cost, it can be utilized to contribute as prospective support to green building criteria especially for material sources and cycle.

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6. REFERENCES

ASTM C216-15. (2015). Standard Specification for Facing Brick (Solid Masonry Units Made from Clayor Shale), USA.

ASTM C652-14. (2014). Standard Specification for Hollow Brick (Hollow Masonry Units Made from Clayor Shale), USA

ASTM 67-14.(2014). Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile, USA.

ASTM C62-10. (2010). Standard Specification for Building Brick (Solid Masonry Units Made from Clayor Shale), USA.

ASTM D 2487-06. (2006). Standard Practice for Classification of Soils for Engineering Purposes, USA.

Flach, M (1997). Yield Potential of the Sago Palm (Metroxyloan sago) and its Realisation. Proc. Sago Conference in Serawak, Malaysia.

Novarianto, Hengky. (2012). Sumber Daya Genetik Sagu Mendukung Pengembangan Sagu di Indonesia, Laporan Balai Penelitian Tanaman Palma, Manado.

Ornam, Kimsan, Cahyono. (2015). Evaluation of Alternative Design of Hollow Brick with Sawdust as Filler for Home-Made Industry. Proceeding of 4th International

Conference on Energy Systems, Environment, Entrepreneurship and Innovation, February 22-24, Dubai.

Rumalatu FJ. (1981). Distribusi dan Potensi Pati Beberapa Sagu (*Metroxylon sp*) di Daerah Seram barat .Karya Ilmiah. Fakultas Pertanian/Kehutanan yang Berafiliasi dengan Fateta IPB, Bogor.

SNI 15-2094. (2000). Bata Merah Pejal untuk Pasangan Dinding, Balitbang Kimpraswil, Bandung.