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Abstract. This paper presented a preliminary results of utilization sago fine waste as a sand replacement material for cement bricks. Sago waste is a by-product of the extraction of sago starch. Usually, the bark is not utilized for other products and being dumped directly into the rivers or left for natural degradation. About 32,250 tons of sago bark waste annually. Sand however usually obtained by using machinery at the riverbank which greatly contribute to damaging the ecosystem of the river and contributing to global warming. For environmental protection and sustainable development, extensive research has been conducted on the production of bricks from waste materials. The replacement percentage of SFW are 0%, 5%, 10%, 15%, 20% and 25% with water content of 50% and 60%. Density, water absorption and compressive strength are the properties that have been investigated. From the results obtained, both density and compressive strength are decreasing as the percentages of SFW increasing. On the other hand, from the data of water absorption it was found that the percentage of water absorption of brick was increased correspond to the increasing percentages of the SFW. Based on the findings, the optimum brick properties are SFW1W0.6 with the strength 5.18 MPa that can be used as non-load bearing bricks and the optimum percentage of water absorption is at 13.33%. From this study, it was found that the replacement of sand by SFW give a significant impact on density, strength, and water absorption performance of concrete brick.

1. Introduction

Building materials industry demand had raised due to increasing of population which causes unceasing shortage of building materials. Higher demand usage of sand for construction material resulted in vastly increasing of river sand mining activities which causes various problems that require authorities to take necessary actions [1]. It has beed stated the amount of sand extracted has a significant impact on river streams, coastal, deltas and marin ecosystems which resulting in land loss through erosion of coastal or river, reductions in sediment supply and lowering of the water table [1]. As a result, developing countries are under pressure to find alternate materials in order to minimise their reliance on natural aggregates as primary source of aggregates in concrete [2]. Today's construction, utilizing of waste material is becoming common among researchers and practicioners. Various attemps are being made to incorporate various waste material in bricks production [3].

Sago waste is a by-product after the extraction of sago starch from the sago trunks where the trunks are washed, debarked,rasped prior to pulping process. Sago waste usually being discharged into streams [4]. Data from the Malaysian Department of Statistics reveal that approximately the production of Sago alone in 2020 is 201,241 tonne [5]. Modern sago starch extraction generates 0.5 tonnes of sago bark waste for every tonne of dry flour [6]. Development of agricultural industry often leads to agricultural waste which increasing of sago production is directly proportional to the increase of waste produce [4].

Prior studies have shown the potential use of sago waste as a material replacement for the future of the industry. A study [7] revealed that lightweight concrete bricks produced from sago waste are more economical. The authors found that the combination of 1:4.5:1.5 with composition of 75% sand and 25% sago pulp has met the requirements of SNI 03-0349-1989 for minimum compressive strength required [7]. Another study [8] stated that the physical properties of the composite board based on sago dregs waste meet the requirement needs of SNI 03-2105-2006. The researcher stated that the combination of 9%, 13% and 17% of sago dregs were used to make the composite board. Other than just using sago waste alone, another study [9] use sago and fly ash where sago husk acted as a filler for fly ash bricks. The results revealed that the highest compressive strength consist of 1.3% of sago husk while the lowest compressive strength is by using 3.3%. Nevertheless, all the combination meet the requirement of ASTM C 67-14, ASTM D 2487-06 and SNI 15-2094-2000 [9].

In general, past study suggested that sago waste has the potential to be used or as a replace materials for construction materials. This research presents the capability of SFW as a sand replacement for the production of bricks. For instant, the properties are density, water absorption and compressive strength were examined and discussed.

2. Materials

Sago fine waste, cement, fine aggregates, and water are the raw materials that were being used in this research. Fine aggregates and cement were obtained locally. The sago fine waste was obtained from the sago mill in Mukah, Sarawak. SFW was cleaned and sun dried for at least 2 to 3 days to avoid any possible moisture in it. After drying, SFW was grind using a grinder machine and using 2.36 mm sieve to be sieved. SFW that passed 2.36 mm sieves used as fine aggregates. SFW and fine aggregates were sieved following the specification of ASTM C125 [10] and the data was shown in Figure 1. Both SFW and fine aggregates that have undergone sieve analysis test is to determine the cement bricks whether it is compatible that can be used as a partial replacement of fine aggregates. From the data, it shows that fine aggregates having fine modulus of 2.98 while SFW 2.78 respectively. Since the fine's modulus for SFW and fine aggregates are almost similar, thus SFW have the potential replacement for fine aggregates. All the raw materials are supplied and gathered for this study was keep and place in an air tight storage and keep it under a sheltered area in the laboratory.

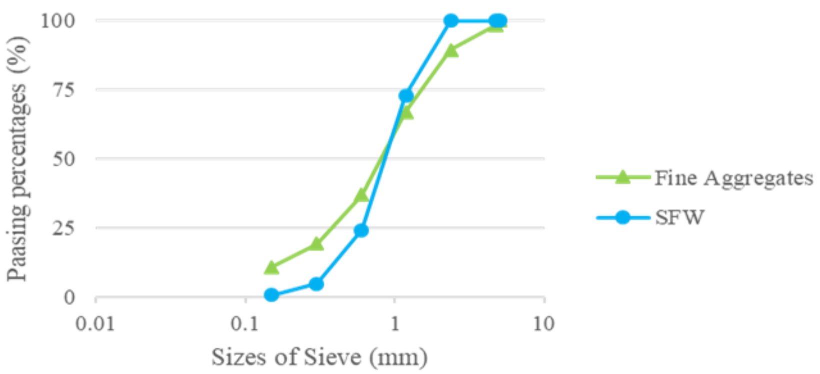

Figure 1. Sieve analysis results for sago fine waste and fine aggregates

3. Methods

3.1 Bricks Design Preparation

Bricks mould design of 215mm x 102.5mm x 65mm with twelve designs mixture with ratio composition of 1:3 as cement:sand prepared with fine aggregates where partially replaced by sago fine waste while the water to cement ratio used was 50% and 60%. Where 0%, 5%, 10%, 15%, 20% and 25% replacement of fine aggregates are the percentages used for the mixture. The SFW cement bricks were casted for 24 hours and cured for standard of 7 days and 28 days. The design ratio of SFW is tabulated in Table 1.

Table 1. Mix design ratio in cement bricks

Design	Cement (%)	Fine Aggregates (%)	SFW (%)	Design	Cement (%)	Fine Aggregates (%)	SFW (%)
SFW0W0.5	33	67	0	SFW0W0.6	33	67	0
SFW5W0.5	33	62	5	SFW5W0.6	33	62	5
SFW10W0.5	33	57	10	SFW10W0.6	33	57	10
SFW15W0.5	33	52	15	SFW15W0.6	33	52	15
SFW20W0.5	33	47	20	SFW20W0.6	33	47	20
SFW25W0.5	33	42	25	SFW25W0.6	33	42	25

3.2 Testing Method

3.2.1 Density Test

Density test is analyse through the physical behaviours of the bricks containing SFW and control sample (SFW0). As known, density of cement bricks usually identified through the materials contained in it which are fine aggregates and cement. Nevertheless, this test is conducted to study the effect of cement brick containing SFW. This test was conducted by referring to BS 6073: Part 1:1981 [11]. The density of the cement brick can be identified and interpreted according to the formula as mention in Eq. (1).

$$\text{Density, } \rho = \frac{m}{V} \qquad (1)$$

Where: m = mass of the brick (kg), V = volume of the bricks (mm^3)

3.2.2 Compressive test

Compressive test is known to identifying the bricks mechanical strength. 7kN is the speed of where the bricks were subjected with load until it is failed by using the Universal Compressive Machine. The results obtained are from the value of maximum load pointed of the brick specimens. Analysis was carried out for 7 and 28 days of the specimens according to BS 6073: Part 1:1981 [11]. Calculation for compressive strength for each type of brick was calculated after the test. The value of compressive strength can be interpreted according to a formula as mention is Eq. (2).

$$F = \frac{P}{A} \qquad (2)$$

Where: F = Compressive strength of the specimen (MPa), Maximum load applied to the specimen (N). A= Cross sectional area of the specimen (mm2)

3.2.3 Water Absorption Test

Water absorption analysis was applied according to standard BS 3921:1985 [12]. This analysis was done to evaluate the water absorption of SFW bricks and the controls brick (SFW0). Result were compared between both water content. The percentages rate was used to classify the type of brick uses in this research. Then the samples dried by using a ventilated oven with 110ºC for 48 hours to prevent moisture in brick specimens. The dry mass is recorded. Then the brick specimen is put into a boiling water approximately for 5 hours and allowing the sample to cool by a natural loss of heat for 16 to 19 hours. Then the wet mass is recorded. Thus, the water absorption percentages can be calculated as mention in Eq. (3).

$$\text{Water absorption}, W_A = \frac{(m2-m1)}{m1}(100) \tag{3}$$

where: m^2 = wet weight specimens(kg), m1: dry weight specimens (kg).

4. Results and Discussion

4.1. Density

The density of the samples was determined as shown in Figure 2 and Figure 3. Generally, the density of the samples decreased as the replacement materials increased. At 7 days, the density of the control brick (SFW0W0.5) is 2094.33 kg/m^3 and (SFW0W0.6) is at 2143.2 kg/m^3. As the percentage of SFW increased, the brick samples indicate a downtrend in density where for each increment of 5% SFW about 6% to 11% of brick density has reduced. For 25% where the maximum replacement applies, the density of brick for 0.5 water content is 1336.88 kg/m^3 which is 36% than the normal brick whereas for 0.6 water content is 1399.71 kg/m^3 with 34%. This has shown the contribution of SFW affecting the reduction of brick density.

Furthermore, for 28 days, the density of brick also indicates the same trend as 7 days brick which is decreasing of density with an increment of SFW. Cement bricks with 5% of SFW with 0.6 water content has the highest density regarding both water content control bricks. The density was affected by the number of air voids in SFW bricks compared to the controls. The Density of SFW 5% (SFW5W0.6) is 2192 kg/m^3. Based on the highest density of bricks (SFW5W0.6), the increment of density between the gap age is 9.4% where the 7 days density is 2003 kg/m^3 while 28 days density is 2192 kg/m^3.

By comparing for water content 0.5 and 0.6, the density brick with water content 0.6 achieved a slightly higher density than the brick samples with water content 0.5. Perhaps the different density was due to different volumes of water content throughout the curing process.

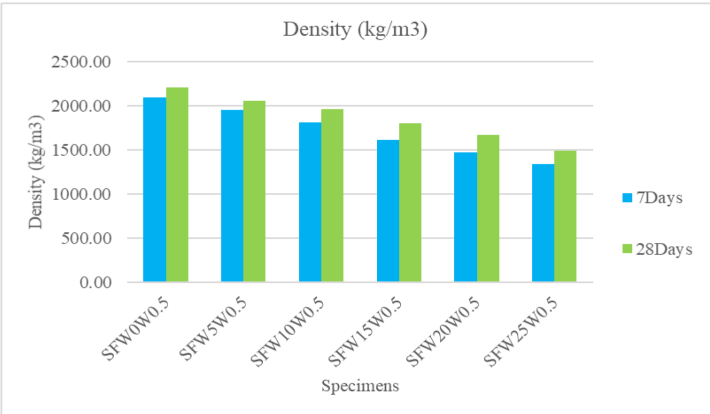

Figure 2. Density of bricks with water content of 0.5

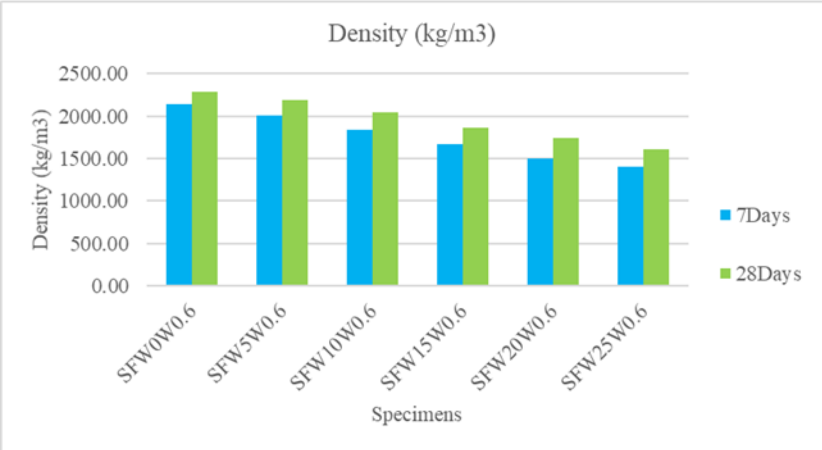

Figure 3. Density of bricks with water content of 0.6

4.2. Water Absorption

Water absorption of the samples is shown in Figure 4. Based on the figure, water absorption for control brick with water content 0.5 (SFW0W0.5) is at 12% while control brick with water content 0.6 (SFW0W0.6) is at 11.9%. The percentages for both water content show a linear decrease following the increment of SFW. For specimen with lowest water absorption based on the data is 0.97% for SFW0W0.5 and 0.64% for SFW0W0.6 as compared to control brick. The maximum water absorption is at 25% where SFW5W0.5 21.65% is at and SFW5W0.6 is 20.07%. The following specimens for water content 0.5 which are SFW1, SFW2, SFW3, SFW4 and SFW5 show that the percentage of water absorption is increasing from 1.14% to 5.36% whereas for water content for 0.6 are from 1.34% to 5.16%. By comparing both water content values, water content with 0.6 percentages are slightly lower than the 0.5 water content percentages but both absorption values are high due to the characteristic of SFW which are highly absorbent material.

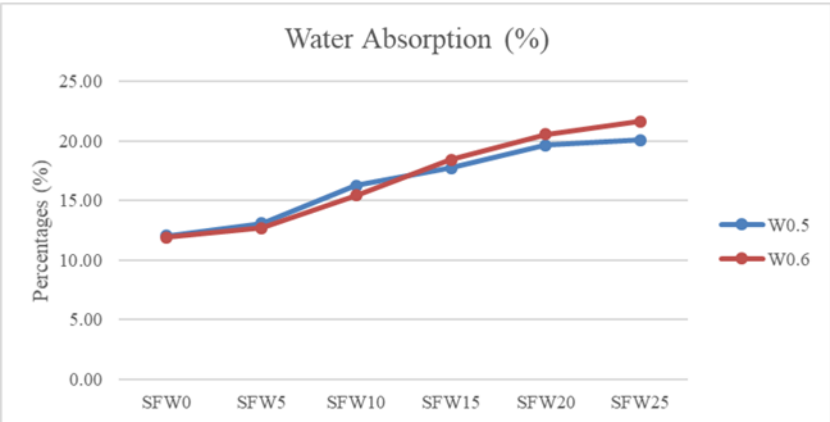

Figure 4. Water absorption of bricks

4.3. Compressive Strength

Compressive strength results for 7 and 28 days are presented in Table 2 and plotted in Figure 5 and Figure 6. According to the data that has been collected, the strength of brick decreasing as the percentage of SFW increase. A similar result was obtained by using natural waste resources such as using palm oil fuel ash (POFA) [13], fly ash [14], and coconut fibre [15]. From the figure 5 and figure 6, the control brick (SFW0W0.5) at 7-day is17.38 MPa, while (SFW0W0.6) at 7 days is 20.54. The reduction of the strength is at 81% for water content 0.5 and 78% for water content 0.6 from the control brick.

Relatively with density data and water absorption, SFW has contribute an impact towards the brick strength. All brick sample containing SFW has lower value compared to the control brick as at 28 days, the control brick for both water content was 20.69 and 23.89 MPa. The strength was decrease as for replacing 5% of SFW the strength is at 3.78 MPa for 0.5 water content and 5.18 MPa for 0.6 water content. The highest compressive strength regarding control bricks is with 5% of SFW replacement. The great reduction in strength was due to the characteristic oof SFW with its low in strength and higher amount average of water absorption percentages [16].

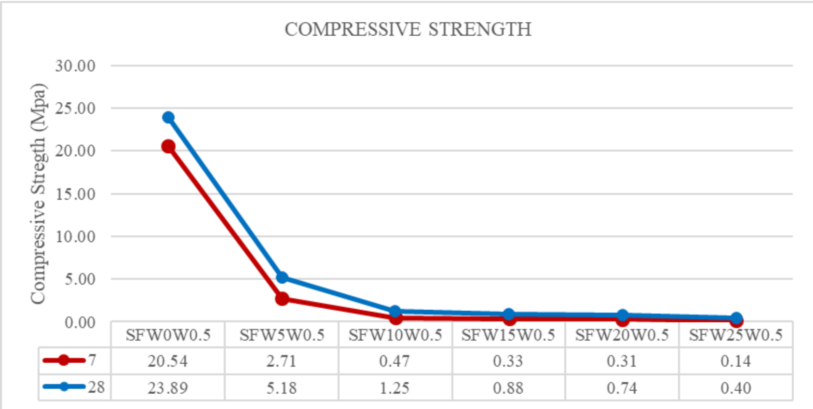

Figure 5. Compressive strength of bricks with water content of 0.5

Figure 6. Compressive strength of bricks with water content of 0.6

Table 2. Bricks specimen compressive strength (MPa)

Specimens	**Curing (days)**		**Specimens**	**Curing (days)**	
	7	**28**		**7**	**28**
SFW0W0.5	20.54	23.89	SFW0W0.6	17.38	20.69
SFW1W0.5	2.71	5.18	SFW1W0.6	1.91	3.78
SFW2W0.5	0.47	1.25	SFW2W0.6	0.39	0.93
SFW3W0.5	0.33	0.88	SFW3W0.6	0.41	1.05
SFW4W0.5	0.31	0.74	SFW4W0.6	0.39	0.86
SFW5W0.5	0.14	0.40	SFW5W0.6	0.27	0.41

5. Conclusion

In this study, replacement of sand with SFW (5%, 10%, 15%, 20% and 25%) in cement brick production has been observed. The deduction for this preliminary study according to the subsequent conclusion:

- The density of the brick was affected by the replacement of SFW n the brick. As the percentages of replacement increase, the density of the brick decrease. In this preliminary study, the maximum replacement of materials is 25% of SFW that has reduced the density of the brick 36% for water content 0.5 and 34% for water content 0.6. This can be stated that SFW might be a potential material to produce lightweight brick.
- The water absorption properties show that, as the SFW increase, the water absorption increase. This is due to the structure and characteristic of SFW that can absorb up to 59% of water which contribute to a higher absorption rate in the brick.
- The compressive strength of brick is highly affected by the existence of SFW in brick. From the data obtained, increasing the percentages of SFW, decreasing the value strength of the brick. However, regarding the data, SFW1W0.6 obtained the highest value of strength overall regarding control bricks with 5.18 MPa and this can be classified as a lightweight brick.
- In regarding that SFW water absorption is high, it is recommended that water content for brick mixture as a crucial parameter.
- Overall, regarding the control bricks, SFW1W0.6 sample obtained the highest compressive strength, the normal rate for water absorption and classify as medium weight brick.

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Acknowledgement
The authors gratefully acknowledge the Universiti Tun Hussein Onn Malaysia (UTHM) for providing the financial support through Tier 1 Grant (Vot Q029) and Postgraduate Research Grant (GPPS) (Vot H735).