Compressive Strength Performance of Composite Sand Cement Brick with Power Saw Wood

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Abstract. Malaysia is experiencing an unprecedented growth of its urban centre due to its developing economy and industrialization, causing the demand of bricks production to be high. This increased the price of river sand. Further, the river sand may be depleted in the future if there is no alternative taken in reducing the usage of river sand in building materials due to the limited natural resources supply. Therefore, this research concentrates on using waste material like wood fiber waste (WFW) in order to reduce river sand in the fabrication of composite sand cement brick. This research is done in order to determine the water absorption and the compressive strength of sand cement brick with powder saw wood. Six batches of bricks were made with different composition of sawdust of 0%, 1%, 2%, 3%, 4% and 5% sawdust. All the bricks undergo 7 days of air-cured process before having the water absorption test and compression test. 3 days of water-cured process was performed on all bricks in order to investigate the results of water absorption test. For water absorption test, 0% of sawdust brick shows the lowest value while 5% of sawdust brick shows the highest value of water absorption rate. This factor is due to the sawdust that is hydrophilic and porous in nature that causes the brick to contain more air space in the brick. Thus, this can be evidenced by the density data that keep decreasing with increasing percentages of sawdust. As for compressive strength test, the results presented 0%, 1%, 2%, 3%, 4% and 5% of sawdust have strength of 20.61 MPa, 25.30 MPa, 15.47 MPa, 2.03 MPa, 1.49 MPa and 1.73 MPa respectively. In summary, it can be concluded that optimum percentage of sawdust is 2% as it contains better compressive strength than other bricks although it has slightly higher water absorption rate than conventional sand cement brick. The compressive strength was influenced by the density of brick. It is shown in density results that decreasing in density will causes declining in compressive strength. As a conclusion, water absorption rate increases linearly proportional to the percentages of sawdust but inversely proportional to the compressive strength and the density of the brick.

Keywords: Wood fiber waste, brick, water absorption, compressive strength.
1. Introduction

Nowadays, Malaysia managed to be one of the world developing countries with respect to its competitive through invention and innovation in technology and infrastructure. Petronas Twin Tower, Kuala Lumpur Tower, Kuala Lumpur International Airport (KLIA) and the Smart Tunnel have been seen as symbolic and proof of successful development in civil engineering. Brick is a basic material that is needed in the common structure. Normally, bricks that can used in building construction are clay brick and sand brick [1]. However, sand cement brick is preferred in building construction as it easy to make and inexpensive to produce [2].

Countries with rapid development will have a high demand of bricks production. Thus, the shortage of natural resources such as river mud and river sand will happen as these natural resources are unsustainable resources and hard to locate adequate sources of natural supply. The lesser the quantity of natural resources, the expensive the price of river sand will be. This contributed into increment in construction cost [3]. Up to now, many researchers have done their researches on brick making process which can reduce the cost of brick production.

Many studies are focusing on the usage of industrial waste material in the production of sand cement brick so that it can minimized the usage of natural resources [1]. A wide variety of industrial waste material such as food waste, rice hush ash, limestone powder and wood waste able to reduce construction costs as well as to minimizing the amount of unmanageable industrial waste that had been accumulated due to the development of industrialization. It is quite a win-win strategy but the industrial waste that being used in the brick fabrication need to meet the requirement strength of the standard brick in order to be used widely in construction industry.

Wood waste product is one of major industrial waste that is accumulated during the furniture making process due too many waste products from wood industries which will affect the environment friendly and human health [4]. According to [5], 3.4 million m³ of wood wastes such as sawdust, wood chips, bark and slab had been generated annually by Malaysian timber industry. Saw wood dust is one of the them, hence, using saw wood dust in the fabrication of sand cement brick can be one of the alternative that can be used in reducing the sand usage and also a solution for wood waste management. Current approach of burning it for disposal is not good for environment. Therefore, in this work, a research about composite sand cement brick containing powder saw wood will be conducted.

2. Methodology

There are three process is that is needed in order to produce the brick with saw wood dust. The brick size has to be according to the standard size that normally uses in industry. Firstly, the process starts with making of brick mould. The brick mould is designed according to the size of brick which is BS 3921; 220 x 100 x 80 mm. The brick mould is made from plywood with thickness of 1.2 cm. All the small pieces of plywood will be joined together by using 2 cm screw instead of using nails as this will make the process of assembly and dis-assembly easier. The second process is preparation of raw materials. The raw material such as wood waste was purchased from the wood industry at Arau, Perlis and will be blended using the dry blender to get the smaller particles which is know as coarse saw wood dust. After that, the coarse saw wood dust will be sieved using 2 mm sieve to get fine saw dust. Other raw materials like Portland Cement (OPC), river sand and water were provided by the university facility. River sand needs to be sifted with 4.75 mm sieve tray to remove large sandstone in the river sand, which can cause the brick texture to be uneven and unsmooth. Thirdly, fabrication of composite brick. All raw materials will be mixed together with water according to the composition of cement to sand ratio 1:3 as shown in Table 1. The mixture is poured in the mould and compactor is used to compact the mixture in the mould to avoid air bubbles and created smooth finishing surface of brick. The mixture will be left in the mould for several days to dry. After that, all the bricks were water-cured for 3 days straight in the water tank. The minimum distance between the surface of water in the tank and the surface of brick is
10 mm. Then, the bricks will be tested with water absorption test (BS 3921:1985) and compressive test (MS EN 12390-3:2012). Results of the test will be recorded and used for analysis. All the machines and apparatus that had been used in this brick fabrication process were provided by the university.

Table 1. Percentages of materials in each batch.

| Batches | Wood Fiber | River Sand | Portland Cement |
|---------|------------|------------|-----------------|
|         | % Mass (g) | % Mass (g) | % Mass (g)      |
| 1       | 0          | 75         | 2025            |
| 2       | 1          | 74         | 1998            |
| 3       | 2          | 73         | 1971            |
| 4       | 3          | 72         | 1944            |
| 5       | 4          | 71         | 1917            |
| 6       | 5          | 70         | 1890            |

3. Results and Discussions

3.1 Water Absorption

This test was conducted to determine the water absorption rate of composite sand cement brick containing powder saw wood. Water absorption rate can be calculated using Equation 1. The differences between dry mass and wet mass indicates the water absorption value. Therefore, the dry brick and wet brick will be weighted and recorded. Average value from three sample of bricks for each batches will be taken in order to obtain the more reliable and accurate results. Figure 1 shows percentages of water absorption for each batches.

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\text{Water Absorption} = \left( \frac{\text{Wet mass} - \text{Dry mass}}{\text{Dry mass}} \right) \times 100\% \quad (1)
\]
From Figure 1, the graph clearly shows that the water absorption increase significantly if the amount of sawdust increase due to sawdust hydrophilic characteristics that allow the composite brick to be more water absorbable. This observation is similar to the study made by [10] that stated increasing in water absorption rate is related to sawdust behaviour which is hydrophilic in nature. Another reason for increasing in absorption is due to the result of air trapped of the brick due to the porosity of sawdust particles.

3.2 Density of Brick
Bricks are classified into three categories with different density namely lightweight brick (300 - 1920 kg/m³), normal brick (2240 - 2480 kg/m³) and heavy brick (more than 2500 kg/m³) [26]. Density of the brick is important in determining the mechanical properties and class of the brick. Even so, the density of brick varies according to the quantities of sawdust being added to the composite brick. It has been clearly shows in Figure 2 that the addition of sawdust will slightly reduce the density of the brick.
Figure 2. Effect percentages of sawdust on the density of brick.

Based on Figure 2, 1% to 5% of sawdust brick have the density around 1664.77 kg/m³ to 2015.15 kg/m³ for uncuring brick. It shows that all the composite brick indirectly appear in range of lightweight brick as it contain low density. The brick density reduced with addition of sawdust particles.

However, the density of bricks raised slightly after the curing process due to complete hydration process that can take place when the brick have enough moisture. This density graph proved that increasing in percentages of sawdust will decreasing the density of brick due to high void content in brick. Low density brick also mean the brick have large water absorption rate.

3.3 Compressive Strength

This test is conducted to determine the compressive strength of the composite sand cement brick containing powder saw wood. Minimum load applied to the brick which is 0.1 MPa. The loads will be gradually increased until the brick cannot withstand the load and this will make a crack to accur. Maximum load that can be applied to the brick will be recorded. The results of compressive test is as in Figure 3.
It also same with the findings from Figure 3, reported which that declining in compressive strength at higher percentages of sawdust replacement is due to the high presence of void and porosity in the hardened brick [1]. Other than that, compressive strength trend is similar to the density graph which conclude that density of brick greatly influenced the porous brick indicates low brick density. Having more porosity mean it become more permeable to water and thus low durability will be expected from this composite brick.

4. Conclusions
Conclusion that could be drawn from this research are:
- Based on the observation, sand cement brick with 5% of sawdust shows the highest value of water absorption rate which is 8.42%. This is because the void contents in brick will be large when more percentages of sawdust is added. Hence, the brick become more penetrable to water.
- From the compressive strength results, 1% of sawdust brick presented 25.298 MPa which is the most the preferable strengthness in this experiment because it surpass the control value brick. However, the compressive strength decline immediately after 2% of sawdust is being added. It may be the result of inadequate curing age and deficient in brick moisture.
- The trend for the density of brick almost the same with compressive strength trend as it increase from 0% to 1% of sawdust but decreasing from 1% to 5%.
- In conclusion, 1% of sawdust is the most suitable and optimum value for the fabrication of composite brick as it contain higher compressive strength, lightweight brick material due to low density and a little bit higher water absorption rate than the 0% of sawdust brick but it still in the manageable range.
- High percentages of sawdust is not suitable for the fabrication of composite brick as it absorb more water and give low compressive strength.

5. References
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