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Development of Hybrid Environmental Brick

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ABSTRACT

A common brick in construction industry use in construction is sand brick. Cement brick or sand brick made from sand mixed with cement. Usage demand of sand cement brick resulted to the increase of demand for sand. As a concern to environmental issues especially on the shortage of natural sand and plastic issues. Therefore a study on exploring replacement material to natural sand is required. Plastic bags are made from crude oil, which is made into a hard or a soft material. In this short time, their extreme convenience has made them widespread all aspects of life, making them the synonym of waste. However, their decomposition is a very long process. In this study the plastics used as sand replacement material to produce sand cement brick grade 5 N/mm2 and 10 N/mm2 called Hybrid Environmental Brick (HEB) The effect of plastic to compressive strength and density of brick containing plastic compared containing river sand was identified and discuss in this paper. HEB is a new type and concept of brick. HEB is casted in three layers with two different strength grades and different materials. The HEB developed through this concept produced different properties of brick as compared to normal sand cement brick. All the important properties of HEB were identified and presented in this study. Then the resulting analysis of this comparison determined the optimum mix for HEB. The finding showed that the optimum mix for this study was acceptable brick by the characteristics study. From results obtained is found that plastic is highly potential to be use as sand replacement material in a production of sand cement brick. Even though, compressive strength of sand cement containing plastic is lower but the properties are still satisfied to use in industry. Finally it can be conclude that the HEB can be produced as new type of brick in construction industry as it reduce the application of sand and cement in order to produce a good quality bricks with followed requirements.

Key Words: Hybrid, brick, plastic, sand, cement

1. INTRODUCTION

One of the main goals of sustainable solid waste management is to maximize the ability of its recycling and reusing. The most common waste materials are metal and plastic which are available in enormous quantities in the world. Therefore, the use of this waste is very important from the environment and sustainability aspects. This leads to the saving of natural resources and resulting in a decrease in environmental pollution The waste generated during various operation and their by-product is one of the

major problem arising in the world today. Plastic waste is one of the major contributing agents to polluting the environment.

Brick is one of the common and widely used construction material in the world. To reduce the burden on environment brick industry, conduct a lot of experiments to utilize this waste (Singh et al., 2016). Reuse of solid waste as partial replacement of aggregate in construction activities result in reducing the demand for extraction of natural raw materials as well as saving landfill space. Thus utilization of plastic waste in brick mixes reduces the demand for natural resources and as a result, leads to sustainable development. Normally practice of making brick in industries by vertical position during the placing of the mixture. This method was applied by press the material in mould at a certain pressure. Actually, the stress maximum of the brick is at the bottom and the top of brick while the centre of brick is the minimum value as practised in block stress distribution concept. In this study the method of placing the material in a horizontal position with the three-layer method. By using this method, the material uses at the centre of the brick can be minimized with the stress minimum at the centre.

2. LITERATURE REVIEW

In civil engineering construction use of shredded plastics has increased drastically as a partial replacement of sand. As it is an added advantage in terms of environmental and potential economic consideration incorporation of waste in brick increases (Osei D Y 2014). Plastic can be incinerated with energy recovery, if material recycling is not feasible. Past investigations suggest that partial replacement of sand of brick with waste plastic can improve properties such as abrasion resistance, impact resistance, ductility, shock absorption and thermal conductivity (Sofi & Phanikumar 2015). It also shows that addition of plastic to brick causes some reduction in mechanical properties such as comprehensive strength, split tensile strength, flexural strength (Pramod et.al., 2014). Literature reviews suggest that addition of steel fibre in normal brick improves these mechanical properties. Taking the advantages of this steel fibre is added plastic waste sand brick to make fibre reinforced waste plastic mix brick. This paper reports the strength characteristics of plastic waste sand mix brick with the addition of steel fibre for specimens of strength 30 Mpa. Tests were performed comprehensive strength, split tensile strength and flexural strength respectively.

3. METHODOLOGY

Before the mixing process, all materials must prepare according to the mix that being designed. Details for all the mix are shown in Table 1.

Table 1: Mixes Proportion for one brick production.

Material	Sand Brick		HEB	
	C5 (kg)	C10 (kg)	C5 (kg)	C10 (kg)
Ordinary Portland cement (OPC)	0.42	0.59	0.42	0.59
Sand	2.51	2.35	0	0
Plastic	0	0	2.51	2.35
Water	0.34	0.35	0.34	0.35

Table 1 shows that two types of brick have been cast which are namely sand brick and HEB. Mixes proportion in this study were using water-cement ratio 0.34 with design mix ratio 1:6 proportion by weight for grade 5 N/mm^2. However, for grade 10 N/mm^2, the water-cement ratio was 0.35 with 1:4 design mix ratio proportion by weight. The mixture was placed in the mixer and mixed until it uniformly. Water was poured gradually until all the materials were uniformly mixed. Then, the fresh mix was poured into a steel mould. The samples were placed at drying area for 24 hours before the mould can be removed. After removal of the brick samples from the steel mould, the bricks were cured in open air sheltered area until date of testing.

HEB produced by combining two different grade strength in the brick matrix. Mortar grade strength involved in the productivity of HEB is grade 5 N/mm^2 and grade 10 N/mm^2. The materials used in

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roducing HEB named as plastic as fine aggregate material, Ordinary Portland Cement (OPC) as binder and water. HEB was prepared to have a size of 220mm x 102.5mm x 65mm. For the HEB, the layer is 20mm for both outer layer and 25mm for the inner layer. Figure 1 shows the dimension of HEB.

All tests were performed on the brick of dimensions 220 mm x 102.5 mm x 65 mm. The total number of a brick unit sample prepared in this study for compressive strength, density and water absorption test was six units for each mix. The test methods were carried out according to standard specified British Standard BS3921 and the average of the three bricks sample is measured, to ensure the reliability of the results.

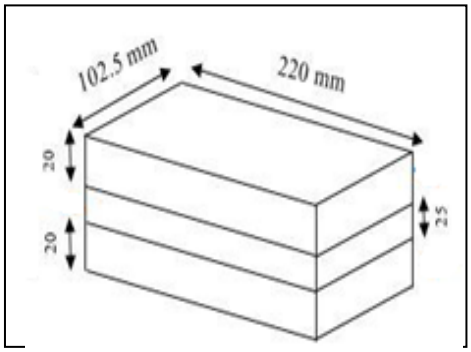

Figure 1. The dimension of HEB

4. RESULTS & DISCUSSION

The results of the testing are evaluated and discuss in this study as shown in Table 2. From the result the discussion elaborates clearly.

Table 2: Results of the testing.

Types of Brick / Testing	Compressive Strength (N/mm^2)		Density Test (kg/m^3)	Water Absorption (%)
	7 days	28 days		7 days
M3	2.73	5.65	1846.97	12.20
M4	5.19	8.05	1988.62	10.15
HEB	2.69	5.56	1619.89	8.30

4.1 Compressive strength

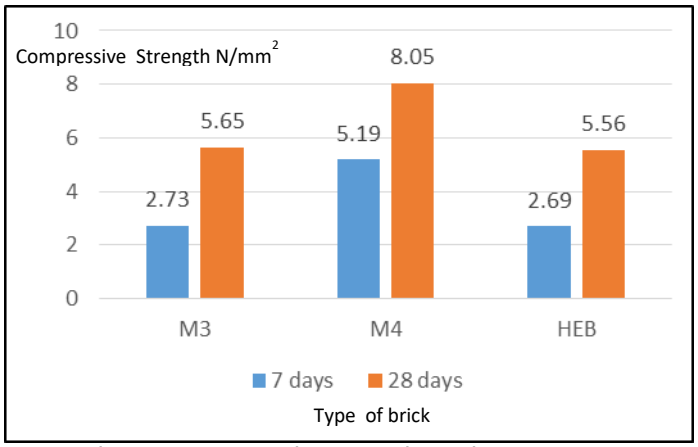

Figure 2: Compressive strength result

From this Figure 2 it is shown that the result of compressive strength of M3, M4 and HEB within 7 and 28 days. It is found that sand brick M4 is the highest compressive strength with 8.05 N/mm^2 and the lowest value of compressive strength is HEB with 5.56 N/mm^2 at age 28 days. It is also found that the

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result for 7 days indicated the compressive strength of M4 is the highest value with 5.19 N/mm^2 and HEB is the lowest value with 2.69 N/mm^2. It can be seen from the data in the percentage difference between the lowest and the highest strength of 28 days was 36.59 % and for 7 days was 63.45%. It seems possible that this result was due to the combination of grade as a part of the layer in brick production was a significant factor effect on the strength of HEB. The observed might be explained that the strength of HEB was affected due to the interlocking between the layers (seen from the elevation of the brick - arbitrary horizontal alignment) whether with the same or different material. Khalid et.al., (2017) reported from the data collected from their study, it is confirmed that brick with 55% replacement of recycled fine aggregate has good interlocking well graduation between coarse and finer particles with angular shape rougher surface texture contributed to compressive strength. Additionally, Kayali (2005) also reports that these surface indentations are believed to be responsible for the interlocking between the brick surface and the mortar. From the result obtained it is also found that all mixes having a compressive strength higher than requirement Standard Specification for Building Works, 2005 which is 5.2 N/mm^2. This finding shows that HEB has a potential.

4.2 Density

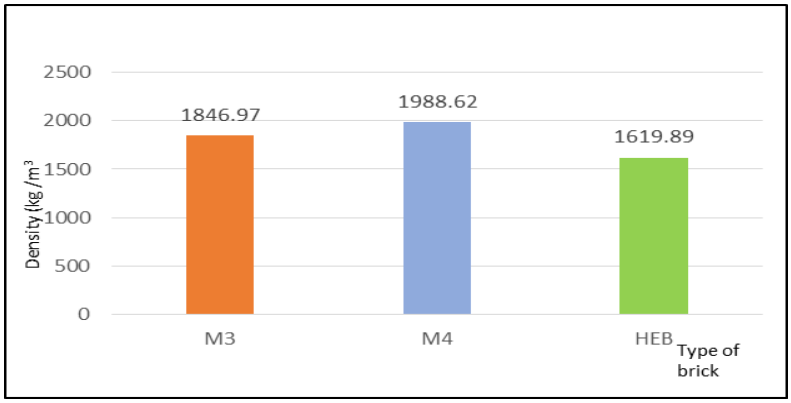

Figure 3: Density result

Figure 3 is shown the density test results. Based on Figure 3, it showed that the density of brick series of mixes brick samples M3 was 1846.97 kg/m^3, M4 was 1988.62 kg/m^3, and HEB was 1619.89 kg/m^3. From the resulted presented, it found that the differential density of HEB and M3 was 13.10% and M4 was 20.44%. Aggarwal and Siddique (2014) reported in his study phenomenon happened may because a particle was more porous and weak than natural sand particles. It then causes the demand for mixing water to increase its use in brick and further causes the density of brick to become low. This fact supported by research conducted by Arumugam et.al., (2011) that found increasing of pond ash replacement level of fine aggregate causes a linear reduction in concrete density. Therefore, the value of density HEB consists of the more plastic waste resulted in the lowest density compared to the bricks used sand.

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4.3 Water absorption

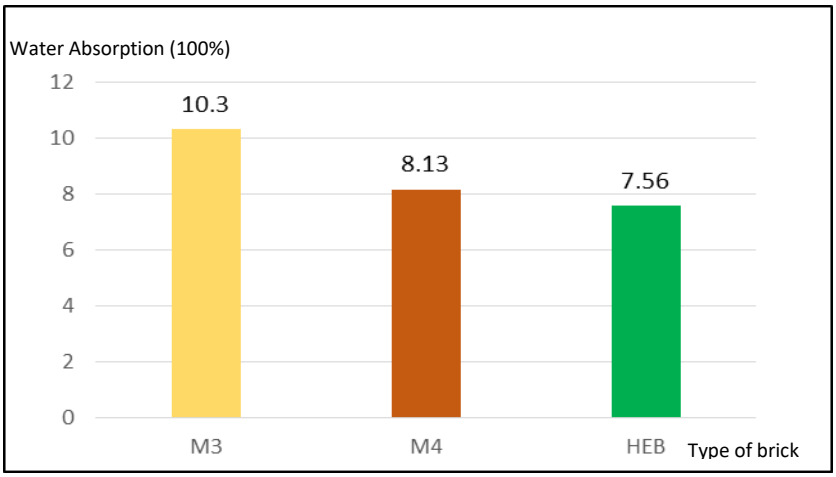

Figure 4: Water absorption result

The results of water absorption are illustrated in Figure 4. From Figure 4, it presented the value of water absorption by percentage for each mix M3, M4 and HEB. It is showed that HEB with 7.56%, M3 with 10.30% and M4 with 8.13% value of water absorption. From Figure 3, it also presented that the differential between the highest and lowest value water absorption for this because of the material itself and used more quantity of sand with a different grade may give different water absorption with surface and internal water absorption. The differences in result between both also could be explained by the differences in the pore structure between specimens (Ezad et.al., 2016). Additionally (Wahab et al., 2018) stated brick has higher water absorption and porosity effect the compressive strength of brick and water absorption and porosity of brick are decreased uniformly as the age of testing is getting longer.

5.0 CONCLUSION & RECOMMENDATION

HEB is a new concept of brick, designed successfully by casting in three layers with two different grades and different materials. In this study five types of HEB were designed and compared with M3 and M4. Properties of HEB are new properties unknown as they haven't been developed beforehand. The comparison proved that the property of HEB is a new innovation and has a potential as a new brick material in the construction industry. In this study, both sand cement brick and bottom ash have specific standard as suggested by design mix. HEB also proved that the layering method is an alternative to reduce the usage of material, in achieving the required strength as compared to sand cement brick which uses the whole material to achieve strength.

Similar studies should be conducted by study of durability of HEB by replacing fine aggregate used with other materials such as slag aggregate or recycle aggregate to produce HSB beside can reduce the usage of natural sources.

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