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HDPE Cement Brick

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Abstract

This paper presents the possibility of using HDPE plastic polyethylene as partial replacement for sand in the production of cement brick. The purpose of the study is to reuse the plastic waste to create new eco-friendly products. High density polyethylene (HDPE) plastic is made from petroleum and commonly used in the production of plastic bottle and corrosion-resistant pipe. It has superior chemical and physical characteristics compared to other type of plastic. HDPE cement brick is made from mix of Ordinary Portland Cement, sand and HDPE plastic. The mix ratio for normal cement bricks is 1:4 (cement: sand). The substitution of HDPE plastic replacing sand is at 10% and 20%. The density and the compressive strength of HDPE cement brick based on these two substitutions were investigated and compared with the normal cement brick. Results show that HDPE cement brick is lighter where the density decreased as the percentage increased. Likewise, the compressive strength is reduced accordingly but still within the limit of MS 76:1972. Compressive strengths of 9.5 N/mm^2, 6.28 N/mm^2 and 5.02 N/mm^2 were achieved for 0%, 10% and 20% HDPE cement brick. The strength of 10% and 20% percentage of HDPE cement brick achieved the standard compressive strength of 5 N/mm^2. It was concluded that HDPE cement brick has potential to be utilized as construction materials with 20% substitution of HDPE only.

Key-word: - HDPE plastic,cement brick, compressive strength

1. Introduction

High-density polyethylene (HDPE) is one of the most commonly used plastic bottles storing milk, juice or oil, ice-cream tubs and toiletries. Due to the tremendous rate increase in global plastic consumption, the disposal of plastic waste has become the biggest environmental challenge to the world, including Malaysia. United Nations Environment Program (2009) reported that the world plastic consumption has increased from around 5 million tons in the 1950s to nearly 100 million tons in 2001(United Nations Environment Programme, 2009).

In 2001, 3 million tons of plastic waste was generated in UK of which, only 7 % was recycled. In the United States, the plastic consumption is more than 11 million tons in which 80% of the post-consumer plastics are sent to landfills, 8 % is incinerated and only 7% is recycled (Rahman, Islam, Ahmed, & Salam, 2012). In Malaysia, approximately 2 million tonnes of resins for the plastics industry are produced locally per annum. However, data on plastic wastes and plastic recycling activities are not known although the wastes constitute the third largest waste tonnage (National Solid Waste Management Department, 2011). Plastics are almost non-biodegradable in the natural environment even after a long period of exposure. Significant efforts have been done by some researchers to create new, reusable, eco-friendly products by recycling plastic waste, and keep millions of pounds of waste from entering the landfills. Re-use of HDPE waste as construction materials can be one of the efforts to reduce the waste. Among the research areas conducted on the reuse of plastic waste are in concrete, paver block, asphalt bitumen and brick (M. Sulyman, Haponiuk, & Formela, 2016).

Chowdhury et al. (Chowdhury, Maniar, & Suganya, 2013) studied the effect of Polyethylene Terephthalate (PET) as reinforcement in concrete and observed a lower compression strength and flexural rigidity but higher ductility in the concrete. The materials produced are light weight due to the reduction of density. For an increase from 0% to 15% of PET replacement to concrete, Rai B et al.(Rai, Rushad, Kr, & Duggal, 2012) observed a decreasing rate of reduction in compressive strengths in which the maximum reduction was only 15%.

While the workability reduced significantly with the increase of PET in the concrete, the flexural strengths also decreased accordingly. Zerdi et al. (Zerdi, Minhajudin, Waseem, Yusuf, & Zerdi, 2016), when reused the HDPE waste plastics as partial replacement to coarse aggregate in M20 light weight concrete, observed that the compressive strength is highest at the replacement of 20% but still lower than the normal concrete. Kathe et al. (Kathe, 2015) used the plastic waste mixture of polyvinyl chloride (PVC), Polypropylene (PP), Polyethylene (PE) to produce green concrete. The replacement of sand with plastic waste by 10 to 20% is recommended for green concrete while a replacement of 30% is suitable for members of building which do not carry high load.

Ohemeng et al. (Ohemeng, Yalley, Dadzie, & Djokoto, 2014) reported that low density polyethylene concrete pavement blocks (PCPB) of 10% - 50% plastic contents performed satisfactorily as pedestrian walkway, light traffic and heavy traffic situation even though the strengths of PCPB decreased as the plastic content increased. Similar investigation on paver block conducted by Tapkire et al. (Tapkire, Patil, & Kumavat, 2014) observed that for 20% recycled plastic aggregate in concrete did not affect the properties of concrete while reducing the weight by 15%. Nivetha et al. (Nivetha, Rubiya, Shobana, Viswanathan, & Vasanthi, 2016) found that the physical and mechanical properties of Plastic Paver block (PPB) with the proportion of 30% PET, 25% fly-ash and 45% quarry dust had more strength than concrete paver block. The performance of road pavement asphalt can be improved with the inclusion of LDPE in combination with crumb rubber tyres (M. O. Sulyman, Sienkiewicz, & Haponiuk, 2013). The rheology properties of asphalts are enhanced with the presence of plastic waste in the mixture.

A study on 100% plastic bricks using low-density polyethylene (LDPE) revealed that the compressive strength is 1.5 times higher than clay brick. Likewise, a combination of PP, rubber powder and calcium carbonate with a proportion of 70:20:10 in the plastic brick gave a compressive strength of 1.74 times higher than clay brick (Shiri, Kajava, Ranjan, Pais, & Naik, 2015). Further study on concrete and masonry poly blocks indicated that a mixture of waste polymer materials decreases density, porosity and water absorption of the blocks significantly. HDPE-based concrete exhibited higher density when compared to Polyurethane formaldehyde (PUF) based block, both in which are recommended for used in non-load bearing structures, floating structures and lightweight materials (Rahman et al., 2012).

2. Methodology

Eighteen samples of 215 mm x 102.5 mm x 65 mm size of brick were prepared with three different percentages by weight of HDPE replacement. For each different percentage, six samples were prepared. The mix proportion was 1: 4 (cement: sand) according to MS 76:1972. The percentage weight of the plastic was 0%, 10%, 20% as a replacement of sand. The plain brick was used as a control brick. Mixing of the concrete was done manually and poured into plywood brick mould. The mixture is placed at a dry and cool location for 24 hours before it was removed from its mould. The materials used to cast the HDPE cement brick in this study consist of ordinary Portland cement (OPC), fine aggregate (sand), HDPE plastic and water. The granulated HDPE plastic was supplied in shredded form.

3. Result and Analysis

Table 1 shows the results of average properties of the bricks for three different sets of samples. Figure 1 to 4 tabulate the results in graphical forms.

Table 1 Average value of 3 sets of brick in different percentage

Data	Average value		
	0% plastic (6 bricks)	10% plastic (6 bricks)	20% plastic (6 bricks)
Mass (kg)	2.9	2.4	2.4
Maximum load (kN)	207.8	135.8	110.2
Compressive strength (N/mm^2)	9.5	6.3	5.0
Density (kg/m^3)	1972.0	1716.4	1660.8
Dimension (mm)	215 x102.5x65	215 x102.5x65	215 x102.5x65

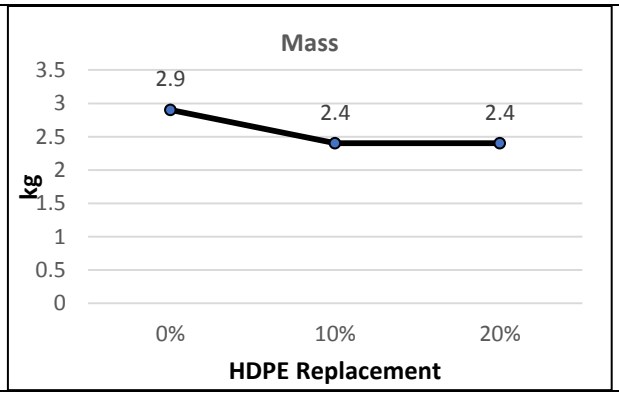

Figure 1 Mass

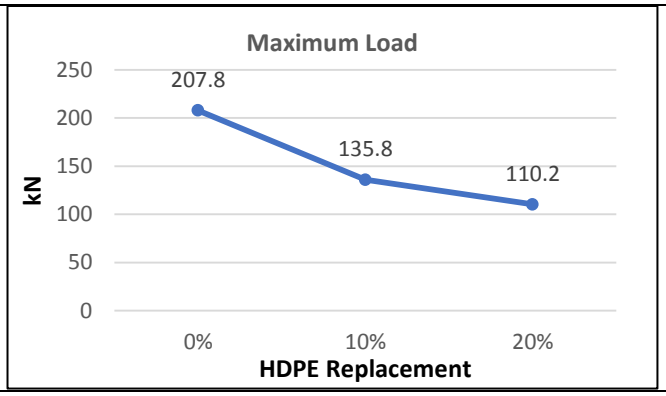

Figure 2 Maximum Load

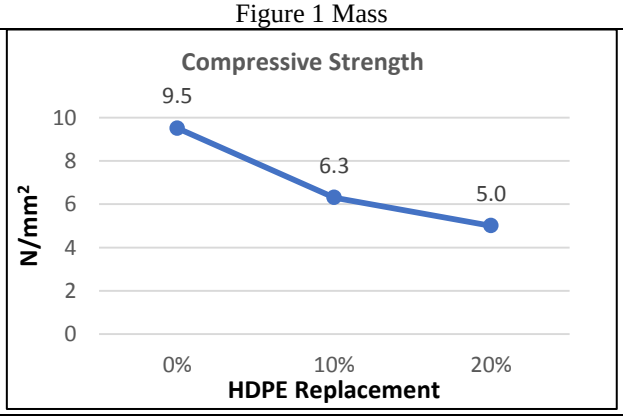

Figure 3 Compressive Strength

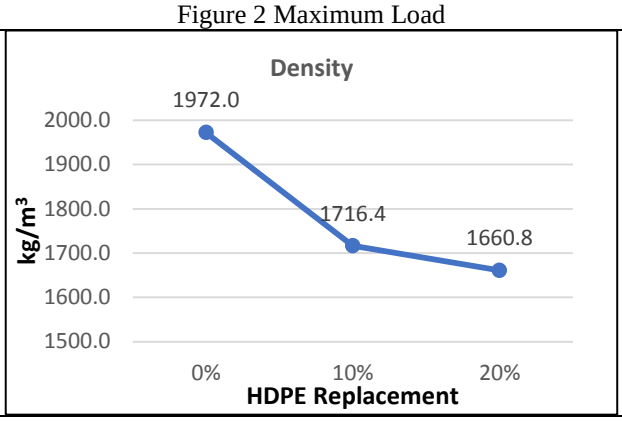

Figure 4 Density

Figure 1-4 Properties of HDPE cement bricks

The followings are some observations on the properties of HDPE bricks:

1. Mass

From the results, the average mass of 10% and 20% HDPE bricks is 2.4 kg while the ordinary cement is 2.9 kg. Whilst both sets of HDPE bricks show no difference in the average mass, the bricks are lighter when compared to the ordinary cement bricks. The HDPE brick is 0.49kg lighter than the ordinary cement brick. Thus, the ease of handling the HDPE bricks is better due to its lightness.

2. Maximum Load and Compressive Strength

The average maximum load achieved by HDPE bricks is lower than the ordinary cement bricks. The maximum load of 10% and 20% HDPE bricks are 135.8 kN and 110.2 kN, respectively compared to 207.8 kN for ordinary cement brick. The 10% HDPE brick absorbs a higher load than the 20% proportion. Figure 2 may imply that subsequent reduction of load will be most likely if the HDPE proportion is increased further by more than 20%.

Similarly, the compressive strengths of HDPE bricks are lower than the strength of ordinary cement bricks. The strengths of 10% and 20% HDPE bricks are 6.3 N/mm^2 and 5.02 N/mm^2 respectively compared to 9.5 N/mm^2 for ordinary cement brick. Again, the 10% HDPE bricks exhibit higher strength compared to the 20% HDPE bricks. The 10% HDPE bricks is 4.5 N/mm^2 lower than the ordinary cement bricks. As expected, the strength of HDPE bricks will further reduce if the proportion is increased. Nevertheless, both sets of HDPE bricks have some comparable compressive strengths well within the limit set by the Standards, thus made them suitable for use in the construction, building and for other purposed. This is in accordance with MS76:1972, clauses 12, 17, 22 which stated that the average strength for the brick is 5.2 MN/m^2 (N/mm^2) whilst BS5628-3:1985 specify strength of equal or more than 5.0 MN/m^2 (N/mm^2).

3. Density

The ordinary cement brick has the highest density of 1972.01kg/m^3 compared to HDPE bricks. The density of 10% HDPE brick is 1716.36 kg/m^3 while the 20% HDPE brick is 1660.8 kg/m^3. The results indicate that the HDPE bricks are less compact and lighter.

CONCLUSION

Based on the result and analysis data obtained from the laboratory testing, a few conclusions can be made from this research. Concrete brick added with HDPE plastic is suitable to be use in building construction industry in Malaysia for non-load bearing members of building. The maximum substitution of HDPE plastic replacing sand is at 20% and from the compression testing results, the strength is in accordance to BS5628-3:1985. Reuse of plastic waste into useful construction materials can help reduce the environmental issues and further decreases the problem of plastic waste disposal. In addition to the environmental benefits, using plastic waste can minimise pollution from sand mining activities.

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