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Utilization of Recycle Plastic Bottle Caps as Partial Replacement in Mortar

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Abstract: In consistent with conservation effort, recycling of waste materials and by-products is a partial solution to environmental and ecological issues. The study was alternative way to solve the problem above by replacing or reducing the material that commonly use to the recycle material which plastic bottle caps. The aim of this study was to determine the density, compressive strength and water absorption of cement mortar that containing recycle plastic bottle caps as a sand replacement. This study was focus on develop the cement mortar that containing recycled plastic bottle caps using design replacement which is 0%, 2.5%, 5% and 7.5%. Besides that, water cement ratio that has been used in this research is 0.45. The cement mortar moulded size was 50mm×50mm×50mm were curing for 7 days and 28 days. The laboratory testing be conducted for density, compressive strength and water absorption. From the analysis that has been done, control mortar was higher than modified mortar that containing plastic bottle caps for the compressive strength test.

Keywords: Plastic Bottle Caps, Density, Compressive Strength, Water Absorption

1. Introduction

Humans require shelter as a basic necessity for survival and protection. Because of the growing population, the number of buildings and houses continue to rise significantly. Mortar is one of the main component or material to construct a building, it is used to bind together the bricks in brick masonry, mortar also used to give a soft even bed between different layers of brick masonry for equal distribution of pressure over the bed. The process of collecting or producing fine aggregate involves the use of an explosion to crush or destroy a large stone into various sizes of aggregate. Due to the increase in population, the demand for natural aggregate increase. However, natural aggregate mining requires heavy equipment and consumes a lot of energy.

The aim of this research is to determine the density, compressive strength and water absorption of cement mortar that containing recycle plastic bottle caps as a sand replacement. Besides, this study will evaluate and analyze the efficiency of sand replacement in mortar as same as specification of standard mortar, a massive experimental work must be developed. The study is an alternative solution to the

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above problem by replacing or reducing the material that is commonly used to recycle, which is plastic bottle caps. Reuse of recycle material that otherwise would have been disposed of in landfills is a conservation choice and at the same time it will be useful for construction industry. Thus, many studies have been conducted on the replacement of natural materials in cement mortar with waste materials in order to address the disposal and environmental issues in construction engineering. A proper recycling method can reduce the demand for new materials while also reducing waste [1].

This study investigates the performance of plastic bottle caps in cement mortar in order to determine the strength of cement mortar.

2. Literature Review

Plastic bottle caps or polypropylene has the lowest density among the commodity plastics. Perfectly isotactic Polypropylene has a melting point of 171℃ (340°F). Depending on atactic material and crystallinity, melting point for the commercial isotactic Polypropylene that ranging from 160℃ to 166℃ (320°F – 331°F), whereas syndiotactic Polypropylene with a crystallinity of 30% has a melting point of 130℃ (266°F). Density tests examine the effect by weight of cement mortar with additional recycled plastic bottle caps used as a partial sand replacement. The lower density, the compressive strength of the mortar produced will be lower [2].

Compressive strength is the ability of a material or structure to resist or sustain compression. A material's compressive strength is defined by its ability to withstand failure in the form of cracks and fissures. One of the previous studies that is to investigate the influence of addition of polypropylene caps as a coarse aggregate replacement in concrete and conclude that it is possible to improve the compressive strength of concrete by incorporating waste crushed plastic bottle caps [3]. According to the findings of this study, the compressive strength of waste bottle caps with concrete is optimum between 5% and 15% (35.85N/mm2 and 27.02N/mm2). This demonstrates an encouraging behaviour for the material to be used in concrete works [4].

A cement mortar sample's water absorption is determined by drying the specimen to a consistent mass, immersing it in water, and measuring the increase in mass as a percentage of dry mass. It is one of the most important factors determining the durability of cement mortars. The sample is weighed, dried in an oven, and then reweighed under standard conditions.

3. Materials and Methods

The specimen which is cement mortar was casted in mould size of 50mm×50mm×50mm.

3.1 Materials

The materials for sampling were prepared in order to ensure that the samples of normal and modified cement mortar met all of the requirements. The materials used in the construction included cement, sand, and water.

- Cement
  Ordinary Portland Cement (OPC) is the most popular form of cement used in Malaysia and around the world for building. The Malaysian Standard, MS 522: 1: 1989, specifies the quality requirements for Portland cement production. OPC Specifications.

- Sand
  Natural sand was used as the natural fine aggregate in the cement mortar. The gradation of fine aggregate is 5 mm, as measured by sieve passing sieve pan.

- Water

In this study, the tap water threat by Syarikat Air Johor (SAJ) was used during the cement mortar mixing process.

3.2 Methods

The specimen size will be the same as the cube mortar test specimen size of 50mm×50mm×50mm. The testing that involved in this study was density, compressive strength, and water absorption tests after 7 days and 28 days curing. Table 1 show the design mix proportion of recycled plastic bottle caps in mortar for this study.

Table 1: Mix Proportion of single mortar specimen

Mix designation (%)	Cement (Kg)	Sand (Kg)	Plastic Bottle Caps (Kg)	Water (Kg)	W/C
Control	0.045	0.155	0	0.0203	0.45
PP2.5	0.045	0.151	0.004	0.0203	0.45
PP5	0.045	0.147	0.009	0.0203	0.45
PP7.5	0.045	0.143	0.012	0.0203	0.45

Density, compressive strength and water absorption testing was performed on the control and modified samples at the UTHM laboratory. For compressive strength was done using a compressive test machine.

4. Results and Discussion

The results of the laboratory tests on the mortar cube specimen have been analysed in this chapter. It describes the outcomes of the density, compressive strength, and water absorption tests performed on the mortar cube. Under curing conditions of 7 and 28 days, an analysis was performed based on the different percentage replacement of recycled plastic bottle caps as a partial replacement of sand in mortar. For each mix, the water cement ratio of 0.45 remained constant.

4.1 Density Test

The density test was performed after the specimens had hardened following the curing process at 7 and 28 days after casting the cement mortar. The result obtained was tabulated in the Table 2.

Table 2: The result for density test

	Average density, (Kg/m^3)	
Mix design	7 days	28 days
Control	2080	2240
PP2.5%	2040	2216
PP5.0%	2024	2160
PP7.5%	2000	2104

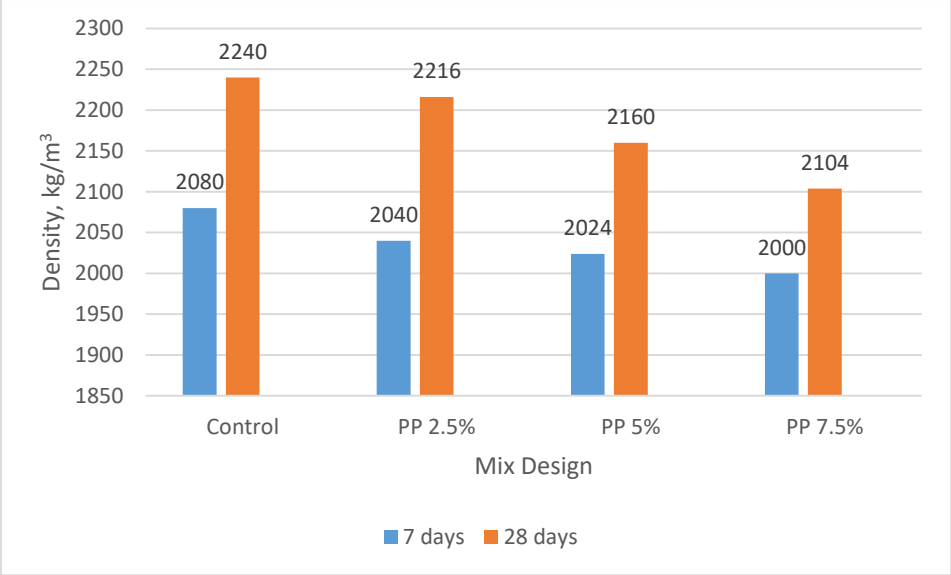

Figure 1: The density for control and replacement mixture

However, as shown in Figure 4.1, the addition of recycled plastic bottle caps to the mortar influences the hardened density of the mortar mixes. The density become decreased after added recycle plastic bottle caps in the cement mortar. Hence, the density value of the mortar will affect the strength of the mortar.

4.2 Compressive Strength Test

The compressive strength of control mortar and modified mortar was compared based on these findings. Table 3 shows the compressive strength results for various mortar specimens. The performance of cement mortar subjected to an ultimate load can be represented by the compressive strength of the cement mortar. To determine the indirect strength of the mortar, the cement mortar specimens were compressed [5].

Table 3: Average compressive strength result and percentage of different strength between control mortar and modified mortar

Mix Design	Average Compressive Strength, (kN/m^2)		Percentage of Different Strength (%) Increase (+) Decrease (-)	
	7 days	28 days	7 days	28 days
Con.	15.1	25.8	0	0
PP 2.5%	16.6	16.9	9.93	-35.5
PP 5%	16.5	16.7	9.27	-35.27
PP 7.5%	18.7	20.6	23.84	-20.16

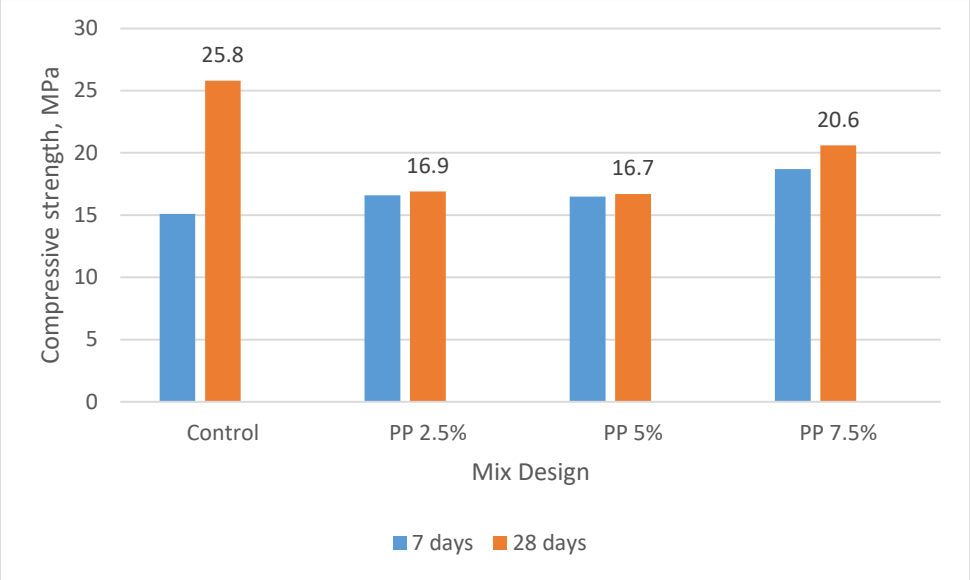

Figure 2: The average value of compressive strength

Figure 2 shows the pattern of compressive strength values. At 7 days, the compressive strength of the cement mortar with added recycled plastic bottle caps was increases by 9.93%, 9.27% and 23% when 2.5%, 5% and 7.5% of replacement in mortar. While at 28 days, compressive strength was decreases by 35.5%, 35.27% and 20.16% when 2.5%, 5% and 7.5% of plastic bottle caps as partial replacement of natural aggregate.

4.3 Water Absorption Test

The water absorption of cement (control) and modified cement mortar was compared based on these findings. Table 4 shows the water absorption results for various mortar cube specimens. The performance of cement mortar in terms of permeability can be represented by the water absorption test of cement mortar. The amount of water absorbed by mortar mixes is determined by their water tightness or waterproofness.

Table 4: Average water absorption result and percentage of different strength control and modified cement mortar

Mix Design	Average Percentage of Water Absorption, (%)	Percentage of Different Water Absorption Between Modified Mortar & Control Mortar, (%)
Control	2.82	0
PP 2.5%	3.73	0.91
PP 5%	5.93	3.11
PP 7.5%	6.84	4.02

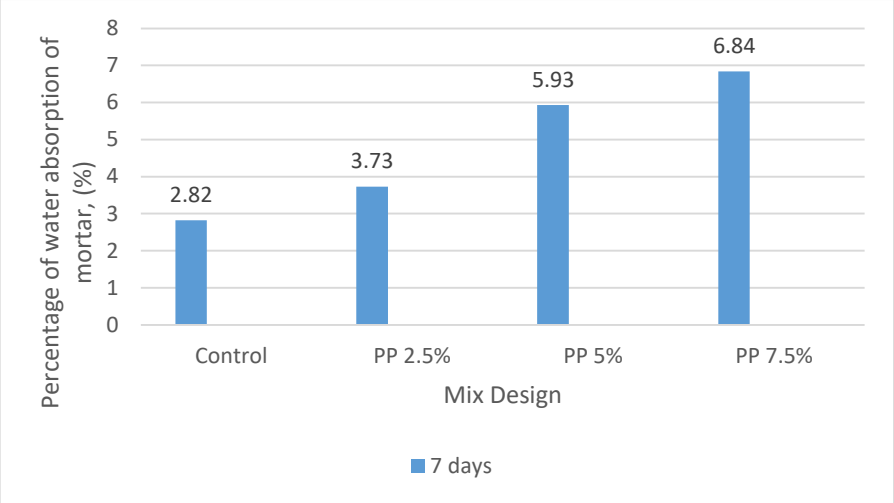

Figure 3: The average percentage value of water absorption

Figure 3 shows the percentage difference of average water absorption of the cement mortar containing recycled plastic bottle caps and the control cement mortar. The range of water absorption was 0% (minimum) to 4.02% for (maximum). The positive percentage of average water absorption of mortar means that the value of absorption was very easy to absorb the water in the mortar. The lower the difference in water absorption between the modified and control cement mortar, the better the ratio of recycled plastic bottle caps in the cement mortar.

5. Conclusion

As conclusion, it was clear that the recycled plastic bottles could not be used as a partial replacement in cement mortar. However, plastic bottle caps can be used as a replacement of natural aggregate in sand cement brick because the strength of modified mortar is higher than 7N/mm^2. According to British standard, the target strength of the sand cement brick must above than 7N/mm^2. More research and improvement are required to prepare to produce cement mortar and sand cement brick by using recycled plastic bottle caps as partial replacement of natural aggregate, as well as to determine a best or optimum for the cement mortar mix design.

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