RECYCLING OF POST-CONSUMER PLASTIC PACKAGING INTO CONSTRUCTION MATERIALS

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1. Introduction

In Madagascar, post-consumer plastic packaging has become a challenge because plastics are dumped into the environment and landfill space is lacking. Among the various types of recycling management approaches, manufacturing a construction material from post-consumer plastic is an interesting outlet because appropriate waste treatment facilities that can handle the plastic waste without environmental issues are not yet available in Madagascar. In addition, these products might be profitable, given that conventional building materials such as cement are expensive. This study aims to assess a construction material made from post-consumer plastics as a replacement for cement in mortar and to evaluate the mechanical and physical properties of the product. The methodology is easy to implement and appropriate for Madagascar.

2. Methods

2.1. Materials

Three types of waste plastics were evaluated: polyethylene terephthalate (PET) obtained from beverage bottles, washed and ground to 15 mm or smaller by a shredder, commercial polyethylene (PE) pellets, and commercial polypropylene (PP) pellets. Standard sand was produced by Japan Cement Association.

2.2. Preparation and test methods

Two types of mortar were prepared. One was made using PET and sand, and the other was made using equivalent parts of PE and PP mixed with sand. In all samples, the plastics were 10% to 40% of the weight of the sand.

The previous research employed a styrene monomer to reduce viscosity in molten plastics (Miranda, 2014). In this study, a commercial styrene monomer comprised 40% of the weight of the plastics was mixed with them before adding sand.

The test method is shown in Figure 1. We used a tubular furnace with a ceramic cylindrical tube, which was rotated with 30 ~ 50 rpm as shown in Figure 2. Plastic and sand samples (275 to 350 g) were put in the electric furnace at 280°C ± 20°C. During two hours of heating, the sample was taken out from the furnace to a container and mixed to obtain homogeneity. After mixing, the sample was returned to the furnace. This process was repeated three to four times until obtaining a homogenous mixture.

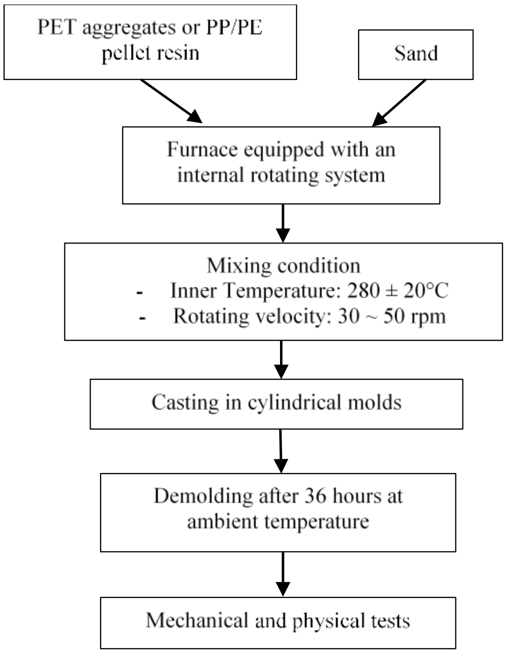

Figure 1. Manufacture of the composite material

Figure 2. Furnace used for the experiment

After two hours, the mixture was put into cylindrical molds (48.5 mm diameter) and manually pressed into them, then allowed to harden, cooling to ambient temperature for 36 hours before demolding. All samples were cut to an average height of 47.5 mm, and their surfaces were polished.

Compressive strength was determined using ASTM C 39 using a hydraulic loading machine with a maximum load capacity of 1500 kN. Mortar strength was calculated by dividing the maximum load at failure by the cross-sectional area. Density and capillary water absorption were evaluated using ASTM C 642-97. Bulk density was calculated after measuring sample weight and volume. Dried samples were completely immersed in water for not less than 48 hours at 20°C, then absorption percentage was calculated from the amount of water absorbed compared to the dried mass.

All test results were performed in triplicate, and averages were used for the study

Figure 3. Samples for the compressive strength test

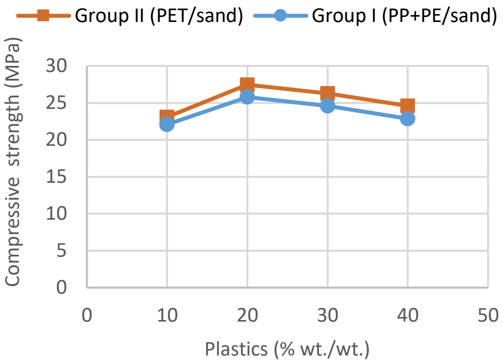

Figure 4. Compressive strength of the materials group I and II

3. Results and discussions

3.1. Compressive strength

Figure 3 shows the samples for the measurement of compressive strength. The greatest compressive strength in Group I was 25.8 MPa obtained from the samples with 20% plastic content. This value decreased as the ratio of plastic increased, presumably because the plasticity of the material weakened the links between the sand and the binder. At 10% plastic ratio, compressive strength decreased because binding between the melted plastics and sand was lacking. Mahdi (2010) reported similar results using polymeric resin (UPER) from PET as a binder. The mortar with 20% UPER shows a better adhesion between PET particles surface and sand and the value (29.0 MPa) was close as that of this study.

The greatest compressive strength (27.5 MPa) in Group II was also found when the mixture was 20% plastics. This value was higher than that in Group I because PP and PE have lower strengths compared to PET. Otherwise, these values were close to the compressive strength of conventional concrete using a cement and sand (28 MPa) in average (Nemati, 2015)

3.2. Bulk density and water absorption

Bulk density and water absorption are shown in Table 1. The former decreased considerably as plastic content increased because plastics are low in density compared to sand. Low density can contribute to a lightweight final material. At 20% of plastics, the density of Group I and II were 1.95 g/cm3 and 2.23 g/cm3, respectively. Although these values were higher than that using lightweight aggregate (less than 1.1 g/cm^3) (Nemati, 2015), lower compared to conventional concrete using normal weight aggregate (2.4 to 2.9 g/cm^3 in average). Similarly, water absorption decreased with increasing plastic content because plastics are impermeable to water. At 20% of plastics, the water adsorption of Group I and II were 3.48 % and 2.14 % respectively. That result showed that PP and PE are more permeable than the PET.

Table 1. Bulk density and water absorption results

Groups	Plastic content (% wt./wt.)	Bulk density (g/cm3)	Water absorption (%)
I PP+PE/Sand	10	2.29	4.03
	20	1.95	3.48
	30	1.67	2.99
	40	1.52	2.33
II PET/Sand	10	2.41	3.06
	20	2.23	2.14
	30	2.08	0.36
	40	1.95	0.28

4. Conclusion and Recommendations

This study demonstrates that the compressive strength of sample using PET wastes as binding agents is greater than that using PP/PE wastes. Using 20% plastics yields the greatest compressive strength, 27.5 MPa, when PET was the plastic component. The two groups of materials showed similar water absorption and bulk density properties. This composite gives good physical properties when a lightweight and impermeable material is desired. This technology can be applied to manufacture building materials such as pavers and bricks for small structures. As for further study, durability of the sample made from post-consumer plastics should be evaluated.

References

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