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ECO-FRIENDLY WALL TILES FROM RECYCLED PET AND PALM OIL FUEL ASH: A WASTE-TO-WEALTH INNOVATION

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Abstract

Plastic waste management is a global problem that threatens the health of our planet due to its high rate of development and non-biodegradability. However, it is important to treat this wastes properly to reduce the environmental pollution associated with its incineration and disposal in landfills. This study investigates the possibility of making tiles from polyethylene terephthalate (PET) waste bottles and POFA (Palm oil fuel ash). PET waste was used in different amounts with POFA by weight (from 30% to 100%). The physical and mechanical properties of the materials were tested, and it was discovered that the tiles made with 30% PET content performed better in terms of material density and strength than the samples made with higher PET content, with the maximum compressive strength of 8.37 N/mm^2. In addition, when compared to pure cement and ceramic tiles, the PET tiles produced has good chemical tolerance and zero water absorption efficiency (the water absorption values were between 1.82% and 0.12%). According to the findings of this report, PET waste bottles and POFA can be used to produce long-lasting, high-strength, and highly low-water-absorption eco-friendly wall tiles for both residential and commercial applications. This possibility of producing tiles from polyethylene terephthalate (PET) waste and POFA would not only reduce the cost of construction materials but would also serve as a waste diversion to reduce environmental pollution generated by plastic waste disposal.

Keywords; Plastic waste; Pollution; Polyethylene terephthalate; Mechanical properties;

Introduction

Plastic is a solid, synthetic polymer derived from hydrocarbons; it can be thermoplastic or thermosetting. Thermoplastic is a type of plastic that softens when heated and hardens when cooled, allowing it to be shaped into a variety of shapes. When thermosetting materials solidify, they cannot be re-melted and are primarily used as Bakelite [1]. Plastics are widely used because they are lightweight, soft, flexible, non-corrosive, and long-lasting. Plastics are useful packaging materials and containers, but their waste is a major source of pollution; when burned, they release toxic gases and are not biodegradable. Since they include chlorine and other carcinogens, plastic products are said to be carcinogenic. Toxic gases such as phosgene, carbon monoxide, chlorine, sulfur dioxide, nitrogen oxide, and other deadly dioxins are generated when plastic waste is burned. Since plastic waste accounts for the lion's share of global waste production, proper waste management is critical. Plastics are widely used as packaging materials, but their waste can be used to manufacture construction materials such as floor tiles, roof tiles, building blocks, and so on. This has the potential to reduce building costs while also reducing environmental emissions.

Plastic waste, for example, maybe combined with sand and other additives to manufacture building materials [5].
Palm oil fuel ash (POFA) is also one of the ash family of materials resulting from the burning of waste materials such as palm kernel shell and palm oil husk [6]. POFA is usually disposed in landfills, which results in the increased amount of Ash deposits every year and now has become a burden [7]. According to the Malaysian Palm Oil Board (MPOB), Malaysia's palm oil plantation area is around 5.07 million hectares [8]. According to the United States Department of Agriculture, the production of palm oil in 2016 and 2017 was anticipated to reach 64.5 million metric tons [9]. Palm oil is mostly produced in Southeast Asian countries. Palm oil fuel ash (POFA) is an important by-product of the palm oil industry [10, 11], and it is obtained by burning waste materials such as palm oil fiber, kernels, empty fruit bunches, and shells in power plants to generate electricity [24]. The amount of POFA produced grows over time as the amount of palm oil produced increases. Malaysia is a major exporter and producer of palm oil in the world [12]. The annual production of POFA in Malaysia is expected to be over 10 million tons [13, 14]. Leaving this material to deteriorate is a significant environmental concern in and of itself. More than 1000 tons of POFA have been dumped into lagoons and landfills in Malaysia, with little consideration given to the material's potential use in other industries [15].

Several studies have identified the possible suitability of plastic waste as building materials. Mehdi et al. [16] stated that when mixed with sand, high-density polythene (HDPE) plastics can be used to make roof tiles. After research, the results of their study showed that composite tiles made with 70% HDPE performed and were of higher quality. Several experimental studies on the use of recycled PET bottles as a replacement for natural aggregates in concrete [16], as well as resin in polymer concrete [30], have recently been released. Akinwumi et al. [17] demonstrated the development of stabilized soil blocks from shredded plastic waste, concluding that 1% finely shredded PET waste (size 6.3 microns) by weight could be used for active block stabilization. Mehdi et al. [18] looked at using PET waste as a partial substitute for fine aggregates in the manufacture of high-impact resistance building materials. The impact resistance of mortars made with a 20% plastic content increased by 39%. Kumi-Larbi et al. [19] announced the efficient production of sand blocks using plastic waste, and their results showed that solid and durable sand blocks can be created without the use of additional water, using only plastic waste. Yang et al. [20] explored the possibility of creating eco-friendly door panels by mixing plastic waste with wood dust.

MATERIALS & METHODS

Materials

Plastic waste, a metal mold, a wood stirrer, a sieve, hand gloves, a coal pot, a nose mask, and engine oil were among the locally manufactured products used to make the wall tiles. Shredded plastic bottle wastes and POFA (palm oil fuel ash) were collected from a Waste dumping site at Federal Polytechnic, Ado Ekiti and palm oil production site along Esure / Ifaki road, Ekiti State respectively. Figures 1 and 2 depict the POFA sample and bags of shredded PET waste,

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respectively. The shredded PET wastes were heated and melted inside the aluminum pot at 230 ^{0}C before adding finely dried and sieved POFA at various percentages to the melted plastic wastes. The mixture was homogenized before being poured into a 5-cm-thick iron mold lubricated with engine oil for easy removal. The mold's edge was regularly banged to ensure sufficient sympathy. After one hour, the samples were de-molded, cooled, and cured for 48 hours at room temperature before testing.

Fig.1. Sample of POFA

Fig.2. Sample of PET wastes

Characterization

The compressive strength of plastic composite tiles was determined using the Instron Universal Testing Machine (UTM 5967) and the ASTM D638 standard. For this test, samples with lengths of 50 mm, widths of 50 mm, and thicknesses of 50 mm were prepared for strength testing. The sample was subjected to a chemical resistance test in conjunction with ASTM D543-14, with the aim of determining the samples' resistance to various chemical reagents. In addition, the ASTM D570 standard method was used to evaluate the relative water absorption rate of the polymer tiles sample after immersion in water for a specified time; all experiments were conducted at room temperature.

RESULTS & DISCUSSIONS

A. Water Absorption

PET wall tiles made of 30% PET and 70% POFA had the highest value (1.82%), while those made of 100% PET and 90% PET + 10% POFA had the lowest values of 0.81 and 0.12 percent, respectively (see Fig.3). This means that the water absorption of PET wall tiles is directly proportional to their PET content but inversely proportional to their POFA content.

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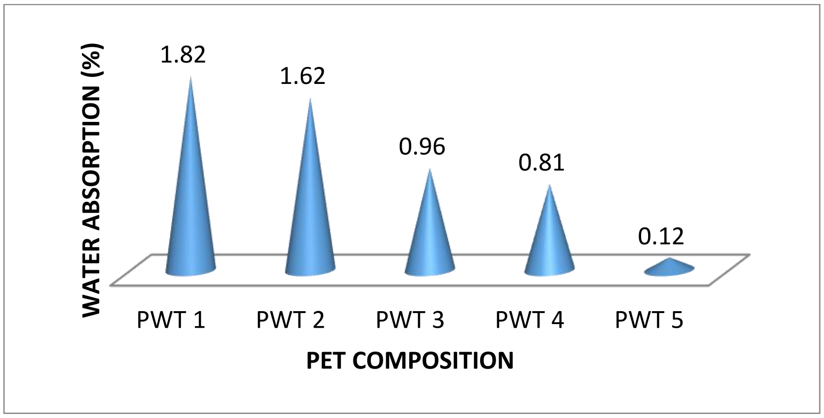

Fig.3. Water Absorption of the samples

B. Density

The density of the PET wall tile was calculated, and the results showed that PWT1, PWT2, PWT3, and PWT4 was 1333.6, 1248.8, 985.6, and 771.2 kg/m3, respectively. The manufactured PET wall tiles with 90 percent PET had the lowest density (771.2 kg/m3), while those produced with 30 percent PET content had the highest density (1331.6 kg/m3), as shown in Figure.4. Increases in PET material, on the other hand, decreased the density of the PET wall tile. Notably, as previously mentioned, the increase in PET content has decreased the density of the resulting composites [18 and 19].

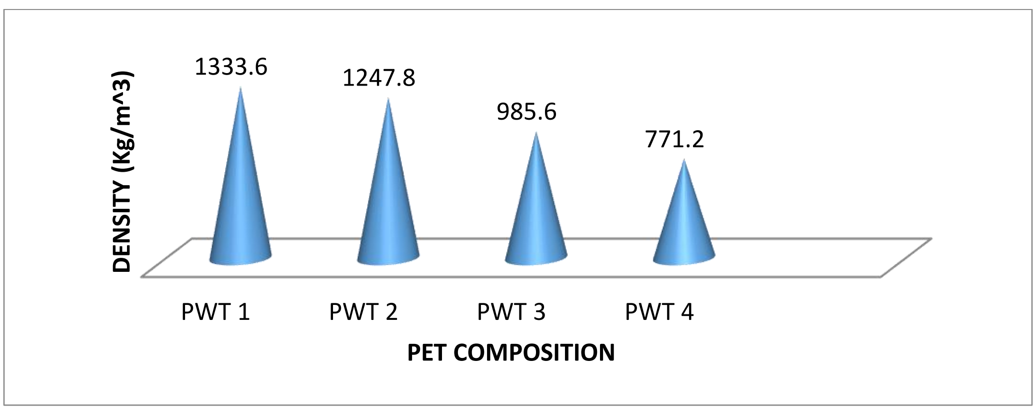

Fig. 4. Density of the samples

C. Porosity

PET wall tiles with a 30 percent PET content had the highest porosity value (8.1 percent), whereas those with 90 percent and 100 percent PET had the lowest porosity values of 1.6 percent and 1.1 percent, respectively (see Fig. 5). This means that as the PET material increases, the porosity of the PET wall tiles decreases.

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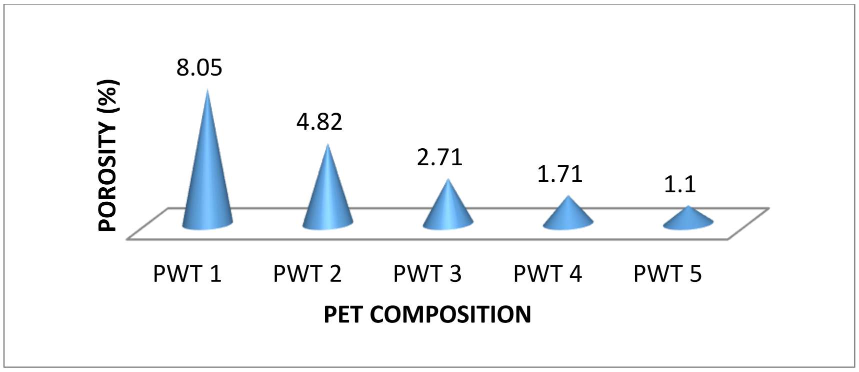

Fig. 5. Porosity of the samples

D. Compressive Strength

As shown in Figure 6, PET composites containing 100 percent PET had the lowest compressive strength value (0.012 MPa), while those containing 30 percent PET had the highest compressive strength value (8.37 MPa). The compressive strength values (8.37, 6.03, 2.01, 1.17, and 0.012 MPa, respectively) increased steadily with the POFA content but decreased with the PET content. The findings show that increasing the PET waste content decreases the compressive intensity of the composite [16, 17-20].

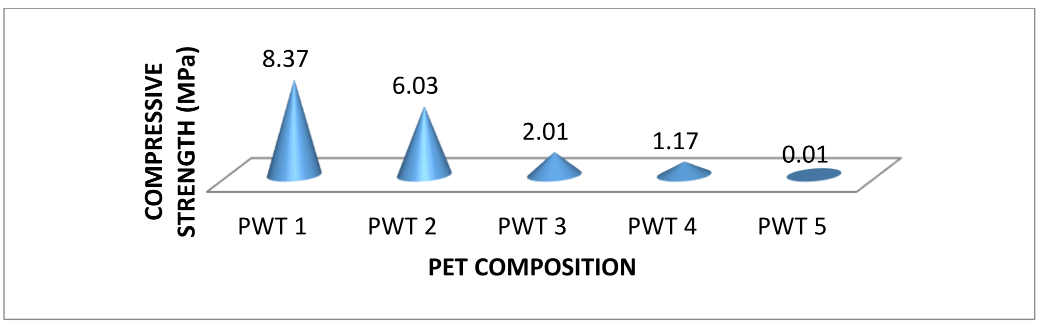

Figure 6. Compressive strength of the samples

CONCLUSION

The following conclusions were drawn based on the experimental results:

• A higher percentage of PET in the tile decreases water absorption. The percentage of water absorption fell from 1.82 percent to 0.12%.

• Samples containing 90% PET had the lowest average density (771.2 kg/m3), whereas samples containing 30% PET had the highest density (1333.6 kg/m3). When compared to control samples, the density increased steadily as the POFA content increased.

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• As the PET material increased, so did the compressive and flexural strength of the PET wall tiles. The compressive intensity decreased from 8.37 MPa for samples with 30% PET content to 0.012 MPa for samples with 100% PET content.

• PET wall tile tolerance in various chemical solutions has been demonstrated, with no major changes in weight or measurements observed after 7 days of soaking in various chemicals.

The findings of this study suggest that PET waste bottles can be used to create long-lasting, high-strength, and highly low-water-absorption eco-friendly wall tiles for both residential and commercial applications. The prospect of producing tiles from polyethylene terephthalate (PET) waste and POFA (palm oil fuel ash) waste not only reduces the cost of construction materials but also acts as a waste conversion to wealth.

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