Recycling High Density Polyethylene(HDPE) into Construction materials as key step in Plastic Waste Reduction:case of Kigali City

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1. Introduction – High-Density Polyethylene (HDPE) are among those plastics category which can be recycled. They are very slow to undergo microbial degradation and can stay intact in the environment for up to centuries. Production of HDPE and other plastics is steadily increasing year by year because of their demand in daily life activities. In general, the increase in worldwide consumption rate for plastics; the synthetic long chains of polymers are about 12% per year while plastic production is 0.15 billion tons per year on a global scale. These polymers generally contain carbon and hydrogen with, sometimes, other elements such as oxygen, nitrogen, chloride or fluoride [8,9]. On the other hand worldwide plastic wastes accumulation in the environment is 25 million tons per year. Despite the commonly used plastic wastes management practices which include landfilling or incineration, these have adverse effects on environment with production of micro plastics and/or toxic gases.

Image 1. Pavers madsande from HDPE and

Recycling of plastics proves to be a more reliable solution to reduce them from the environment though its rate is still low.
When plastics are recycled into construction materials, sand has the capability of improving their mechanical properties such as rigidity and characteristic strength [10,11]. It is noted that modulus of rigidity and viscosity of polymer sand nanocomposite (PCN) increases with the increase in sand content. Another study showed that clay particles; due to their large surface area; have the potential of increasing modulus of rigidity (G) and viscosity (η) of PCN though sand was found to better bind with plastics which makes it a promising solution when recycled into construction materials especially for the case of HDPE. In line with this, recycling HDPE plastics into construction materials will tremendously reduce the amount of such wastes that would rather accumulate in landfills, open environment, lakes, rivers or oceans.
Plastic wastes are increasing at an alarming rate and adversely affecting environment as they are not easily degraded. Worse still, roads along with parking yards have significantly shorter design life and so do other alternative road paving techniques such as reinforced concrete slabs and concrete paving blocks (developing countries). Owing to these challenges, this research aimed to minimize the quantity of plastic wastes dumped in Kigali landfills by recycling it into construction materials while considering both economic and environmental benefits. Specific objectives included to maximize the use of post-consumer plastic waste and produce alternative eco-friendly building products.

Similarly, the research aimed at determining the melting point and subsequent effects of temperature on high density polyethylene (HDPE) as well as determining the mix ratio of the material components that gives the highest compressive strength. Finally, the research aimed at assessing the performance of paving material made of sand and plastic wastes.

The research concluded that if made and put into use, these pavers will not only reduce construction costs especially those for repairs, but also assist in environmental conservation. Roads and parking yards will be cheaply constructed, and with the increased durability, accessibility will be improved and economic growth bolstered.

2. Experimental -In order to achieve the stated objectives, three samples per data point were prepared and quantity of sand content was varying by 1:3; 1:4; 1:5 respectively while keeping plastic content constant. The samples were placed in mold of dimension 100,65 mm in diameter and height respectively where they cooled and set. Compaction was done using standard method. Afterwards, the respective samples were tested for compressive strength and water absorption. Compressive strength test showed the values of 21.73 N/mm2, 26.15 N/mm2, 4.79 N/mm2 before heat exposure and 17.79 N/mm2, 22.37 N/mm2, 3.52 N/mm2 after exposure to 35 0C for 12 hours for the pavers in HDPE and sand mix ratio of 1:3, 1:4 and 1:5 respectively. Water absorption test showed an average value of 0.052% which is lower compared to the cement concrete made pavers.

3.Results and Discussion -

Table I: Water absorption Test

Sl. No:	Dry weight Wd (g)	Saturated weight Ws (g)	Change in mass (g)	Water absorption (%)
1	1942.9	1943.7	0.8	0.041
2	1894.0	1895.2	1.2	0.063
Average water absorption				**0.052**

water absorption of high density polyethylene and sand composite is low. This is majorly because in normal circumstances, polyethylene registers water absorption of less than 0.02%. As such, the low water absorption observed can only be attributed to the absence of pore formation because of compaction. Therefore, the research concludes that the paving blocks made of high density polyethylene and sand has higher performance in terms of water absorption compared to concrete ones that absorb relatively high amount of water with an average absorption of 5%

i.e. In this research two different compressive tests were carried out; one test was to determine the loading capacity of polyethylene and sand paver and other was to evaluate the change in loading capacity after exposure to temperature.

Table II: Ordinal compressive strength test results

All three types of ratio were tested one by one and average result was taken as paver's compressive strength. Two specimens of each ratio were tested.

Sample ratios (plastic: sand)	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1:3	21.65	21.73
	21.65	
	21.91	
1:4	27.38	26.15
	24.84	
	26.24	
1:5	4.45	4.79
	5.09	
	4.84	

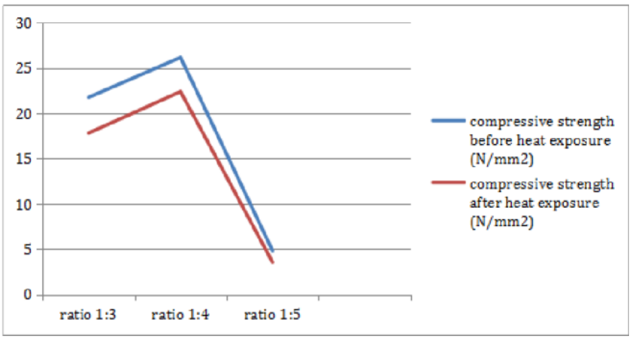
The table above shows impressive developments in mechanical qualities compared to cement and sand pavers. This actually, conforms to the findings of this research which indicate that mixture of sand and HDPE leads to improvement in compressive strength up to a given level before the strength begins to reduce as will be shown in Figure 1.

Table III. Compressive strength after heat exposure

The effect of temperature on compressive strength of pavers was tested after a constant heat exposure of 35 degrees Celsius in an oven for 24 hours. Results of this test are summarized in Table 2.

Sample ratios (plastic: sand)	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1:3	17.83	17.75
	17.59	
	17.96	
1:4	23.18	22.37
	21.52	
	22.42	
1:5	3.56	3.54
	3.82	
	3.18	

The results as illustrated in Table 3 show that prolonged heat has influence on manufactured pavers. Variations of compressive strength before and after heat exposure are illustrated in Figure 1.



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4. Conclusions - Highly challenging is the fact that solving these problems one by one can be very daunting and economically difficult. From the data collection analysis, it has been shown that paving materials made from high density polyethylene wastes and sand composite registers higher performance relative to the conventional one.

The plastic sand pavers possess more advantages which include cost efficiency, removal of wastes products thus abolishing the land requirement problem for dumping plastics. These pavers have important advantages over the heavier concrete and ceramic pavers as they are impervious to moisture, mildew fungus and other algae resistant; lighter in weight and eco-friendly.

If made and put into use, these Pavers will not only reduce construction costs especially those for repairs, but also assist in environmental conservation. Roads will be cheaply constructed, and with the increased durability, accessibility will be improved and economic growth bolstered

5. Referencies.

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