Study on Effects of Plastic Waste in Paver blocks

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Abstract **- Most of the developing nations lack a proper solid waste management system owing to the difficulties faced during the sample collection and treatment phases. Low-density polyethylene (LDPE) contribute as a major source of such pollution due to the widespread use of its products which include water sachets, thin bags, wrapping paper etc. Improper disposal of this waste in the form of landfilling can not only cause environmental impact but also negatively harm the surrounding soil and water bodies. A relatively simple technology has been proposed in this paper that produces LDPE-bonded sand blocks and pavers. Developing countries (DCs) typically have inadequate solid waste management, with low waste collection rates, disposal primarily by dumping and limited outlets for reusing potentially recyclable materials. It was observed that LDPE-bonded sand is a strong, tough material with compressive strengths up to 17 MPa when produced under optimum processing conditions. The density and compressive strength were found to be increased as the particle size of the sand was decreased. The samples also exhibited far superior impact resistance as compared to traditional clay paver blocks.**

Index Terms **- Plastic waste, low density polyethylene, polyethylene properties, plastic sand paving block, paving block; LDPE bonded sand.**

I.INTRODUCTION

Generally, the level of plastics in waste composition is high. The largest component of the plastic waste is polyethylene, followed by polypropylene, polyethylene Terepthalate and polystyrene.

Among different waste fractions, plastic waste deserves special attention on account non-biodegradable property which is creating a lot of problems in the environment. In India approximately 40 million tons of solid waste is produced annually. This is increasing at a rate of 1.5 to 2% every year. Plastics constitute 12.3% of total waste produced most of which is from discarded water bottles. The plastic waste cannot be disposed off by dumping or burning, as they produce uncontrolled fire or contaminate the soil and vegetation.

Considerable researches and studies were carried out in some countries like USA and UK on this topic. However, there have been very limited studies in India on plastics in concrete. Hence an attempt on the utilization of waste Low Density Polyethylene (LDPE) as partial replacement of coarse aggregate is done and its mechanical behaviour is investigated.

The purpose of this project is to evaluate the possibility of using plastic waste materials to partially substitute for the fine aggregate composites.

Following are some literature reviews on various national and international papers on Paver Block and improvement on the paver block characteristic by adding various waste material into paver block.

Zainab Z. Ismail et al. (2007) [43] to determine the feasibility of reusing plastic sand as partial replacement of fine aggregate in concrete.

R L Ramesh et al (2009) [44] used waste plastic of low-density polyethylene as replacement to coarse aggregate.

Praveen Mathew et al. (2013) [45] investigated the suitability of recycled plastic as partial replacement to coarse aggregate in concrete mix.

Raghatate Atul M. (2014) [37] Investigated the tensile strength of concrete by adding up to 0.8% of plastic bag pieces in the concrete mix.

Youcef Ghernouti et al. (2017) [41] to determine the amount of Fine aggregate in the mix proportion of concrete to be replaced with plastic bag waste sand at 10%, 20%, 30% and 40%.

II.OBJECTIVES OF THIS STUDY

To determine the suitability of waste plastic bags in the development of pavement blocks for construction

and to reduce the burden of waste plastic by reusing into pavement.

b. To evaluate the performance of plastic concrete for paver blocks for use in pavements and other application areas.

c. To evaluate compressive strength and durability for ordinary concrete paver blocks, the same have been studied for various plastic paver block.

d. To produce cost-effective paver block which a common person can afford easily

III.MODELING AND ANALYSIS

PROPRTIES OF MATERIAL

Plastic waste (LDPE)

Plastic waste used in making paver block was collected from the surrounding locality LDPE is indicated by resin number 4. It includes plastic bags. The plastic bag used is of about 50 microns. The basic properties are provided below

Table -1: properties of LDPE

SL NO	PARTICULARS	. VALUE
1	Melting Point	150˚c
2	Thermal Coefficient of Expansion	100-200x10-6
3	Density	940 kg/m3

Sand

Sand is a granular material composed of finely divided rock and mineral particles. The properties of sand were determined by conducting test as per IS:2386 The results indicate that the sand conforms to zone II of IS:383-1970.

Table 2 -Physical Properties of Sand

SL NO	PARTICULARS	. VALUE
1	Specific gravity	2.64
2	Fineness modulus	2.923

Fig 1: Plastic Paver blocks prepared

IV.METHODOLOGY

In all, the samples were categorized in to five categories based on the adopted plastic: sand ratio as listed below in Table 3.

Table 3: Batch Designation

S.No.	*Batch Designation*	*Plastic: Sand Ratio*
1	*PB1*	*1: 2.5*
2	*PB2*	*1: 3.0*
3	*PB3*	*1: 3.5*
4	*PB4*	*1: 4.0*
5	*PB5*	*1: 4.5*

Step 1 - Material Procurement was done from local scrap vendors. Special care was taken to avoid collecting plastics of HDPE grade (Figure 2). Also, locally available sand of size smaller than 2.36mm was used. Wood logs were used as fuel source.

Fig.2: Waste LDPE collected from scrap vendors

Step 2 - A setup for heating the sand was prepared using bricks and wood logs (Figure 3).

Fig.3: (a) Setup, (b) Adding the filtere sand to the mixing container, (c) Heating it to180oC

Step 3 - After heating the sand to the predetermined temperature, LDPE plastics were added over it uniformly (Figure 4). Following this, a thorough mixing was done so as to intimately mix the sand and molten plastics together. Proper safety gears such as gloves, boots, masks etc were used during the testing phase.

(a) (b) (c)

Fig.4: (a) Heating the sand, (b) Adding LDPE over heated sand, (c) Mixing the batch

Step 4 - Once the mixture is ready, it is transferred to the cuboidal moulds directly without any significant delay. Size of the moulds adopted for this study was 30cm x 15cm x 10cm (Figure 5). The moulds were properly oiled to avoid any sticking of plastic to the surface

Fig.5: Transferring the mixture of sand and plastic to the mould

Step 5 - Once the mixture is transferred to the mould, it is allowed to cool down. During this time, entrapped air bubbles get released from the mould which lead to the formation of capillaries and minor surface cracks (Figure 6). These need to be filled using a trowel. Thus, a constant degree of supervision was needed during the initial 30 minutes of cooling. After almost 4 hours, the samples were demoulded (Figure 7).

Fig.6: Releasing air bubbles from the mould by minor shaking and tamping

Fig.7: Set paver block just before demoulding

Step 6 - After the paver blocks are hardened i.e. after 4 hours of setting, they were demoulded and kept in a cool dry place for 20 hours. The final end product is a dark colored, dense and hard composite material with smooth even surfaces and well defined edges. This sample is now ready for testing. The following array of tests were carried out to determine the efficiency of recycled LDPE bonded sand paver block in contrast to the traditional clay paver blocks-Compressive Strength Test; Tensile Strength Test; Water Absorption Test; Drop Impact Strength Test; and Heat Resistance Test.

V.RESULTS & DISCUSSIONS

A total of 75 samples (characterized into 5 batches) were evaluated for their performances. Five samples each were tested for their compressive strength, tensile strength, water absorption, impact resistance, and thermal resistance, for varying plastic: sand ratio of 1:2.5, 1:3, 1:3.5, 1:4 and 1: 4.5. The results of the above-mentioned tests are listed ahead-

Compressive Strength Test

It can be clearly seen from Figure 9 that the compressive strengths obtained for PB2 batch were the highest and the strength kept decreasing for further batches with larger sand proportions. This can be attributed to the fact that with increase in sand content, it becomes difficult for the plastic binder to uniformly spread out and bind all the sand grains together, thereby forming a strong cohesive mass. The samples were tested 4 hours after molding and an average compressive strength of 8.14 N/mm2 was observed for

a plastic: sand ratio of 1:3 i.e. PB2 batch, after just a small cool down period of 4 hours. This means the samples are suitable for rapid production and distribution making it an ideal end product in terms of market supply.

Fig.8: Crushed paver block sample of PB2 after CTM testing

It was also observed that the paver block only deformed around the contact area i.e. the area surrounding the actual contact area of load bulged and cracked, whereas the actual area under the load remained more or less unaffected. The only visible difference was the change in color from black to white over the contact area (Figure 8).

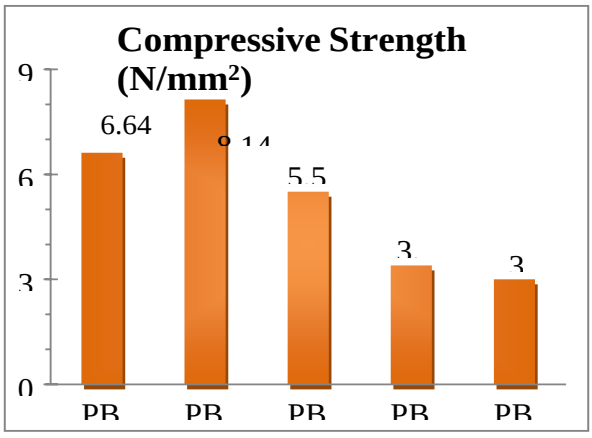

Fig.9: Results of compression strength test

Tensile Strength Test

As observed in Figure 10, a total of 15 samples were evaluated for their tensile strength too. Three briquette samples were tested for each batch. Similar to the previous results, the tensile strengths obtained for PB2 batch were the highest and the strength kept decreasing for further batches(Fig.10).

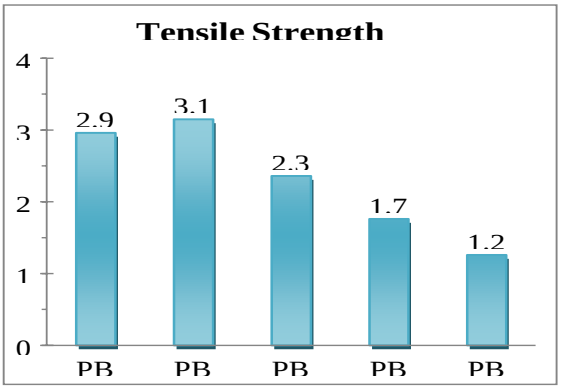

Fig.10: Results of tensile strength test

Water Absorption Test

Five samples of each batch were immersed in cold water for 24 hours straight, to determine their water absorption. It was found that the water absorption was extremely small for PB1 which increased with increase in the sand content (Figure 11). This can be attributed to the fact that higher sand content in the mix leads to more number of voids. The plastic binder itself becomes insufficient to uniformly cover up the entire surface are of the sand grains, which not only reduces the sample's strength, but also leads to an increased water absorption characteristic.

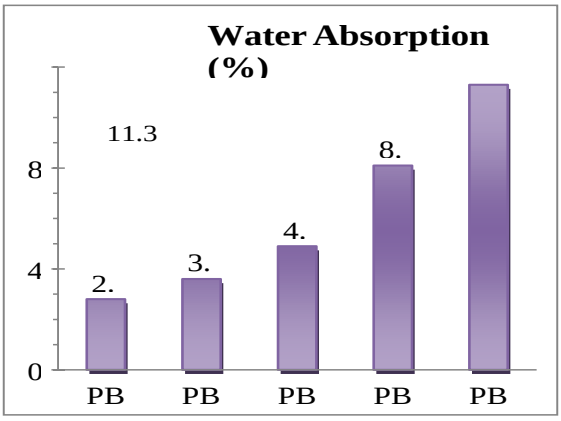

Fig.11: Results of water absorption test

Efflorescence Test

The presence of alkalis in blocks is harmful and they form a grey or white layer on block surface by absorbing moisture. To find out the presence of alkalis in blocks, this test is performed. In this test a block will immerse in fresh water for 24 hours and then it's taken out from water and allowed to dry in shade, And then surface of block will be check out .

Fire Resistance Test

To check the fire resistance capacity, the plastic paver block will be placed in oven for an increasing temperature up to 1800 degree centigrade . To observe effects of higher temperature on block such as crack development or melting of plastic.

Drop Impact Strength Test-

Table 4: Results of Drop Impact Strength Test

Batch	Plastic: Sand Ratio	Observations for varying drop heights		
		Drop Height = 4 m	Drop Height = 7 m	Drop Height = 10 m
PB1	1 : 2.5	No visible deformations	No visible deformations	Surface disintegration at edges
PB2	1 : 3	No visible deformations	No visible deformations	No visible deformations
PB3	1 : 3.5	No visible deformations	No visible deformations	Surface disintegration at edges
PB4	1 : 4	No visible deformations	Surface disintegration at edges	Sample broke in two halves
PB5	1 : 4.5	No visible deformations	Surface disintegration at edges	Total failure (sample crumbled and broke)

Three samples of each proportion were used for this test. One sample each from PB1, PB2, PB3, PB4 and PB5 batch was dropped from a height of 4m, 7m and 10m to evaluate their resistance against impact (Table 4). It was observed that no visible dents or deformations occurred on any of the sample for a drop height of 4m.

However, when dropped from higher heights, slight dents were formed and, in some cases, the sample of paver broke down in two pieces (Figure 12). The samples of PB2 batch displayed the highest impact resistance with no visible deformations on the surface even for a drop height of 10m.

Fig.12: Breaking of PB4 batch sample when dropped from a height of 10m

VI.CONCLUSIONS

- The above findings suggest that recycled LDPE bonded-sand paver blocks can be an effective alternative to the traditional building materials, with the optimum results being obtained for a plastic: sand ratio of 1:3.[2226]
- In drop impact test, all sample shows no dent when it drop from 4m, but when drop from higher height slight dent is observed ,the sample of PB2 with ratio 1:3 shows
- higher impact resistance even drops from 10m than other sample
- The waste plastic used for experiments is of LDPE (Low Density Polyethylene), 5-7mm size and specific gravity of waste plastic is found to be 0.92.
- The mechanical properties of the test concrete did not display any notable differences depending on the color of the plastic waste.

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