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Experimental study on the replacement of coarse aggregates with recycled hospital plastic waste in paver blocks

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ABSTRACT

This paper aims to study the possibility of using recycled hospital plastic waste as a replacement of coarse aggregates in the manufacturing of paver blocks. Use of concrete paver block in road pavements is more common, which is a better option when compared to bitumen and gravel. The use of waste plastic in concrete pavement block is one of the solution to the environment and ecological issues associated with the use of plastics and the disposal of plastic waste from the hospital industry. This project aims to reduce the unit weight, cost of the block, and also to reduce the environmental pollution arising due to the disposal of hospital plastic. Here, various percentages of plastics were replaced for coarse aggregates in concrete, and the properties were found.

Keywords— *Paver blocks, Hospital plastic waste*

1. INTRODUCTION

The aim of the project is to determine the suitability of hospital plastic waste in the development of pavement blocks and analyse its various properties for the application of this in pavement construction. Reason to choose the hospital plastic waste to develop a novel technique to handover it to the respected invention and to explain the difficult of removal loads of plastic waste. The results of the experiment will show the feasibility to use hospital plastic in real mixes.

The hospital plastic waste collected from various sources were sorted and shredded which was replaced for coarse aggregates in concrete pavement blocks and strength tests were carried out for different percentages of replacement out of which 10% gave optimum results.

2. MATERIALS

(a) Cement
(b) Fine aggregates
(c) Coarse aggregates
(d) Water
(e) Plastic
(f) Pigments

2.1 Cement

It is a binder, a substance that sets hardens and adheres to other materials, binding together. Here, Ordinary Portland cement of 53 grade is used confirming to IS 8112-1989.

Table 1: Properties of cement

S no.	Property	Value
1.	Specific Gravity	3.15 (Le-Chatelier's Flask)
2.	Initial Setting Time	30.10 Minutes
3.	Final Setting Time	10 Hours
4.	Standard Consistency	32% (Vicat Apparatus)

2.2 Fine aggregates

Quarry dust of good strength and size less than 4.75 mm having the required properties as specified in IS 383 were used.

Table 2: Properties of fine aggregates

S no.	Property	Value
1.	Specific Gravity	2.64
2.	Fineness Modulus	2.41
3.	Water Absorption	16.8 %

2.3 Coarse aggregates

Hard broken stones are used as coarse aggregate. The IS 15658: 2006, describes that the maximum size of coarse aggregate should be 12mm for paver design. Hence, 10mm coarse aggregates are used in this work. Coarse aggregates complying with the requirements of IS 383 is used.

Table 3: Properties of coarse aggregates

S no.	Property	Value
1.	Specific Gravity	2.84
2.	Fineness modulus	1.92
3.	Impact test	26.47%
4.	Water Absorption	0%

2.4 Water

Portable water free from impurities and salt used for casting and curing the concrete blocks as per IS – 456-2000 Water-cement ratio is 0.4.

2.5 Plastic

Plastic waste was collected from different hospitals and clinics in the city. For sorting and shredding of waste a shredding unit in Vannappuram, Thodupuzha was approached. Different categories of plastic were separated from waste. 35% of the waste was HDPE, 28.67% was Polypropylene, 22.2% of Polyethylene and 14.167% LDPE. All four types of waste were shredded, mixed together and then sieved to a size range of 5mm to 10mm using sieves. According to the Indian standard

specifications the property of aggregates such as specific gravity, density, tensile strength and melting point were found.

Table 4: Properties of Plastics

Type	HDPE	PP	PET	LDPE
Weight	2.8 KG	2.3 KG	1.78 KG	1.13 KG
Percentage	35 %	28.67 %	22.2 %	14.167 %
Specific gravity	0.96 - 0.97	0.90 – 0.92	0.91 – 0.95	0.91-0.963
Density	0.941-0.965 g/cm³	0.895 – 0.92 g/cm³	0.88 – 0.96 g/cm³	0.923 g/cm³
Tensile strength	20 Mpa	32 Mpa	11.7 Mpa	10.5 Mpa
Melting point	130 °C	160 – 171 °C	115-135 °C	120 °C

2.6 Pigments

Black pigments are used and relevant Indian Standard used is IS 44. Pigment quantity to be restricted to a maximum of 9 per cent by weight of cement content. The pigment should be finer than the cement (Fineness value between 2-15 m2/kg).

3. EXPERIMENTAL PROCEDURE

3.1 Mould

The plastic moulds having rectangular shape are used for casting paving block. They were made in such a manner as to facilitate the removal of the moulded specimen without any damage. The size of the mould is 200mm x175mmx60mm and the volume of one mould is 0.0021m^3.

3.2 Weighing

The proportions or materials can be taken by weight or by volume. The procedure we adopted was by weighing of the material as it is more accurate in comparison with the volumetric method.

3.3 Mixing

After weighing all the ingredients which are to be used are taken for the mixing process. The mixing process can be done either by hand mixing or machine mixing. We chose to mix it by machine. At first, cement and fine aggregates with the required amount of shredded plastics were mixed uniformly. Then coarse aggregate is mixed along with this (nominal 12 mm size).

Samples are to be cast with varying proportions of replacements. Sample 1 will be with 0% plastic replacement in order to compare the obtained results. Sample 2 will be with 5% plastic replacement, sample 3 with 10% plastic replacement, sample 4 with 15% plastic replacement and sample 5 with 20% plastic replacement.

Then the calculated quantity of water is poured and mixed by machine. As plastic is mixed, it requires more water. Because plastic has the basic property of high resistance to water and non-absorbents. The final result of the mix ratio obtained from the IS 15658:2006, is 1:1.7:3.75 as cement: fine aggregate: coarse aggregate.

3.4 Compacting

Compacting of concrete was done after placing the mixed concrete in the paper mould. The compaction work is carried out manually and mechanically with tamping steel rods and mechanical vibrator. The concrete was filled in three layers. The concrete should be properly compacted to remove the water and air voids and confirms that the concrete becomes denser, as it improves the strength of concrete.

3.5 Drying and curing

The casted concrete paver block was allowed for drying for 24 hours in normal atmospheric temperature. After that, the concrete is de-moulded and the blocks are cured with water to permit complete moisturisation for the required days of testing. Water in the curing tanks is changed every 3 to 4 days. After curing, the blocks are dried in a natural atmosphere.

Table 5: Mix proportions by weight for each specimen

Material percentage	Cement	Fine aggregates	Coarse aggregates	Plastic
0 %	0.5432 kg	0.9 kg	1.66 kg	0
5 %	0.5432 kg	0.9 kg	1.577 kg	0.083 kg
10 %	0.5432 kg	0.9 kg	1.494 kg	0.166 kg
15 %	0.5432 kg	0.9 kg	1.411 kg	0.249 kg
20 %	0.5432 kg	0.9 kg	1.328 kg	0.332 kg

4. TESTS CARRIED OUT AND RESULTS

4.1 Compressive strength test

At the time of testing, each specimen was kept in the compressive testing machine. The maximum load at the breakage of the concrete block will be noted. Also, more than 90% of the target strength was achieved on the 14-day strength. The compressive strength was found to be maximum for 10% replacement of coarse aggregates by shredded plastic waste after which it was found to be decreasing.

4.2 Water absorption test

Water absorption of test specimens made by hand mixing ranges between 1.896 % and 2.14% and for test specimens by machine mixing ranges between 1.84% and 2.20%. The water absorption decreases with the increase in plastic content. As per IS 15658:2006 water absorption percentage within 5%, hence it is satisfied.

Table 6: Water absorption test results

S no.	Sample with plastic %	Wet weight kg	Dry weight kg	Water absorption %
1.	0%	5.398	5.279	2.20
2.	5%	5.320	5.209	2.09
3.	10%	5.301	5.196	1.98
4.	15%	5.286	5.182	1.97
5.	20%	5.265	5.168	1.84

4.3 Hardness test

In this test, a scratch is made on block surface with a steel rod (any hard material can be used) which was difficult to imply the blocks were hard. This shows the brick possess high quality.

4.4 Efflorescence test

The presence of alkalis in bricks is harmful and they form a grey or white layer on the brick surface by absorbing moisture. To find out the presence of alkalis in bricks this test is performed. In this test, a brick is immersed in fresh water for 24 hours and then it's taken out from the water and allowed to dry in shade. The plastic sand brick has low alkali content and so a little white patch is formed over the surface.

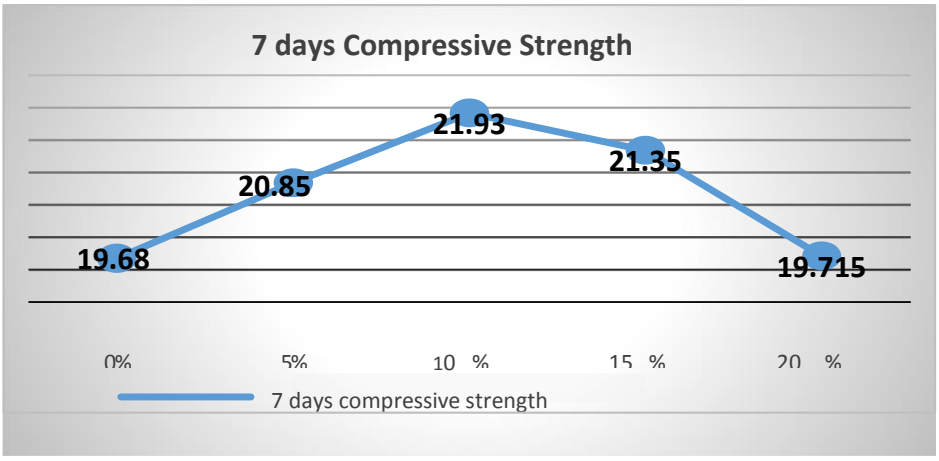

Fig. 1: 7 Days Compressive Strength Test Results

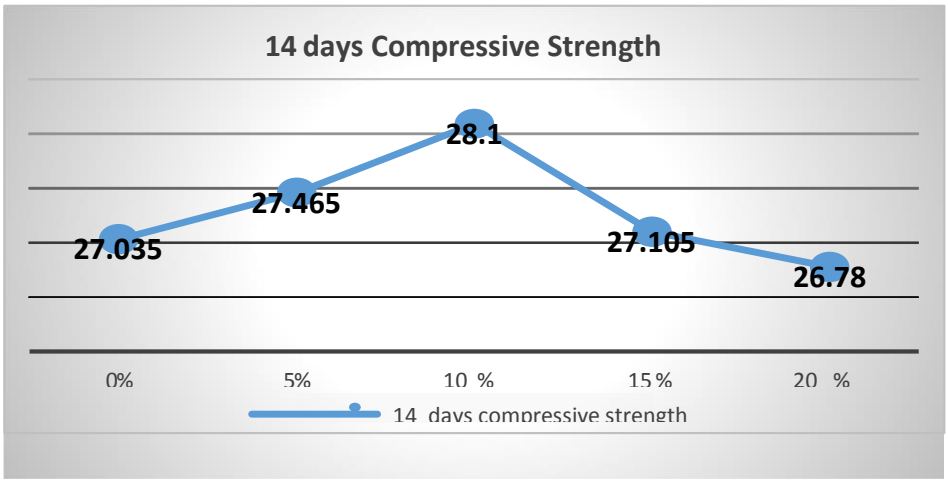

Fig. 2: 14 Days Compressive Strength Test Results

5. CONCLUSIONS

- Reduction in land requirement problem for dumping plastic, reduction in the emission of greenhouse gases by the conversion of flue gases into synthetic oil etc.
- 10% of shredded hospital plastic waste by weight of coarse aggregates is the optimum content which does not affect the properties of concrete and has maximum compressive strength.
- After 10% of shredded hospital plastic waste, the reduction in strength is may be due to a reduction in bonding due the introduction of plastic pieces.
- The plastic in concrete reduces the unit weight of concrete. As plastic has the basic property of water resistance, the concrete mix requires more quantity of water than the calculated amount during mixing.
- The cost of plastic paver block decreases with increase in shredded hospital plastic waste replacement.
- Hence it can be concluded that 10% of hospital plastic waste aggregate can be incorporated as coarse aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties.

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