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Research paper

Experimental Investigations on Concrete with Fly Ash and Marble Powder for Paver Blocks

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Abstract

The construction industry is capable of absorbing large amounts of wastes by utilizing them in other useful products. Thermal power plants and marble industries produce huge quantities of bi-products which causes environmental problems. Utilization of these in concrete will save natural resources to some extent and solve the disposal. Interlocking concrete block pavements are simple to construct and maintain. The main objective of this research is to develop an eco-friendly paver block while considering the economy as a defining parameter. In this research, experimental investigations were carried out on the paver blocks to know the feasibility of using fly ash and marble powder. For paving block concrete, it is partly replaced with cement and aggregates with fly ash and waste marble powder. Various tests for mechanical and durability properties were conducted. All the properties were improved when compared to the control mix. Utilization of fly ash and marble powder in concrete reduces the cost of paver blocks and making it economical and eco-friendly.

Keywords: *Paver blocks; Marble Powder; Fly ash; concrete; cost.*

1. Introduction

Interlocking concrete block pavement (ICBP) is a system of individually shaped blocks to form a continuous hard wearing surface overlay. These pavements have been over decades and are very cost-effective when compared with conventional flexible or rigid pavements. The main reasons for using concrete block pavements over conventional pavements are low maintenance cost, high salvage value, aesthetic appeal, ease of placement and removal, able to withstand heavy loads and durable. Utilizing fly ash from Thermal power plants and waste marble powder by being cut and polished from marble querys in concrete for paver blocks will solve some problems. Also, cost effective and eco-freindly.

M M Islam & M S Islam (2013) [1] studied the strength and durability characteristics of concrete with fly ash blended cement and found that optimum replacement of cement with fly ash is 30%. Manpreet Singh & Kailash Choudhary (2017) [2] studied the environmental and economic impacts of using marble in concrete and found that durability properties like porosity, carbonation, and abrasion resistance have improved. Economical concrete was obtained at 15% cement replacement by marble powder. Mateusz Popek & Lukasz Sadowski (2016) [3] found that replacing part of cement with mineral powder in concrete changes its abrasion resistance. Basil M Mali & Renjan Abraham (2016)[4] did the study on geopolymer concrete used for paver blocks and found that geopolymer concrete can be used effectively for the manufacture of paver blocks.

Materials:

The cement used in mixes was 43 grade ordinary Portland cement conforming to IS 8112[5]. Blaine's fineness and specific gravity of cement were 290 m2/kg and 3.14 respectively. Fly ash used in mixes was siliceous confirming to IS 3812 (part1)[6] Blaine's fineness and specific gravity of fly ash were 343 m2/kg and 2.1 respectively. Waste marble powder used in mixes was obtained from local marble industry in Delhi. The fineness and specific gravity of marble powder were 150m2/kg and 2.56. Locally available natural fine aggregate belongs zone 2 was used. Fineness modulus and specific gravity of fine aggregate were 4.08 and 2.60 respectively. Coarse aggregate used in mixes was crushed granite stones having specific gravities 2.76 and 2.78 respctively. All the properties of fine and course aggregate were confirming to IS 383[7]. Potable water sourced from municipal water supply was used for concrete mixing and curing of specimens. Quality of water is confirming to specifications of IS 456:2000.[8]

Mix Proportion

Three serieses of mix containing fly ash and marble powder and both, maintaining powder contents same and one control mix was prepared for experimental investigation as shown in Table 1. The water to binder ratio used for all mixes was 0.4. Efficiency factor of fly ash concept was used in fly ash mixes Each series contains three proportions with varying percentages of fly ash and marble powder.

Table 1: Mix proportions corresponding to w/b=0.4

Series name	Specimen mark	f%	K-value	Powder content (kg)	water (kg)	cement (kg)	Fly ash (kg)	Marble powder (kg)	Sand (kg)	10mm aggregate (kg)	20mm aggregate (kg)	Volume
Control mix	D1	0%	1	388	155	388	0	0	784	444	666	981
Series 1	D2	25%	0.51	442	155	332	111	0	732	428	642	981
	D3	35%	0.35	502	155	326	176	0	688	414	621	981
	D4	45%	0.26	579	155	319	261	0	637	394	591	981
Series 2	D5	0%	1	442	155	388	0	54	747	437	655	981
	D6	0%	1	502	155	388	0	114	710	427	640	981

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Series 3	D7	0%	1	579	155	388	0	191	666	412	618	981
	D8	19%	0.65	442	155	335	80	27	735	430	645	981
	D9	26%	0.49	502	155	331	114	57	694	418	627	981
	D10	32%	0.38	579	155	328	156	95	647	400	600	981

2. Test Methods

As the research objective is checking the feasibility of eco-friendly material for paver blocks, various tests was carried out. Compressive strength, Abrasion resistance, Split tensile strength, and Flexural strength were determined based on the methods given in IS 15658: 2006 (Indian standard for precast concrete blocks for paving specifications). Cost analysis was done to evaluate econimic benefit.

3. Results and Discussions:

1. Compressive Strength

It is observed from the Fig: 1(a) that the early development of strength is high for series 2 when compared to series 1 and series 3. The compressive strength is decreasing with increasing powder content. In Fig: 1(b), it is observed that in series 2 the compressive strength at 28 days is decreasing with increase in powder content whereas, in series 1 and series 3, compressive strength is increasing with increase in powder content. All the mixes attained required strength at 7 days and 28 days.

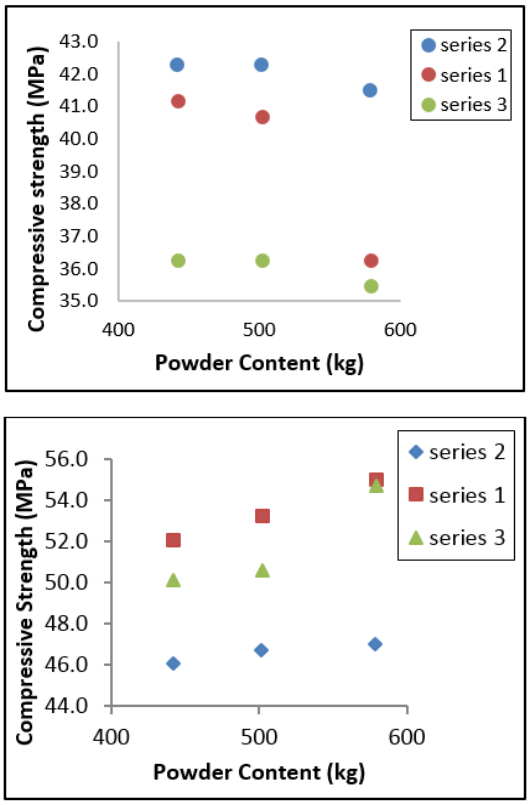


Fig. 1(a) and 1(b): Powder content Vs Compressive strength at 7 days and 28 days

2. Split Tensile Strength

Fig: 2(a) shows split tensile strength which was increased with increase in powder content in series 1 and series 3. But in series 2 the split tensile strength was decreased with increase in powder content. The split tensile strength of control mix i is 2.65MPa.

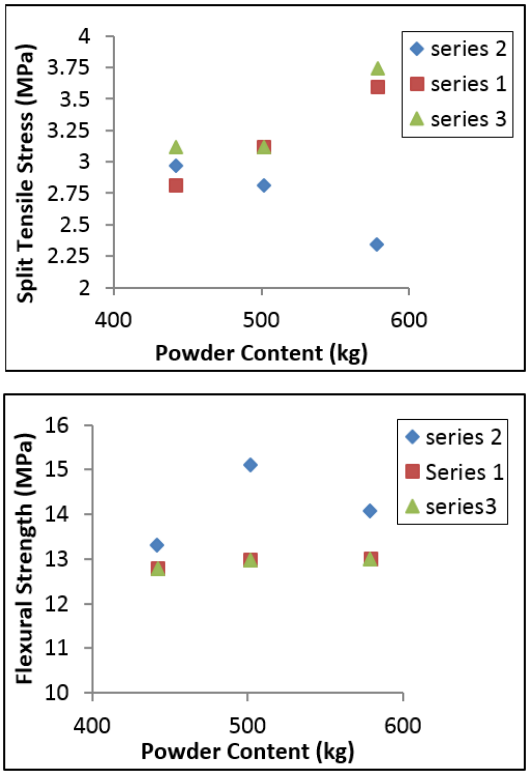


Fig. 2(a) and 2(b): Powder content Vs Split tensile and Flextural strength at 28 days

3. Flexural Strength

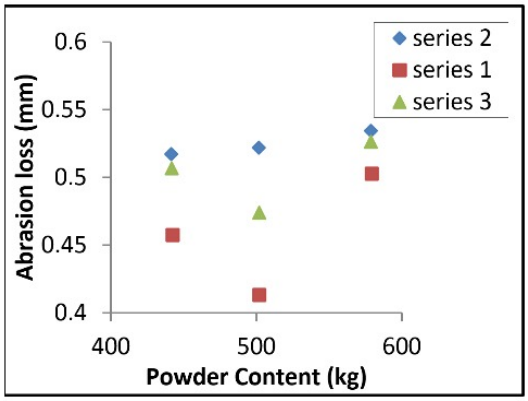
Fig 2(b) shows flextural strength which reveals that up to 500kg powder content the flexural strength was increasing but after that, the flexural strength was decreasing with increase in powder content. Series 2 got higher flexural strength when compared to series 1 and series 3. Flexural strength of control mix is 11MPa. All the mixes in series1,2 &3 showed better performance than control mix in flexure.

4. Abrasion Resistance

Fig 3(a) shows abrassion loss which reveals series 3 showed a better resistance to abrasion when compared to series 1 and series 2. As per IS 15658, the abrasion loss should be less than 3mm. For all the mixes in series1, 2 &3, abrasion loss was less than 0.55mm.

5. Cost Analysis

Costs of constituents of concrete were taken from the Standard schedule of rates- New Delhi. Cost of marble powder assumed to be 0.50 INR The cost was calculated per m3 of concrete for all the mixes shown in fig.3(b). Cost concrete used in control mix was Rs.3965/m3. The decrease in cost with an increase in powder content was observed in series 1, 2 and 3. Series 1 and series 3 mixes were very economical when compared to control mix. Cost of series 2 mixes was higher than that of series 1&3 but less than control mix.



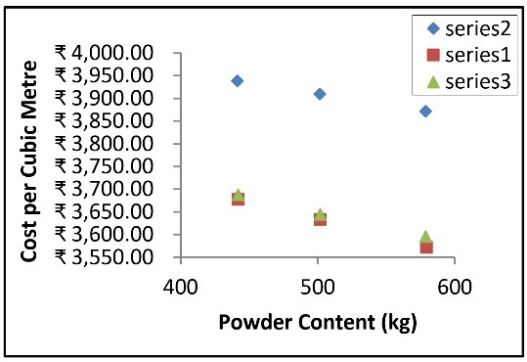


Fig. 3(a) and 3(b): Powder content Vs abrasion loss at 28 days and cost of Concrete

4. Conclusions:

After carrying out the experimental investigations on concrete specimens, the following conclusions were drawn.

1. Series 1 mixes i.e. mix containing cement, fly ash and no marble powder were showing a better performance under compression and abrasion.
2. Series 2 mixes i.e. mix containing cement; marble powder and no fly ash were showing better performance under flexure.
3. Series 3 mixes i.e. mix containing cement, fly ash and marble powder showed better performance under splitting tension.
4. After observing cost, compressive, split tensile, flexure, and abrasion resistance of all mixes, it is concluded that series 3 mixes were preferred over all mixes for paver blocks.
5. Utilization of fly ash and marble powder in concrete for paver blocks will solve the disposal problems of these wastes and indicates the positive signs of reduced environmental impacts. It makes the paver blocks produced from this concrete eco-friendly.

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