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An Experimental Study on The Properties of Compac-Pressed Sustainable Paver Blocks

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Abstract: The construction industry is facing increasing challenges related to sustainability, resource depletion, and environmental pollution caused by traditional building materials. Cement, a key component in concrete, significantly contributes to CO_2 emissions during its production. Similarly, the accumulation of waste glass and plastic poses environmental hazards, necessitating innovative strategies for waste management. This study addresses these issues by developing paver blocks that utilize glass powder as a partial replacement for cement and incorporate waste HDPE plastic fibers as reinforcement. The primary objective is to reduce the environmental impact of traditional cement-based paver blocks by incorporating recycled materials while enhancing their performance characteristics. This experimental work involves replacing cement with glass powder at varying percentages from 0%, 10%, 20% & 30% and reinforcing the mix with HDPE fibers at 0.5% by volume derived from plastic waste. Key tests, including water absorption and compressive strength, are conducted to assess the durability and structural performance of the paver blocks. The results reveal that the addition of glass powder significantly reduces cement consumption and improves sustainability without compromising compressive strength. Meanwhile, the inclusion of HDPE fibers enhances crack resistance and contributes to better mechanical properties. This study demonstrates the feasibility of using waste materials in producing eco-friendly paver blocks, aligning with the principles of sustainable construction and circular economy.

Keywords: Glass powder, waste plastic fibers, sustainability.

INTRODUCTION

Concrete is the most widely used building material and ranks as the second most consumed substance globally after water. Its main ingredient, cement, contributes significantly to greenhouse gas emissions, leading to global warming concerns. To reduce this impact, alternative cementitious materials like fly ash, silica fume, and glass powder are being used to replace cement. Glass powder, a byproduct of glass manufacturing, is rich in silica and enhances concrete's strength and durability.

Cement is a binding agent that hardens and bonds materials like sand and gravel. It is essential in concrete production and civil engineering.

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Plastic, a non-biodegradable synthetic material, poses a significant environmental threat, especially due to plastic waste in oceans and ecosystems. It harms marine life, causes pollution, and disrupts drainage systems. Recycling plastic into products like paver blocks helps reduce pollution and manufacturing costs, though challenges in managing plastic waste remain.

Glass is versatile but poses environmental problems due to its low recycling rate. Despite being fully recyclable, large amounts of glass waste end up in landfills. Recycling glass is crucial to reducing its environmental impact.
Sustainable construction methods focusing on recycling and reducing waste can improve energy efficiency, reduce greenhouse gas emissions, and enhance resource productivity.

OBJECTIVES OF THE STUDY

In this project the paver blocks are produced using waste glass powder as partial replacement with cement in percentage of 0%,10%,20% & 30% by weight and with addition of waste plastic fibres [aspect ratio 40] with 0.75 % by volume. To study the effects of glass powder and waste plastic fibres on the produced pave blocks following objectives are framed

- To study and fabricate a paver block pressing technique with a help of compression testing machine
- To determine the physical properties of ingredients of paver block and assess their suitability as per IS codes
- To determine 28 days compressive strength of produced paver blocks and compare with reference paver block
- To determine water absorption of produced paver blocks and compare with reference paver block
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MATERIALS AND METHODOLOGY

1.Cement
Cement is crucial in concrete production, with key properties including setting time, hydraulic properties, workability, durability, heat of hydration, shrinkage, fineness, chemical composition, and compressive strength. Cement's ability to harden through a chemical reaction with water makes it ideal for wet environments. In this project, the specific gravity of Birla Shakti cement was calculated to be 3.10.

2.Sand
Manufactured sand (M-Sand) is tested for grain size, moisture content, density, permeability, strength, and durability to ensure it's suitable for concrete. The average specific gravity of the sand used in the project was 2.66.

3.Chipping Stone
Stone chippings, used in concrete, enhance strength and workability. They come in various sizes and shapes, impacting concrete's texture, strength, and compaction. The stone's strength and durability are key to the concrete's overall performance. The average specific gravity of the chipping stone used was 2.99.

4.Glass Powder
Glass powder, a byproduct of glass manufacturing, improves concrete's mechanical properties through pozzolanic reactions, especially due to its high silica content. It's a local, environmentally friendly material with 71.53% silica and other compounds like calcium oxide and magnesium oxide.

5. Plastic Fibers
Recycled HDPE plastic fibers are added to paver blocks to enhance their mechanical properties. These fibers improve strength, reduce shrinkage, and resist corrosion. They make up 0.75% by volume of the paver mix, contributing to durability and sustainability

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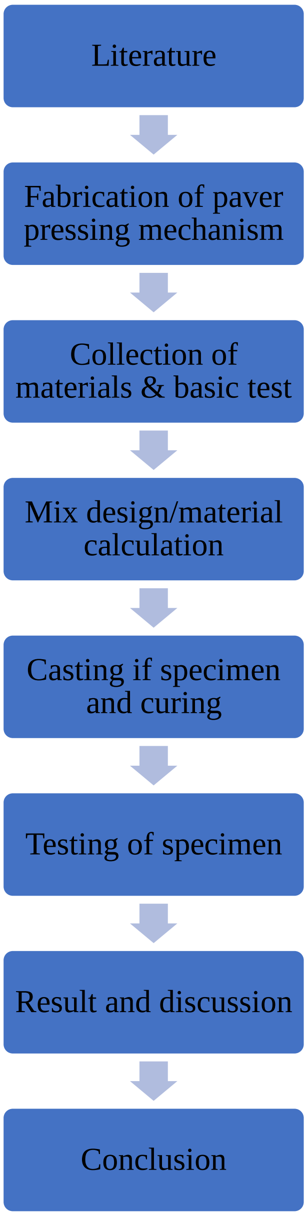
METHODOLOGY



Experimental results:

This chapter deals with the carrying out testing of casted paver blocks. The prepared paver blocks for trial mixes such as 0%, 10%, 20% & 30% are tested for water absorption and compressive strength test. The detailed observations and test results are as discussed below

WATER ABSORPTION TEST

The water absorption test for paver blocks determines the amount of water a block can absorb when exposed to moisture. This is crucial as high-water absorption can weaken the paver block, affecting its strength, durability, and weather resistance

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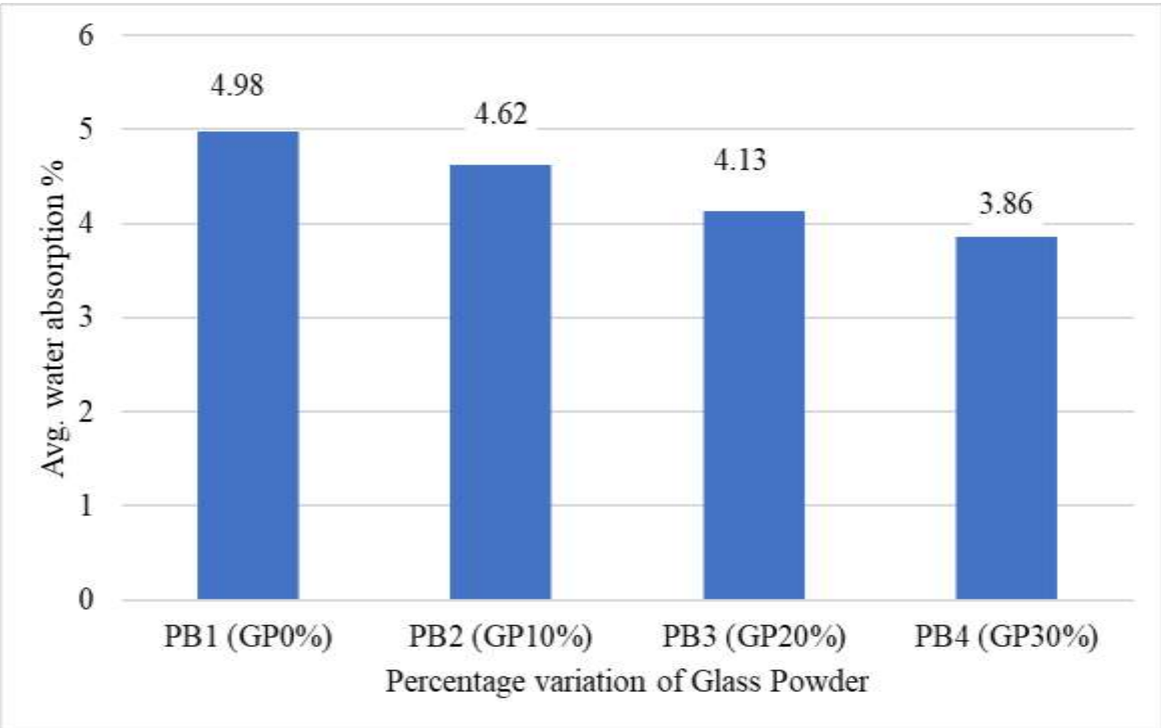
Table: Water absorption test results of produced paver blocks

SL. NO	Mix ID. NO	Weight of paver block in wet W1(gm)	Weight of paver block in dry W2(gm)	Water Absorption (%)	Average Water Absorption (%)
01	PB1 (GP0%)	5.016	4.825	3.950	**4.98**
		5.064	4.768	6.200	
		5.324	5.080	4.800	
02	PB2 (GP10%)	5.010	4.800	4.375	**4.62**
		4.980	4.785	4.070	
		5.220	4.951	5.433	
03	PB3 (GP20%)	4.950	4.755	4.100	**4.13**
		4.985	4.785	4.017	
		4.973	4.775	4.140	
03	PB4 (GP30%)	5.018	4.827	3.960	**3.86**
		4.987	4.792	4.060	
		5.010	4.837	3.570	



Graph: Water absorption graph

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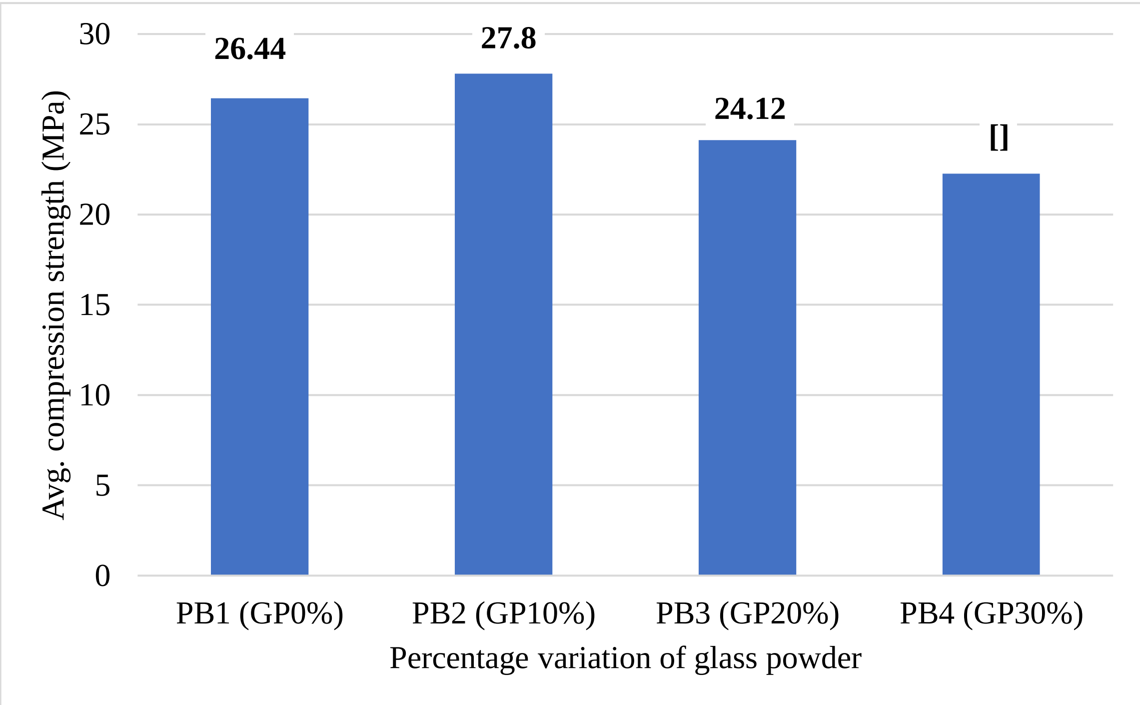
2 COMPRESSION TEST

Compressive strength test assesses the ability of paver blocks to withstand compressive loads. Paver block specimens of varying mixes of glass powder replacement level such as 0, 10%, 20% & 30%, cast in molds and properly cured for 28 days, are tested by applying compressive force using a compressive testing machine to determine their strength. The tests results are as shown in table below.

Table: Compressive Strength Test results of produced paver blocks

SL. NO	Mix ID.NO	Area (mm^2)	Failure load (N)	Compressive strength (N/mm^2)	Average Compressive strength (MPa)
01	PB1 (GP0%)	28800	$760x10^3$	26.38	**26.44**
		28800	$755x10^3$	26.21	
		28800	$770x10^3$	26.73	
02	PB2 (GP10%)	28800	$780x10^3$	27.08	**27.80**
		28800	$770x10^3$	26.73	
		28800	$790x10^3$	27.43	
03	PB2 (GP20%)	28800	$710x10^3$	24.65	**24.12**
		28800	$690x10^3$	23.94	
		28800	$685x10^3$	23.78	
04	PB2 (GP30%)	28800	$650x10^3$	22.56	**22.27**
		28800	$630x10^3$	21.87	
		28800	$645x10^3$	22.39	



Graph: Compression strength test results

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RESULTS AND DISCUSSION

This chapter deals with the interpretation of the tests results obtained on the paver blocks produced by replacing cement with glass powder in percentage 0%, 10%,20%,30% by weight and with addition of waste plastic fibers 0.75% by volume. The water absorption test and compressive strength tests were conducted on the paver blocks.

The results obtained are as discussed below.

1. It is observed that the compressive strength of the paver blocks tested at 28 days increases up to 10% replacement of glass powder with cement and there by decreases as the percentage of glass powder increases in comparison with the paver block of 0% replacement of glass powder with cement. The obtained compressive strength at 10% replacement of glass powder & 0.75%waste plastic fiber is 27.80 N/mm^2 .

   This may be due to fact that 10% replacement of cement by glass powder may induce maximum pozzolanic reaction through which additional CSH gel is produced. This is also may be due to the fact that at 10% replacement of cement by glass powder all the voids will be filled thereby improving the microstructure of cement. And also due to the enhanced crack resistance and load distribution of waste plastic fibers the compressive strength is improved.

   Thus, it may be concluded that the highest compressive strength at 28 days of paver blocks produced by using glass powder as partial replacement with cement and with addition of waste plastic fiber is obtained at 10% replacement i.e. 27.80 N/mm^2

2. It is observed that the water absorption of all the paver blocks produced by replacing cement with glass powder in percentage 0%, 10%,20%,30% by weight and with addition of waste plastic fibers 0.75% by volume is found to be lesser than 6% as per IS 15658 (2006).

3. It is observed that the water absorption of the paver blocks go on reducing with the increase in glass powder content up to 30% replacement with cement & 0.75% waste plastic fiber. The water absorption of the paver blocks with 30% replacement level is found to be 3.86% and at 0% replacement level is found to be 4.98% which is 22.48% reduction in water absorption as compared with normal paver block.

   This may be due to fact that the pozzolanic activity of finely powdered glass powder densifies the microstructure and better packing effect reduces porosity. Also the waste plastic fiber being hydrophobic do not absorb the water and also might bridge micro cracks, reducing connectivity between pores leading to the lesser water absorption.

Thus, it may be also concluded that the paver block produced have lesser water absorption rate than compared with normal paver blocks.

CONCLUSIONS

The experimental study on the effect of paver blocks produced by replacing cement with glass powder in percentage of 0%, 10%, 20% & 30% and with addition of waste plastic fibers 0.75% by volume concludes the following

1. The replacement of glass powder upto 10% with cement significantly enhances the compressive strength at 28 days of paver blocks due to its pozzolanic activity and finer particle size improving the packing density of the mix.

2. The addition of waste HDPE plastic fibers by 0.75% in paver blocks, improve crack resistance and enhances compressive strength of the paver blocks.

3. The paver block produced have lesser water absorption rate than compared with normal paver blocks. This is due to better packing effect of glass powder and also due to hydrophobic nature of waste plastic fibers.

By decreasing the need for cement (which lowers carbon emissions) and efficiently using waste resources, glass powder and waste HDPE plastic fibers help to prevent environmental contamination and promote sustainable building practices.

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