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An Experimental Study on Green and Sustainable Paver Blocks

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ABSTRACT: Rapid urbanization and infrastructure development have increased the demand for concrete paver blocks, leading to high consumption of natural resources and cement. Cement production contributes significantly to carbon dioxide emissions, while disposal of waste rubber poses serious environmental challenges. This experimental study investigates the feasibility of producing green and sustainable concrete paver blocks by partially replacing cement with Ground Granulated Blast Furnace Slag (GGBS) at 20%, 30%, and 40%, and coarse aggregate with waste rubber at 5%, 10%, and 15%. Two types of paver blocks were used in this study. Different types of concrete mixes were used, including a control mix, were prepared and tested for compressive strength, water absorption, and durability characteristics as per relevant Indian Standards. The results show a gradual decrease in compressive strength with increased replacement of cement by GGBS and rubber. Both specimen shapes exhibit similar behaviour, with zig-zag pavers showing slightly higher strength. However, the achieved strengths are still suitable for paving and non-structural applications.

KEY WORDS: Sustainable paver blocks, GGBS, waste rubber, compressive strength, green concrete.

I. INTRODUCTION

Concrete paver blocks are widely used in pavements, footpaths, parking areas, and low-traffic roads due to their durability, ease of installation, and aesthetic appearance. Conventional paver blocks rely heavily on Ordinary Portland Cement (OPC) and natural aggregates, the excessive use of which results in environmental degradation and depletion of natural resources.

Cement manufacturing is responsible for nearly 8% of global $C0_2$ emissions. At the same time, disposal of waste rubber, particularly from discarded automobile tyres, has become a major environmental concern due to its non-biodegradable nature. Incorporating industrial by-products such as Ground Granulated Blast Furnace Slag (GGBS) and waste rubber into concrete offers a sustainable solution to these problems. This study focuses on developing green paver blocks by partially replacing cement with GGBS and coarse aggregate with waste rubber.

II. METHODOLOGY

- Collection of materials.
- Material testing & characterization.
- Mix design & proportioning.
- Batching & mixing of ingredients.
- Casting of paver blocks in moulds.
- Curing of specimens.
- Testing of paver blocks.
- Data recording & analysis
- Conclusion & recommendations.

III. MATERIALS USED

Materials used for the casting and investigation are listed below:

3.1 Cement: Ordinary Portland cement of 53 grade conforming to IS: 169-1989 has been used for this investigation. The result of tests included on cement are as follow.

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Fig 1: Cement

TABLE 3.1 Properties of cement

S.no	Property	Required as per IS 12269: 2013	Value
1.	Fineness	<10%	6%
2.	Specific gravity	3.0-3.15	3.1
3.	Soundness	Minimum 10	6
4.	Initial setting time	Minimum 30 min	35 min
5.	Final setting time	<600 min	590 min

3.2 Ground granulated blast furnace slag:

GGBS obtained from a steel manufacturing plant was used as a partial replacement for cement at 20%, 30%, and 40%..The result of tests included on GGBS are as follow.

Fig 2: GGBS

TABLE 3.2 Properties of GGBS

S.no	Property	Required as per IS 383: 1970	Value
1.	Fineness	<10%	9%
2.	Specific gravity	2.7 - 2.9	2.8
3.	Soundness	Minimum 10	2.5
4.	Initial setting time	Minimum	45 min

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		30 min	
5.	Final setting time	<600 min	285 min

3.3 Rubber:

Using a waste tyre rubber in concrete to replacement for coarse aggregate of 5% ,10%,15% The result of tests included on rubber are as follow.

Fig 3: Rubber

TABLE 3.3 Properties of Rubber

S.no	Property	Required as per IS 2386: 1963	Value
1.	Water absorption	<1%	0.2%
2.	Specific gravity	1.05–1.25	1.15
3.	Bulk density	500–750 kg/m³	620 kg/m³

3.4 Fine aggregate:

Natural river sand conforming to Zone II as per IS 383 has been used for this experiment. The result of tests included on fine aggregate are as follow.

Fig 4: FINE AGGREGATE

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TABLE 3.4 Properties of fine aggregate

S.no	Property	Required as per IS 2386 parts	Value
1.	Fineness	Less than 3 %	6%
2.	Specific gravity	2.6 – 2.8	2.62
3.	Silt content	Less than 8	6.9

3.5 Coarse aggregate:

Aggregate of size 10-12 mm has been used for this experiment. The result of tests included on Coarse aggregate are as follow.

Fig 5: COARSE AGGREGATE

TABLE 3.5 Properties of coarse aggregate

S.no	Property	Required as per IS 2386 parts	Value
1.	Fineness modulus	6 – 8.5 %	6.9 %
2.	Specific gravity	2.6 – 2.9	2.63

3.5 Moulds:

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For this study, zig-zag and Milano shaped paver block moulds were used in accordance with **IS 15658:2006**. These commonly used interlocking shapes were chosen to study the effect of paver geometry on compressive strength. All specimens were cast using standard mould dimensions to ensure consistency and reliable comparison of results.

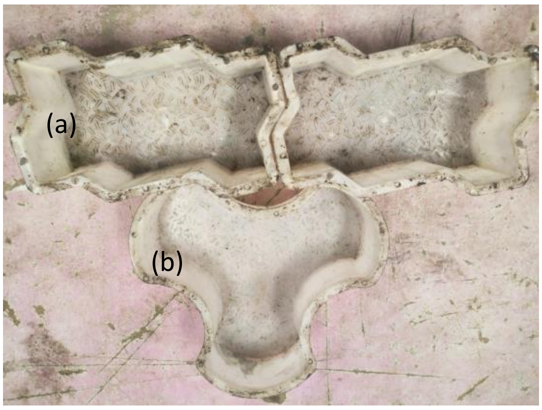

Fig 6:(a) ZIG ZAG MOULDS & (b) MILANO SHAPE MOULD

IV. MIX DESIGN

The casting of paver blocks has been prepared as per the below mix design.

Table 4.1Proportion of mix as per IS 10262: 2019:

Concrete Grade	Cement (kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	WATER (litre)
M30	427	516	1070	192
Proportion	1	1.2	2.5	0.45

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Table 4.2 Material quantities for zig zag shape mould

Specimen number	Specimen type	Cement [Kg]	GGBS [Kg]	Coarse Aggregate [Kg]	Rubber [Kg]	Fine Aggregate [Kg]	Water [lt]
1	Conventional cement paver	1.22	-	3	-	1.63	0.6
2	20% Replacement of cement with GGBS & 5% Replacement of coarse aggregate with rubber	1.04	0.26	2.9	0.15	1.63	0.6
3	30% Replacement of cement with GGBS & 10% Replacement of coarse aggregate with rubber	0.91	0.39	2.79	0.31	1.63	0.6
4	40% Replacement of cement with GGBS & 15% Replacement of coarse aggregate with rubber	0.78	0.52	2.63	0.465	1.63	0.6

Table 4.3 Material quantities for milano shape mould

Specimen number	Specimen type	Cement [Kg]	GGBS [Kg]	Coarse Aggregate [Kg]	Rubber [Kg]	Fine Aggregate [Kg]	Water [lt]
1	Conventional cement paver	1.7	-	3.5	-	2.3	0.85
2	20% Replacement of cement with GGBS & 5% Replacement of coarse aggregate with rubber	1.36	0.34	3.325	0.17	2.3	0.85
3	30% Replacement of cement with GGBS & 10% Replacement of coarse aggregate with rubber	1.19	0.51	3.15	0.35	2.3	0.85
4	40% Replacement of cement with GGBS & 15% Replacement of coarse aggregate with rubber	1.02	0.68	2.97	0.52	2.3	0.85

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V. RESULTS AND CONCLUSIONS

All the casted specimens are tested for compression test as per the investigation and the test results has been compared keenly the conclusions were made as per the results obtained.

5.1 Compressive Strength

Table 5.1 Compressive Strength Test Results in MPa for **Zig Zag Shape**

Specimen number	**Specimen Type**	**Compression Load (KN)**	**Compressive strength (MPa)**
1.	Conventional cement paver	1100	33.85
2.	20% Replacement of cement with GGBS & 5% Replacement of coarse aggregate with rubber	1010	31.08
3.	30% Replacement of cement with GGBS & 10% Replacement of coarse aggregate with rubber	950	29.23
4.	40% Replacement of cement with GGBS & 15% Replacement of coarse aggregate with rubber	880	27.08

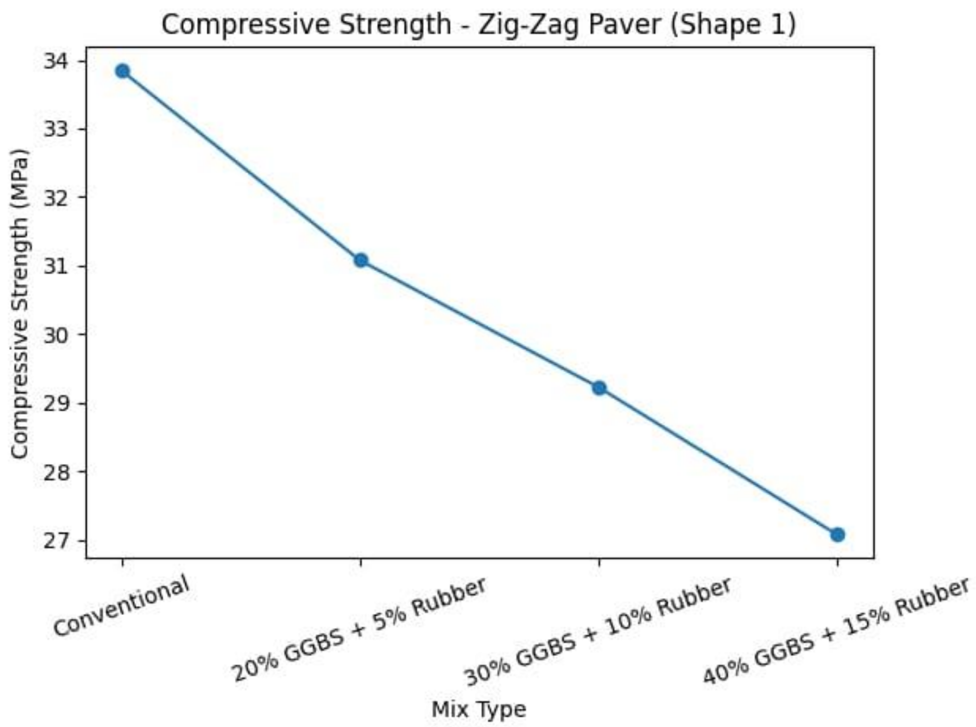

Fig 5.1 Compressive Strength Test Results in MPa for **Zig Zag Shape**

Table 5.2 Compressive Strength Test Results in MPa for **Milano Shape**

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Specimen number	Specimen Type	Compression Load (KN)	Compressive strength (MPa)
1.	Conventional cement paver	1248	34.05
2.	20% Replacement of cement with GGBS & 5% Replacement of coarse aggregate with rubber	1125	30.68
3.	30% Replacement of cement with GGBS & 10% Replacement of coarse aggregate with rubber	1050	28.64
4.	40% Replacement of cement with GGBS & 15% Replacement of coarse aggregate with rubber	970	26.46

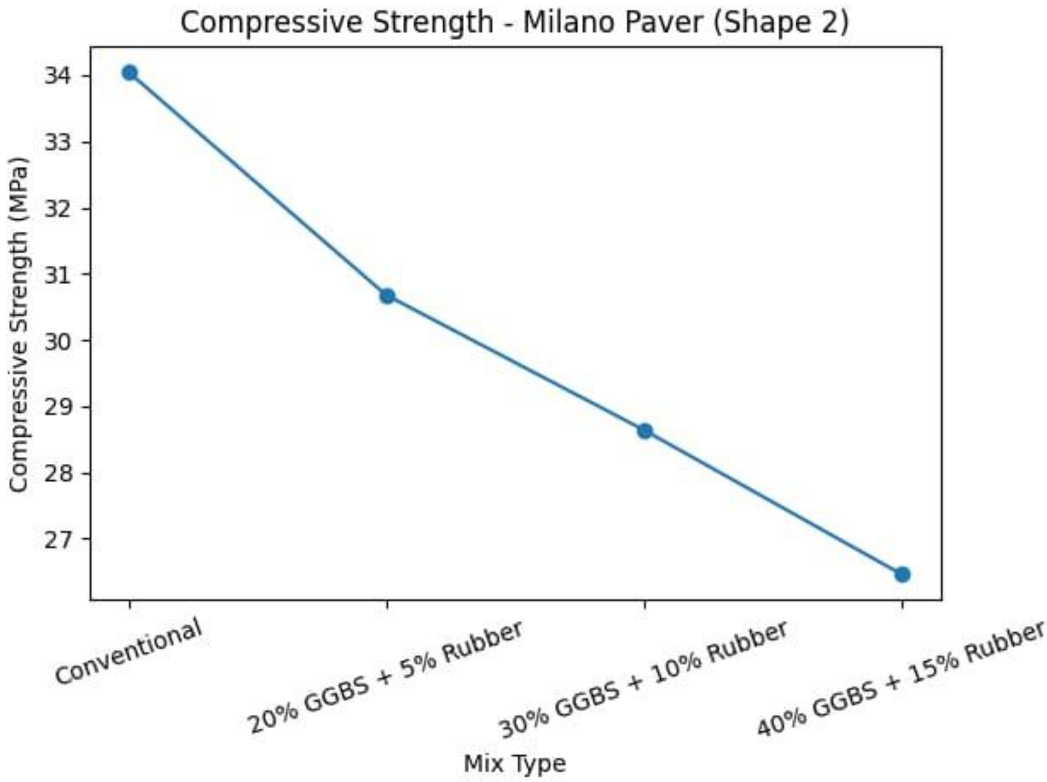

Fig 5.2 Compressive Strength Test Results in MPa for **Milano Shape**

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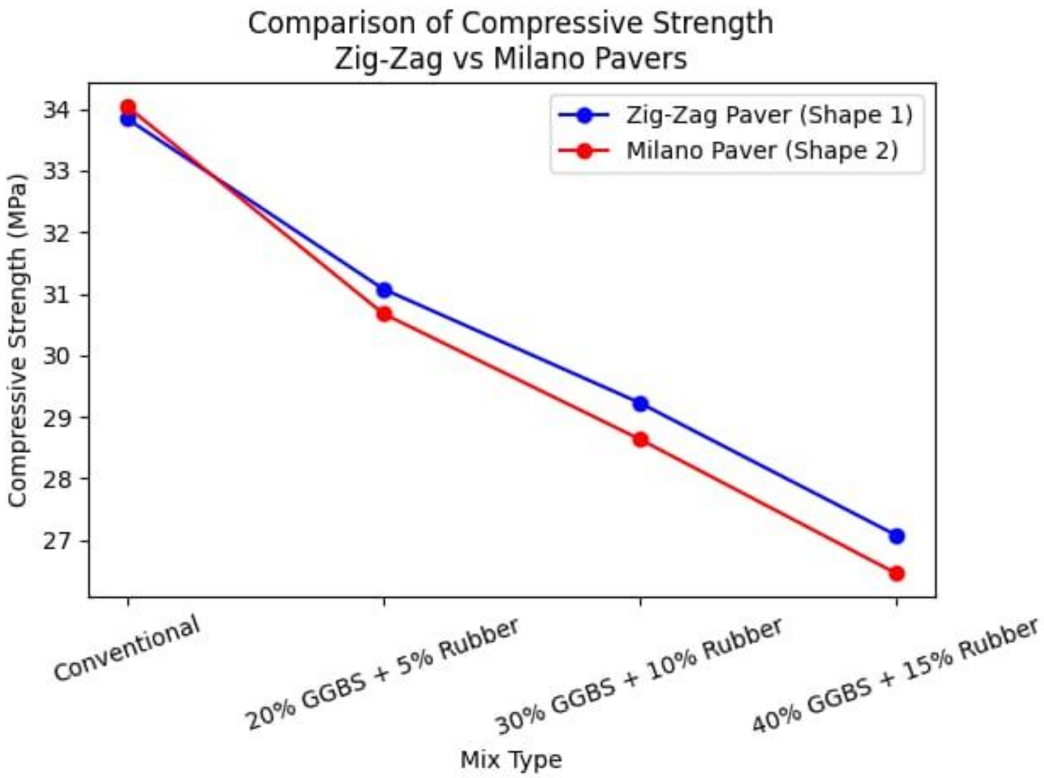

Fig 5.3- Variation of compression strength with respect to percentages of replacements

VI. CONCLUSION

This study shows that replacing a portion of cement with GGBS and rubber affects the compressive strength of paver blocks, with strength gradually decreasing as the replacement level increases. Even so, mixes with lower replacement percentages meet the minimum strength requirements specified in **IS 15658:2006**, making them suitable for light to medium traffic paving applications.

Zig-zag paver blocks consistently performed slightly better than rectangular blocks, likely due to improved interlocking and load distribution. The results also highlight the importance of paver shape and material composition in overall performance. Overall, the findings confirm that GGBS and rubber can be effectively used to produce sustainable paver blocks while reducing cement usage and promoting waste utilization without compromising practical performance.

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