Performance Analysis of Concrete Paver Blocks Manufactured Using Recycled Aggregates and Silica Fume

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***Abstract*— The rapid growth of construction activities has led to excessive consumption of natural aggregates and the generation of large volumes of construction and demolition waste. This study focuses on the development of sustainable paver blocks by utilizing recycled aggregates and silica fume as partial replacements in concrete. Recycled aggregates obtained from demolished concrete structures are used to replace natural coarse aggregates, while silica fume, a highly reactive pozzolanic material, is incorporated as a partial replacement for cement to enhance strength and durability.**

The experimental program involves the preparation of concrete paver blocks with varying percentages of recycled aggregates and silica fume. Standard tests are conducted to evaluate compressive strength, water absorption, and durability characteristics at different curing periods. The results indicate that the inclusion of silica fume significantly improves the mechanical properties and microstructure of recycled aggregate concrete, compensating for the reduction in strength typically associated with recycled aggregates.

The study demonstrates that an optimum combination of recycled aggregates and silica fume can produce paver blocks with satisfactory strength and performance suitable for pedestrian and light traffic applications. This approach not only reduces environmental impact by minimizing waste and conserving natural resources but also promotes sustainable construction practices. The findings of this research contribute to the development of eco-friendly and cost-effective paving materials for modern infrastructure.

***Index Terms*— Recycled Aggregate Concrete (RAC), Silica Fume, Paver Blocks, Sustainable Construction, Construction and Demolition Waste, Compressive Strength**

I. INTRODUCTION

The construction industry is one of the largest contributors to economic development, but it also generates a significant amount of waste, particularly in the form of construction and demolition debris. At the same time, the continuous extraction of natural aggregates for concrete production has led to the depletion of natural resources and environmental imbalance. This has created a growing need for sustainable and eco-friendly construction practices.

In recent years, the use of recycled aggregates obtained from demolished concrete has gained attention as an alternative to natural aggregates. Recycled aggregate concrete (RAC) helps in reducing landfill waste and conserving natural resources. However, RAC often shows lower strength and durability compared to conventional concrete due to the presence of adhered mortar and higher water absorption.

To overcome these limitations, supplementary cementitious materials such as silica fume have been widely used. Silica fume is a highly reactive pozzolanic material that improves the microstructure of concrete by filling voids and enhancing the bond between cement paste and aggregates. Its use can significantly improve the strength, durability, and overall performance of recycled aggregate concrete.

Paver blocks are commonly used in pavements, walkways, and low-traffic roads due to their ease of

installation and maintenance. The development of paver blocks using recycled aggregates and silica fume presents an effective solution for sustainable construction. It not only utilizes waste materials but also enhances the engineering properties of concrete.
Although several studies have been conducted on recycled aggregate concrete and silica fume individually, limited research is available on their combined use in the production of concrete paver blocks. Therefore, this study focuses on the development and performance evaluation of recycled aggregate concrete paver blocks incorporating silica fume. The aim is to assess their compressive strength, durability, and suitability for practical applications.

Objectives

1. To reduce environmental impact by utilizing recycled aggregates and minimizing the consumption of natural resources.
2. To analysis the economic benefits of using recycled aggregates.
3. To determine the optimum percentage of recycled aggregate that provides the best performance in terms of strength and durability.
4. To determine the compressive strength of paver blocks at different curing periods (7 days and 28 days).

II. MATERIALS USED

1. Cement

Ordinary Portland Cement (OPC) of 53 grade conforming to Bureau of Indian Standards IS 12269:2013 was used as the primary binding material. The cement had a specific gravity of 3.15.

2. Silica Fume

Silica fume was used as a partial replacement of cement at 5% by weight. It is a highly reactive pozzolanic material containing approximately 85–95% silicon dioxide (SiO_2), conforming to ASTM International C1240. It enhances strength and durability by filling micro-voids.

3. Fine Aggregate

Natural river sand conforming to IS 383:2016 was used as fine aggregate. The sand belonged to Zone II and was clean, well-graded, and free from deleterious materials.

4. Coarse Aggregate

Coarse aggregates of 10 mm maximum size conforming to IS 383:2016 were used. The aggregates were angular in shape with good strength and durability characteristics.

5. Recycled Aggregate

Recycled aggregates were obtained from construction and demolition waste. The material was crushed, cleaned, and sieved before use. These aggregates were used as partial replacement of natural coarse aggregates in varying proportions.

6. Water

Potable water conforming to IS 456:2000 was used for mixing and curing. It was free from harmful impurities.

Mix Design

Mix Details (M40 Design)

Material	Quantity
Cement	5.47 kg
Silica Fume (5%)	0.29 kg
Fine Aggregate	9.36 kg
Coarse Aggregate (10 mm)	16.56 kg
Water	2.30 liters
Water-Cement Ratio	0.38–0.40
Replacement Details Silica Fume → 5% (constant) Recycled Aggregate →0% (Control Mix) 20% 40% 60%	

III. METHODOLOGY

Material Selection

Cement (OPC 53 grade), fine aggregate, coarse aggregate (10 mm), recycled aggregate, silica fume (5%), and potable water were selected as per relevant Indian Standards.

Mix Design

The mix design for M40 grade concrete was carried out as per IS 10262 and IS 456.
The quantities were proportionally calculated for casting 9 paver blocks (total volume = 0.0144 m^3).

Replacement Levels

Silica fume was used as a constant replacement of cement at 5%. Recycled aggregates were used as

partial replacement of natural aggregates at 0%, 20%, 40%, and 60%.

Mixing of Concrete

All materials were weighed accurately. Dry mixing of cement, silica fume, fine aggregate, and coarse aggregate was carried out. Water was then added gradually and mixing was continued until a uniform and workable mix was obtained.

Casting of Paver Blocks

The prepared concrete was placed into paver block moulds of size 200 mm × 100 mm × 80 mm. Proper compaction was done manually or using vibration to remove air voids. The surface was finished smoothly.

Curing

The specimens were demoulded after 24 hours and cured in water for 7 days and 28 days.

IV. TESTING

Compressive Strength Test

The compressive strength test was conducted after 7 and 28 days of curing as per standard procedures. The average value of three specimens was considered for analysis.

Sustainability Evaluation

The sustainability aspect was evaluated based on reduction in natural aggregate usage, utilization of construction waste, and improvement in durability due to silica fume.

Results and Discussion

The compressive strength of concrete paver blocks shows a gradual decrease with an increase in recycled aggregate content. However, up to 40% replacement, the reduction in strength is marginal and remains within acceptable limits for M40 grade concrete.

The incorporation of 5% silica fume improves the microstructure by filling micro-voids and enhancing the bond between the cement paste and aggregates. This compensates for the inferior quality and higher porosity of recycled aggregates.

At 60% replacement, a significant reduction in strength is observed due to increased porosity and weaker interfacial transition zones between the aggregates and cement matrix.

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