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# Replacement of River Sand by Waste Foundry Sand in Paver Blocks

**Dattayray Dnyandev Chopade, Adesh Ratnakar Salve, Sudhir Rambhau Kambale**
**Jaywant Shankar Chaudhari, Prof. A.D. Daule**
Department of E&TC Engineering
Adsul Technical Campus, Chas, Ahilyanagar

**Abstract:** *This study investigates the feasibility of replacing natural river sand with waste foundry sand (WFS) in the production of paver blocks, aiming to address both environmental concerns and resource scarcity. Paver blocks were manufactured using two distinct techniques: the Rubber Mould Method and the Hydraulic Press Method, with WFS replacing river sand at varying levels of 0%, 25%, 50%, 75%, and 100%. Comprehensive experimental evaluations were conducted to assess compressive strength, water absorption, flexural strength, split tensile strength, and abrasion resistance, following IS:15658-2006 and related standards. Results indicated that compressive, flexural, and tensile strengths decreased progressively with higher WFS content, while water absorption and surface wear increased. However, up to 50% replacement, paver blocks demonstrated acceptable mechanical properties and durability suitable for non-traffic, pedestrian applications. Hydraulic pressed blocks consistently outperformed rubber moulded blocks due to superior compaction and reduced porosity. The study concludes that WFS can successfully replace river sand up to 50% without compromising essential performance criteria, offering a sustainable, eco-friendly alternative for paver block manufacturing while contributing to effective industrial waste utilization.*

**Keywords**: Waste Foundry Sand, Paver Blocks, Compressive Strength, Durability, Sustainable Construction.

## I. INTRODUCTION

The increasing demand for construction materials, driven by rapid urbanization and infrastructure development, has led to the over-extraction of natural resources such as river sand. River sand, widely used as a fine aggregate in concrete and related products, is facing a critical shortage, causing environmental degradation including riverbank erosion, loss of aquatic habitats, and depletion of groundwater levels. In response to these challenges, the construction industry is exploring alternative materials that can substitute river sand without compromising the quality and durability of concrete products. One such alternative that has gained attention in recent years is Waste Foundry Sand (WFS), a by-product of the metal casting industry.

Waste Foundry Sand is generated in significant quantities during metal casting operations, where it is used repeatedly in moulding and casting processes. After several cycles, the sand loses its binding properties and must be discarded. Disposing of large volumes of WFS poses serious environmental concerns, including land contamination and groundwater pollution due to the presence of residual metals and chemical additives. However, WFS possesses physical characteristics that are similar to natural sand, such as particle size and gradation, making it a promising candidate for partial replacement in concrete production. Utilizing WFS not only helps address the problem of industrial waste management but also contributes to conserving natural sand resources, aligning with global sustainability goals.

The manufacturing of concrete paver blocks presents an excellent opportunity to incorporate WFS. Paver blocks are widely used in pedestrian walkways, parking lots, garden pathways, and other non-traffic areas due to their versatility, aesthetic appeal, and ease of installation. Unlike structural concrete, paver blocks are subjected to moderate loads and environmental conditions, making them suitable for evaluating the performance of alternative fine aggregates like WFS.


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By incorporating WFS into paver block production, the dual objectives of resource conservation and waste utilization can be effectively achieved, thereby supporting eco-friendly and sustainable construction practices.

In this study, paver blocks were manufactured using M30 grade concrete by replacing river sand with WFS in varying proportions of 0%, 25%, 50%, 75%, and 100%. Two manufacturing techniques, namely the Rubber Mould Method and the Hydraulic Press Method, were employed to assess the influence of production processes on the performance of the paver blocks. The Rubber Mould Method, which involves a wet casting process with two layers for enhanced surface finish, was compared against the Hydraulic Press Method that uses high compaction to produce denser and stronger blocks. This comparative approach helps in identifying the most efficient manufacturing process for incorporating WFS.

To comprehensively evaluate the feasibility of using WFS in paver blocks, a series of mechanical and durability tests were conducted. The parameters investigated include compressive strength, water absorption, flexural strength, split tensile strength, and abrasion resistance. These tests were carried out in accordance with Indian Standards such as IS: 15658-2006, IS: 516-1959, IS: 10262-2009, and IS: 1237-1980. The results were analyzed to determine the optimum replacement level of WFS that satisfies the performance criteria for non-traffic applications, ensuring that the blocks remain structurally sound and durable over time.

The preliminary findings from this research indicate that up to 50% replacement of river sand with WFS yields satisfactory performance in both strength and durability tests. Beyond this threshold, significant reductions in mechanical properties and increases in water absorption and surface wear were observed. The denser matrix achieved through the Hydraulic Press Method generally provided superior strength and durability compared to the Rubber Mould Method, although the latter offered better surface finish and aesthetics. These observations highlight the importance of selecting appropriate mix designs and manufacturing techniques when incorporating WFS into paver block production.

This research not only demonstrates the technical feasibility of utilizing Waste Foundry Sand in concrete paver blocks but also underscores its environmental and economic benefits. By integrating industrial waste into the construction industry, it is possible to reduce dependency on natural resources, minimize environmental pollution, and promote sustainable construction practices. The outcomes of this study can serve as a reference for industries and policymakers aiming to implement circular economy principles in construction materials management.

## II. PROBLEM STATEMENT

The excessive extraction of natural river sand for concrete production is causing severe environmental degradation, while large quantities of waste foundry sand (WFS) are being discarded without effective reuse. There is a critical need to evaluate the feasibility of partially replacing river sand with WFS in paver block manufacturing to address both resource scarcity and industrial waste management challenges.

## III. OBJECTIVE

- To investigate the suitability of waste foundry sand as a partial replacement for natural river sand in paver block production.
- To analyze the mechanical properties of paver blocks at varying WFS replacement levels.
- To compare the performance of Rubber Mould and Hydraulic Press manufacturing methods.
- To evaluate the durability characteristics such as water absorption and abrasion resistance.
- To promote sustainable and eco-friendly construction practices by utilizing industrial waste.

## IV. LITERATURE SURVEY

**Khatib, J.M., & Herbert, J.M. (2010)** – *"Effect of waste foundry sand on the mechanical properties of concrete"*
The study examined the influence of waste foundry sand on compressive strength, workability, and durability of concrete mixes. It was observed that up to 30% replacement of natural sand with WFS can produce concrete with comparable strength and reduced environmental impact.

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**Kumar, V., & Bhattacharjee, B. (2015)** – *"Sustainable utilization of foundry waste sand in construction materials"* This paper evaluated the physical and chemical characteristics of WFS and demonstrated its potential to partially replace fine aggregates in concrete and paver blocks, significantly reducing disposal problems.

**Siddique, R., & Noumowe, A. (2008)** – *"Utilization of spent foundry sand in concrete production"* The research focused on mechanical and durability properties of concrete made with varying percentages of WFS. The results indicated that up to 40–50% replacement levels, the strength and durability remain within acceptable standards.

**Tiwari, A., & Mehta, P.K. (2016)** – *"Experimental study on the performance of concrete with foundry sand"* The authors conducted compressive, flexural, and split tensile strength tests on concrete containing different levels of WFS. They reported that 50% replacement yielded optimal results for non-structural applications.

**IS: 15658-2006 & IS: 10262-2009 (Bureau of Indian Standards)**

These Indian Standards provided the framework for mix design, testing procedures, and performance evaluation criteria for concrete paver blocks and were referenced extensively in various research works on industrial waste utilization.

## IV. METHODOLOGY

The experimental methodology was designed to systematically investigate the feasibility of replacing natural river sand with Waste Foundry Sand (WFS) in paver block manufacturing. The study was carried out in the following stages:

**Material Collection and Characterization:**

The primary materials used were Ordinary Portland Cement (OPC), natural river sand, Waste Foundry Sand, coarse aggregates, water, and admixtures. The WFS was collected from local foundries and characterized for its physical and chemical properties such as particle size distribution, specific gravity, fineness modulus, and chemical composition to ensure its suitability as a partial replacement.

**Mix Design Preparation:**

Two different manufacturing techniques were adopted:

- **Rubber Mould Method:** Mix proportion of 1:2.1:1.9 (Cement: Fine Aggregate: Coarse Aggregate)
- **Hydraulic Press Method:** Mix proportion of 1:1.53:2.21 (Cement: Fine Aggregate: Coarse Aggregate)

Mix designs were prepared for M30 grade concrete following IS: 10262-2009. The fine aggregate component was replaced with WFS at varying percentages: 0% (control), 25%, 50%, 75%, and 100%.

**Casting of Paver Blocks:**

The paver blocks were cast according to IS: 15658-2006 specifications, with dimensions of 200 mm x 100 mm x 80 mm. For the rubber mould method, a two-layer process was used with a colored top layer for aesthetics. For the hydraulic press method, a single homogeneous layer was compacted under high pressure.

**Curing:**

All the cast paver blocks were cured under water for 28 days to achieve full strength development and hydration.

**Testing and Evaluation:**

After curing, the paver blocks underwent a series of tests as per relevant IS standards:

- Compressive Strength (IS 516)
- Water Absorption (IS 15658)
- Flexural Strength (IS 516)
- Split Tensile Strength (IS 5816)
- Abrasion Resistance (IS 1237)

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## V. DATA ANALYSIS AND INTERPRETATION

The results obtained from the tests were systematically analyzed to compare the performance of the paver blocks at different WFS replacement levels. Graphical representations were prepared to highlight the trends in mechanical and durability properties. Both manufacturing methods were compared to identify the most effective approach.

**Optimization and Recommendations:**

Based on the comprehensive analysis, the optimum replacement level of WFS was identified, and recommendations were made for practical implementation in the production of eco-friendly paver blocks suitable for non-traffic applications.

## VI. DESIGN OF MODULE

The design of the experimental module was developed to evaluate the suitability of Waste Foundry Sand (WFS) as a partial replacement for natural river sand in paver block manufacturing. This module integrates material preparation, manufacturing processes, mix proportioning, and quality assessment to ensure comprehensive analysis.

### A. Experimental Variables

**Replacement Levels:**

WFS replaced natural river sand at 0%, 25%, 50%, 75%, and 100%.

**Manufacturing Techniques:**

- Rubber Mould Method
- Hydraulic Press Method

**Concrete Grade:**

All mixes were designed for M30 grade concrete as per IS: 10262-2009.

### B. Mix Proportions

**Rubber Mould Method:**

Cement : Fine Aggregate : Coarse Aggregate = 1 : 2.1 : 1.9

**Hydraulic Press Method:**

Cement : Fine Aggregate : Coarse Aggregate = 1 : 1.53 : 2.21

Admixtures were used as needed to improve workability, compaction, and strength.

### C. Manufacturing Process

**Material Preparation:**

All materials were weighed as per mix design, and WFS was dried and sieved to remove impurities.

**Mixing:**

Thorough mixing was done to ensure uniform distribution of WFS in the mix.

**Casting:**

- **Rubber Mould:** Two-layer casting with colored top layer for aesthetic finish.
- **Hydraulic Press:** Single-layer compaction using high-pressure pressing.

**Curing:**

Paver blocks were water cured for 28 days as per standard curing practices.

### D. Dimensions of Paver Blocks

Length: 200 mm
Width: 100 mm
Thickness: 80 mm
(As per IS: 15658-2006 for pedestrian paver blocks.)

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**E. Testing Parameters**

The paver blocks were subjected to the following tests after curing:

| Test | Standard Followed | Purpose |
|---|---|---|
| Compressive Strength | IS: 516 | Load-bearing capacity |
| Water Absorption | IS: 15658 | Porosity & durability |
| Flexural Strength | IS: 516 | Bending resistance |
| Split Tensile Strength | IS: 5816 | Crack resistance |
| Abrasion Resistance | IS: 1237 | Surface wear resistance |

**F. Data Analysis**

Results were analyzed using comparative graphs for all strength and durability parameters across different replacement levels.

Both manufacturing methods were evaluated to determine the optimum WFS content.

Environmental and economic benefits were assessed to promote sustainable construction practices.

**G. Outcome of Module Design**

The module identified that up to 50% replacement of river sand with WFS yields paver blocks meeting IS standards for non-traffic applications. The hydraulic press method showed superior mechanical properties, while the rubber mould method offered better surface aesthetics.

## VII. RESULT AND DISCUSSION

Fig.1 Implementation

The experimental analysis was conducted to evaluate the impact of Waste Foundry Sand (WFS) on the performance of paver blocks produced by Rubber Mould and Hydraulic Press methods. The following summarizes the results obtained from various tests:

**A. Compressive Strength**

- The compressive strength decreased progressively with higher WFS replacement in both methods.
- For both manufacturing methods, paver blocks with 0% WFS replacement displayed maximum strength, consistent with M30 grade concrete.
- Up to 50% replacement, the compressive strength remained within permissible IS:10262-2009 limits, suitable for non-traffic applications.

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- Beyond 50%, strength declined sharply due to poor bonding and increased porosity caused by excessive fine particles in WFS.
- The Hydraulic Press method consistently provided higher compressive strength due to better compaction compared to the Rubber Mould method.

**B. Water Absorption**

- Water absorption increased with increasing WFS content, mainly because of the finer particle size and irregular shape of WFS.
- At 0% replacement, water absorption was lowest, indicating a denser mix.
- Even at 50% replacement, water absorption remained within the acceptable limit of 6% as per IS:15658-2006.
- Higher replacement levels (75% and 100%) led to water absorption exceeding permissible limits, indicating a risk of durability issues.
- Hydraulic Press blocks exhibited lower water absorption across all replacement levels due to dense packing.

**C. Flexural Strength**

- Flexural strength showed a declining trend as WFS content increased.
- At 50% WFS replacement, flexural strength remained above the minimum required breaking load of 2 kN for pedestrian applications.
- Beyond 50%, flexural strength reduced significantly, making the blocks unsuitable for even light traffic conditions.
- Hydraulic Press blocks consistently outperformed Rubber Mould blocks due to superior matrix densification.

**D. Split Tensile Strength**

- Split tensile strength decreased with increasing WFS replacement, following a similar trend as compressive and flexural strength.
- Up to 50% replacement, tensile strength remained acceptable for non-traffic applications.
- The reduction in tensile strength beyond 50% was attributed to weak bonding and increased internal cracks caused by fine particles of WFS.
- Again, Hydraulic Press blocks exhibited marginally higher tensile strength due to effective particle interlocking.

**E. Abrasion Resistance**

- Abrasion resistance declined as WFS replacement increased, owing to the lower hardness of WFS compared to river sand.
- At 50% WFS, abrasion resistance remained satisfactory for footpath and parking lot applications.
- Beyond 50%, surface wear increased significantly, reducing the life expectancy of paver blocks.
- Hydraulic Press blocks had better abrasion resistance compared to Rubber Mould blocks due to tighter surface compaction and reduced surface porosity.

**F. Overall Discussion**

- Both manufacturing methods demonstrated that 50% WFS replacement is the optimal limit where mechanical and durability properties remain within acceptable standards.
- Rubber Mould method produced aesthetically superior paver blocks but exhibited slightly lower mechanical properties.
- Hydraulic Press method yielded stronger and more durable blocks due to high compaction but required additional surface finishing for appearance.

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- The use of WFS provides an environmentally friendly alternative by addressing river sand depletion and managing foundry waste responsibly.
- Paver blocks with up to 50% WFS replacement can be confidently used for non-load bearing applications such as pedestrian pathways, sidewalks, garden pavements, and parking areas.

## VIII. CONCLUSION

The study successfully demonstrated that waste foundry sand (WFS) can be effectively utilized as a partial replacement for natural river sand in the production of paver blocks. Through comprehensive experimental evaluation, it was found that replacing river sand with WFS up to 50% maintains acceptable compressive strength, flexural strength, split tensile strength, water absorption, and abrasion resistance, as per IS standards, for non-traffic applications. The Hydraulic Press method consistently provided superior mechanical properties compared to the Rubber Mould method due to better compaction and matrix densification. Beyond 50% replacement, a significant deterioration in strength and durability parameters was observed, limiting its applicability. The adoption of WFS not only addresses the growing scarcity of natural sand but also promotes sustainable waste management in the foundry industry, contributing to environmental conservation and resource optimization in the construction sector.

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