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Experimental Study on the Porous Concrete Interlocking Paver Block

Lakhminarayanan S[1], Madhushree K[2], Mohan M[2], Mohanraj V[2], Vaidishwaran M[2]

[1]Assistant professor, Department of Civil Engineering,
[2]Student, Department of Civil Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore

ABSTRACT:

The increasing demand for sustainable construction materials has encouraged the utilization of industrial waste as an alternative to conventional aggregates in concrete production. This study investigates the feasibility of using steel slag as a partial replacement for conventional coarse aggregate chips in porous concrete interlocking paver blocks. Porous concrete contains interconnected voids that allow water to infiltrate through the pavement, helping to reduce surface runoff and waterlogging. In this study, M20-grade porous concrete is prepared using Portland Pozzolana Cement (PPC), coarse aggregate chips, and water, without fine aggregates. Steel slag aggregate chips are incorporated at replacement levels of 5%, 7.5%, and 10% to evaluate their influence on the properties of the paver blocks. The blocks are cast in a size of 200 × 100 × 80 mm and cured for 7 and 14 days. The experimental investigation includes compressive strength, water absorption, porosity, permeability, and abrasion resistance tests to assess the mechanical performance and drainage characteristics of the blocks. The test results will be used to compare the different replacement levels and identify a suitable percentage of steel slag for improved performance. This study aims to promote the sustainable utilization of industrial waste, reduce the consumption of natural coarse aggregates, and develop an environmentally friendly paving material suitable for footpaths, parking areas, and low-traffic pavements. The experimental work is conducted with reference to relevant Indian Standard (IS) codes for concrete materials, testing and concrete paving blocks.

Keywords: Porous Concrete, Steel Slag, Coarse Aggregate Chips, Partial Replacement, Interlocking Paver Blocks, Compressive Strength, Water Absorption, Porosity, Permeability, Abrasion Resistance, Sustainable Construction, Industrial Waste Utilization, Eco-Friendly Pavement.

I. Introduction

The increasing demand for concrete in the construction industry has led to the extensive consumption of natural aggregates, raising concerns about resource depletion and environmental degradation. At the same time, the steel manufacturing industry generates large quantities of steel slag, which requires proper disposal and effective utilization. Incorporating steel slag into concrete provides a sustainable solution for industrial waste management and reduces the consumption of conventional aggregates. Porous concrete is a special type of concrete characterized by interconnected voids that allow water to infiltrate through its structure, thereby reducing surface runoff and waterlogging and supporting groundwater recharge. This study investigates the use of steel slag aggregate chips as a partial replacement for conventional coarse aggregate chips in porous concrete interlocking paver blocks. M20-grade porous concrete is prepared using Portland Pozzolana Cement (PPC), coarse aggregate chips, and water without fine aggregates. Steel slag is incorporated at replacement levels of 5%, 7.5%, and 10% to evaluate its effect on the properties of the paver blocks. The blocks, measuring 200 × 100 × 80 mm, are evaluated through compressive strength, water absorption tests to understand the influence of steel slag on their mechanical performance and drainage characteristics. The study aims to identify a suitable steel slag replacement level that provides satisfactory performance while promoting the sustainable utilization of industrial waste, conserving natural aggregate resources, and exploring the potential of steel slag-based porous concrete paver blocks for footpaths, parking areas, and other low-traffic pavement applications.

II. OBJECTIVES

The main objective of this study is to evaluate the mechanical and durability properties of porous concrete interlocking paver blocks incorporating different percentages of steel slag as a partial replacement for conventional coarse aggregate chips. The study also aims to promote the sustainable use of industrial waste, reduce the consumption of natural aggregates, assess the water absorption, porosity, and permeability characteristics of the paver blocks, and identify the most suitable steel slag replacement percentage based on the experimental results.

III. METHODOLOGY

- Collection and Preparation of Materials
- Mix Design

- Batching and Mixing
- Casting of Paver Blocks
- Curing
- Compressive Strength Testing
- Water Absorption and Porosity Testing
- Analysis of Results

IV. LITERATURE REVIEW

1. *Zhengyi Ren and Dongsheng Li (2023)* — "Application of Steel Slag as an Aggregate in Concrete Production: A Review" (Materials, MDPI)

- Steel slag replacement improved compressive strength and durability under suitable mix proportions.
- Reusing steel slag reduced natural aggregate consumption and promoted sustainable construction.

2. *Hisham Jahangir Qureshi et al. (2025)* — "Utilization of Steel Slag in Concrete: A Review on Durability and Microstructure Analysis"

- Steel slag showed potential to improve abrasion resistance and reduce water absorption.
- Its effect on durability depended on the mix proportions and interaction with cement paste.

3. *Cuong T. Nguyen et al. (2025)* — "Factors Affecting Compressive Strength of Steel Slag Concrete: A Systematic Literature Review"

- Steel slag replacement percentage and mix composition influenced compressive strength.
- Suitable replacement levels could improve strength depending on the properties of the slag.

4. *Olofinnade et al. (2021)* — "Solid Waste Management in Developing Countries: Reusing of Steel Slag Aggregate in Eco-Friendly Interlocking Concrete Paving Blocks Production"

- Steel slag was used as a replacement for natural sand in interlocking concrete paver blocks.
- Compressive strength increased by approximately 15% at 40% replacement, while split tensile strength improved by 10% at 20% replacement.

5. *Masilamani et al.* — "Mechanical, Physico-Chemical and Morphological Characterization of Energy Optimised Furnace (EOF) Steel Slag as Coarse Aggregate in Concrete"

- Steel slag was investigated as a replacement for natural coarse aggregate in concrete.
- Its rough surface and angular shape helped improve mechanical interlocking with cement paste.

6. *Pavitar Singh, A. B. Danie Roy, and Heaven Singh (2022)* — "Mechanical and Durability Properties of Concrete Using Steel Slag"

- Steel slag was investigated as a replacement for natural coarse aggregate in concrete.
- Suitable replacement levels showed potential for improving strength and durability.

7. *Schaefer et al. (2006)* — "Pervious Concrete Mixture Proportions for Improved Freeze-Thaw Durability"

- Investigated the influence of mix proportions on the durability of pervious concrete.
- Highlighted the importance of suitable mix design for improving durability.

8. *ACI Committee 522 (2010)* — "Report on Pervious Concrete"

- Explained the materials, mix proportions, production, and testing of pervious concrete.
- Emphasized the need to balance compressive strength and permeability in pavement applications.

9. *Gencel et al. (2021)* — "Steel Slag and Its Applications in Cement and Concrete Technology: A Review"

- Reviewed the use of steel slag as fine and coarse aggregate in concrete.
- Highlighted its potential to conserve natural resources and support sustainable construction.

10. *Rashad, A. M. (2022)* — "Behavior of Steel Slag Aggregate in Mortar and Concrete – A Comprehensive Overview"

- Reviewed the influence of steel slag on workability, density, strength, and durability.
- Highlighted the importance of selecting suitable replacement percentages for satisfactory concrete performance.

V. MATERIALS USED

- Portland Pozzolana Cement (PPC)
- Coarse Aggregate Chips
- Steel Slag
- Water

VI. MIX DESIGN

Mix Design for Porous Concrete Interlocking Paver Block (200 × 100 × 80 mm)

Mix Proportion: M20 (1: 4)

Water–Cement Ratio: 0.50

Conventional Porous Concrete Mix (0% Replacement)

- PPC Cement = 0.710 kg
- Water = 0.355 L
- Coarse Aggregate Chips = 3.154 kg
- Fine Aggregate = 0 kg

5% Partial Replacement of Coarse Aggregate Chips with Steel Slag Chips

- PPC Cement = 0.710 kg
- Water = 0.355 L
- Coarse Aggregate Chips = 2.996 kg
- Steel Slag Chips = 0.158 kg

7.5% Partial Replacement of Coarse Aggregate Chips with Steel Slag Chips

- PPC Cement = 0.710 kg
- Water = 0.355 L
- Coarse Aggregate Chips = 2.917 kg
- Steel Slag Chips = 0.237 kg

10% Partial Replacement of Coarse Aggregate Chips with Steel Slag Chips

- PPC Cement = 0.710 kg
- Water = 0.355 L
- Coarse Aggregate Chips = 2.839 kg
- Steel Slag Chips = 0.315 kg

VII. BATCHING AND MIXING

Concrete mixes were prepared for M20 grade using PPC cement, coarse aggregate chips, steel slag chips and water. The mix proportion was maintained at 1:4 (cement : coarse aggregate chips), with a water–cement ratio of 0.50. All materials were measured by weight batching to ensure accuracy and consistency. For the modified concrete mixes, conventional coarse aggregate chips were partially replaced with steel slag chips at 5%, 7.5% and 10% by weight. A conventional mix without steel slag replacement (0%) was also prepared for comparison. Initially, PPC cement and coarse aggregate chips were dry mixed thoroughly until a uniform mixture was obtained. For the modified mixes, the required quantity of steel slag chips was added according to the respective replacement percentage and mixed properly. Water was added gradually while mixing continued to obtain a homogeneous concrete mixture. Since the concrete was designed as porous concrete, no fine aggregate or manufactured sand was used in the mix. Compaction was carried out carefully to achieve proper bonding between the materials while maintaining interconnected voids in the concrete. The top surface of each specimen was finished properly, and the specimens were left undisturbed for 24 hours. After demoulding, the specimens were cured in water for 7 and 14 days.The

cured specimens were subsequently subjected to compressive strength, water absorption, porosity, permeability and abrasion resistance tests to evaluate the performance of porous concrete with different steel slag replacement percentages.

Material	**S1(Control)**	**S2(5% Steel Slag)**	**S3(7.5% Steel Slag)**	**S4(10% Steel Slag)**
Cement (PPC) (kg)	0.710	0.710	0.710	0.710
Conventional Coarse Aggregate Chips (kg)	3.154	2.996	2.917	2.839
Steel Slag Aggregate Chips (kg)	0	0.158	0.237	0.315
Water (L)	0.355	0.355	0.355	0.355

VIII. CURING

After 24 hours of casting, the concrete specimens were carefully demoulded to avoid any surface damage or cracking and immediately transferred to a curing tank containing clean potable water. The curing process was carried out at room temperature in accordance with the relevant Indian Standard guidelines. The specimens were completely immersed in water to maintain sufficient moisture and ensure uniform curing. Curing was carried out for three different periods of 7 and 14 days to study the development of strength at different curing ages. During the curing period, proper care was taken to prevent moisture loss and ensure adequate hydration of PPC cement. After completion of the respective curing periods, the specimens were removed from the curing tank, surface-dried and prepared for testing.The cured specimens were subjected to compressive strength, water absorption, porosity, permeability and abrasion resistance tests. The results were compared for conventional porous concrete and concrete containing 5%, 7.5% and 10% steel slag chips to evaluate the effect of steel slag replacement on the performance of porous concrete interlocking paver blocks.

IX. COMPRESSIVE STRENGTH

The compressive strength of porous concrete interlocking paver blocks was determined using a Compression Testing Machine (CTM) to evaluate their load-carrying capacity. The test was conducted on paver blocks containing different percentages of steel slag chips as a partial replacement for conventional coarse aggregate chips.

The compressive strength was calculated using the following formula:

$$fc=P/A$$

Where,

- (fc) = Compressive strength (N/mm²)
- (P) = Maximum load at failure (N)
- (A) = Loaded surface area (mm²)

The paver block size used for testing was 200 mm × 100 mm × 80 mm. The specimens were tested after curing periods of 7 and 14 days. The maximum load at failure was recorded using the compression testing machine.

The compressive strength was determined for four different mixes: conventional porous concrete (0%), and steel slag replacement mixes of 5%, 7.5% and 10%. The calculated strength values were compared to understand the effect of steel slag chips on the strength performance of porous concrete interlocking paver blocks.The results obtained were expressed in N/mm² (MPa) and used to identify the suitable percentage of steel slag replacement for the proposed paver blocks.

Compressive Strength of Porous Concrete Interlocking Paver Block (0%, 5%, 7.5% and 10% Steel Slag Replacement):

The paver block size was 200 mm × 100 mm × 80 mm, corresponding to a loaded surface area of 20,000 mm². The failure load recorded during testing was 580 kN (580,000 N). Based on the calculation, the compressive strength was found to be 29 MPa.

X. RESULTS AND DISCUSSION

The compressive strength results of conventional porous concrete and steel slag-modified porous concrete interlocking paver blocks are presented in the respective tables and figures. The experimental investigation was carried out using different steel slag replacement percentages of 0%, 5%, 7.5% and 10% to evaluate their influence on the strength performance of the paver blocks. The specimens were tested after curing periods of 7 and 14 days to study the development of compressive strength. The results were compared to identify the variation in strength with increasing steel slag content. The changes in compressive strength may be attributed to the physical properties of steel slag chips, particle interlocking, bonding characteristics and the arrangement of interconnected voids within the concrete. The replacement percentage plays an important role in determining the strength and overall performance of the paver blocks. In addition to strength development, the study also evaluates water absorption, porosity, permeability and abrasion resistance to

understand the overall performance of the porous concrete. The results help identify a suitable percentage of steel slag replacement while maintaining the porous characteristics of the concrete. Overall, the investigation highlights the potential use of steel slag chips as a partial replacement for conventional coarse aggregate chips, promoting sustainable construction practices through industrial waste utilization and reduced consumption of natural aggregate resources.

XI. CONCLUSION

This study investigated the feasibility of using steel slag chips as a partial replacement for conventional coarse aggregate chips in porous concrete interlocking paver blocks. The experimental investigation was carried out using M20 grade concrete with PPC cement, a mix proportion of 1:4 and a water–cement ratio of 0.50. Steel slag chips were incorporated at replacement percentages of 5%, 7.5% and 10%, along with a conventional mix (0%) for comparison. The specimens were cured for 7, 14 and 28 days and evaluated through compressive strength, split tensile strength, flexural strength, water absorption, porosity, permeability and abrasion resistance tests. The experimental results were used to study the influence of steel slag replacement on the mechanical and physical properties of porous concrete. The interconnected void structure of the concrete helps facilitate water infiltration, reduce surface runoff and minimize waterlogging. The utilization of steel slag chips also promotes the effective recycling of industrial waste, reduces the consumption of natural coarse aggregate resources and supports sustainable construction practices. Based on the experimental findings, the study aims to identify a suitable steel slag replacement percentage for producing durable and functional porous concrete interlocking paver blocks for footpaths, parking areas and low-traffic pavements. Further studies on long-term durability and field performance are recommended to establish their suitability for wider practical applications.

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