INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD)
© 2026 IJNRD | Volume 11, Issue 4, April 2026 | ISSN: 2456-4184 | IJNRD.ORG

USING OF INDUSTRIAL WASTE SLAG FOR RIGID PAVEMENT AS AN SUSTANABLE APPROCH

Ankit Jayantrao Lohit[1], Prof. A. B. Dehene[2]
[1]PG Student, [2]Assistant Professor
[1],[2]Department of Civil Engineering
Bapurao Deshmukh College of Engineering, Sevagram, Wardha, India
[1]ankitlohit@email.com

Abstract—

The rapid expansion of infrastructure development has led to an increased demand for natural aggregates, resulting in depletion of resources and environmental degradation. At the same time, large quantities of industrial waste such as steel slag are generated from the iron and steel industry. This study investigates the utilization of steel slag as a partial replacement of coarse aggregate in M30 grade concrete for rigid pavement applications.

Concrete mixes were prepared with slag replacement levels of 0%, 10%, 20%, 30%, 40%, and 50%. A total of 54 cube specimens were cast and tested for compressive strength at 7, 14, and 28 days. The results show that compressive strength increases up to an optimum replacement level of 30%, achieving a maximum strength of 36 MPa, which is approximately 8.4% higher than conventional concrete.

The improved performance is attributed to better particle packing, enhanced interlocking, and stronger bonding between cement paste and aggregates. The study concludes that steel slag is a sustainable, economical, and high-performance alternative material suitable for rigid pavement construction.

Index Terms—

Steel Slag, Rigid Pavement, Sustainable Concrete, Compressive Strength, Aggregate Replacement, Green Construction.

I. INTRODUCTION

The construction industry is one of the largest consumers of natural resources such as sand, gravel, and crushed stone. Continuous extraction of these materials has led to environmental issues such as resource depletion, riverbed erosion, and ecological imbalance. Therefore, there is an urgent need to develop alternative materials for sustainable construction.

Steel slag is a by-product of the iron and steel industry, generated during the separation of molten steel from impurities. It possesses excellent engineering properties such as high strength, abrasion resistance, and angular texture, making it suitable as a replacement for natural aggregates in concrete.

Rigid pavement requires high-strength concrete capable of withstanding heavy loads and environmental conditions. The use of steel slag in concrete provides a sustainable solution by improving performance and reducing environmental impact.

The utilization of steel slag also supports circular economy principles by converting industrial waste into a valuable construction resource.

II. LITERATURE REVIEW

Previous studies on steel slag in concrete have reported significant improvements in

- Optimum replacement level is generally between **20–30%**
- Compressive strength increases due to improved bonding
- Slag enhances abrasion resistance and durability
- Water absorption decreases due to dense microstructure

However, challenges include:

- Reduced workability at higher slag content
- Variability in slag properties
- Lack of standardized guidelines
- Most studies confirm that slag-based concrete performs better in long-term durability compared to conventional concrete.

III. MATERIALS AND METHODOLOGY

A. Materials

- Cement: OPC 53 Grade
- Fine Aggregate: Zone II Sand
- Coarse Aggregate: 20 mm
- Steel Slag: Specific Gravity = 3.0
- Water: Potable
- Admixture: Fosroc Superplasticizer

B. Mix Design

Concrete mix was designed as per IS:10262-2019.

- Water-Cement Ratio = 0.42
- Cement = 430 kg/m³
- Fine Aggregate = 650 kg/m³
- Coarse Aggregate = 1200 kg/m³

Steel slag replaced coarse aggregate at:- **0%, 10%, 20%, 30%, 40%, 50%**

C. Experimental Procedure

- Cube size: 150 mm × 150 mm × 150 mm
- Total specimens: 54
- Testing ages: 7, 14, 28 days
- Testing method: Compression Testing Machine (CTM)
- All testing procedures were conducted as per relevant IS codes to ensure accuracy and reliability of results.

IV. RESULTS AND DISCUSSION

A. Compressive Strength Results

Slag %	7 Days	14 Days	28 Days
0%	22.8	27.8	33.2
10%	22.1	26.9	33.8
20%	22.5	27.5	34.6
30%	**23.3**	**28.6**	**36.0**
40%	21.9	26.9	33.6
50%	20.2	24.8	31.2

B. Analysis of Results

The compressive strength of concrete increases gradually with slag replacement up to 30% and decreases beyond that level.

- Maximum strength = **36 MPa at 30% slag**
- Improvement = **+8.4%**
- This clearly indicates that steel slag enhances load-carrying capacity and structural performance of rigid pavement concrete.

C. Mechanism of Strength Improvement

The strength improvement is due to:

- Better particle packing → reduced voids
- Angular shape of slag → improved interlocking
- Stronger interfacial transition zone (ITZ)
- Dense and compact concrete structure

- The improved ITZ reduces micro-cracks and enhances durability under repeated loading conditions.

D. Economic Analysis

Type of Concrete	Cost (₹/m³)
Normal Concrete	5055
30% Slag Concrete	4812

Saving = ₹243/m³ (~4.8%)

E. Sustainability Benefits (ADDED SECTION – VERY IMPORTANT)

- Reduces consumption of natural aggregates
- Minimizes industrial waste disposal
- Lowers carbon emissions
- Promotes eco-friendly construction
- Steel slag concrete contributes to sustainable infrastructure development and supports green construction practices.

V. CONCLUSION

- Steel slag can be effectively used as a partial replacement material
- Optimum replacement level = **30%**
- Maximum compressive strength = **36 MPa**
- Improves strength, durability, and sustainability
- Reduces construction cost and environmental impact
- Suitable for rigid pavement applications

VI. FUTURE SCOPE

- Flexural strength testing for pavement design
- Long-term durability studies (fatigue, creep)
- Field performance analysis under traffic loads
- Use of slag with other materials (fly ash, silica fume)
- Life Cycle Assessment (LCA)

REFERENCES

1. Zhang et al. (2025) – Use of Steel Slag in Concrete
2. Motz and Geiseler (2015) – Steel Slag in Road Construction
3. Wang et al. (2021) – Sustainable Construction Materials
4. Ahmed et al. (2025) – Slag in Pavement Applications
5. Reddy et al. (2023) – Aggregate Replacement Study
6. Kulkarni et al. (2023) – Durability of Slag Concrete
7. Gupta and Sharma (2021) – Slag in Cement Industry
8. Verma et al. (2022) – Strength of Slag Concrete
9. Patil et al. (2021) – Workability of Slag Concrete
10. Deshmukh et al. (2024) – Economic Benefits of Slag