



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

# Effect of Experimental Study on Partial Replacement of Steel Slag as Fine and Coarse Aggregate in Concrete Mix

Rushikesh Niranjana Sayre, Dr. S. K. Hirde

P.G. Student, Department of Applied Mechanics, Government College of Engineering, Amravati, Maharashtra, India

Head of Department, Department of Applied Mechanics, Government College of Engineering, Amravati, India

**ABSTRACT:** In this investigation, Steel Slag is used as a partial replacement for fine as well as coarse aggregate in the concrete mix. This deals with the results of an experimental investigation on the partial replacement of steel slag in concrete. M40 grade of concrete was considered for this study. Fine aggregate was replaced by fine steel slag and coarse aggregate with coarse steel slag with 20%, 30%, and 50% effects of the replacement of steel slag on compressive strength, flexural strength, Split tensile strength, and direct shear test are studied. Cubes of 150 mm x 150 mm x 150 mm for compressive strength, beams of 100 x 100 x 400 mm for flexural strength, Cylinders of 150 mm (dia) x 300 mm (height) for split tensile strength, and push-off specimens of 450 x 150 x 150 mm for the direct shear test were cast. And cured for 28 days. All specimens were tested subsequently to study the strength performance of this concrete.

**KEYWORDS:** Fine Steel Slag, Coarse Steel Slag, compressive strength, flexural strength, workability, strength of concrete, split tensile strength, push-off Specimen, direct Shear test.

## I. INTRODUCTION

India is the third-highest producer of crude steel in Asia, according to the World Steel Association (WSA) report 2014. The majority of steel slag is used for earth filling in low laying areas. Slag chemical properties are very similar to those of natural aggregates, and steel slag can be used as a replacement for them. In addition, steel slag can be used as aggregates in filters in wastewater engineering it also positively affects the removal of various heavy metals from wastewater. There are many steelmaking plants in India. The production of iron or steel is associated with the generation of solid waste material like slag. Usually, 1 metric ton of steel production produces 1 tonne of solid waste. Large steelmaking plants generate about 29 million metric ton of waste material annually. Slag is usually a mixture of metal oxides and silicon dioxides. One of the most beneficial uses for furnace slag is in concrete. Because of its chemical and physical properties, it is a very reactive aggregate. Concrete containing slag can have very high strength and can be very durable. So Slag can be used in concrete. When it is used in concrete, it acts as filler and as a strengthening material. The furnace slag also combines with calcium oxide and iron oxide. Both of these actions result in a denser, stronger and less permeable material. In this slag concrete we have replaced fine as well as coarse aggregate up to 20, 30 and 50 per cent by furnace steel slag.

## II. RELATED WORK

In earlier studies (Amjad Ali K.Sharba 2021) the improvement in mechanical properties in concrete due to the replacement of steel slag were expressed as a function in concrete. In this work, the study reports on the test data for various percentages like 10%, 20%. The maximum strength parameters satisfy all the strengths. Amit rana carried the test on steel slag replacement to natural aggregate in road construction giving the maximum strength in comparison to natural aggregate. B. Venkatesan, V.J Lijina (2020) partial replacement of steel slag as fine aggregate and coarse aggregate by walnut shell. M.H.Lai (2021) Improving mechanical behaviour and microstructure of concrete by using BOF steel slag aggregate. Oluwarotimi Olofinnade (2021) solid waste management in developing countries reusing of steel slag aggregate in eco friendly interlocking concrete paving block production. Steel slag coarse as well as fine are used in different percent to find compressive strength at different percent replacement.

## III. METHODOLOGY

Firstly the material was collected in order to design the mix concrete of grade M40. Material needed was fine aggregate, coarse aggregate, cement, and admixture. Now each material was tested according to Indian standards each material was tested and result were noted. Now according to IS10262:2019 mix design was calculated and a fixed proportion was

adopted to cast the specimen for conventional concrete. Now as I have partially replaced steel slag as coarse and fine aggregate the properties of the steel slag was examined which comes out to be somewhat similar. For example, a sieve analysis was performed for fine steel slag as well as for natural fine aggregate results were noted and compared accordingly. As the M40 mix design calculation was done 9 cubes of conventional concrete cast of size 150x150x150mm was demould after 24 hrs and was kept in a curing tank for 7,14,28 days the result was noted down. As I have partially replaced steel slag as 20%,30%, and 50% it the cube were cast again after replacement of fine as well as coarse aggregate and were kept for curing for 7,14, and 28 days as well. As cubes were cast for compressive strength same alike the beams of 100mmx100mmx400mm were also cast for 14,28 days and was kept for curing in the curing tank. Cylinder of size 150mm(dia)x300mm(ht) was also cast for different percent which I have replaced steel slag with natural aggregate accordingly were kept for curing for 28 days For direct shear test a push off specimen mold was firstly made by my side of size 150mmx150mmx450mm according to it reinforcement of 6mm dia bar was used to cast a concrete in the mold total of 21 push off specimen were cast and was kept in curing for 28 days. All the cube, beams, cylinders as well as push-off specimens after curing for 28 days test were perform on them Compressive test on cube, Flexural test on beam, Split tensile test on cylinder & Direct shear test on push off specimen were performed.

### Cement

For this investigation Ordinary Portland Cement (OPC) of 53 grade conforming to IS 12269-1987 has been used.

Table: 1 Physical properties of cement

Fineness	3.75%
Intitial setting time (min)	35
Final setting time (min)	600
Specific gravity	2.88
Standard consistency	29%

### Fine Aggregate

Locally available natural sand from Krishna River confirming (zone II) to I.S. 383-1970[33] was used. Various tests such as specific gravity, water absorption, sieve analysis, etc. have been conducted on fine aggregates to know quality and grading (dust). Silt content was removed by washing sand.

### Coarse Aggregate

Locally available coarse aggregate having a maximum size of 20 mm down to 10 mm is used for the present work. Testing of coarse aggregate was conformed from IS 383-1970. Various tests such as specific gravity, water absorption, sieve analysis, etc have been conducted on coarse aggregate.

### Water

Ordinary tap water is available in the laboratory and used for drinking purposes and has been used for preparing the concrete mix. Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength-giving cement gel, the quantity and quality of water play a very important role.

### Steel Slag

Blast Furnace Slag fine aggregates was collected from the steel industries during the manufacturing process of steel. The sample was collected from JSW steel pvt.Ltd. I have used the waste Blast Furnace Slag as fine aggregates

Properties of steel slag

Specific gravity of fine steel slag	2.51	IS 2386:1963
Bulk density of fine steel slag	1572kg/m <sup>3</sup>	IS 2386:1963
Water absorption of fine steel slag	0.6%	IS 2386:1963
Fineness modulus of fine steel slag	3.62	IS 2386:1963

### Compressive Strength test

The cubes of size 150x150x150mm are placed in the machine such that load is applied on the opposite side of the cubes as cast. Align carefully and load is applied, till the specimen breaks.



a) Compressive testing machine    b) Flexural testing machine

### Flexural Strength Test

The test is carried out to find the flexural strength of the prism of dimension 100 x 100 x 400 mm. The prism is then placed in the machine in such a manner that the load is applied to the uppermost surface as cast in the mould.

### Split Tensile Test

The test is carried out by placing a cylinder specimen of dimension 150mm diameter and 300mm length, horizontally between the loading surface of the compression testing machine and the load is applied until failure of the cylinder along the vertical diameter. The failure load of the specimen is noted.

### Direct shear strength

The shear transfer strength was studied using a push-off specimen with dimensions of 150 mm x 150 mm x 450 mm with a shear plane length of 150mm. The 6 mm steel bar reinforcement was provided away from the shear plane to prevent failure other than the shear mode, All the specimens were tested in direct compression on the universal testing machine of 1000 Tonne capacity.



c) Split tensile machine    d) Direct shear test

## IV. EXPERIMENTAL RESULTS

### 4.1 Testing on fresh concrete

#### Workability

The workability of fresh concrete mix, fine steel slag and coarse steel slag concrete mix was determined by using the slump cone test.

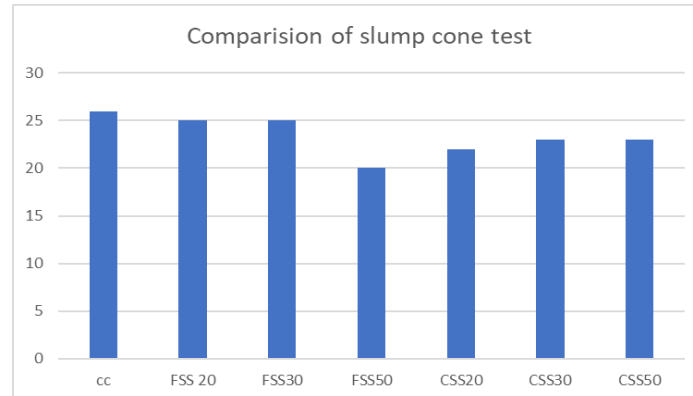


Fig: 1 Comparison of slump cone test

Fig. 1 The above fig shows the comparison of conventional concrete, fine steel slag, coarse steel slag at 20, 30, 50%. Average of each concrete mix design is taken to compare the slump value specimens.

### Dry density

Dry density is obtained by measuring the weight and volume of cubes, cylinders, beams, and push-off specimens.

### Testing on hardened concrete

#### Cube compressive strength

The compressive tests were conducted as per I.S. (I.S.516-1959). Cube was subjected to a concentrated compressive force where failure under compression was expected to occur. A calibrated stiff CTM with capacity of 3000kN was used for testing of the cube specimen. The results obtained from this test are shown below.

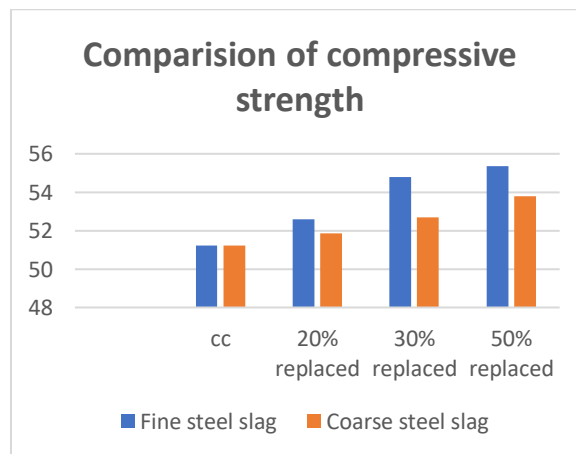


Fig: 2 cube compressive strength

### Flexural strength

The two point bending beam tests were conducted on flexure specimens as per I.S. (I.S.516-1959). A calibrated flexural testing machine with capacity of 600kN was used for testing of the flexure specimens and load was applied at the rate of 400kg/minute. The results calculated from test are shown below.

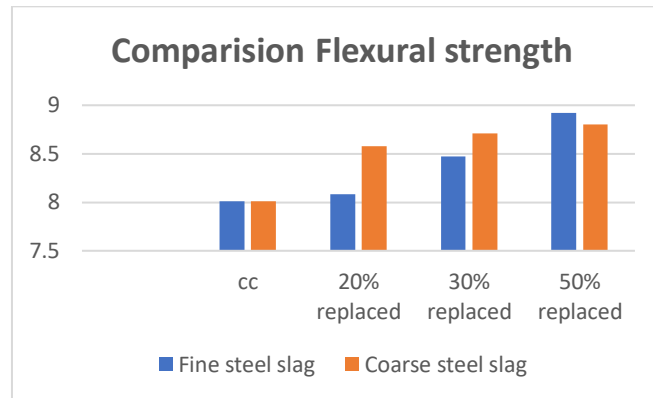


Fig. 3 Flexural Strength

### Split Tensile Strength

The split tensile test is well well-known indirect test used to determine the tensile strength of concrete. Due to difficulties involved in conducting direct tension tests, several indirect methods have been developed to determine the tensile strength of concrete. In this test generally, a compressive force is applied to concrete specimens in such a way that the specimens fail due to tensile stress induced in the specimen.

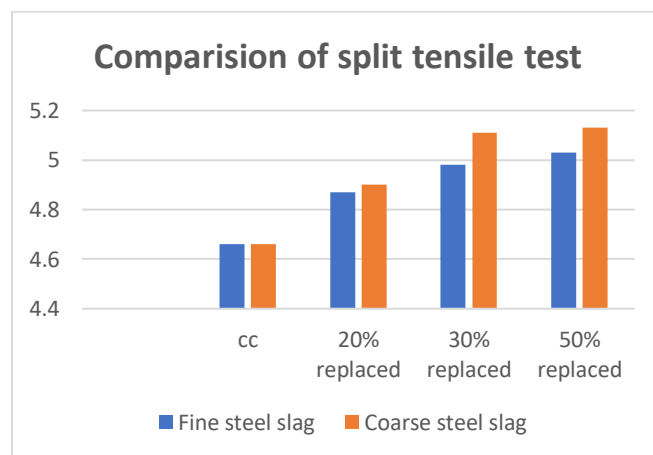


Fig. 4 split tensile strength

### Direct shear strength

The shear transfer strength was studied using a push-off specimen with dimensions of 150 mm x 150 mm x 450 mm (Length x Width x Depth) with a shear plane length of 150mm. The 6 mm steel bar reinforcement was provided away from the shear plane to prevent failure other than the shear mode, All the specimens were tested in direct compression on the universal testing machine of 1000 Tonne capacity.

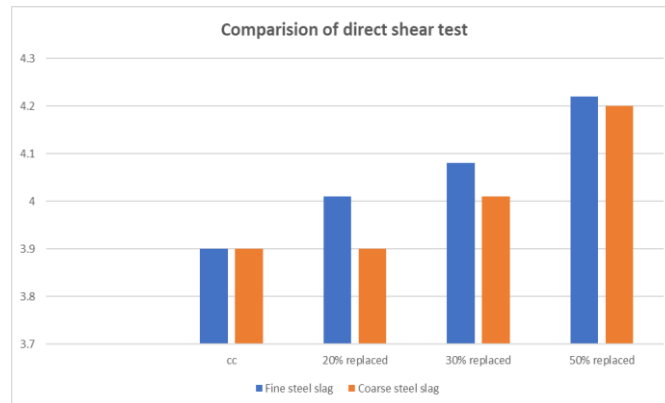


Fig. 5 Direct shear test

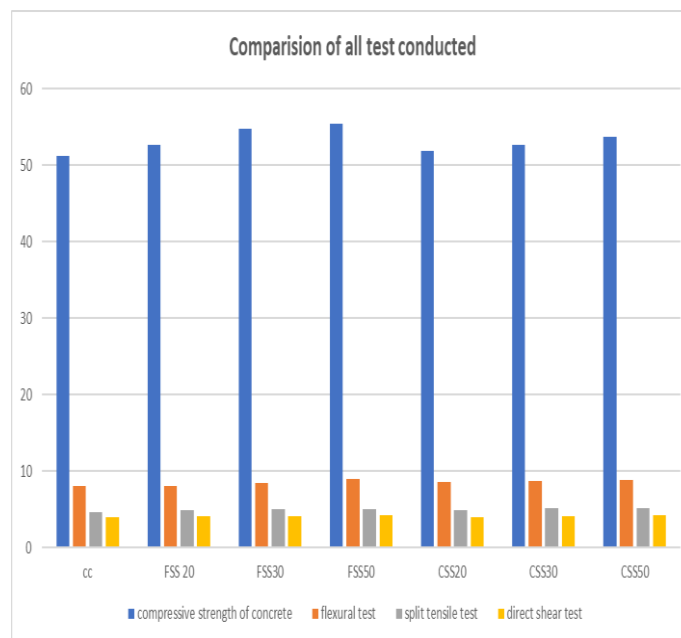


Fig. 6 Comparison of all test conducted

### V. COST ANALYSIS

Specimen	Cost	Percentage decrease
Cost of M40 grade concrete	6592/- rs cost per m3	-
Cost of 20% fine steel slag replaced M40 concrete	6402/- rs cost per m3	-2.88%
Cost of 30% fine steel slag replaced M40 concrete	5986/- rs cost per m3	-9.19%
Cost of 50% fine steel slag replaced M40 concrete	5812/- rs cost per m3	-11.83%
Cost of 20% coarse steel slag replaced M40 concrete	6412/- rs cost per m3	-2.73%
Cost of 20% coarse steel slag replaced M40 concrete	6314/- rs cost per m3	-4.21%
Cost of 20% coarse steel slag replaced M40 concrete	5759/- rs cost per m3	-12.63%

### VI. CONCLUSION

- 1] The workability of concrete partially replaced coarse steel slag as 20%, 30% and 50% and same for fine steel slag was examine.
- 2] The compressive strength of concrete with steel slag was calculated and it was found that the partial replacement of fine steel slag of 20% strength was increase by 2.65% ,for 30% replacement strength was increased by 6.94% and for

50% the strength was increase by 8.06%. Comparing with coarse steel slag thr replacement for 20% slag strength was increase by 1.2% for 30% replacement the strength was increase by 2.63% and for 50% replacement 4.86% was increase.

3] The increase of strength result in reduction in cement for mix design and following it lower grade concrete were design to get desired M40 strength in concrete.

4] Test like split tensile, flexural test, direct shear test was done and result were obtained accordingly.

5] The % of cement that can be reduced in order to get the desired strength of M40 grade was calculated

6] The cost analysis are also done for per meter cube of concrete for fine steel slag replacement as well as coarse steel slag replacement for 20%, 30% and 50% as well.

## REFERENCES

1. Amjad Ali K. Sharba, Ahmed Abbas G. Abu Altemen, Mahir M. Hason (2021) Shear behavior of exploiting recycled brick waste and steel slag as an alternative aggregate for concrete production. *ELSEVIER, Materials Today: Proceedings* 42, 2621-2628.
2. Ali Mohammed Babalghaith et. al (2022) A systematic review of the utilization of waste materials as aggregate replacement in stone matrix asphalt mixes. *Environmental Science and Pollution Research* 29, 35557-35582.
3. B. Venkatesan, V.J. Lijina t. al (2020) Partial replacement of fine aggregate by steel slag and coarse aggregate by walnut shell in concrete. *ELSEVIER*
4. M.H. Lai, Jijajun Zou et. al (2021) Improving mechanical behavior and microstructure of concrete by using BOF steel slag aggregate. *ELSEVIER, construction and Building Materials* 277, 122269.
5. Maan Lardhi, Faisal Mukhtar et. al (2023) Radiation shielding performance of seawater-mixed concrete incorporating recycled coarse aggregate and steel slag. *ELSEVIER*.
6. Oluwarotimi Olofinnade, Ayoyinka Morawo et. al (2021) Solid waste management in developing countries: Reusing of steel slag aggregate in eco-friendly interlocking concrete paving blocks production. *ELSEVIER, case studies in construction material* 14, e00532.
7. SeyedMohsen Mirnezami, Abolfazl Hassani et. al (2023) Evaluation of the effect of metallurgical aggregates (steel and copper slag) on the thermal conductivity and mechanical properties of concrete in jointed plain concrete pavements (JPCP). *ELSEVIER*
8. Ahmedzade, P., Sengoz, B., 2009. Evaluation of steel slag coarse aggregate in hot mix asphalt 506 concrete. *Journal of Hazardous Materials* 165, 300–305
9. Sateesh Kumar. P et al., (2015) “Study on Behaviour of Concrete Mix Replacing Fine Aggregate With Steel Slag At Different Properties”, *Int. J. Eng. Res. Appl.*, ISSN: 2248-9622, Vol. 5, Issue 11, (Part- 4) November 2015.
10. Padmapriya. R. et al.,(2015) “Study on Replacement of Coarse Aggregate by Steel Slag and Fine Aggregate by Manufacturing Sand in Concrete”, *Int. J. Chem. Tech. Res. CODEN (USA): IJCRGG* ISSN: 0974-4290 Vol.8, No.4, pp 1721-1729, 2015.
11. Kaviya. B et al., (2014) “Experimental Study on Partial Replacement of Fine Aggregate by Steel Slag”, *Int. J. Innov. Res. Sci., Engineering and Technology*, Vol. 3, Issue 11, November 2014.
12. Vidhya. J et al., (2016) “Study on Strength Properties of Concrete by Partially Replacing Fine Aggregate as Steel Slag”, *Int. J. Innov. Res. Technol.*, Volume 2, Issue 8, ISSN: 2349-6002.





INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details