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# An Experimental Study of Partial Replacement of Fine Aggregate by Steel Slag in Concrete

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**ABSTRACT:** A significant field of this research is the alteration of concrete properties through the addition of suitable components. This study focuses on using steel slag, a specific waste steel product of the steel industry, to partially substitute fine aggregate in concrete mixes using the M30 grade mix design. Steel slag was used to make concrete in this research study instead of raw fine aggregate. These wastes were used as fine aggregate in varying weight proportions (0%, 5%, 10%, and 15%). This study looks at the material characteristics, compressive strength and split tensile strength of concrete that has steel slag used in place of fine aggregate. According to the experimental findings, concrete that has been combined with steel slag is stronger than regular concrete.

**KEYWORDS:** Steel Slag, Fine Aggregate, Concrete, Mix design, Materials, concrete admixtures.

## I. INTRODUCTION

As steel waste is melted, impurities and fluxing agents are released, producing a liquid slag in induction boilers and other melting units that floats on top of the liquid steel. This by-product is called as steel slag. Historically, the ferroalloys sector has produced a significant amount of solid waste. Industries produce a large amount of waste materials, which has severely harmed both the ecology and surroundings. Separately extracted trash from the boilers at a value of roughly 10% to 15% of the steel manufacture. Because of the tightening of environmental restrictions over the past ten years, which mandate minimising waste disposal, the reuse of waste material has become increasingly significant. Aggregates are in high demand in India, mostly from the civil engineering sector for the production of concrete and roads. Natural resources are under significant pressure from the expansion of several roads and the building of highways for high-speed lines. Numerous investigations and research initiatives regarding the viability, environmentally acceptability, and performance of employing waste industrial products in roadway building are now being completed by private organisations and highway agencies. These studies aim to balance the demands of the highway industry for better and more affordable building materials with the needs of society for the safe and efficient disposal of waste materials.

## II. LITERATURE REVIEW

Subathra Devi V, Gnanavel B K (2014):- Utilising an M20 grade mix design, the intent of this project is about to investigate experimentally the effect of partially substituting steel slag (SS) for coarse and fine aggregates on the different strength and durability parameters of concrete. It is determined what percentage of steel slag should be used to substitute fine and coarse material. Slump cone testing is employed to verify how quickly concrete becomes less workable as the substitute percent rises. Experimental research is done on compressive strength, tensile strength and flexural strength utilising HCl, H<sub>2</sub>SO<sub>4</sub>, and rapid chloride penetration. The findings show that adding steel slag in place of some fine and coarse materials in traditional concrete increases its compressive, tensile, and flexural strengths.

Mahalingam R and Sri Durga G (2018):- A crucial field of study for concrete is the alteration of concrete properties through the addition of suitable components. Our focus is on utilizing steel slag, a specific waste product of the steel industry, to partially replace fine aggregate in concrete production. The waste product is replace with in different proportion of (20%, 40% and 60%). The purpose of the study is to examine the material characteristics, compressive strength and split tensile strength of concrete that contains steel chips in place of some of the fine



aggregate. According to the experimental results, concrete combined with steel metals has a higher strength than normal concrete, and concrete mixed with a 40% scale achieves the highest strength.

Bharani S and Rameshkumar G (2020):- The primary problem at hand in the current situation is industrial waste. Numerous financial challenges arise when recycling entire garbage through the use of recycling units. The primary goal of this study is to determine the mechanical strength of concrete by partially replacing steel slag and e-waste from industrial settings. To determine the qualities of concrete, including its compressive, split tensile, and flexural strengths, four mixes with varying mix proportions are obtained. The best replacement percentage for M-sand can be found by partially replacing it with steel slag at 10%, 20%, and 30%. E-Waste replaces a set amount of the coarse aggregate, keeping the optimal percentage constant.

### III. EXPERIMENTAL INVESTIGATION

The percentage of steel slag used to substitute fine aggregate:

- Conventional concrete (CC) = 0% fine aggregate is replaced with steel slag
  - Mix 1 (M1) = 5% fine aggregate is replaced with steel slag
  - Mix 2 (M2) = 10% fine aggregate is replaced with steel slag
  - Mix 3 (M3) = 15% fine aggregate is replaced with steel slag
- Design of concrete mix

Concrete mix refers to the optimal combination of raw materials chosen to provide a concrete with the necessary properties both in the fresh and hardened stages, including workability and slump cone, for a particular application. According to IS 10626-2019, the grade M30 mix for concrete will be used for this experimental study. The different ratios for substituting steel slag for fine aggregate were also prepared.

The conventional concrete mix ratio is given below:

- Concrete Grade : M30
- Type of Cement : OPC - 53 Grade
- Zone of Fine Aggregates : Zone II
- Specific Gravity of Cement : 3.15
- Specific Gravity of Fine Aggregates : 2.68
- Specific Gravity of Course Aggregates of 20mm : 7.82
- Water-Cement ratio : 0.42

TABLE: 1 CONVENTIONAL CONCRETE MIX DESIGN

Cement	Fine aggregate	Coarse aggregate	Water	Super plasticizer
1	2.30	3.18	0.42	0.01

### IV. RESULT AND DISCUSSION

The results got from testing of concrete specimen are as follows:

Test result on compressive strength:

For each mix 3 samples are tested and the average values is taken as compressive strength of concrete. The values of the compressive strength for conventional and other variation mix are shown in table.

**TABLE: 2 COMPRESSIVE STRENGTH TEST RESULT**

GRADE OF CONCRETE	% OF STEEL SLAG REPLACED	7 DAYS (N/MM <sup>2</sup> )	28 DAYS (N/MM <sup>2</sup> )
M30	CC: 0%	17.6	32.2
	M1: 5%	19.2	34.5
	M2: 10%	22.1	35.8
	M3: 15%	18.9	33.4

Test result on split tensile strength

The cylinder was carried in the size of 15 cm dia and 30 cm depth, after curing it was tested by compression testing machine. The cylinder should be placed in horizontal position for this test.

**TABLE: 3 SPLIT TENSILE STRENGTH TEST RESULT**

GRADE OF CONCRETE	% OF STEEL SLAG REPLACED	7 DAYS (N/MM <sup>2</sup> )	28 DAYS (N/MM <sup>2</sup> )
M30	CC: 0%	2.3	3.5
	M1: 5%	2.6	3.8
	M2: 10%	2.8	3.9
	M3: 15%	2.5	3.6

Test results on flexural strength test

This test was conducted to determine the strength of flexural of concrete. The prism was casted in the size of 500x100x100 mm. It was conducted by universal testing machine (UTM). The load was given to the sample by two point load method. In each percentages of ceramic waste M30 grade was determined at 7 & 28 days.

**TABLE: 4 FLEXURAL STRENGTH TEST RESULT**

GRADE OF CONCRETE	% OF STEEL SLAG REPLACED	7 DAYS (N/MM <sup>2</sup> )	28 DAYS (N/MM <sup>2</sup> )
M30	CC: 0%	2.0	3.4
	M1: 5%	2.3	3.7
	M2: 10%	2.4	3.8
	M3: 15%	2.1	3.6

The result are show in the graph. The graph is based on the 7 &28 days result of compressive strength, split tensile and flexural strength.

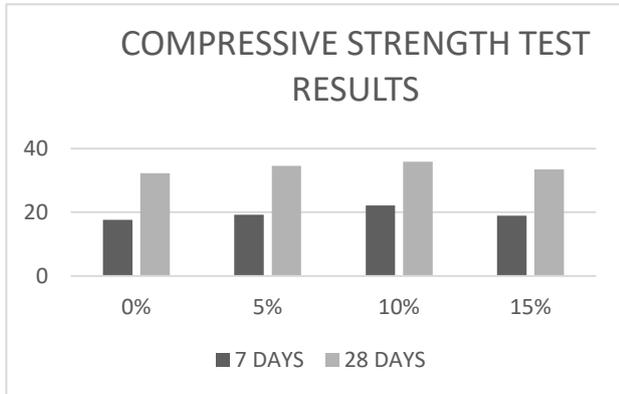


Fig.1 Compressive strength

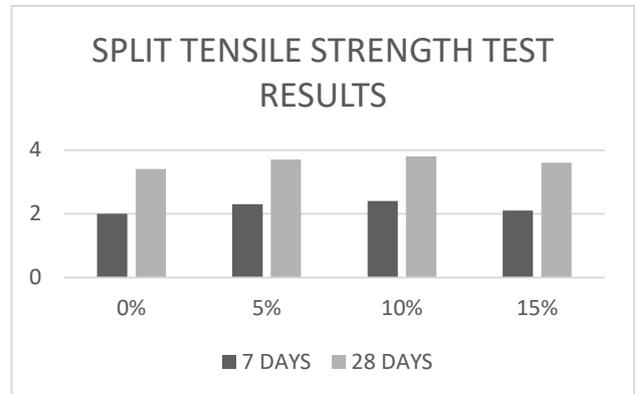


Fig.2 Split tensile strength

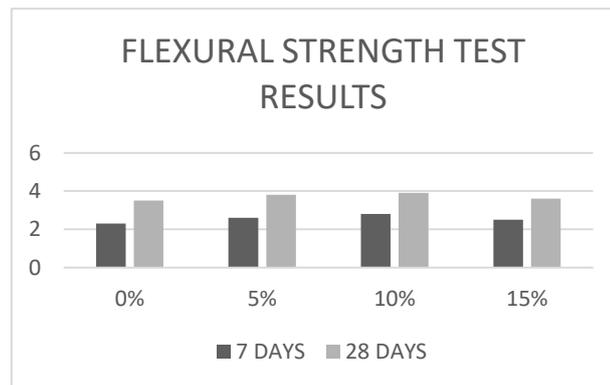


Fig.3 Flexural strength

## V. CONCLUSION

In summary, this experimental work offers encouraging insights into the possible advantages and difficulties of adding steel slag to concrete mixes by partially replacing fine aggregate by steel slag. Through a series of rigorous experiments and analyses, several key findings have emerged:

1. When steel slag is used in place of fine aggregate, tests for compressive strength, split tensile strength, and flexural strength demonstrate improved results at 10%.
2. In comparison of conventional concrete, mix 2 (10% replacement) is increased as 3.6 N/mm<sup>2</sup> in compressive strength at 28 days curing period and 0.4 N/mm<sup>2</sup> increased in split tensile strength and flexural strength test.
3. Mechanical Properties Enhancement: It has shown promising results in enhancing the mechanical properties of concrete. This includes improvements in compressive strength, flexural strength, and abrasion resistance, attributed to the hardness and angularity of steel slag particles.
4. Environmental Sustainability: Utilizing steel slag as a replacement on fine aggregate helps to reduce reliance on natural resources, mitigate environmental impact, and promote the circular economy by valorizing industrial byproducts.

Overall, the results of this experimental investigation highlight steel slag's potential as a competitive substitute for conventional fine aggregate in the manufacturing of concrete. The results of this study offer a useful basis for future investigation and use in sustainable building techniques, even if more study and testing are required to completely comprehend the long-term performance and consequences of utilising steel slag in concrete.

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