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Effect of Steel Slag as Partial Replacement of Fine Aggregate in M35 Grade of Concrete

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***Abstract**: In construction materials, concrete is the largest production of all other materials. Aggregates are the important constituents in concrete. The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials which is obtained by means of various industries such as plastic waste glass waste or steel waste. Steel slag is a waste product generated during the production of steel. In India, annual outcome of Steel Slag is about 10 Million Tone .The increasing demand to protect the normal environment, especially in build-up areas, the needs to use these wastes are very important. Therefore, replacing all or some portion of natural aggregates with steel slag would lead to considerable environmental benefits. The utilization of waste materials from the industries has been continuously emphasized in the research work. The present work is to use steel Slag as partial replacement for fine aggregate. The M35 concrete with steel slag partial replacement for fine aggregate are examined in the present study. According to material properties compressive strength, flexural strength and split tensile strength were found experimentally. The results were compared with conventional concrete property. The results showed that partially replacing about 0%, 11 % , 22 %, 33%, and 44% of steel slag aggregates by weight for natural aggregates will not do any harm to concrete and also it will not have any adverse effects on the strength and durability*
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***Keywords** -Steel Slag, Compressive Strength, Flexural Strength, Spilt Tensile Strength, etc*

1. Introduction

The possibility of our undertaking is to use steel Slag in the development purposes which generally would have been a waste item. The substance makes appealing and amazing exhibit when sprinkled on a white card. Steel slag, a by-result of steel making, is created amid the partition of the liquid steel from debasements in steel-production furnaces. The slag happens as a liquid fluid liquefy and is an intricate arrangement of silicates and oxides that sets after cooling. Steel Furnace Slag or just Steel Slag is created in a furnace as its name proposes. It really is delivered in two sorts of furnaces to be specific BOF and EAF. BOF stand for Basic Oxygen Furnace though EAF remains for Electric Arc Furnace. The essential metals utilized for the making of steel slag are hot iron and scrap metal. The segments of steel slag are FeO, CaO, SiO_2. Due to its water powered property and the vast bearing limit it can give, steelmaking slag is utilized as a street base course material. With high molecule thickness and hardness, this slag has prevalent wear resistance and consequently it is utilized as a aggregate for asphalt concrete. In addition, due to its high angle
of shearing resistance, high particle density, and large weight per unit volume, it is also used as a material for civil engineering works and as a ground improvement material (i.e., material for sand compaction piles). In our detailed study we have hammered the spiral steel waste into powdered form to be used in concrete mix
so that it can be homogeneously mixed with cement concrete. Steel slag aggregates are highly angular in shape and have rough surface texture. They have high bulk specific gravity and moderate water absorption. Slag is a co-product of the iron and steel making process. When any new material is used as a concrete aggregate, three major considerations are relevant: (1) economy, (2) compatibility with other materials and (3) concrete properties. Steel slag has a high degree of internal friction and high shear strength.

Fig No.1 Steel Slag

Today steel slag is used in many fields where its unique characteristics can be put to effective use such as road base course material. Fine aggregate for concrete. Blending material for Portland Cement. The application of steel slag is Greater Hardness, Better adhesion and greater stability and reduced wear.

2. Material and its properties

1. Cement Ordinary Portland cement of 43 grade has been used in this work and its specific gravity is 3.12. It was fresh and without any lumps. The physical properties of the cement as determined from various tests conforming to Indian Standard IS: 8112:1989

Table 2.1 Characteristics Properties of Cement

Sr. No.	Name of Test		Observed Value	Standard value as per IS : 8112-1989)
1	Normal consistency		29.75 %	----
2	Setting Time (Minutes)	Initial	42	Not less than 30 minutes
		Final	340	Not more than 600 minutes
3	Fineness (By Sieves Analysis) %		7.13 %	Should not more than 10 %
4	Compressive Strength (N/mm^2)	After 3 Days	28.60	Should not less 23
		After 7 Days	39.80	Should not less 33
		After 28 Days	48.50	Should not less 43
5	Soundness Test		1.5 mm	Should not more than 10 mm

2. Coarse Aggregate: Coarse aggregate of maximum size 20 mm is used throughout the concrete. The physical Properties of coarse aggregates like Fineness Modulus, Specific Gravity are 7.13, 2.69 respectively.

3. Fine Aggregate: The fine aggregate locally available zone those passed through 4.75mm IS sieve has been used. It confirms to IS 383-1970 which comes under Zone I. The physical Properties of fine aggregate like Fineness Modulus, Specific Gravity and water absorption are 3.25, 2.71 and 2.31% respectively.

Table 2.2 Physical Properties of Aggregates

1	Specific Gravity of Fine Aggregates	2.71
2	Specific Gravity of Coarse Aggregates	2.69
3	Free Moisture Content	2%
4	Water Absorption	2.31%

5. Steel Slag: Steel slag is a by-product obtained either from conversion of iron to steel in a Basic Oxygen Furnace (BOF), or by the melting of scrap to make steel in the Electric Arc Furnace (EAF). Like other industrial by products, slag actually has many uses, and rarely goes to waste.

Table 2.3 Physical properties of steel slag

Sr. No.	Designation	Properties
1	Colour	Light to dark brown
2	Shape	Highly angular
3	Bulk density	1870 kg/m3
4	pH (in water)	8
5	Combustibility	Non-combustible
6	Surface Texture	Rough
7	Specific gravity	2.93

4. Water: Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly, potable tap water was used for the preparation of all concrete specimens.

3. TEST AND RESULTS

3.1 Casting of specimen

Standard cubical moulds of size 150mm×150mm×150mm and cylinder mould of depth 150mm ,height 300mm and diameter of 100mm and beam mould of 150mm×150mm×700mm made of cast iron were used to cast concrete specimens to test compressive strength ,split tensile strength and flexural strength respectively. The quantities of cement, fine aggregates, coarse aggregates, and water for each batch were weighted to an accuracy of 1kg separately. Sand and steel waste is added to this mixture in dry form. Finally, coarse aggregates were added and thoroughly mixed to get a uniform mixture throughout the batch. Required dosage of water was added in the course of mixing. Through mixing was done until concrete appeared to be homogeneous and of desired consistency. Concrete mix so prepared was tested for slump flow and reading of slump carefully recorded. The inner surfaces of moulds were oiled so as to avoid the sticking of concrete. Concrete was then filled in previously prepared moulds with controlled vibration to the concrete. Surface of concrete was finished level using a trowel and date along with batch number was marked properly on it. Finished specimens were left to harden and removed from moulds approximate after 24 hours of casting. They were then placed in water tank containing portable water and were left for curing.

Table -3.1: Compressive, Split tensile and Flexural strength of steel slag added concrete

Sr.No.	%of steel slag	No. of cubes	No. of cylinder	No. of beam
1	0	6	6	6
2	11	6	6	6
3	22	6	6	6
4	33	6	6	6
5	44	6	6	6

3.2 TESTING OF CONCRETE

The test was conducted on cubes according to IS code 516-1959. Specimens were taken out from curing tank at the age of 7 and 28 days of moist curing and were then tested. Specimens were tested on 200 tones capacity of universal testing machine (UTM). The compression and tensile strength tested on UTM and flexural strength test of flexural strength testing machine.

Fig. No. 2: Testing of samples

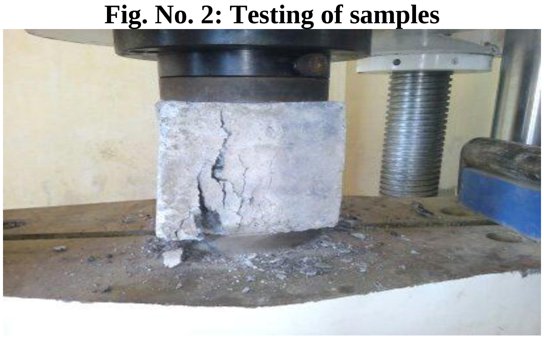

Table -3.2: Compressive Strength by adding steel slag

Sr. No.	% of steel slag	Compressive Strength at 7 days	Compressive Strength at 28 days
1	0	24.89	37.99
2	11	26	39.19
3	22	28.07	41.10
4	33	29.11	43.19
5	44	28.58	42.29

Table -3.3: Flexural Strength by adding steel slag

Sr.No.	% of steel slag	Flexural Strength at 7 days	Flexural Strength at 28 days
1	0	2.22	4.04
2	11	2.72	5.07
3	22	3.11	5.62
4	33	3.44	6.08
5	44	3.10	5.80

Table -3.4: Split Tensile Strength by adding steel slag

Sr. No.	% of steel slag	Split Tensile Strength at 7 days	Split Tensile Strength at 28 days
1	0	1.69	2.67
2	11	2.01	3.24
3	22	2.14	3.77
4	33	2.29	4.11
5	44	2.21	3.83

4. INTERPRETATION OF TEST RESULTS

4.1 Compressive Strength

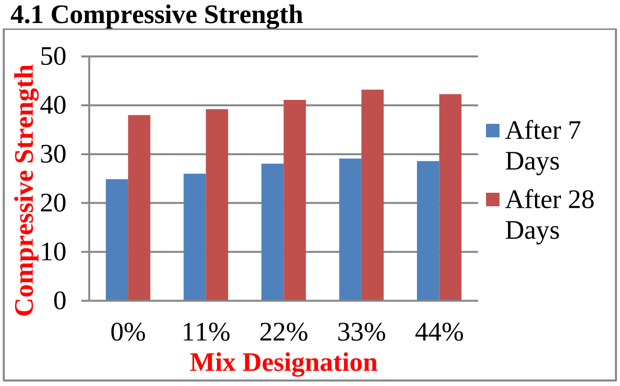

Fig. No. 4: Graph comparing compressive strength for 7 and 28 days

It can be seen from the above tables and figures the addition 33% of Steel slag increase in compressive strength of concrete after that at addition 44% of steel slag the compressive strength decrease as curing age of 7 days and 28 days. The percentage increase or decrease in strength of concrete at 28 days after adding 11, 22, 33 and 44 percentage steel slag is 3.15%, 8.18%, 13.65% and 11.32% respectively. However the good compressive strength of the mixes was found to be comparable to the control mix containing steel slag concrete

4.2 Flexural Strength

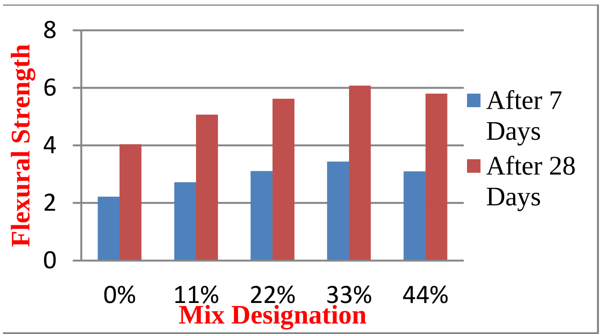

Fig. No. 5: Graph comparing Flexural Strength for 7 and 28 days

It can be seen from the above tables and figures the addition 33% of Steel slag increase in flexural strength of concrete after that at addition 44% of steel slag the flexural strength decrease as curing age of 7 days and 28 days. The percentage increase or decrease in strength of concrete at 28 days after adding 11, 22, 33 and 44 percentage steel slag is 25.50%, 39.10%, 50.49% and 43.56% respectively. However the better flexural strength of the mixes was found to be comparable to the control mix containing steel slag concrete.

4.3 Split Tensile Strength

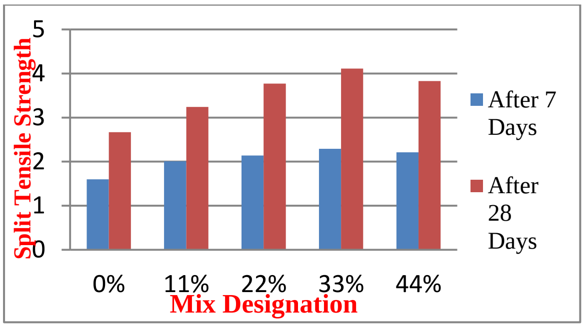

Fig. No. 4: Graph comparing Split Tensile Strength for 7 and 28 days

It can be seen from the above tables and figures the addition 33% of Steel slag increase in split tensile strength of concrete after that at addition 44% of steel slag the split tensile strength decrease as curing age of 7 days and 28 days. The percentage increase or decrease in strength of concrete at 28 days after adding 11, 22, 33 and 44 percentage steel slag is 21.34%, 41.19%, 53.93% and 43.44% respectively. However the better split tensile strength of the mixes was found to be comparable to the control mix containing steel slag concrete.

5. CONCLUSIONS

1. The optimum value of compressive strength , flexural strength, split tensile strength can be achieved by 33% replacement of steel slag.

2. Workability decreases as the percentage replacement of fine aggregate by steel slag increases. This is due to the higher water absorption property of steel slag as compared to natural fine aggregate.

3. The Experimental work shows that workability of steel slag concrete decreased significantly as we increased the Steel Slag amount.

4. It can be concluded that the compressive strength of steel slag concrete gets increased up to 13.68 % with 33% Steel Slags as compared to plain concrete.

5. It is observed that the addition of Steel Slags into reinforced concrete improves the Compressive strength at 28 days

6. It is observed that the Flexural strength of Steel Slag reinforced concrete gets increased up to 50.49 % as compared to plain concrete.

7. It can be concluded that Flexural strength of the steel slag concrete gets increased continuously and decrease at 44 % of steel slag.

8. It is also observed that the Split Tensile strength of Steel Slag reinforced concrete gets increased, increases up to 53.93 % with 33% Steel Slags as compared to plain concrete.

9. It can be concluded that Split Tensile strength of the steel slag concrete gets increased continuously and decrease at 44 % of steel slag.

10. Steel slag reinforced concrete is very effective in resisting flexural tensile stresses as compared to compressive stresses and split tensile strength.

11. By addition of Steel Slag in concrete reduces the cracks causing interconnecting voids to be minimum.

12. From the experimental investigation, it has been found that the flexural strength of steel slag concrete increases very much as compared to compressive stresses and split tensile strength.

13. Steel Slag concrete mixes are observed to give higher strengths on thermal effect than ordinary concrete mixes.

14. The performance of steel slag concrete increased with regard to durability.

15. The use of steel slag concrete on higher replacement percentage may lead to an efficient use of waste material and solve various environmental issues. As in this research work, if steel slag concrete of 44% replacement is used, it may solve the shortage issues of deficit natural sand and also lead to economical construction as steel slag is freely and readily available.

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