

Partial Replacement Of Fine Aggregate Using Steel Slag

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Abstract—The steel making industry has generated substantial solid waste. Steel slag is an industrial by product obtained from the steel manufacturing industry and hundreds of tons of it are produced every year all over the world in the process of refining metals and making alloys. As a construction material, concrete is the largest production of all other materials. Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. It appears in concrete, aggregate road materials, as ballast, and is sometimes used as a component of phosphate fertilizer. Steel slag can be used in the construction industry as aggregates in concrete by replacing natural aggregates. Natural aggregates are becoming increasingly scarce and their production and shipment is becoming more difficult. Steel slag is currently used as aggregate in hot mix asphalt surface applications, but there is a need for some additional work to determine the feasibility of utilizing this industrial by-product more wisely as a replacement for both fine and coarse aggregates in a conventional concrete mixture. Replacing all or some portion of natural aggregates with steel slag would lead to considerable environmental benefits.

Index Terms—Steel slag, mix proportions, Engineering properties of concrete

I. INTRODUCTION

In this project, mix design is done as per the bureau of Indian standards, IS 10262- 1982 for M20 and M40 grade concrete with good degree of quality control .For the mix designed, specimens are cast and investigated experimentally. Preliminary attempt is made to study the effect of partial replacement of fine aggregate by steel slag in the properties of concrete. The properties involve of compressive strength, split tensile strength and flexural strengths of M20 conventional concrete by replacing the 0%, 10%, 20% and 30% of steel slag was added, tests were conducted on concrete cubes, cylinders and Beam to study compressive strength, split tensile strength, and flexural strengths.

The results are compared with the normal conventional concrete. The strength properties of concrete are determined with the various replacement level of steel slag with fine aggregate. The use of steel slag aggregates in concrete by replacing natural aggregates is a most promising concept. Steel slag aggregates are already being used as aggregates in asphalt paving road mixes due to their mechanical strength, stiffness, porosity, wear resistance.

II. MATERIALS USED

In this study the following materials are used – Cement (53grade confirming to IS 12269-1987), fine aggregates, coarse aggregates, steel slag of specific gravity 2.5 to 3.5 (2.36 mm to 4.75 mm) & potable water. With the help above materials the concrete of grade M 20 is prepared by varying the proportions of steel slag. In this study the sand is replaced by 0%, 10%, 20% & 30% by the steel slag. The various tests has been conducted to find out the engineering properties of harden concrete.

III. EXPERIMENTAL SETUP AND RESULT

Keeping in mind the gap in the research area, the objective of this study was to determine the strength of concrete containing steel slag as partial replacement of fine aggregate. For this purpose different test on harden concrete were conducted at the age of 28 days like compressive strength on 150 x 150 x 150 mm size cube, splitting tensile strength on 150 mm X 300 mm cylinder, flexural strength on beam of size 100 x100 x 500 mm. As per IS 516 Total 72 number of specimen were tested and Results are tabulated as below-

A. COMPRESSIVE STRENGTH

Compressive strength tests were performed on cube samples using compression testing machine. Three samples per batch were tested with the average strength values reported in table 1.



Fig. 1 Compressive Strength setup

Table 1-Average Compressive strength of M 20 grade concrete

Sr. no	Percentage of Steel Slag (%)	Compressive Strength at 3 days (N/mm ²)	Compressive Strength at 7 days (N/mm ²)	Compressive Strength at 28 days (N/mm ²)
1	0	9.12	15.34	25.31
2	10	12.65	21.81	32.85
3	20	13.23	22.96	33.68
4	30	12.96	21.32	32.02

B. SPLITTING TENSILE STRENGTH

Splitting tensile strength tests were performed on cylindrical specimen. Three samples per batch were tested with the average strength values reported in table 2

Table 2 - Average Split Tensile Strength of Concrete for M 20grade

Sr. No.	Percentage of Steel Slag (%)	Split Tensile Strength at 3 days (N/mm ²)	Split Tensile Strength at 7 days (N/mm ²)	Split Tensile Strength at 28days (N/mm ²)
1	0	1.39	2.40	3.75
2	10	1.66	2.75	3.98
3	20	1.97	3.35	4.19
4	30	1.81	2.83	3.89

C. FLEXURAL STRENGTH

In flexure test, the beam specimen was placed in the machine in such a manner that the load was applied to the upper most surface as cast in the mould. All beams were tested under two points loading in Universal Testing Machine of 60 ton capacity. The load was applied at a rate of 180Kg/min for 15 cm x 15cm x 70 cm specimens. The load was increased until the specimen failed and the failure load was recorded in table 3.

Table 3 - Average Flexural Strength of M20 Grade Concrete

Sr. No.	Percentage of Steel Slag (%)	Flexural Strength at 3 days (N/mm ²)	Flexural Strength at 7 days (N/mm ²)	Flexural Strength at 28days (N/mm ²)
1	0	1.29	2.90	4.75
2	10	1.56	3.47	5.45
3	20	1.86	3.83	5.65
4	30	1.64	3.67	5.57

IV. RESULTS AND DISCUSSION

From the above table it is observed that the compressive strength, Split tensile strength and Flexural strength is highest at 20% replacement of fine aggregate by steel slag whereas at 30% replacement of sand by steel slag there is reduction in strength.

V. APPLICATIONS

- It is used in base application, construction of unpaved parking lots, as a shoulder material, and also in the construction of beams and embankment.
- It is also used in agriculture because it has minerals like iron, manganese, magnesium, zinc and molybdenum which are valuable plant nutrients.
- It is environment friendly. During the production of cement, the CO₂ emissions are reduced as slag has previously undergone the calcinations process.
- Steel slag aggregates are used for soil stabilization or soil improvement material and for remediation of industrial waste water run-off.

VI. CONCLUSIONS

- The Compressive strength, flexural strength and splitting tensile strength for steel slag aggregates concrete were similar to conventional concrete. The strength may be affected with time and so long term effects on hardened properties of concrete require further investigation.
- The slight improvement in strength may be due to shape, size and surface texture of steel slag aggregates, which provide better adhesion between the particles and cement matrix.
- No major difficulty in handling the concrete which incorporated steel slag aggregates was encountered
- Proper care should be taken during the aging of steel slag and during the stockpiling of steel slag.
- This project initiative will give solution to solid waste disposal and also reduces the natural sand exploitation. Hence this attempt towards eco-friendly built environment is need of hour.
- This work relates the use of steel slag, a waste cheap material used as fine aggregates in M20 grade of concrete and recommends the approval of the material for use in concrete as a replacement material for fine aggregates. The partial substitution of natural aggregates with steel slag aggregates permits a gain of compressive, tensile and flexural strength and modulus of elasticity of concrete up to an optimum value of replacement.

The following benefits can also be obtained:

- Cost reduction
- Social benefits &
- Mass utilization of waste material is possible in construction, by using steel slag as a partial replacement material for fine aggregates in concrete.

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