ISSN:2348-2079

Volume-5 Issue-1

International Journal of Intellectual Advancements and Research in Engineering Computations

Experimental study on strength properties of concrete by partial replacement of fine aggregate with furnace slag

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***Abstract*—Waste management is one of the most common and challenging problems in the world. The steel making industry has generated substantial solid waste. Furnace slag is a residue obtained in steel making operation. This paper deals with the implementation of furnace slag as an effective replacement for sand. Furnace slag, which is considered as the solid waste pollutant, can be used for road construction, clinker raw materials, filling materials, etc. This method can be implemented for producing hollow blocks, solid blocks, paver blocks, concrete structures, etc. Accordingly, advantages can be achieved by using Steel slag instead of natural aggregates. This will also encourage other researchers to find another field of using furnace slag.**

Key words*— *Furnace Slag, Strength Properties, Compressive strength, Flexural strength, Split tensile strength.

I. INTRODUCTION

Furnace slag exist as by-product during melting of steel scrap from the impurities and fluxing agents, which form the liquid slag floating over the liquid steel in arc or induction furnaces, or other melting units. The ferroalloys industry has generated historically substantial solid waste. Great amount of wasted materials is generated by industries and has caused tremendous harm to both the environment and ecology.

The waste removed from the furnace separately in a rate of about(10-15%) of the produced steel. Reuse of waste material has become very important during the past decade because of the reinforcement of environmental regulations that require minimizing waste disposal.Not much research has been carried out in India and other countries concerning the incorporation of Furnace slag in concrete. Therefore, to generate specific experimental data on strength and other characteristics of furnace slag as a fine aggregate, this work is performed.

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A. SCOPE AND PRESENT INVESTIGATION

- Laboratory testing of cement, sand, fine aggregate, coarse aggregate and furnace slag
- Proportioning of concrete mix
- Casting of concrete cube for compressive strength fortesting at 7-days and 28-days.
- Casting of concrete beams for flexural strength for testing at 7-days and 28-days.
- Casting of concrete cylinders for split tensile strength for testing at 7-days and 28-days

B. OBJECTIVES

- The purpose of this research was to explore the feasibility of utilizing the furnace slag as a replacement for natural aggregate in the concrete. Furnace slag aggregates generally exhibit the potential to expand due to the presence of un-hydrated free lime and magnesium oxides which hydrate in humid environments. If such a product is used in the concrete, it influences both the mechanical and physical properties of concrete along with its durability.

II. MATERIALS

- ***Cement***

  Ordinary Portland cement of grade 53 was used. The initial setting time of cement is 30 minutes and the specific gravity of cement is 3.15.

- ***Water***

  Clean potable water is used for Mixing and Curing operation for the work. The Water supplied in the campus is of the potable standard of PH value 7 is used.

Super plasticizer

To improve the workability of fresh concrete sulphonated naphthalene based super plasticizer i.e., Sikament 2002 NS was used supplied by Sika products. 1.4% dosages were used to increase the workability of concrete. Use of Super plasticizer permits the reduction of water to the extent up to 30% without reducing workability. Chemical admixture like super plasticizer conforming to IS: 9103-1999.

Fine Aggregate

Fine aggregate used was clear sand passing through 4.75mm sieve with a specific gravity of 2.64. The grading zone of aggregate was zone III.

Coarse Aggregate

Coarse aggregate used was angular crushed aggregate with a specific gravity of 2.8.

Furnace Slag

Furnace slag has been sourced from JSW Steel Ltd, Salem and has been under weathering process for a certain period (because better properties will be attained to furnace slag when exposed to air for more period).The specific gravity of furnace slag is 2.40.

Concrete Mix Design

Design concrete mix of 1:1.70:3.36 is adopted to attain 40N/mm2.

The water cement ratio of 0.4 is used. After several trails this mix design was finalized.

III. METHODOLOGY

The experimental investigation has been carried out on the test specimens (Cubes, Cylinders, Beams) to study the strength properties as a result of replacing fine aggregate by Steel slag in various percentages namely 0%, 25%, 30%, 35%, 40% and 45%. The slump test was conducted on the fresh concrete and compressive strength, split tensile test and Flexural Strength test were conducted on the hardened concrete.

IV. TESTING

The cubes, cylinders and Prism were casted and after completion of 7 and 28 days curing the following tests have been conducted,

Test	**Stage of Concrete**
Slump test	Fresh (Immediately)
Compressive Strength	Hardened (After curing of 7 & 28 days)
Flexural Strength	
Split Tensile	

V. RESULT

a) SLUMP TEST

The slump test was done on the fresh concrete at various percentages of Steel slag,

Slump values for various % of Steel slag

% of Slag	0	25	30	35	40	45	
Slump in mm	110	105	105	100	95	95	

b). COMPRESSIVESTRENGTH

For every percentage of replacement 6 cubes have been casted. Among them, 3 cubes were tested on the 7th and the other 3 cubes were tested on the 28th day. Totally 48 cubes were casted and 7th day testing has been completed.

Compressive Testing for Cubes

Percentage of Steel Slag (%)	Compressive Strength Testing in 7th Day (N/mm2)
0	28.1
25	31.6
30	35.8
35	30.5
40	27.3
45	25.2

c) FLEXURAL STRENGTH

For every percentage of replacement 6 beams have been casted. Among them, 3 beams were tested on the 7th and the other 3 beams were tested on the 28th day. Totally 48 beams were casted and 7th day testing has been completed.

Flexural Strength Testing for Cylinders

Percentage of Steel Slag (%)	Flexural Strength Testing in 7th Day (N/mm2)
0	4.80
25	5.33
30	5.85
35	5.35
40	4.53
45	4.15

d) SPLIT TENSILE STRENGTH

For every percentage of replacement 6 cylinders have been casted. Among them, 3 cylinders were tested on the 7th and the other 3 cylinders were tested on the 28th day. Totally 48 cylinders were casted and 7th day testing has been completed.

Split Tensile Testing for Prisms

Percentage of Steel Slag (%)	Flexural Strength Testing in 7th Day (N/mm2)
0	4.33
25	4.99
30	5.28
35	4.71
40	4.35
45	4.05

VI. SUMMARY

The mix design for M40concrete was obtained as 1:1.70:3.36 with water- cement ratio of 0.40. The mechanical properties of replacing fine aggregate by furnace slag in various percentages namely 0%, 25%, 30%, 35%, 40%, and 45% was determined. The conclusion of the project work is

- As per the 7th day result, compressive strength increases with increase in percentage of furnace slag by 30% by weight of fine aggregate.
- The compressive strength decreases after 30% replacement of furnace slag.
- As per the 7th day result,split tensile strength increases with increase in percentage of furnace slag by 30% by weight of fine aggregate.
- As per the 7th day result,flexural strength increases with increase in percentage of furnace slag by 30% by weight of fine aggregate.
- From the results of compressive strength, split tensile strength and flexural strength of 7 days curing, 30% replacement of fine aggregate by furnace slag is the optimum percentage of replacement of M40 grade concrete and decreases considerably in further

replacement of slag in concrete. 28 days curing in progress.

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