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Experimental investigation of coarse aggregate with steel slag in concrete

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Abstract **- This paper present the Experimental investigation carried out to evaluate the effects of concrete by replacing the normal coarse aggregate by steel slag on properties of concrete. Concrete is used more than any other material in the world so the use of concrete is unavoidable at the same time scarcity of aggregate is also increased nowadays. The industrial waste has been encouraged in construction industries because it contributes to reduce the usage of natural resources for many years by product such as fly ash, silica fume and steel slag were considered as waste materials. They have been successfully used in the construction industry for the partial and full substitution in concrete. In this study concrete of M30 grades were considered for a W/C ratio of 0.45 respectively for the replacement of coarse aggregate 50% 60%,and 70% by steel slag. This study revealed that there is aim provident in compressive strength 5 to 10% for all the grades of concrete. There is 4 to 8% increase in split tensile strength in all grades of concrete. The Flexural strength of concrete is increase about 2 to 6% for all the grades steel slag can be use up to 60%replacement in all grades of concrete. Full replacement by steel slag decreases the strength considerably.**

Key Words: Steel slag, Strength Properties, Compressive strength, Flexural strength, Split tensile strength

I. INTRODUCTION

The aggregates typically account about 75% of the concrete volume and play a substantial role in different concrete properties such as workability, strength, dimensional stability and durability, Conventional concrete consists of sand as fine aggregate and gravel, limestone or granite in various sizes and shapes as coarse aggregate. There is a growing interest in using waste materials as alternative aggregate materials and significant research is made on the use of many different materials as aggregate substitutes such as coal ash, steel slag and steel slag aggregate. This type of use of a waste material can solve problems of lack of aggregate in various construction sites and reduce environmental problems related to aggregate mining and waste disposal.

SCOPE OF PRESENT INVESTIGATION

- Laboratory testing of cement, sand, fine aggregate, coarse aggregate and Steel slag
- Proportioning of concrete mix
- Casting of concrete cube for compressive strength for testing 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

II. 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.
- Steel 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.

III. 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., conplast SP 430 was used. 1% dosages were used to increase the workability of concrete. Use of Super plasticizer permits the reduction of water to the extent up to 20% without reducing workability.

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.

Steel Slag

Steel slag has been sourced from Agni Steel Ltd, Perundurai 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 2.75.

Concrete Mix Design

Design concrete mix of 1:2.09:3.74 is adopted to attain 30 N/mm2.

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

IV. METHODOLOGY

The experimental investigation has been carried out on the test specimens (Cubes, Cylinders, and Beams) to study the strength properties as a result of replacing fine aggregate by Steel slag in various percentages namely 50% 60% and 70%. 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.

V. 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	

VI.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	50	60	70
Slump in mm	110	105	105	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	24.78
50	26.89
60	27.5
70	26.45

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	4.46
50	5.39
60	6.95
70	6.0

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	2.45
50	2.83
60	3.4
70	3.18

VII. SUMMARY

The mix design for M40concrete was obtained as 1:2.09:3.74 with water- cement ratio of 0.40. The mechanical properties of

replacing fine aggregate by furnace slag in various percentages namely 0%, 50%, 60%, and 70% was determined. The conclusion of the project work is

- The Strength of concrete containing furnace slag of 60 % was high compared with that of the conventional mix.
- The coefficient of permeability was found to be negligible in all the samples of concrete mixes containing furnace slag whereas the coefficient of permeability was more in concrete mixes without steel slag.
- The presence of steel slag in concrete mixes acts as pore fillers and causes reduction in the pores, resulting fine and discontinuous pore structures and thereby increases the impermeability of concrete.
- Coarse aggregate replacement level of 60 % slag in concrete mixes was found to be the optimum level to obtain higher value of the strength and durability at the age of 7 days. 28 days is curing in progress.
- Therefore slag replacement on coarse aggregate up to 60 % is resulted to optimum.

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