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Experimental Study on High Performance Concrete using Slag as Fine Aggregate

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Abstract: In this modern era the availability of river sand is becoming diminished. Increase in demand and decrease in availability of aggregates needs to pinpoint the new source of materials. This paper deals with the feasibility study on the utilization of Induction Furnace Steel slag as partial replacement for conventional fine aggregate. In this study the materials are tested as per BIS standards. The compressive strength and split tensile strength characteristics of concrete made with partial replacement of fine aggregate using Induction Furnace Steel Slag was investigated. For this experimental investigation, different mixes were prepared with various replacement levels of Induction Furnace Steel Slag (0% ,10%, 20%, 30%, and 40%) to arrive the optimum replacement percentage for fine aggregate. Compressive strength test and tensile strength test were conducted on the test specimens and the results were compared. The results of this investigations indicated that the induction furnace steel slag at 30% replacement by the weight of fine aggregates showed a better performance compared to conventional mix.
Keywords: compressive strength, tensile strength, optimum replacement

I. INTRODUCTION

Concrete is a composite material composed mainly of cement, aggregate and water. The cement and other Cementitious materials serve as a binder for the aggregate. The aggregates occupy almost 70-75 percent of total volume of concrete. To meet the global demand of aggregates in future, it is becoming a challenge to find suitable alternative materials to fully or partially replace the natural aggregate without affecting the property of concrete.

Induction furnace slag is a by-product of steel manufacturing industry, which is produced in an induction furnace. These waste materials are otherwise not useful and so is been dumped as landfill in the vicinity of the industry. Unprocessed waste can result in environmental issues and consequently waste disposal becomes a major issue. Thus, the effective utilization of this material could bring about economy and will no longer be of environmental concern. Through the present work, the use of induction furnace slag as a partial replacement for fine aggregate along with super plasticizer (conplast SP430) in cement concrete is studied.

II. MATERIAL CHARACTERISTICS

A. Cement

The cement used for this work is OPC of 53 grades conforming to IS 12296:1987. According to IS4031(part III) thespecific gravity of cement is 3.15; normal consistency is 30% and particle size lies between 31µm to 7.5µm.

B. Aggregates

The fine aggregate used for the study is river sand. The coarse aggregate was 6 -20mm size. Tests were carried out on fine aggregate and coarse aggregate in-order to obtain their physical properties. The obtained results in the tests conducted for aggregates are tabulated below.

Table 1.Physical Characteristics of Aggregates

Property	Fine aggregate		Coarse aggregate	Reference
	River sand	IFS		
Specific gravity	2.74	2.93	2.74	IS 383:2016
Water absorption	1.175%	Nil	3.305%	IS 383:1970
Fineness	3.63%	2.97%	27%	IS 383:1970

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C. Super Plasticizer

A super plasticizer, CONPLAST SP430 has been used for obtaining workable concrete at low w/c ratio. CONPLAST SP430 complies with BIS: 9103-1999 and BIS: 5705-(part III) and ASTM C494. As Super plasticizer molecules and cement grains are oppositely charged, they repel each other. This increases the mobility and makes concrete flow.

Table 2.Physical Characteristics of Superplasticizer

PROPERTIES	RESULTS OBTAINED
Type	Sulfonated naphthalene formaldehyde condensate
Specific gravity	1.22
Chloride content	Nil
Dosage	0.6 liters per 100kg of cement
Compatibility	All type of cement except high alumina cement
Solid content	40%
Compressive strength	Early strength up to 40-50%

III. MIX PROPORTIONING

The mix design is carried out as per IS: 10262-2009. The grade of concrete adopted for this study is M30. Maximum size of aggregate taken is 20mm. The super plasticizer used is CONPLAST SP430. The water cement ratio adopted for concrete mix was 0.45 and mix proportion carried out for a slump of 100±20mm with superplasticizer addition. The quantity of material required for 1m3 of concrete is given below.

Table 3.Mix Ratios

Sample	Mix proportion	Cement (kg/m^3)	FA (kg/m^3)	IFS (kg/m^3)	CA (kg/m^3)	SP	W/C
IF_0	0%	352	776.00	0	1215	0	0.45
IF_{10}	10%	352	698.40	77.60	1215	0.2	0.45
IF_{20}	20%	352	620.80	155.20	1215	0.2	0.45
IF_{30}	30%	352	543.20	232.80	1215	0.2	0.45
IF_{40}	40%	352	465.60	310.40	1215	0.2	0.45

IV. SPECIMEN PREPARATION

The concrete specimens were cast with desired mix proportions and tested for compressive strength and split tensile strength at 7, 14 and 28 days. The tests specimens are of cubical shape with 150mm X 150mm X 150mm and of cylindrical shape with 150mm X 300mm size. Specimens were made by following the specifications as per IS: 4031 (Part 6) – 1988 and stored in water curing tank for the specified time period. The control mixes were tested for concrete cube compressive strength and concrete cylinder split tensile strength. There are five different control mixes of which replacement of fine aggregates are prepared by 0% (IF0), 10% (IF10), 20%(IF20), 30%(IF30), 40%(IF40). The compressive strength test and split tensile strength test were alsoconducted with addition of super plasticizer called CONPLAST SP430.

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V. RESULTS AND DISCUSSION

A. Compression Strength

The casted cubes are tested in CTM and the results obtained are tabulated below for the replacement of IFS in the place of fine aggregate.

Table 4.Compresion strength

Specimen identity	% replacement of IFS	Average compressive strength at 7 days	Average compressive strength at 28 days
IF_0	0	32.14	33.23
IF_{10}	10	32.35	34.75
IF_{20}	20	35.50	40.30
IF_{30}	30	40.32	45.61
IF_{40}	40	34.62	43.29

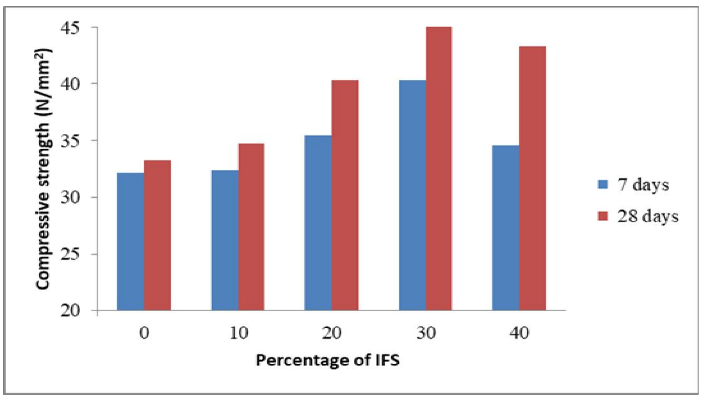

Fig. 1 Relationship between Percentage of IFS and Compressive strength(N/mm^2).

The variation of compressive strength for percentage replacement of Fine aggregate with Industrial Furnace slag for 7th and 28th day is shown in Figure 1. The seventh day compressive strength increases with the increase in IndustrialFurnace slag concentration up to 30% of Fine aggregate replacement.in the replacement of 30%having the higher strength of 45.61N/mm^2.Further replacement the slag 40% compressive strength of concrete is reduced to 43.29 N/mm2 as expected earlier, while the 28th day compressive strength of controlled concrete is 33.23 N/mm2. Also, 20% and 30% Fine aggregate replacement shows more compressive strength than that of controlled concrete.

B. Split Tensile Strength

The casted cylinders are tested in UTM and the results obtained are tabulated below for the replacement of IFS in the place of fine aggregate.

Table 5.Compresion strength

Specimen identity	% replacement of IFS	Average split tensile strength at 7 days	Average split tensile strength at 28 days
IF_0	0	2.34	2.56
IF_{10}	10	2.48	2.85
IF_{20}	20	2.72	2.96
IF_{30}	30	2.81	3.20
IF_{40}	40	2.43	2.84

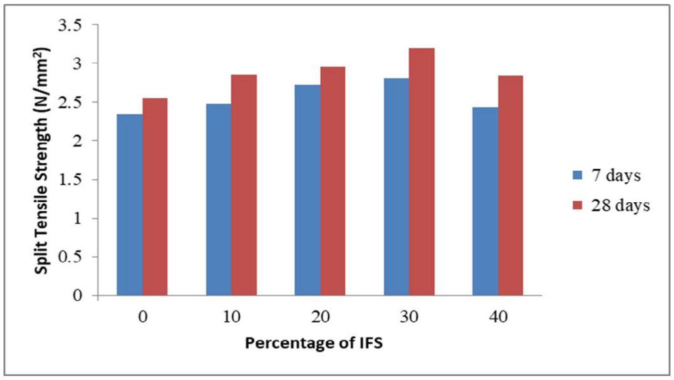

Fig. 2Relationship between Percentage of IFS and Split tensile strength(N/mm^2).

The variation of Split tensile strength for percentage replacement of Fine aggregate with Industrial Furnace slag for 7th and 28th day is shown in Figure 2. The seventh day Split tensile strength increases with the increase in IndustrialFurnace slag concentration up to 30% of Fine aggregate replacement. in the replacement of 30%having the higher strength of 45.61%.Further replacement the slag 40% compressive strength of concrete is reduced to 43.29 N/mm^2 as expected earlier, while the 28th day compressive strength of controlled concrete is 33.23 N/mm^2. Also, 20% and 30% Fine aggregate replacement shows more compressive strength than that of controlled concrete.

VI. CONCLUSION

A. The use of industrial waste by products as a construction material in concrete as a partial replacement of fine aggregate with induction furnace steel slag.

B. The percentage of induction furnace slag is directly proportional to the increase in compressive strength of concrete mix up to 30% replacement by the weight of fine aggregate.

C. As per IS: 5816-1970 specification suggests a value of 0.7 $\sqrt{fck}$ for split tensile strength obtained maximum as 3.2MPa at 30% replacement of induction furnace steel slag by the weight of fine aggregate.

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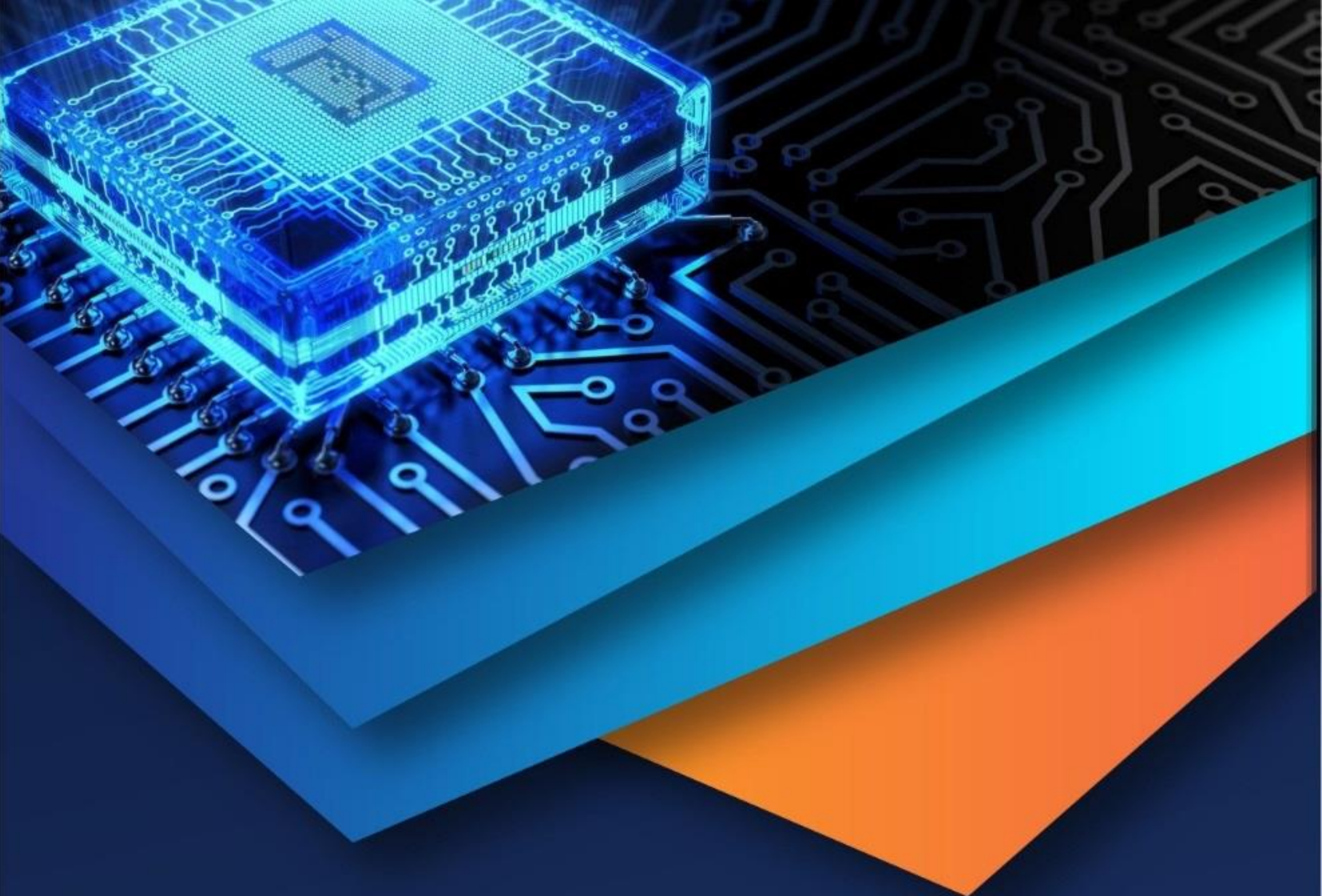

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