Study on Effect of Steel Dust on Strength Characteristics of Concrete

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ABSTRACT
Conservation of natural resources and preservation of environment is the essence of any development. The problem arising from continuous technological and industrial development is the disposal of waste material. The utilization of waste material in concrete, not only can reduce the cost of construction, but also proves to be a safest method of its disposal. In this project a similar effort is taken to find the feasibility of such a waste material in concrete technology. This paper deals with the idea of finding suitable proportions of steel slag that could be related in attaining the target strength of concrete. Experiments were conducted to find the compressive strength and split tensile strength of concrete of M25 grade, with OPC 53 grade of cement and 60%- 20mm and 40%-12mm coarse aggregate. The fine aggregate was replaced by steel dust by 10%, 20%, 30%, 40% and 50% by weight of fine aggregate, were the optimum percentage was found out to be 30%. Fly ash of class F was used to replace cement by 30% by weight of cement and Ceraplast-300 was used as superplasticizer to attain strength and workability.

Keywords *: Steel Dust , class F Fly Ash, Ceraplast-300, Partial Replacement, mechanical properties of concrete*

1. INTRODUCTION

Concrete is the most preferred and the single largest building material used by the construction industry. Concrete is basically made of aggregate, both fine and coarse, glued by a cement paste which is made of cement and water. In fact, many by-products and solid wastes can be used in concrete mixes as aggregate or cement replacement, depending on their chemical and physical characterization, if adequately treated. At present many steel plants are being set up across the globe causing a huge production of solid waste material like slag. Steel plants in India generate about 29 million tons of waste material annually, and 50 million tons worldwide. Now most of the industrial slag is being used without taking full advantage of its properties or thrown off rather than being used.

Owing to the large production, the research work for the last 30 years has shown that 65% of steel slag used today is for qualified fields of application. But remaining 35% of slag is still dumped. The slag present in concrete satisfy physical properties which slow down the hydration of blended cement due to morphology and low calcium silicate content. Thus steel slag can be used in conventional concrete to improve its mechanical, chemical and physical properties. In the present study the experimental investigations were carried out to evaluate the effects of replacing the fly ash with cement and steel slag with fine aggregate, on various concrete properties. Use of steel slag and fly ash provides great opportunity to utilize it as an alternative to normally available aggregate and cement respectively. In this study, M25 grade concrete was considered with water cement in the ratio of 0.40. The tested hardened properties of M_{25} grade concrete will consist of compressive strength, split tensile and flexural strength.

2. EXPERIMENTAL INVESTIGATION

2.1. Materials

Cement: Ordinary Portland Cement (53 grade) conforming to IS 12269:1987 was used for the experimental work. Laboratory tests were conducted on cement to determine specific gravity, fineness, standard consistency, initial setting time, final setting time and compressive strength. In this work 30% of cement was replaced by Class F fly ash. Specific gravity of cement was 3.15.

Flyash: Fly Ash is the finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by the electrostatic precipitator. In recent times, the importance and use of fly ash in concrete has grown so much that it has almost become a common ingredient in concrete, particularly in making high strength and high performance concrete. High fineness, low carbon content, good reactivity are the essence of good fly ash. Since fly ash is produced by rapid cooling and solidification of molten ash, a large portion of components comprising fly ash particles are in an amorphous state. The amorphous character greatly contributed to the pozzolanic reaction between cement and fly ash. In this experiment 30% of cement was replaced by Class F fly ash. Class F fly ash is normally produced by burning anthracite or bituminous coal usually less than 5 % of CaO

Fine Aggregate: Tests were done according to IS 2386 (part 3):1963. M sand passing through 4.75mm sieve conforming to zone II as per IS 383:1970 was used for the experiment. The properties of fine aggregate are given in Table 1

Table –1. Physical properties of fine aggregate

Sl.No:	Test conducted	Result
1	Specific gravity	2.61
2	Fineness modulus	2.97

Coarse Aggregate: Coarse aggregate used in this study were 20mm nominal size, and were tested as per the Indian Standard Specifications IS 383:1970. Its physical properties and sieve analysis results are shown in Table 3.5 and 3.6 respectively. The particle size distribution curve in Fig. 3.4 shows that the coarse aggregate belongs to the standard zone.

Table –2. Physical properties of coarse aggregate

Physical Property	Result
Specific Gravity	2.70
Bulk density (g/cc)	1.69
Porosity (%)	40.21
Void Ratio	0.69
Fineness Modulus	7.03

Steel dust**:** Slag is a partially vitreous by-product of the process of smelting ore, which separates the desired metal fraction from the unwanted mass. slag is usually a mixture of metal oxides and silicon dioxide. Ground granulated slag is often used in concrete in combination with Portland cement as part of blended cement. Ground granulated slag reacts with water to produce cementitious properties. Concrete containing ground granulated slag develops strength over a longer period, leading to reduced permeability and better durability. Since the unit volume of Portland cement is reduced, this concrete is less vulnerable to alkali-silica and sulphate attack. The physical properties and particle size distribution of steel slag are given in Table

Table –3.Physical properties of steel slag

Test conducted	Result
Specific gravity	2.68
Fineness modulus	2.96

Fig – 1. Steel slag

2.2 Mix Proportion

The percentage of cement replacement was selected from the literature reviews as 30%. Seven concrete mixes were prepared by varying the steel slag contents by 10%, 20%, 30%, 40% and 50%.The mix specimen designation details are shown in Table 4

Table – 4. Quantities of materials required for M_{25} mix for $1m^3$

Material	Mix designation						
	SS 0	SS 10	SS 20	SS 30	SS 40	SS 50	SS 100
Coarse Aggregate (kg/m^3)	1270.08	1270.08	1270.08	1270.08	1270.08	1270.08	1270.08
Fine Aggregate (kg/m^3)	690.60	621.54	552.48	483.42	414.36	345.3	0
Steel slag (kg/m^3)	0	69.06	138.12	207.18	276.24	345.3	690.60
Cement (kg/m^3)	231.10	231.10	231.10	231.10	231.10	231.10	231.10
Class F Fly ash (kg/m^3)	99.04	99.04	99.04	99.04	99.04	99.04	99.04
Water (kg/m^3)	132.06	132.06	132.06	132.06	132.06	132.06	132.06
Ceraplast 300 (%)	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Water-Cement Ratio	0.40	0.40	0.40	0.40	0.40	0.40	0.40

3. RESULTS AND DISCUSSION

3.1. Casting

The concrete is prepared in laboratory. The concrete is poured into the mould in 3 layers by 25 strokes with tamping rod. The cast specimens are removed after 24 hours and these are immersed in a water tank. After curing 7 and 28 days the specimens are removed and these are tested for Workability, Compression, and Split tensile strength is found out for concrete which was replaced with steel dust in the proportion of 10%, 20%, 30%, 40% and 50%. This was to be partial replacement of fine aggregate and cement. The results compared with conventional concrete.

3.2. Workability

Slump test and compacting factor tests are the most widely used workability tests for concrete. The degree of workability of concrete depends on the values of test results obtained from slump test and compacting factor tests as in the Table – 5.

Table – 5. Slump value and Compaction factor

Sl.No.	Mix designation	Workability	
		Slump (mm)	Compacting factor
1	SS 0	28	0.84
2	SS 10	29	0.85
3	SS 20	30	0.88
4	SS 30	33	0.90
5	SS 40	36	0.91
6	SS 50	40	0.93

3.3. Compressive Strength

The compressive strength is one of the important properties of hardened concrete.The testing was done in the compression testing machine and the failure load was noted and compressive strength was calculated. The test results are shown in the Table 6.

Table – 6. Compressive strength of concrete

Sl.No.	Mix designation	Average compressive strength (N/mm^2)	
		7th day	28th day
1	SS 0	16.59	25.34
2	SS 10	17.12	27.33
3	SS 20	18.66	28.12
4	SS 30	19.18	29.49
5	SS 40	19.02	28.04
6	SS 50	18.43	27.56

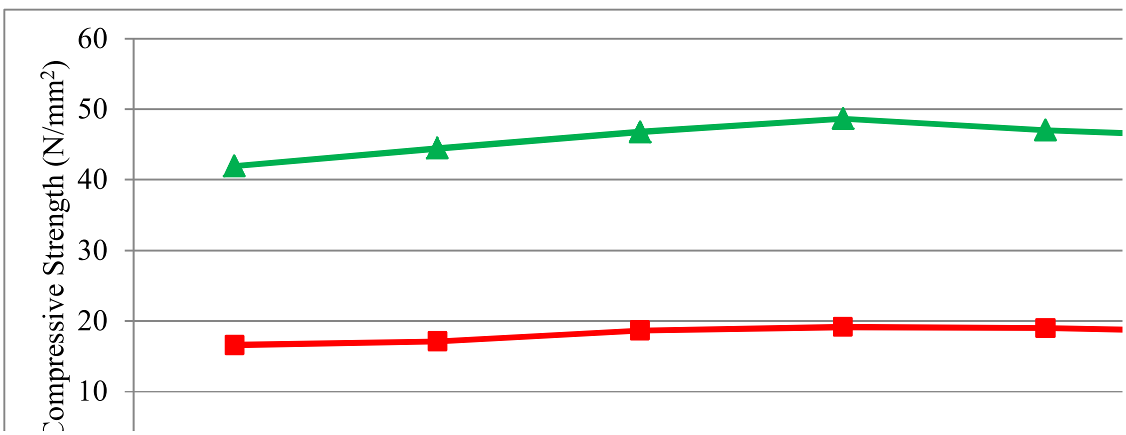

Fig – 2. Compressive strength for 7 & 28 days

3.4. Split tensile Strength Test

The splitting tensile strength was determined after 7 and 28 days of water curing. The splitting tensile strength of concrete was determined for three mixes and is shown in Table 4.5.

Table – 7. Splitting tensile strength of cylinder

Sl.No.	Mix designation	Average Splitting tensile strength (N/mm^2)	
		7th day	28th day
1	SS 0	1.96	4.23
2	SS 10	2.12	4.39
3	SS 20	2.23	4.56
4	SS 30	2.39	4.86
5	SS 40	2.25	4.42
6	SS 50	2.09	4.33

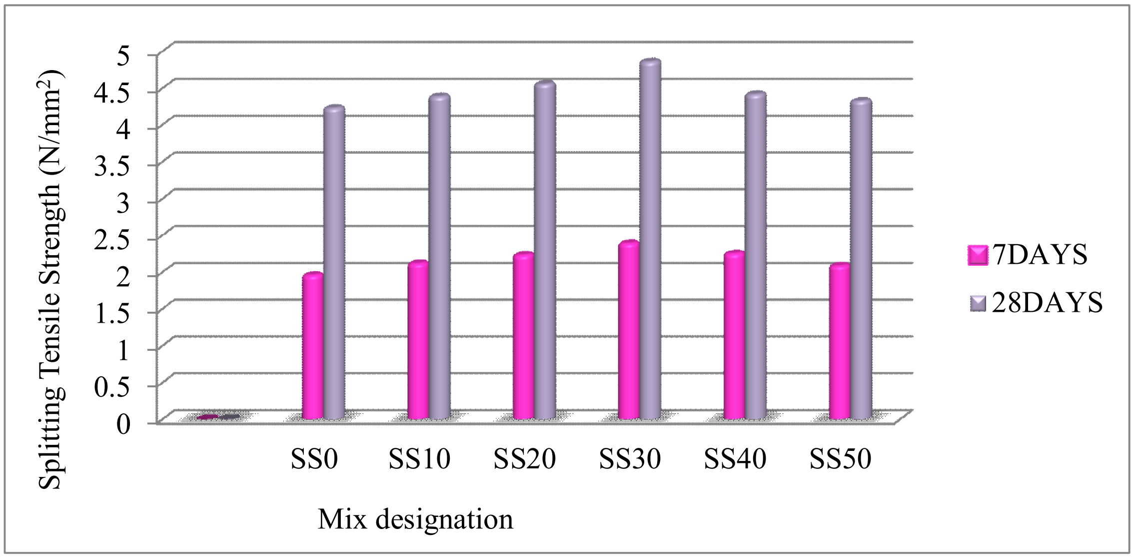

Fig – 3. Splitting tensile for 7 & 28 days

CONCLUSION

Based on the experimental investigation the following conclusions were derived Workability increased with increase in steel slag content. Fine aggregate with 30% replacement (SS 30) showed better mechanical properties in the hardened state. Compressive strength increased upto 30% of replacement with steel slag, and then decreased at all ages. The increase in compressive strength at 28th day of SS 30 was about 13.47% than control mix (SS 0). At 30% of replacement the compressive strength of cylinder was 14.85% more than control mix. The compressive strength of cylinder for SS 100 was higher than SS 0. The splitting tensile strength of cylinder was maximum for 30% of replacement. The percentage of increase in splitting tensile strength of SS 30 was about 14.89% than SS 0.

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