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Study on Structural Behavior of Steel Slag in Concrete

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Abstract: Concrete materials are one of the most important in construction. It consists of cement, stones, river sand as aggregates and water. Due to the growth of construction industries the requirement of aggregates and cements also gets increased. Because of river sand mining nature is getting affected in many ways. This study deals with an alternate material for the replacement of coarse aggregate such as river sand. Here, aggregates are replaced by steel slag in various percentages such as 10, 15 and 20% and the strength on concrete is going to be analyzed.

Key words: Steel slag, concrete aggregates, reinforcement, compressive strength, flexural strength, river snad

INTRODUCTION

Solid waste which is obtained from steel production is called as Steel slag and it can be of 2 types such as carbon type and stainless steel type (Yi *et al*., 2012). More than 400 mln.tons of iron and steel slag is produced each year. Slags are a mixture of silica, calcium oxide, magnesium oxide and aluminium and iron oxides. On average the production of one tonne of steel results in 200 kg (EAF) to 400 kg (BF/BOF) of by-products. These include slags, dusts, sludges and other materials (Anonymous, 2010).

The use of steel slag as a concrete aggregate is likely to be more economically acceptable than its use as a concrete binder. In addition, since, aggregates account for more than three quarters of concrete volume, greater amounts of steel slag could be used as an aggregate than as a binder (Netinger *et al*., 2014).

Slag generation is inseparable from steel production. As long as steel is produced, it is imperative to effectively use the amount of slag corresponding to the steel production and it is necessary to cultivate methods of safe and stable use of iron/steel slag (Horii *et al*., 2015).

MATERIALS AND METHODS

Steel slag aggregates are highly angular in shape and have rough surface texture. They have high bulk specific gravity and moderate water absorption (<3%) (Chesner *et al*., 1998). Physical properties of steel slag are shown in Table 1.

The chemical composition of steel slag is usually expressed in terms of simple oxides calculated from elemental analysis determined by X-ray fluorescence. Table 2 lists the range of compounds present in steel slag from a typical base oxygen furnace. Virtually all steel slags fall within these chemical ranges but not all steel slags are suitable as aggregates. Of more importance is the mineralogical form of the slag which is highly dependent on the rate of slag cooling in the steel-making process (Chesner *et al*., 1998).

Table 1: Physical properties of steel slag

Description	Values
S. Gravity	3.2-3.6
Unit weight (kg/m^3)	1600-1920
Water absorption	up to 3 (%)

Table 2: Chemical properties of steel slag

Description	Percentage
CaO	40-52
SiO_2	10-19
FeO	10-40 (70-80% FeO)
MnO	5-8
MgO	5-10
Al_2O_3	1-3
P_2O_5	0.5-1
S	<0.1
Metallic Fe	0.5-10

The concrete mix was prepared for the M_{25} grade concrete and few sample cubes and beams was cast and tested with partial replacement of aggregates by steel slag with various percentages of 10, 15 and 20%. The samples are included for the compressive and flexural strength in the time intervals of 7, 14 and 28 days. The results are tabulated.

RESULTS AND DISCUSSION

The test results of compressive strength and flexural strength of different concrete samples are listed in Table 3 and 4. Figure 1 and 2 shows the comparison chart of compressive strength of different cube samples and flexural strength of different beam samples. The table and graph results confirm that maximum compressive and flexural strength achieved in the replacement percentage of 15.

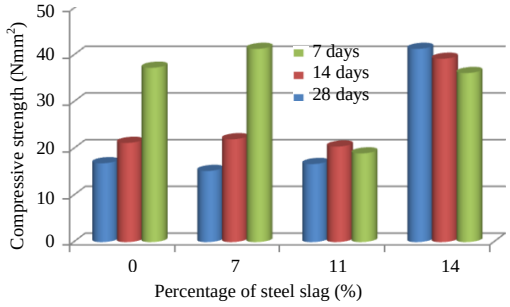

Fig. 1: Compressive strength of cubes

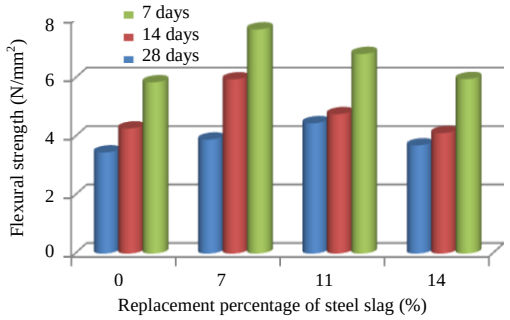

Fig. 2: Flexural strength of beams

Table 3: Test results for compressive strength of cubes

	Average compressive strength (N/mm^2)			
		Steel slag concrete		
Number of curing days	Plain concrete	10 (%)	15 (%)	20 (%)
7	16.78	15.32	16.17	14.56
14	21.42	22.10	20.54	18.89
28	37.27	41.63	39.42	36.91

Table 4: Test results for flexural strength of beams

	Average flexural strength (N/mm^2)			
		Steel slag concrete		
Curing days	Plain concrete	10 (%)	15 (%)	20 (%)
7	3.64	3.78	4.64	3.68
14	4.87	5.96	4.87	4.21
28	5.68	7.76	6.38	5.79

CONCLUSION

The mix design was prepared for the M_{25} grade concrete with partial replacement of fine aggregate by Steel Slag with various percentages of 10, 15 and 20%. The maximum flexural strength for partial replacement of fine aggregate with steel slag be achieved by 15% is found to be greater than the conventional concrete. It achieved maximum compressive strength when there is partial replacement of fine aggregate with steel slag 15%. So, the optimum percentage of replacement of steel slag is 15%.

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